# HAYNES® 244® Alloy

## Principal Features

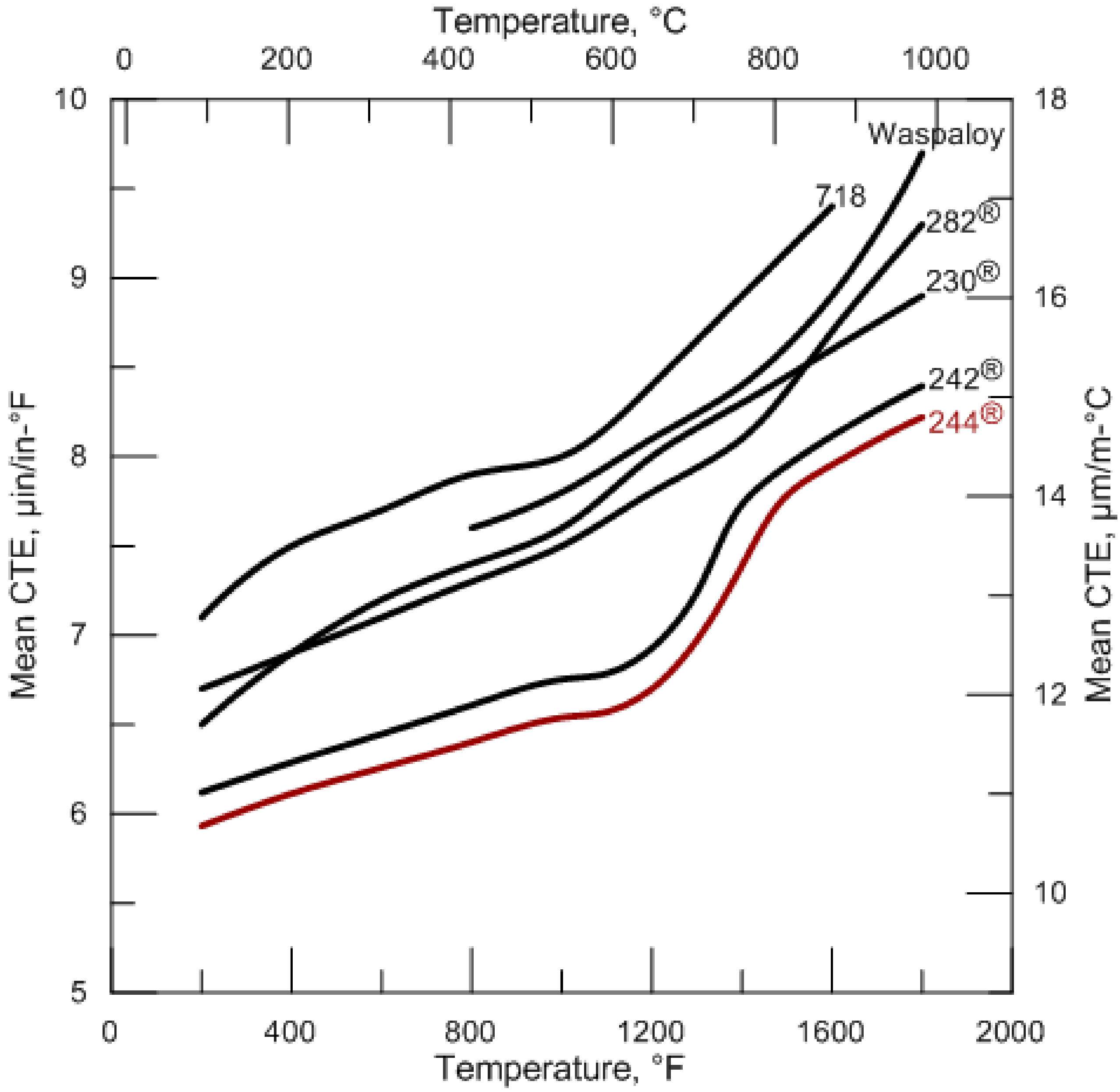
HAYNES® 244® alloy is a new Ni-Mo-Cr-W alloy developed for static parts in advanced gas turbine engines which require low thermal expansion at temperatures up to 1400°F (760°C). It offers a higher maximum use temperature than other low thermal expansion alloys currently available, including a 100-200°F (55-110°C) improvement over HAYNES® 242® alloy. The alloy is age-hardenable by formation of $Ni_2$ (Cr,Mo,W) domains, which are structurally similar to the strengthening domains in 242® alloy. Judicious alloying with tungsten increased the thermal stability of these domains and lowered the coefficient of thermal expansion. Other important properties such as oxidation resistance and low-cycle fatigue performance are comparable or better than those of 242® alloy.

## Nominal Composition

**Weight %**

| | |
|---|---|
| **Nickel:** | Balance |
| **Aluminum:** | 0.5 max. |
| **Carbon:** | 0.03 max. |
| **Chromium:** | 8 |
| **Iron:** | 2 max. |
| **Manganese:** | 0.8 max. |
| **Molybdenum:** | 22.5 |
| **Tungsten:** | 6 |

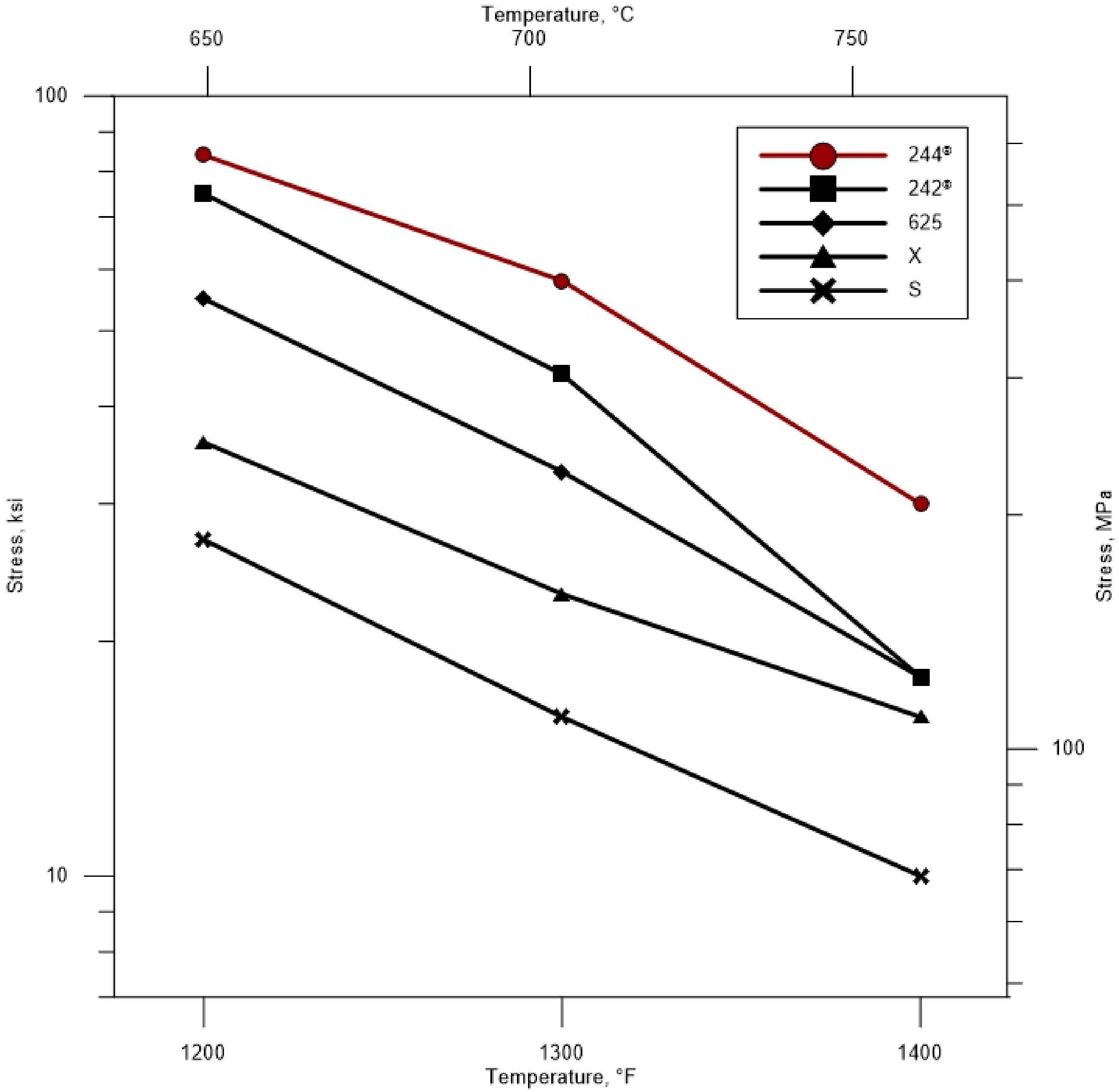
# Coefficient of Thermal Expansion




*244® Thermal Expansion data can be found on the Physical Properties page.

## Creep and Stress-Rupture Strength

Approximate Initial Stress Required to Cause Rupture in 1000 Hours

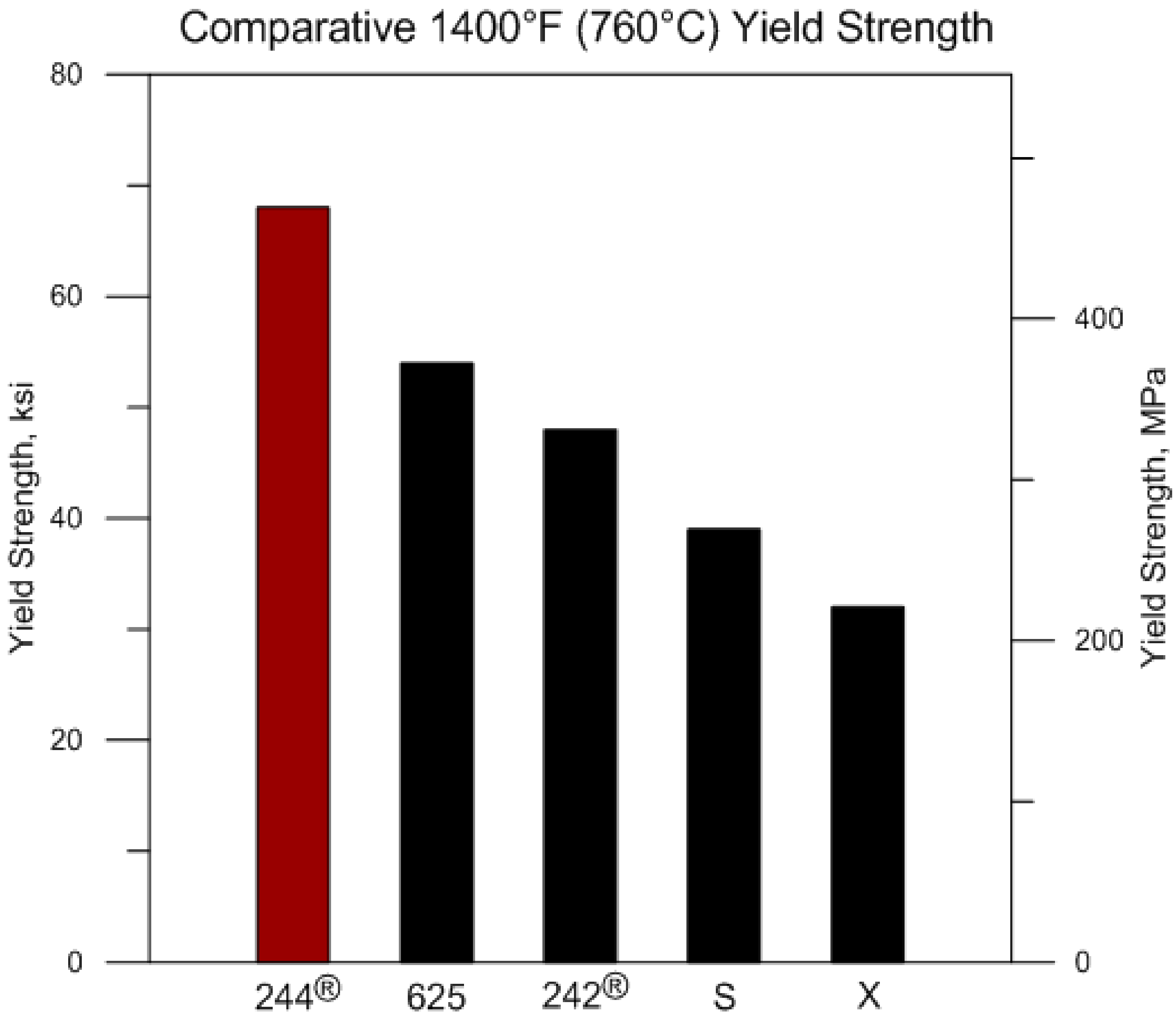



**244® Plate, Age-Hardened (Limited Data)**

| Temperature | | Creep | Approximate Initial Stress to Produce Specified Creep in | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | 10 Hours | | 100 Hours | | 1,000 Hours | | 10,000 Hours | |
| °F | °C | % | ksi | MPa | ksi | MPa | ksi | MPa | ksi | MPa |
| 1200 | 649 | 1 | - | - | 92 | 634 | 75 | 517 | 58* | 400* |
| | | R | 102 | 703 | 93 | 641 | 84 | 579 | 65 | 448 |
| 1300 | 704 | 1 | 80 | 552 | 62 | 427 | 49 | 338 | 35 | 241 |
| | | R | 92 | 634 | 74 | 510 | 58 | 400 | 39 | 269 |
| 1400 | 760 | 1 | 47 | 324 | 34 | 234 | 25 | 172 | 13* | 90* |
| | | R | 58 | 400 | 43 | 296 | 30 | 207 | 18 | 124 |

*Significant extrapolation

## Tensile Properties



# Tensile Properties Continued

**244® Alloy Plate**

| Test Temperature | | 0.2% Offset Yield Strength | | Ultimate Tensile Strength | | Elongation | Reduction in Area |
|---|---|---|---|---|---|---|---|
| °F | °C | ksi | MPa | ksi | MPa | % | % |
| RT | RT | 123.3 | 850 | 196.6 | 1356 | 33 | 37 |
| 200 | 93 | 115.8* | 789* | 190.7* | 1315* | 39* | 43* |
| 400 | 204 | 109.6* | 756* | 181.4* | 1251* | 40* | 47* |
| 600 | 316 | 103.1* | 711* | 174.9* | 1206* | 42* | 47* |
| 800 | 427 | 98.9 | 682 | 171.1 | 1179 | 42 | 47 |
| 1000 | 538 | 103.3 | 712 | 167.3 | 1153 | 34 | 37 |
| 1100 | 593 | 95.7* | 660* | 155.6* | 1073* | 37* | 46* |
| 1200 | 649 | 94.0 | 648 | 140.0 | 965 | 21 | 25 |
| 1300 | 705 | 86.0 | 593 | 124.6 | 859 | 16 | 21 |
| 1400 | 760 | 68.0 | 469 | 105.4 | 726 | 40 | 36 |
| 1500 | 816 | 36.1* | 249* | 72.2* | 498* | 96.5* | 65.3* |
| 1600 | 871 | 36.5* | 252* | 54.9* | 379* | 120* | 84* |
| 1800 | 982 | 25.9* | 179* | 33.9* | 234* | 150* | 98* |

RT= Room Temperature
Solution annealed + aged 1400°F / 16h / furnace cool to 1200°F/ 32h / air cool
*Single test

**244® Alloy Sheet, Limited Data**

| Test Temperature | | 0.2% Offset Yield Strength | | Ultimate Tensile Strength | | Elongation |
|---|---|---|---|---|---|---|
| °F | °C | ksi | MPa | ksi | MPa | % |
| RT | RT | 129.6 | 894 | 201.2 | 1387 | 35 |
| 200 | 93 | 128.0 | 883 | 195.0 | 1345 | 33 |
| 400 | 204 | 123.0 | 848 | 191.5 | 1320 | 35 |
| 600 | 316 | 114.0 | 786 | 187.5 | 1293 | 41 |
| 800 | 427 | 112.5 | 776 | 181.5 | 1251 | 39 |
| 1000 | 538 | 110.5 | 762 | 171.0 | 1179 | 30 |
| 1100 | 593 | 109.5 | 755 | 160.0 | 1103 | 18.0 |
| 1200 | 649 | 105.5 | 727 | 147.5 | 1017 | 12 |
| 1300 | 704 | 91.2 | 629 | 125.3 | 864 | 9.0 |
| 1400 | 760 | 78.4 | 541 | 113.0 | 779 | 20 |
| 1500 | 816 | 42.6 | 294 | 70.6 | 487 | 95.0 |
| 1600 | 871 | 41.8 | 288 | 53.8 | 371 | 118 |
| 1800 | 982 | 16.9 | 117 | 25.2 | 174 | 103 |

RT= Room Temperature
Solution annealed + aged 1400°F / 16h / furnace cool to 1200°F/ 32h / air cool

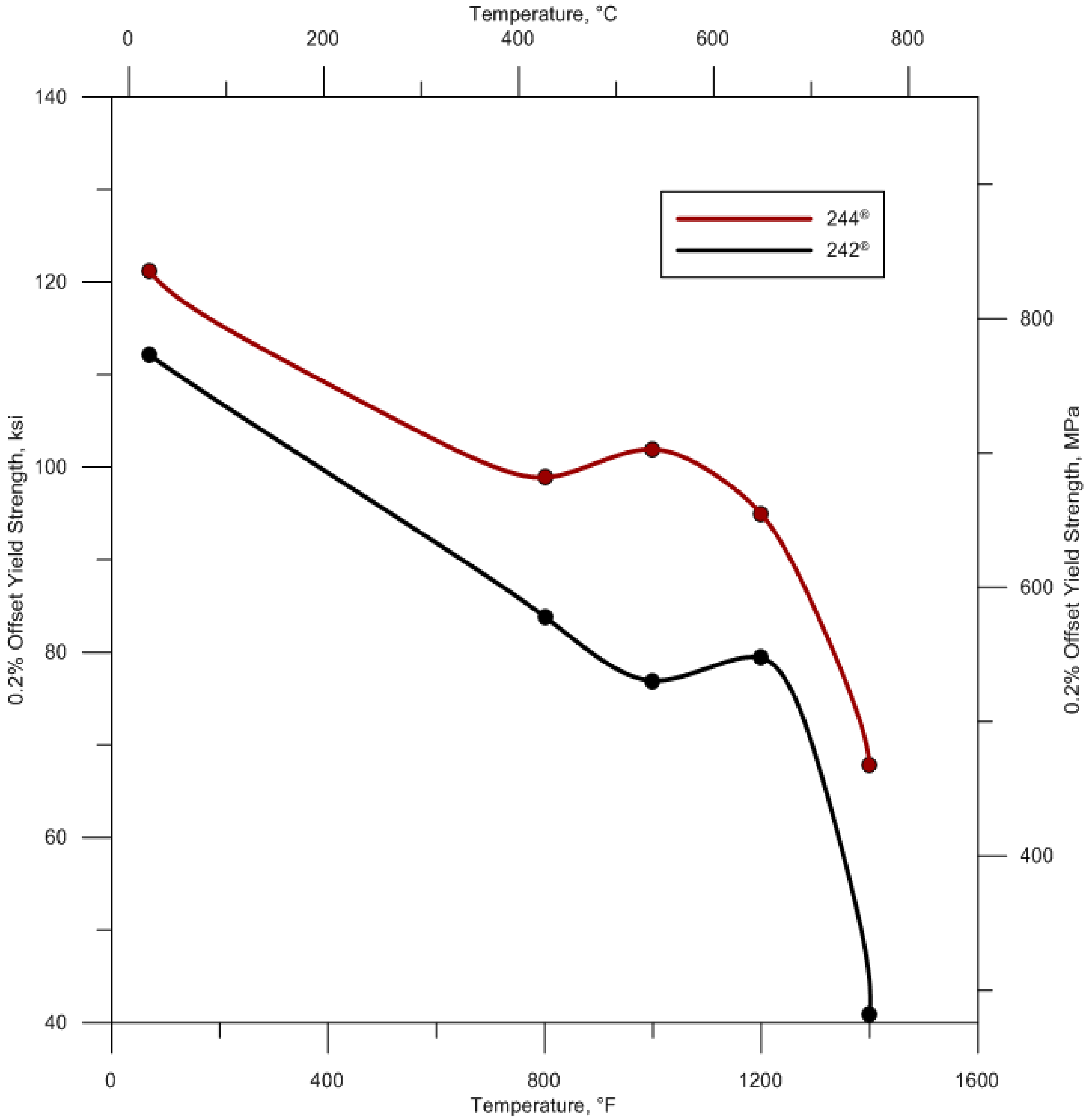
# Tensile Properties Continued

**244® Alloy Rings**

| Test Temperature | | 0.2% Offset Yield Strength | | Ultimate Tensile Strength | | Elongation | Reduction in Area |
|---|---|---|---|---|---|---|---|
| °F | °C | ksi | MPa | ksi | MPa | % | % |
| RT | RT | 130.9 | 902 | 205.1 | 1414 | 29.6 | 32.3 |
| 1400 | 760 | 74.1 | 511 | 111 | 765 | 53.5 | 50 |

RT= Room Temperature
Solution annealed + aged 1400°F / 16 h / furnace cool to 1200°F / 32 h / air cool

**Comparison of 244® and 242® Yield Strengths**



# Physical Properties

| Physical Property | British Units | | Metric Units | |
|---|---|---|---|---|
| Density | RT | 0.335 lb/in³ | RT | 9.27 g/cm³ |
| Melting Range | 2480-2550°F | - | 1360-1400°C | - |
| Electrical Resistivity | RT | 38.9 µohm-in | RT | 98.9 µohm-cm |
| | 200°F | 40.0 µohm-in | 100°C | 101.7 µohm-cm |
| | 400°F | 41.5 µohm-in | 200°C | 105.1 µohm-cm |
| | 600°F | 42.8 µohm-in | 300°C | 108.3 µohm-cm |
| | 800°F | 44.2 µohm-in | 400°C | 111.4 µohm-cm |
| | 1000°F | 45.5 µohm-in | 500°C | 114.4 µohm-cm |
| | 1200°F | 46.4 µohm-in | 600°C | 117.5 µohm-cm |
| | 1400°F | 49.4 µohm-in | 700°C | 119.8 µohm-cm |
| | 1600°F | 51.6 µohm-in | 800°C | 128.8 µohm-cm |
| | 1800°F | 50.5 µohm-in | 900°C | 130.1 µohm-cm |
| Thermal Diffusivity | RT | $5.5 \times 10^{-3}$ in²/s | RT | $35.5 \times 10^{-3}$ cm²/s |
| | 125°F | $5.8 \times 10^{-3}$ in²/s | 100°C | $38.3 \times 10^{-3}$ cm²/s |
| | 200°F | $5.9 \times 10^{-3}$ in²/s | 200°C | $41.1 \times 10^{-3}$ cm²/s |
| | 400°F | $6.4 \times 10^{-3}$ in²/s | 300°C | $44.1 \times 10^{-3}$ cm²/s |
| | 600°F | $6.9 \times 10^{-3}$ in²/s | 400°C | $47.4 \times 10^{-3}$ cm²/s |
| | 800°F | $7.5 \times 10^{-3}$ in²/s | 500°C | $50.5 \times 10^{-3}$ cm²/s |
| | 1000°F | $8.0 \times 10^{-3}$ in²/s | 600°C | $53.4 \times 10^{-3}$ cm²/s |
| | 1200°F | $8.5 \times 10^{-3}$ in²/s | 700°C | $55.4 \times 10^{-3}$ cm²/s |
| | 1400°F | $8.7 \times 10^{-3}$ in²/s | 800°C | $53.1 \times 10^{-3}$ cm²/s |
| | 1600°F | $7.4 \times 10^{-3}$ in²/s | 900°C | $48.2 \times 10^{-3}$ cm²/s |
| | 1800°F | $7.7 \times 10^{-3}$ in²/s | - | - |
| Thermal Conductivity | RT | 86.2 BTU-in/ft²-hr-°F | RT | 12.4 W/m-°C |
| | 200°F | 94.8 BTU-in/ft²-hr-°F | 100°C | 13.8 W/m-°C |
| | 400°F | 106.9 BTU-in/ft²-hr-°F | 200°C | 15.3 W/m-°C |
| | 600°F | 120.9 BTU-in/ft²-hr-°F | 300°C | 17.1 W/m-°C |
| | 800°F | 134.2 BTU-in/ft²-hr-°F | 400°C | 18.9 W/m-°C |
| | 1000°F | 144.8 BTU-in/ft²-hr-°F | 500°C | 20.4 W/m-°C |
| | 1200°F | 171.5 BTU-in/ft²-hr-°F | 600°C | 23.0 W/m-°C |
| | 1400°F | 308.3 BTU-in/ft²-hr-°F | 700°C | 33.8 W/m-°C |
| | 1600°F | 164.5 BTU-in/ft²-hr-°F | 800°C | 37.0 W/m-°C |
| | 1800°F | 142.7 BTU-in/ft²-hr-°F | 900°C | 22.9 W/m-°C |

## Physical Properties Continued

| Physical Property | British Units | | Metric Units | |
|---|---|---|---|---|
| Specific Heat | RT | 0.090 BTU/lb-°F | RT | 376 J/kg-ºC |
| | 200°F | 0.093 BTU/lb-°F | 100°C | 389 J/kg-ºC |
| | 400°F | 0.096 BTU/lb-°F | 200°C | 404 J/kg-ºC |
| | 600°F | 0.100 BTU/lb-°F | 300°C | 416 J/kg-ºC |
| | 800°F | 0.103 BTU/lb-°F | 400°C | 427 J/kg-ºC |
| | 1000°F | 0.104 BTU/lb-°F | 500°C | 438 J/kg-ºC |
| | 1200°F | 0.116 BTU/lb-°F | 600°C | 428 J/kg-ºC |
| | 1400°F | 0.204 BTU/lb-°F | 700°C | 588 J/kg-ºC |
| | 1600°F | 0.127 BTU/lb-°F | 800°C | 852 J/kg-ºC |
| | 1800°F | 0.106 BTU/lb-°F | 900°C | 480 J/kg-ºC |
| Mean Coefficient of Thermal Expansion | 70-200°F | 5.93 µin/in-°F | 25-100°C | 10.7 µm/m-°C |
| | 70-400°F | 6.11 µin/in-°F | 25-200°C | 11.0 µm/m-°C |
| | 70-600°F | 6.26 µin/in-°F | 25-300°C | 11.2 µm/m-°C |
| | 70-800°F | 6.40 µin/in-°F | 25-400°C | 11.5 µm/m-°C |
| | 70-1000°F | 6.54 µin/in-°F | 25-500°C | 11.7 µm/m-°C |
| | 70-1100°F | 6.57 µin/in-°F | 25-550°C | 11.8 µm/m-°C |
| | 70-1200°F | 6.70 µin/in-°F | 25-600°C | 11.9 µm/m-°C |
| | 70-1300°F | 6.97 µin/in-°F | 25-650°C | 12.1 µm/m-°C |
| | 70-1400°F | 7.39 µin/in-°F | 25-700°C | 12.5 µm/m-°C |
| | 70-1500°F | 7.78 µin/in-°F | 25-750°C | 13.2 µm/m-°C |
| | 70-1600°F | 7.95 µin/in-°F | 25-800°C | 13.8 µm/m-°C |
| | 70-1800°F | 8.22 µin/in-°F | 25-900°C | 14.4 µm/m-°C |
| Dynamic Modulus of Elasticity | RT | 32.3 x $10^6$psi | RT | 223 GPa |
| | 200°F | 31.9 x $10^6$psi | 100°C | 220 GPa |
| | 400°F | 30.8 x $10^6$psi | 200°C | 213 GPa |
| | 600°F | 29.7 x $10^6$psi | 300°C | 206 GPa |
| | 800°F | 28.7 x $10^6$psi | 400°C | 199 GPa |
| | 1000°F | 27.7 x $10^6$psi | 500°C | 193 GPa |
| | 1200°F | 26.6 x $10^6$psi | 600°C | 186 GPa |
| | 1400°F | 23.9 x $10^6$psi | 700°C | 175 GPa |
| | 1600°F | 21.9 x $10^6$psi | 800°C | 159 GPa |
| | 1800°F | 20.6 x $10^6$psi | 900°C | 150 GPa |

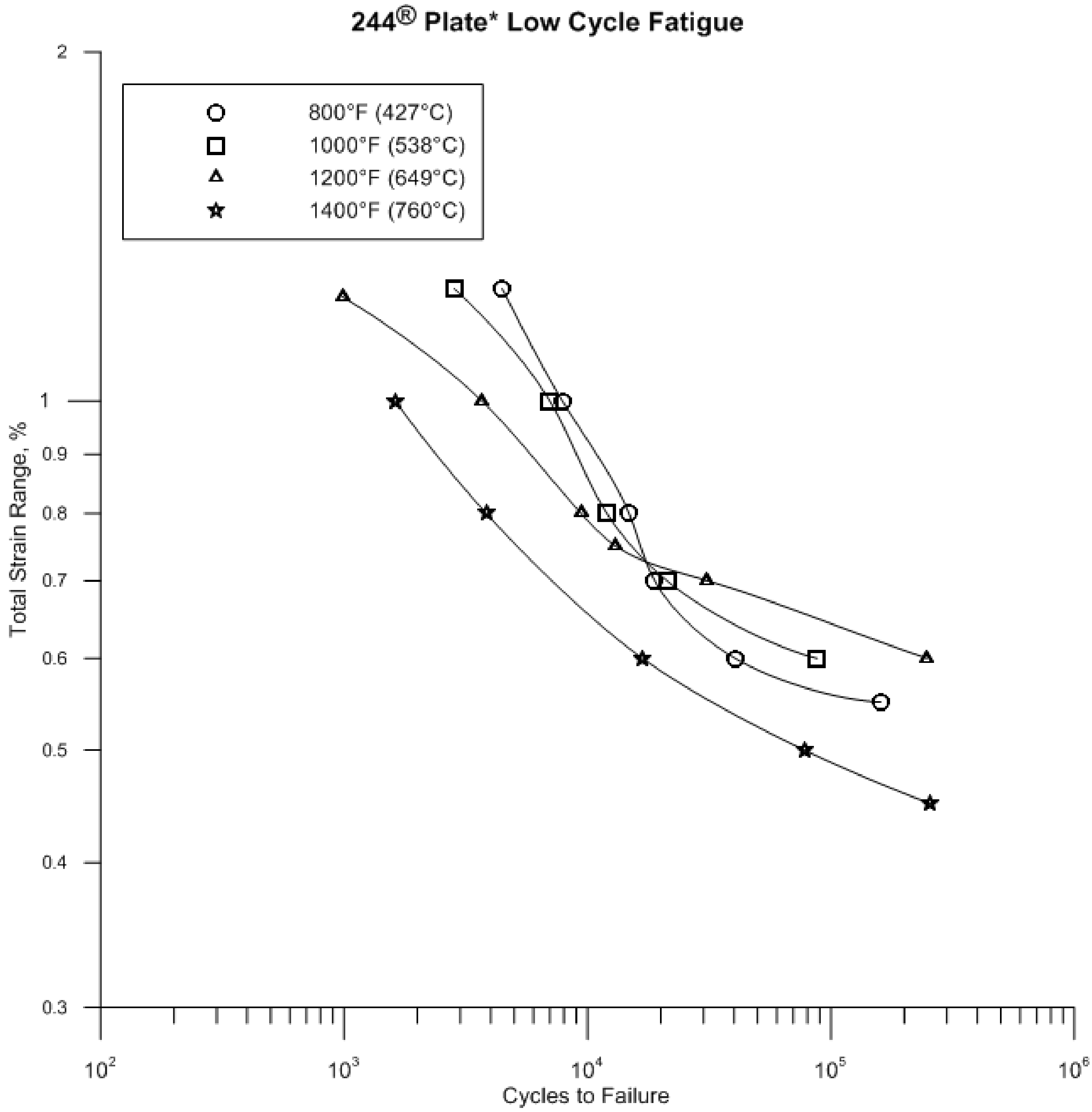
# Physical Properties Continued

| Physical Property | British Units | | Metric Units | |
|---|---|---|---|---|
| Dynamic Shear Modulus | RT | $12.4 \times 10^6$psi | RT | 85 GPa |
| | 200°F | $12.2 \times 10^6$psi | 100°C | 84 GPa |
| | 400°F | $11.7 \times 10^6$psi | 200°C | 81 GPa |
| | 600°F | $11.2 \times 10^6$psi | 300°C | 78 GPa |
| | 800°F | $10.8 \times 10^6$psi | 400°C | 75 GPa |
| | 1000°F | $10.4 \times 10^6$psi | 500°C | 73 GPa |
| | 1200°F | $10.1 \times 10^6$psi | 600°C | 70 GPa |
| | 1400°F | $9.2 \times 10^6$psi | 700°C | 68 GPa |
| | 1600°F | $8.7 \times 10^6$psi | 800°C | 62 GPa |
| | 1800°F | $7.4 \times 10^6$psi | 900°C | 59 GPa |
| Poisson's Ratio | RT | 0.31 | RT | 0.31 |
| | 200°F | 0.31 | 100°C | 0.31 |
| | 400°F | 0.32 | 200°C | 0.32 |
| | 600°F | 0.32 | 300°C | 0.32 |
| | 800°F | 0.33 | 400°C | 0.32 |
| | 1000°F | 0.33 | 500°C | 0.33 |
| | 1200°F | 0.32 | 600°C | 0.33 |
| | 1400°F | 0.30 | 700°C | 0.30 |
| | 1600°F | 0.28 | 800°C | 0.29 |
| | 1800°F | 0.27 | 900°C | 0.26 |

All properties measured as solution annealed + aged 1400°F / 16 h / furnace cool to 1200°F / 32h / air cool

# Low Cycle Fatigue

HAYNES® 244® alloy exhibits excellent low cycle fatigue properties at elevated temperature. Results shown below are for strain-controlled tests run in the temperature range from 800 to 1400°F (425 to 760°C). Samples were machined from plate. Tests were run with fully reversed strain (R=-1) at a frequency of 20 cpm (0.33 Hz).



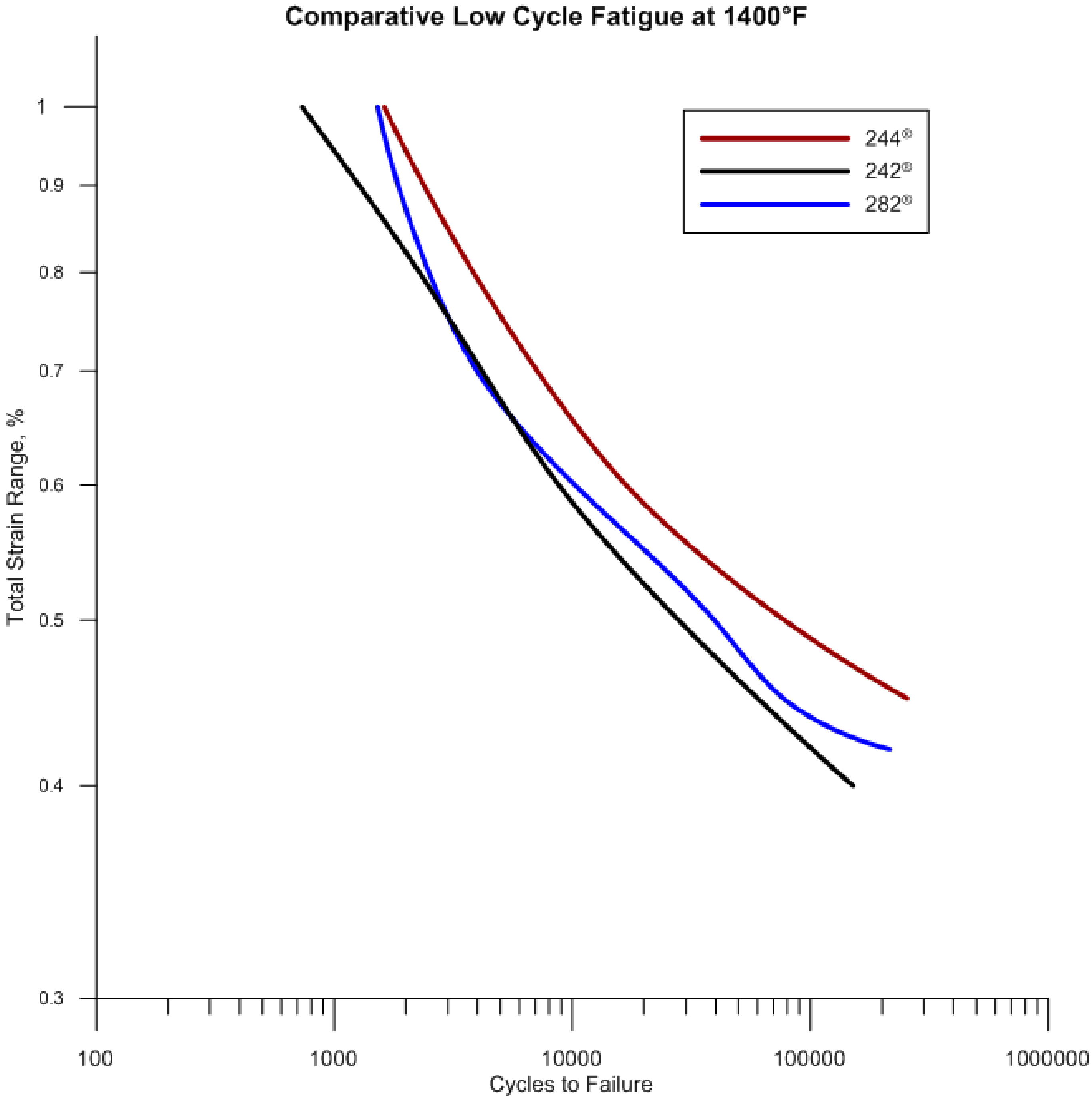

*Solution Annealed + Aged Hardened 1400°F / 16 h / furnace cool to 1200°F / 32 h / air cool

# Low Cycle Fatigue Continued

| Temperature | | Δεtot/% | Ni, Cycles to Initiation | Nf, Cycles to Failure |
|---|---|---|---|---|
| °F | °C | | | |
| 800 | 427 | 1.25 | 3,949 | 4,461 |
| | | 1.00 | 6,398 | 7,889 |
| | | 0.80 | 12,380 | 14,820 |
| | | 0.70 | 16,159 | 18,881 |
| | | 0.65 | 36,244 | 41,256 |
| | | 0.60 | 39,419 | 40,506 |
| | | 0.55 | 145,998 | 160,614 |
| | | 0.50 | N/A | 200,826* |
| 1000 | 538 | 1.25 | 2,753 | 2,835 |
| | | 1.00 | 5,520 | 7,006 |
| | | 0.80 | 9,859 | 12,877 |
| | | 0.80 | 10,058 | 11,169 |
| | | 0.70 | 16,291 | 17,989 |
| | | 0.70 | 23,438 | 24,443 |
| | | 0.60 | 82,871 | 87,701 |
| | | 0.55 | N/A | 201,022* |
| 1200 | 649 | 1.23 | 897 | 983 |
| | | 1.00 | 3,644 | 3,686 |
| | | 0.80 | 8,980 | 9,422 |
| | | 0.75 | 12,370 | 13,066 |
| | | 0.70 | 30,898 | 31,078 |
| | | 0.60 | 249,079 | 249,284 |
| 1400 | 760 | 1.00 | 1,460 | 1,625 |
| | | 0.80 | 3,634 | 3,842 |
| | | 0.60 | 16,495 | 16,858 |
| | | 0.50 | 73,906 | 78,024 |
| | | 0.45 | 251,579 | 255,801 |
| | | 0.40 | N/A | 305,391* |

*Discontinued

# Low Cycle Fatigue Continued




244®: Solution Annealed + Aged Hardened 1400°F / 16 h / furnace cool to 1200°F / 32 h / air cool
242®: Solution Annealed + Aged Hardened 1200°F / 24 h / air cool
282®: Solution Annealed + Aged Hardened 1850°F / 2 h / air cool to 1450°F / 8 h / air cool

# Oxidation Resistance

HAYNES® 244® alloy exhibits very good oxidation resistance at temperatures up to 1400°F (760°C), and should not require protective coatings for continuous or intermittent service at these temperatures. The alloy is not specifically designed for use at higher temperatures, but can tolerate short-term exposures.

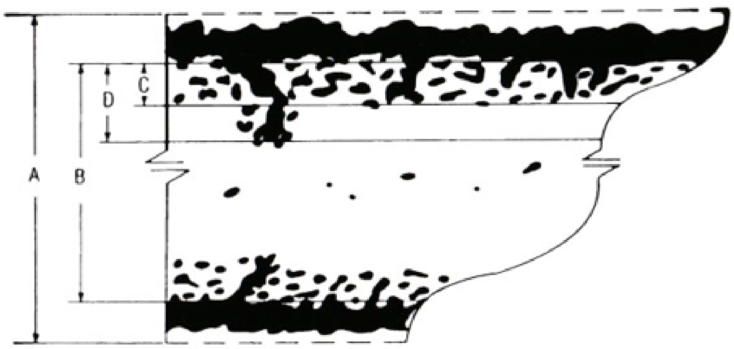
### Static Oxidation

| Alloy | 1400°F (760°C) | | | |
|---|---|---|---|---|
| | Metal Loss | | Average Metal Affected | |
| | mils | µm | mils | µm |
| **625** | 0 | 0 | 0 | 0 |
| **244®** | **0** | **0** | **0.2** | **5** |
| **242®** | 0.1 | 3 | 0.3 | 8 |
| **R-41** | 0.1 | 3 | 0.4 | 10 |
| **282®** | 0.1 | 3 | 0.4 | 10 |
| **Waspaloy** | 0.1 | 3 | 0.6 | 15 |

### Comparative Cyclic Oxidation Resistance

| Alloy | 1400°F (760°C), 1000 h, Cycled 1x/10 h | | | | 1400°F (760°C), 1000 h, Cycled 1x/1h | | | |
|---|---|---|---|---|---|---|---|---|
| | Metal Loss | | Average Metal Affected | | Metal Loss | | Average Metal Affected | |
| | mils | µm | mils | µm | mils | µm | mils | µm |
| **244®** | **< 0.1** | **0.6** | **0.1** | **1.9** | **< 0.1** | **0.5** | **0.1** | **3** |
| **242®** | < 0.1 | 0.7 | 0.1 | 1.9 | < 0.1 | 0.5 | 0.1 | 3 |
| **282®** | 0.1 | 1.5 | 0.4 | 10 | 0.1 | 1.5 | 0.4 | 10 |
| **Waspaloy** | 0.1 | 2.2 | 0.6 | 15 | 0.1 | 2.2 | 0.6 | 15 |

Amount of metal affected for alloys exposed to flowing air for 1000-h at 1400°F. Cycled as noted.




1. Metal Loss = (A-B)/2
2. Average Internal Penetration = C
3. Maximum Internal Penetration = D
4. Average Metal Affected = [(A-B)/2] + C
5. Maximum Metal Affected = [(A-B)/2] + D

## Thermal Stability

**Thermal Stability of 244® alloy – 1400°F Tensile Data After Exposure, 0.500” Plate**

| Condition | 0.2% Yield Strength | | Ultimate Tensile Strength | | Elongation | Reduction of Area |
|---|---|---|---|---|---|---|
| | ksi | MPa | ksi | MPa | % | % |
| As-Heat Treated* | 68.9 | 461 | 103.4 | 728 | 33.5 | 32.4 |
| +1400°F/1,000 hr | 71.3 | 492 | 111.6 | 770 | 36.5 | 32.5 |
| +1400°F/8,000 hr | 62.6 | 432 | 102.8 | 709 | 60.3 | 37.2 |

*Age hardened 1400ºF / 16 h / furnace cool to 1200ºF / 32 h / air cool

**Thermal Stability of 244® alloy – Room Temperature Tensile Data After Exposure, 0.500” Plate**

| Condition | 0.2% Yield Strength | | Ultimate Tensile Strength | | Elongation | Reduction of Area |
|---|---|---|---|---|---|---|
| | ksi | MPa | ksi | MPa | % | % |
| As-Heat Treated* | 122.8 | 847 | 193.3 | 1333 | 34.7 | 39.2 |
| + 800°F/1,000 hr | 123.3 | 850 | 196.2 | 1353 | 31.8 | 37.1 |
| + 800°F/8,000 hr | 128.2 | 884 | 200.7 | 1384 | 32.3 | 20.6 |
| | | | | | | |
| + 1200°F/1,000 hr | 122.8 | 847 | 204.6 | 1411 | 25.5 | 25.6 |
| + 1200°F/8,000 hr | 122.0 | 841 | 205.9 | 1420 | 25.4 | 27.3 |
| | | | | | | |
| +1300°F/1,000 hr | 121.1 | 835 | 198.7 | 1370 | 24.4 | 26.4 |
| +1300°F/8,000 hr | 115.4 | 796 | 190.1 | 1311 | 15.5 | 17.0 |
| | | | | | | |
| +1400°F/1,000 hr | 97.8 | 674 | 159 | 1096 | 13.1 | 13.3 |
| +1400°F/8,000 hr | 86.1 | 594 | 145.9 | 1006 | 8.7 | 6.6 |

*Age hardened 1400ºF /16h / furnace cool to 1200ºF / 32h /air cool

## Dimensional Stability

| Temper | Density | | Linear Change | Additional Linear Change |
|---|---|---|---|---|
| | lb/in³ | g/cm³ | % | % |
| Solution Annealed | 0.3356 | 9.290 | Reference | Reference |
| Age Hardened* | 0.3370 | 9.329 | -0.14 | - |
| Aged + 800°F/1,000h | 0.3371 | 9.332 | - | -0.01 |
| Aged + 800°F/8,000h | 0.3372 | 9.334 | - | -0.02 |
| Aged + 1200°F/1,000h | 0.3368 | 9.323 | - | +0.02 |
| Aged + 1200°F/8,000h | 0.3368 | 9.323 | - | +0.02 |
| Aged + 1300°F/1,000h | 0.3367 | 9.320 | - | +0.03 |
| Aged + 1300°F/8,000h | 0.3365 | 9.315 | - | +0.04 |
| Aged + 1400°F/1,000h | 0.3363 | 9.309 | - | +0.07 |
| Aged + 1400°F/8,000h | 0.3364 | 9.312 | - | +0.06 |

*1400°F / 16 h / furnace cool to 1200°F / 32 h / air cool

# Heat Treatment

HAYNES® 244® alloy is furnished in the annealed condition, unless otherwise specified. The alloy is usually annealed in the range of 2000-2100°F (1093-1149°C), depending upon specific requirements, followed by an air cool (or more rapid cooling) before aging. A water quench is recommended for heavy section components. Aging is performed by holding at 1400°F (760°C) for 16 hours, furnace cooling to 1200°F (649°C) and holding for 32 hours, followed by air cool.

# Formability

| Cold Work | 0.2% Yield Strength | | Ultimate Tensile Strength | | Elongation |
|---|---|---|---|---|---|
| % | ksi | MPa | ksi | MPa | % |
| 0 | 74 | 510 | 134 | 924 | 57 |
| 10 | 112 | 772 | 150 | 1034 | 38 |
| 20 | 142 | 979 | 167 | 1151 | 26 |
| 30 | 168 | 1158 | 191 | 1317 | 14 |
| 40 | 194 | 1338 | 215 | 1482 | 8 |

# Welding

HAYNES® 244® alloy can be welded by a variety of processes, including gas tungsten arc and gas metal arc. High heat input processes such as submerged arc and oxyacetalyne welding are not recommended.

### Welding Procedures

Welding procedures common to most high-temperature, nickel-base alloys are recommended. These include use of stringer beads and an interpass temperature less than 200°F (95°C). Preheat is not required. Cleanliness is critical, and careful attention should be given to the removal of grease, oil, crayon marks, shop dirt, etc. prior to welding. Because of the alloy's high nickel content, the weld puddle will be somewhat "sluggish" relative to steels. To avoid lack of fusion and incomplete penetration defects, the root opening and bevel should be sufficiently open.

### Filler Metals

HAYNES® 244® alloy should be joined using matching filler metal.  Please contact Haynes International for more information.

### Postweld Heat Treatment

HAYNES® 244® alloy is normally used in the fully-aged condition. However, following forming and welding, a full solution anneal is recommended prior to aging in order to develop the best joint and overall mechanical properties.

# Welding Continued

### Transverse Weld Tensile Results, GTAW & GMAW of 0.5” plate with 0.045” dia. 244® filler metal

| Condition | Temperature | | 0.2% Yield Strength | | Ultimate Tensile Strength | | Elongation | Reduction of Area | Failure Location |
|---|---|---|---|---|---|---|---|---|---|
| | °F | °C | ksi | MPa | ksi | MPa | % | % | |
| GTAW + Solution Annealed* + Age Hardened** | RT | RT | 120.4 | 830 | 184.7 | 1273 | 18 | 19 | Weld Metal |
| | 1200 | 649 | 93.4 | 644 | 135.5 | 934 | 14 | 18 | Weld Metal |
| | 1300 | 704 | 83.9 | 578 | 119.1 | 821 | 13 | 17 | Weld Metal |
| | 1400 | 760 | 67.8 | 467 | 105.1 | 725 | 32 | 22 | Weld Metal |
| GMAW + Solution Annealed* + Age Hardened** | RT | RT | 121.3 | 836 | 187.0 | 1289 | 19 | 14 | Weld Metal |
| | 1200 | 649 | 95.7 | 660 | 129.1 | 890 | 14 | 25 | Base Metal |
| | 1300 | 704 | 84.8 | 585 | 117.8 | 812 | 17 | 20 | Base Metal |
| | 1400 | 760 | 68.2 | 470 | 105.6 | 728 | 30 | 26 | Weld Metal |

*Annealing treatment: 2050°F / 30 minutes AT / water quench
**Age hardening treatment: 1400°F / 16 hr / FC to 1200°F / 32 hr / air cool

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