# MECHANICAL-PROPERTY DATA
# HP 9Ni-4Co-25C
# STEEL

Tempered Forging

Issued by

Air Force Materials Laboratory
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HP 9-4-25

The HP 9-4-25 alloy is a nickel-cobalt steel possessing excellent toughness when quenched and tempered to yield strength levels up to about 200 ksi. It is especially suitable for highly stressed structures requiring good material reliability and weldability and is intended for fabrication in the heat-treated condition for moderate and heavy section.

This steel is sensitive to thermal-mechanical treatments and both the strength and toughness can be increased by hot-cold working.

HP 9-4-25 is available as sheet, plate, wire, rod, bar, and forgings.

HP 9-4-25 Data[a]

Condition: 1025 F Temper[b]
Thickness: 2-1/2 in. Forging

| Properties | Temperature, F | | | |
|---|---|---|---|---|
| | RT | 500 | 700 | 900 |
| **Tension** | | | | |
| $F_{tu}$ (longitudinal), ksi | 196 | 182 | 167 | 142 |
| $F_{tu}$ (transverse), ksi | 194 | 181 | 167 | 141 |
| $F_{tu}$ (short transverse), ksi | 197 | -- | -- | -- |
| $F_{ty}$ (longitudinal), ksi | 186 | 160 | 145 | 128 |
| $F_{ty}$ (transverse), ksi | 185 | 162 | 145 | 125 |
| $F_{ty}$ (short transverse), ksi | 186 | -- | -- | -- |
| $e_t$ (longitudinal), percent in 2 in. | 19.3 | 19.8 | 18.2 | 19.9 |
| $e_t$ (transverse), percent in 2 in. | 18.2 | 17.8 | 18.0 | 18.5 |
| et (short transverse), percent in 1 in. | 17.7 | -- | -- | -- |
| RA (longitudinal), percent | 66.2 | 68.5 | 71.2 | 73.3 |
| $E_t$ (longitudinal), $10^6$ psi | 27.8 | 27.6 | 26.2 | 25.6 |
| $E_t$ (transverse), $10^6$ psi | 27.6 | 26.9 | 26.3 | 24.2 |
| **Compression** | | | | |
| $F_{cy}$ (longitudinal), ksi | 196 | 169 | 155 | 131 |
| $F_{cy}$ (transverse), ksi | 196 | 168 | 155 | 130 |
| $E_c$ (longitudinal), $10^6$ psi | 30.1 | 27.9 | 26.1 | 23.2 |
| $E_c$ (transverse), $10^6$ psi | 30.1 | 27.8 | 27.0 | 23.5 |
| **Shear**[c] | | | | |
| $F_{su}$ (longitudinal), ksi | 123.6 | U[d] | U | U |
| $F_{su}$ (transverse), ksi | 124.5 | U | U | U |
| **Impact** (V-notch Charpy), ft-lb | 35-50[a] | U | U | U |
| **Fracture Toughness**, $K_{Ic}$, ksi $\sqrt{in.}$ | No pop-in[f] | U | U | U |

| Properties | Temperature, F | | | |
|---|---|---|---|---|
| | RT | 500 | 700 | 900 |
| **Axial Fatigue (transverse)[g]** | | | | |
| Unnotched, R = 0.1 | | | | |
| $10^3$ cycles, ksi | 205 | 198 | 194 | U |
| $10^5$ cycles, ksi | 183 | 174 | 172 | U |
| $10^7$ cycles, ksi | 160 | 144 | 120 | U |
| Notched, $K_t$ = 3.0, R = 0.1 | | | | |
| $10^3$ cycles, ksi | 195 | 191 | 182 | U |
| $10^5$ cycles, ksi | 83 | 74 | 71 | U |
| $10^7$ cycles, ksi | 60 | 55 | 49 | U |
| **Creep (transverse)** | | | | |
| 0.5% elongation, 100 hr, ksi | NA[d] | NA | 135 | 73 |
| 0.5% elongation, 1000 hr, ksi | NA | NA | 130 | 62 |
| **Stress Rupture (transverse)** | | | | |
| Rupture, 100 hr, ksi | NA | NA | 155 | 95 |
| Rupture, 1000 hr, ksi | NA | NA | 148 | 70 |
| **Stress Corrosion** | | | | |
| 80% $F_{ty}$, 1000 hr max. | No cracks[b] | U | U | U |
| **Coefficient of Thermal Expansion[i]** | | | | |
| 68 to 800 F = $6.4 \times 10^{-6}$ in./in./F | | | | |
| **Density[i]** 0.28 lb./in.$^3$ | | | | |

(a) Data are average of triplicate tests conducted at Battelle under the subject contract unless otherwise specified. Fatigue, creep, and stress-rupture values are from data curves generated using a greater number of tests.

(b) Treatment: 1 hr at 1600 F, AC; 1 hr at 1525 F, OQ; 2+2 hr at 1025 F.

(c) Double shear (1/4-inch pin).

(d) U, unavailable; NA, not applicable.

(e) Values from Reference (1).

(f) Fatigue-cracked single-edge-notched slow-bend specimen (1" x 2" x 18") tested under four-point loading. No pop-in detected.

(g) "R" represents algebraic ratio of the minimum stress to the maximum stress in one cycle; that is, $R = S_{min.}/S_{max.}$. "$K_t$" represents the Neuber-Peterson theoretical stress-concentration factor.

(h) Alternate immersion, 3-1/2% NaCl. Three-point loading bend test.

(i) Values from Reference (2).

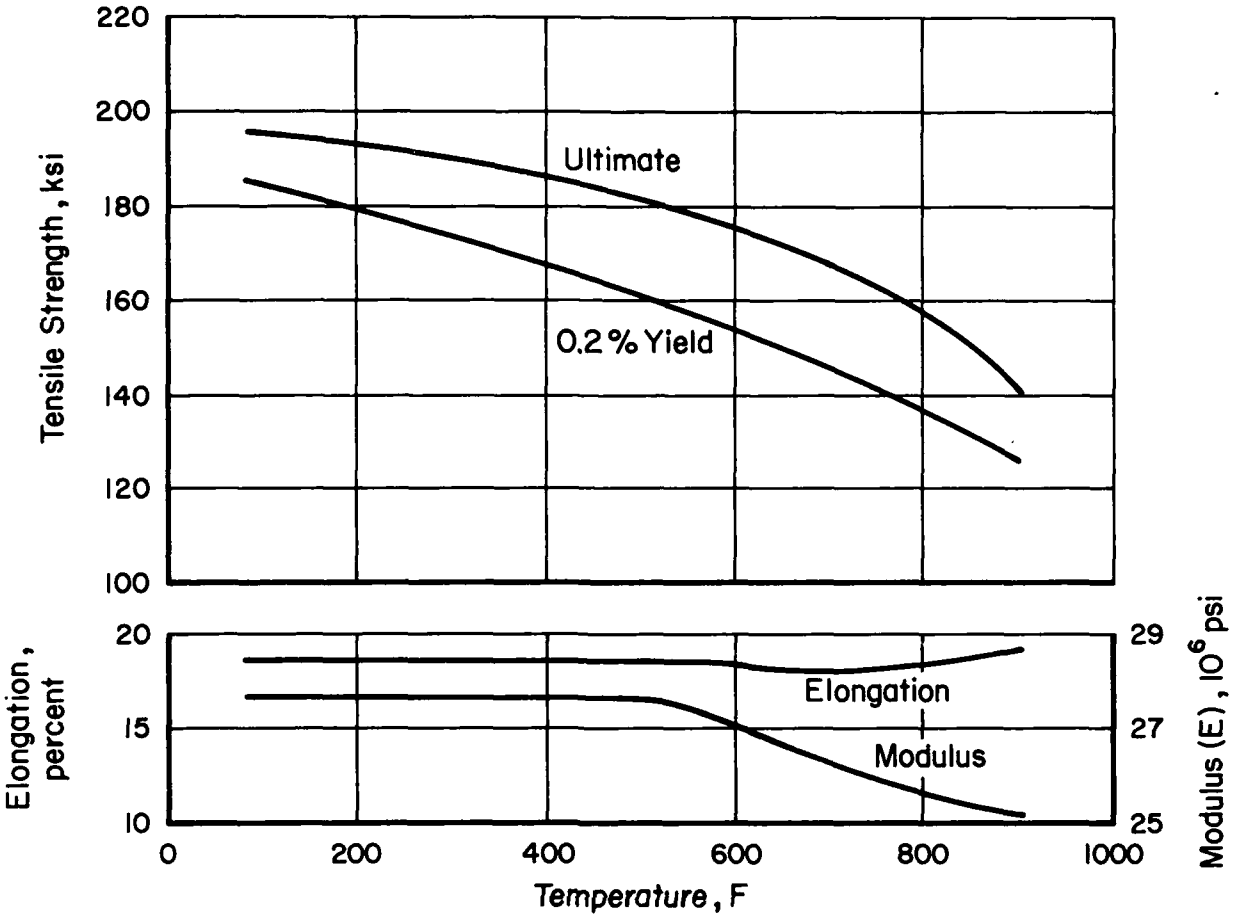


FIGURE 1. EFFECT OF TEMPERATURE ON THE TENSILE PROPERTIES OF HP 9-4-25 FORGINGS

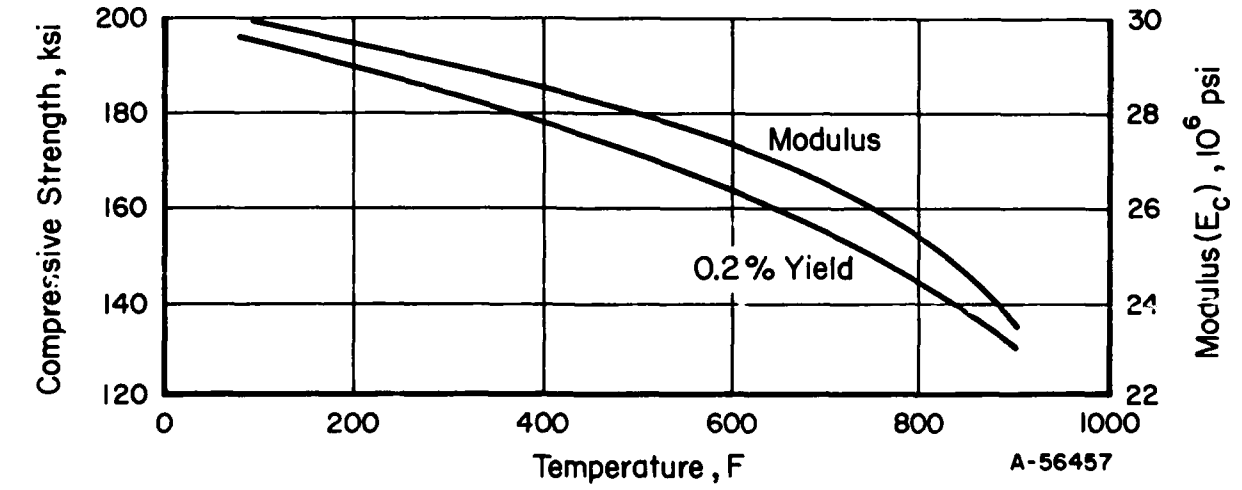


FIGURE 2. EFFECT OF TEMPERATURE ON THE COMPRESSION PROPERTIES OF HP 9-4-25 FORGINGS

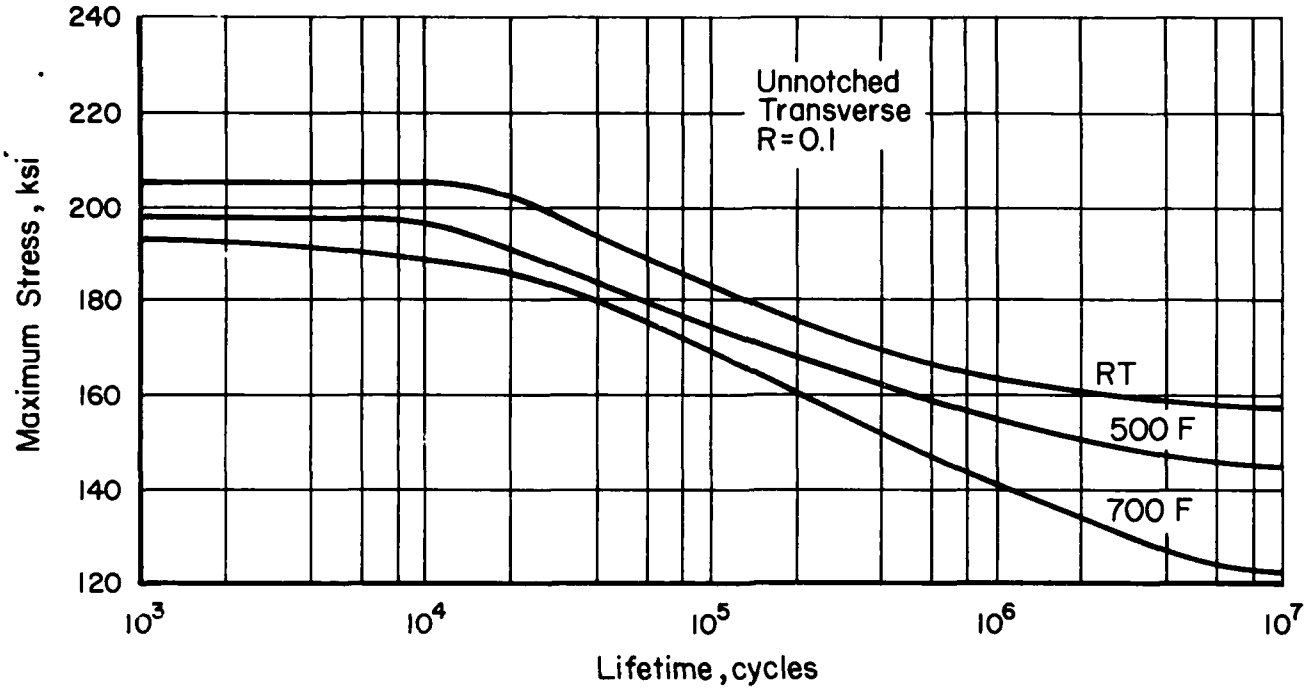


FIGURE 3. AXIAL LOAD FATIGUE RESULTS FOR HP 9-4-25 FORGINGS AT THREE TEMPERATURES

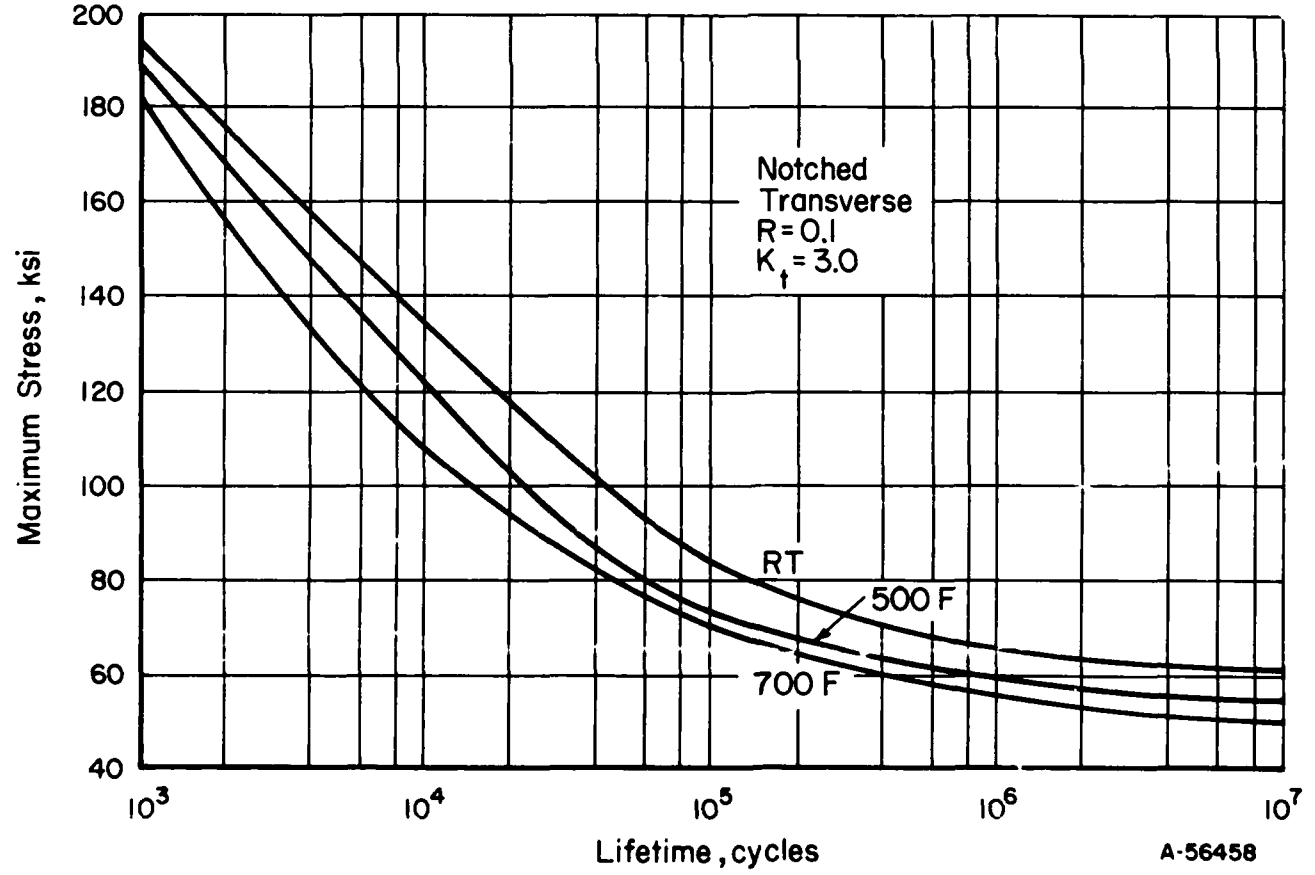


FIGURE 4. AXIAL LOAD FATIGUE RESULTS FOR HP 9-4-25 FORGINGS AT THREE TEMPERATURES

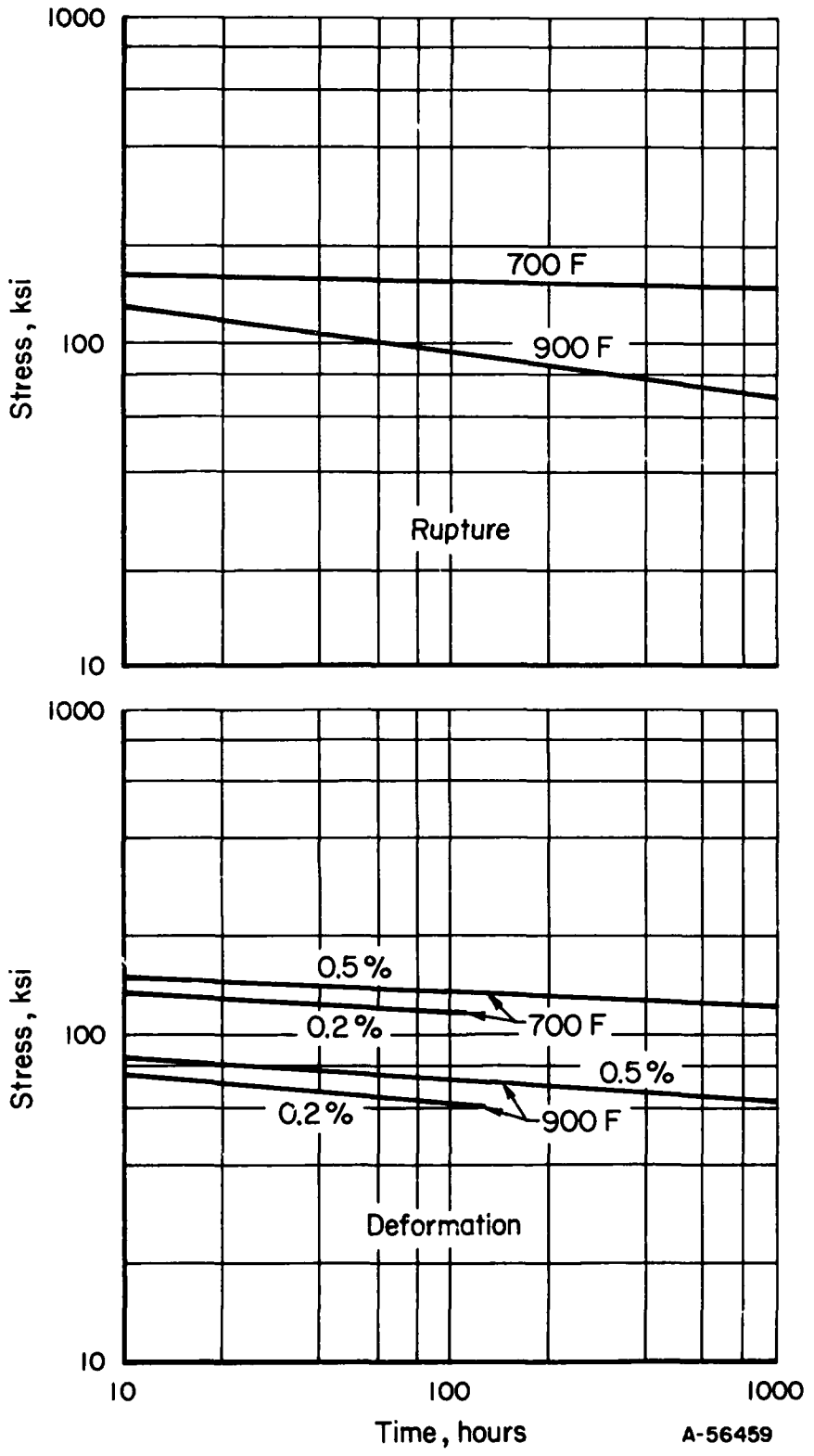


FIGURE 5. STRESS-RUPTURE AND PLASTIC DEFORMATION CURVES FOR HP 9-4-25 FORGINGS AT TWO TEMPERATURES

## REFERENCES


(1) Pascover, J. S., and Matas, A. J., "Properties of HP 9-4-X Alloy Steels", WADC TDR 64-225 (1964).

(2) "Preliminary Technical Data on the Republic Hi Performance Steels", Republic Steel Brochure.