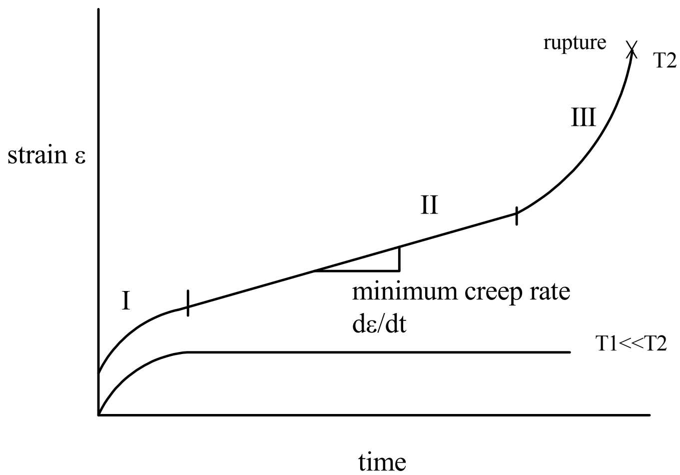
Creep

Creep is slow plastic extension (strain) at elevated temperatures (T ~> 0.3 melting T) and stress. Typical strain vs time at elevated temperature and stress is:

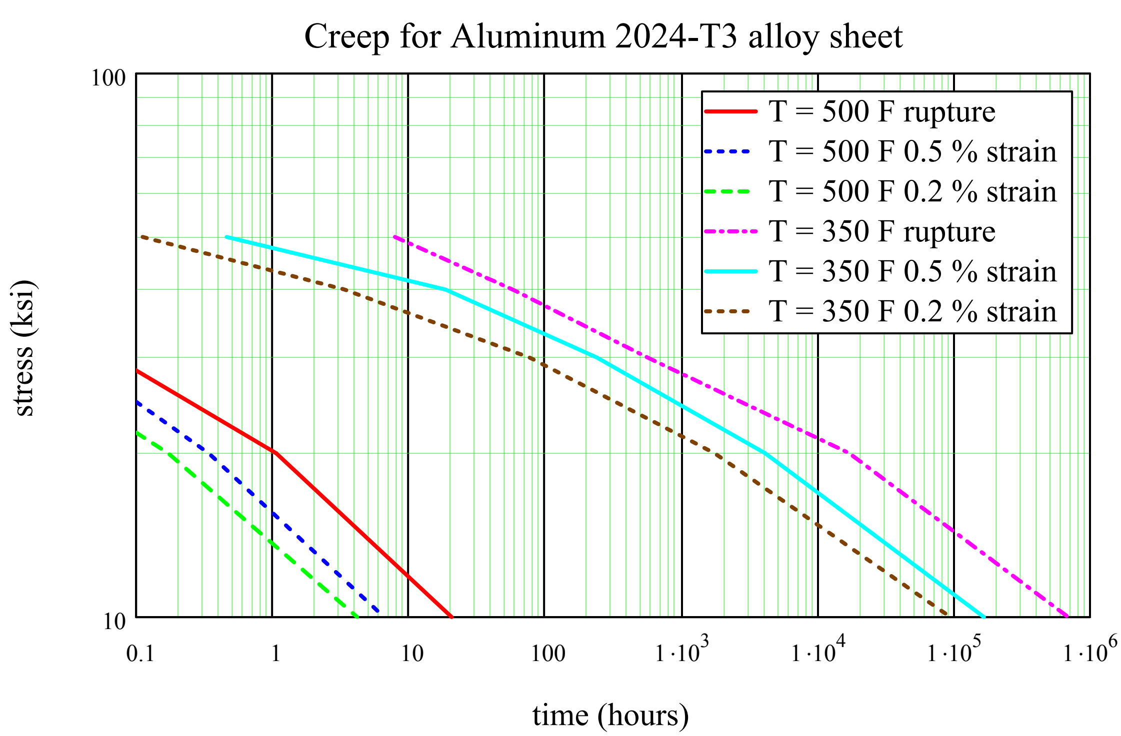


stage I: primary creep: rapid initial deformation
stage II: secondary creep: a.k.a. steady state creep: constant strain rate designated "minimum strain rate"
stage III: tertiary creep: reduction in cross section eventually leading to fracture

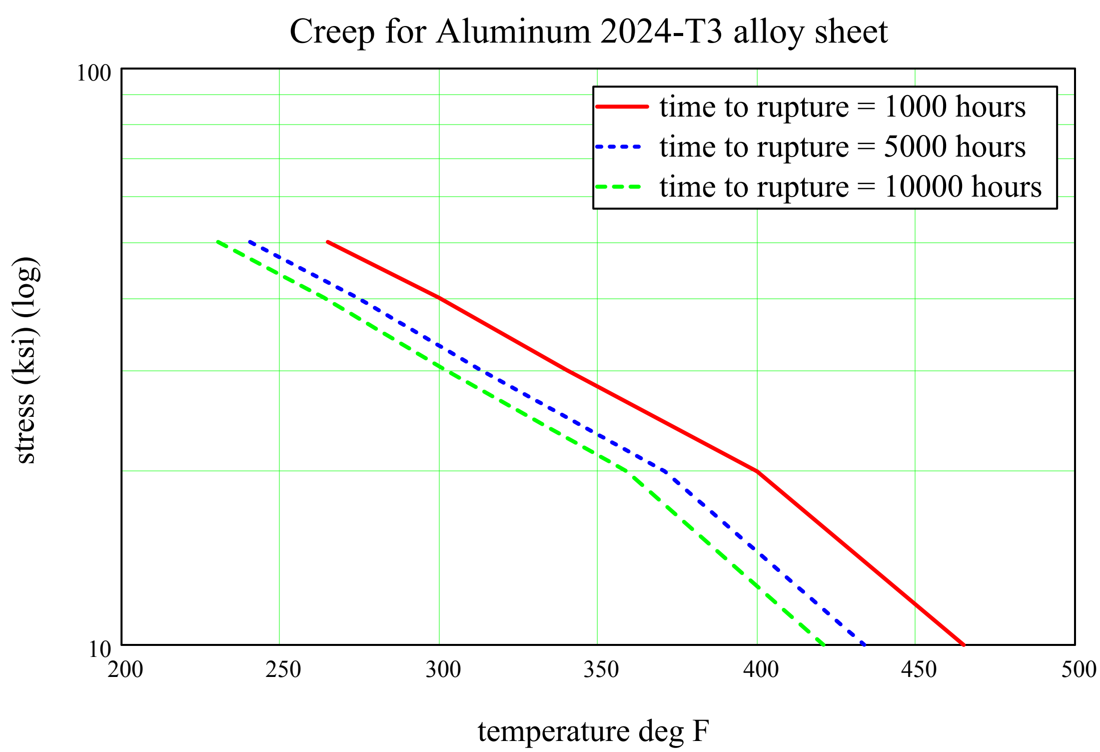
Typical creep data is usually shown as stress vs time to rupture, 0.5% strain, and 0.2% strain for a given temperature. A set of curves derived manually from NACA TN 4112 Generalized Master Curves for Creep and Rupture, Heimerl and McEvily Oct 1957 (Aero Library) for Aluminum 2024-T3 alloy plate is shown:

▶ NACA TN 4112 data

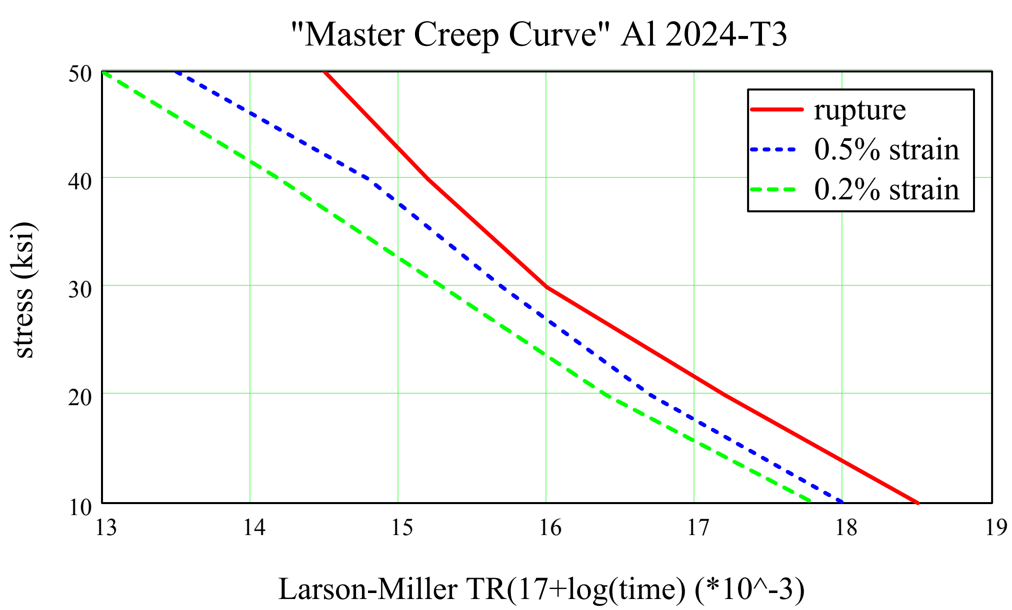
creep data shown as stress (ksi) vs time (hours) parameterized by temperature - includes rupture, 0.5% strain and 0.2% strain



creep data shown as stress (ksi) vs temperature parameterized by time (hours) - rupture only shown - gets too busy



These curves are difficult to use so researchers proposed a parameter that collapses data empirically. E.g.these data can be represented can be represented on a Master Curve for Creep using the Larson-Miller (or another similar parameter). The plots lack smoothness due to manual extraction of data.



The Larson Miller parameter combines temperature and times (rupture, strain) as follows:

$LM = T_R \cdot (C_1 + \log(t_r))$ C_1 = constant_based_on_material $C_{1\_al\_2024} := 17$ above curves

$C_{1\_carbon\_molybdenum\_steel} := 20$

T_R = temperature_deg_R = deg_F + 460

t_r = time_to_rupture_hours similar parameter for $t_{\varepsilon\_0.5}$

$t_{\varepsilon\_0.5}$ = time_to_point_5%_strain_hours $t_{\varepsilon\_0.2}$ = time_to_point_2%_strain_hours