

Martensite



Cementite



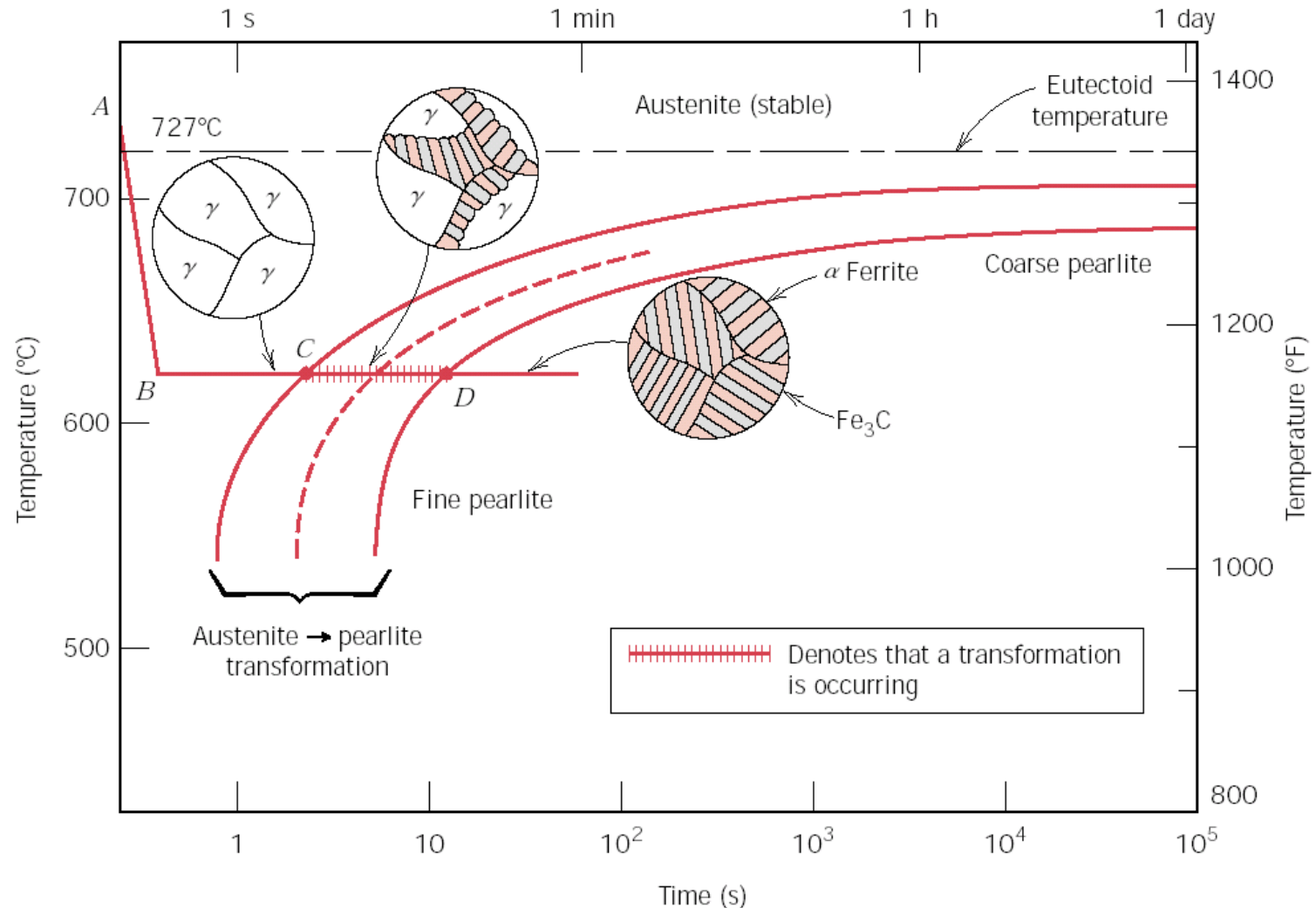
Ferrite



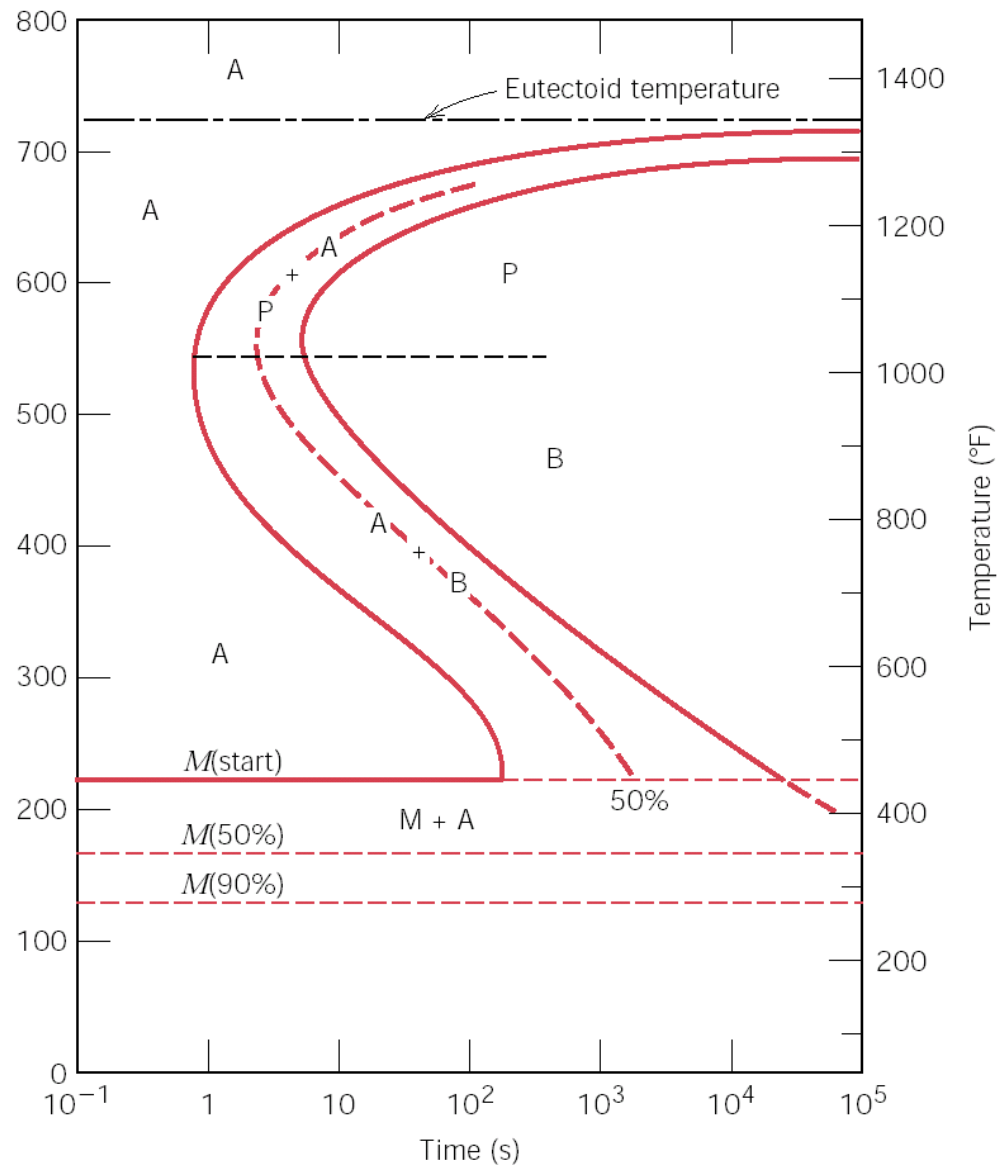
Phase Transformation and Microstructure - The Jominy Bar



Isothermal Transformation Diagram (Fe-Fe₃C)



Complete Isothermal Transformation Diagram for Eutectoid Composition



“Slow Cooling” - Pearlite

coarse

fine

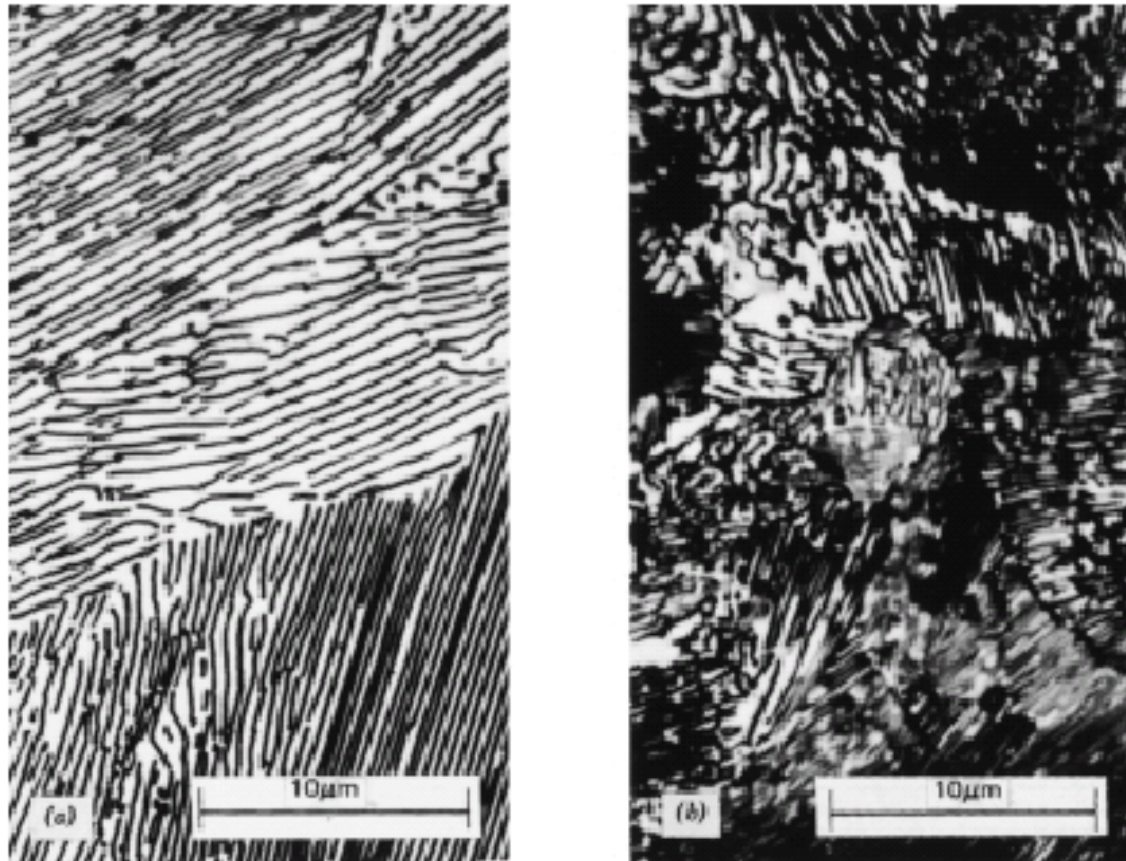
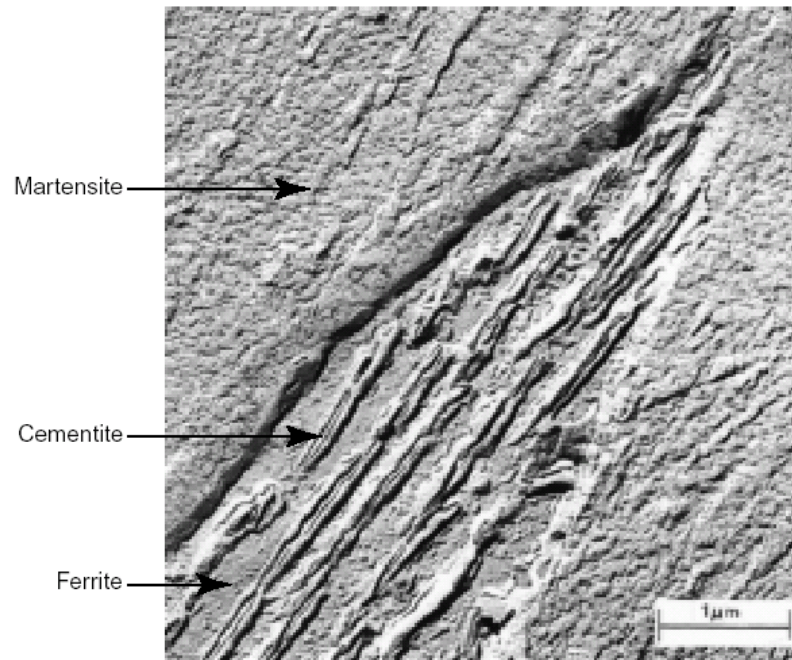


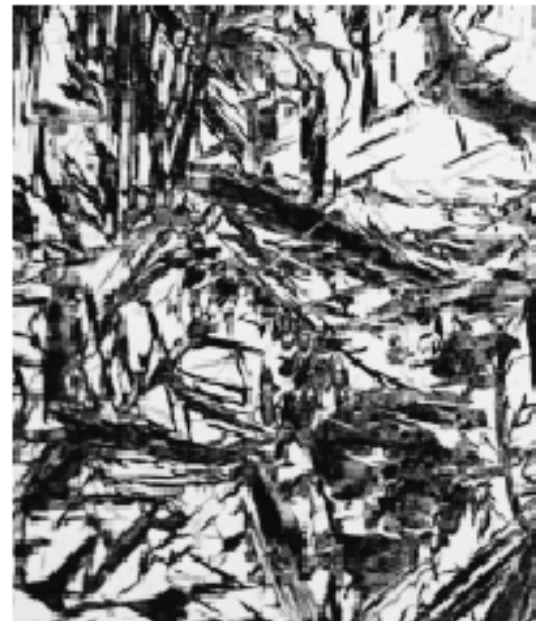
FIGURE 11.6 Photomicrographs of (a) coarse pearlite and (b) fine pearlite. 3000 \times . (From K. M. Ralls, et al., *An Introduction to Materials Science and Engineering*, p. 361. Copyright © 1976 by John Wiley & Sons, New York. Reprinted by permission of John Wiley & Sons, Inc.)

“Fast Cooling” – Bainite and Martensite*

Bainite

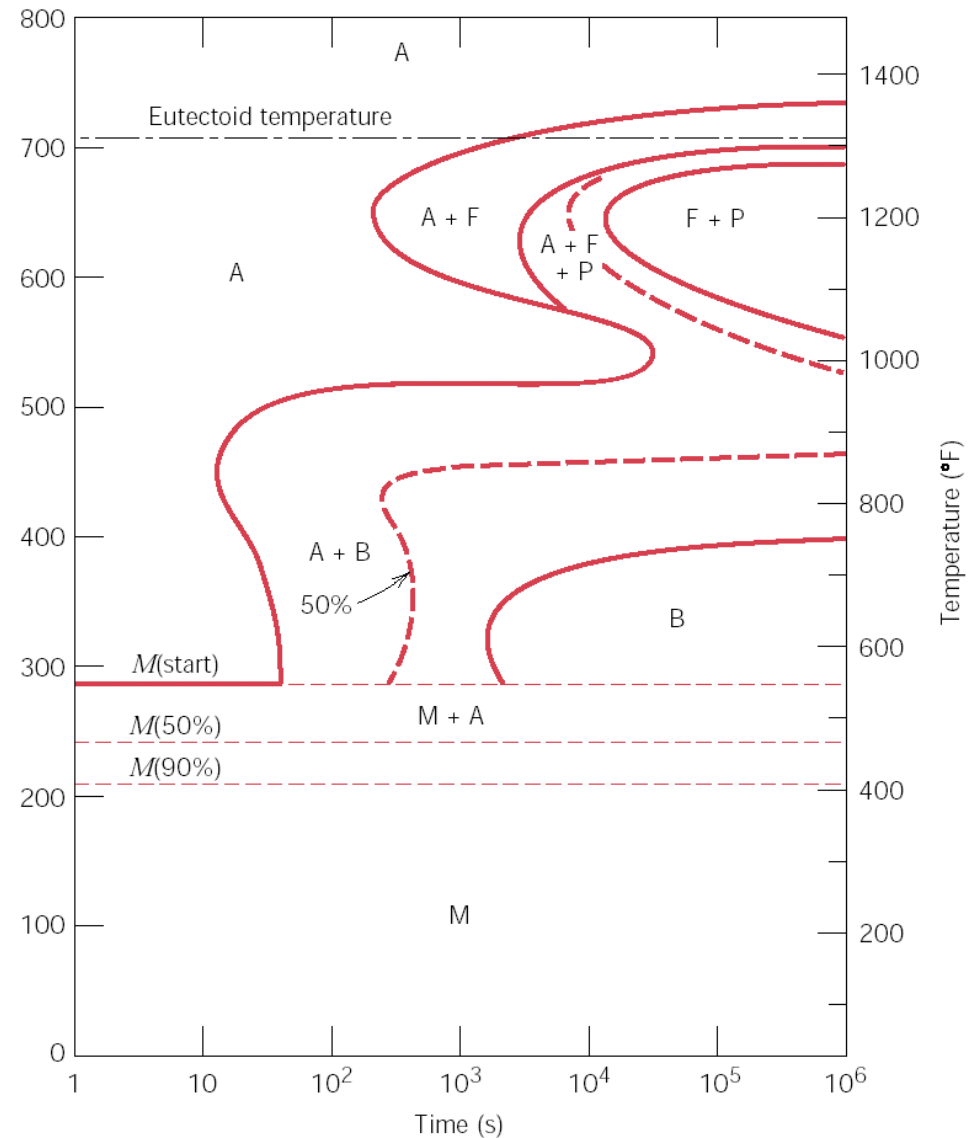


Martensite

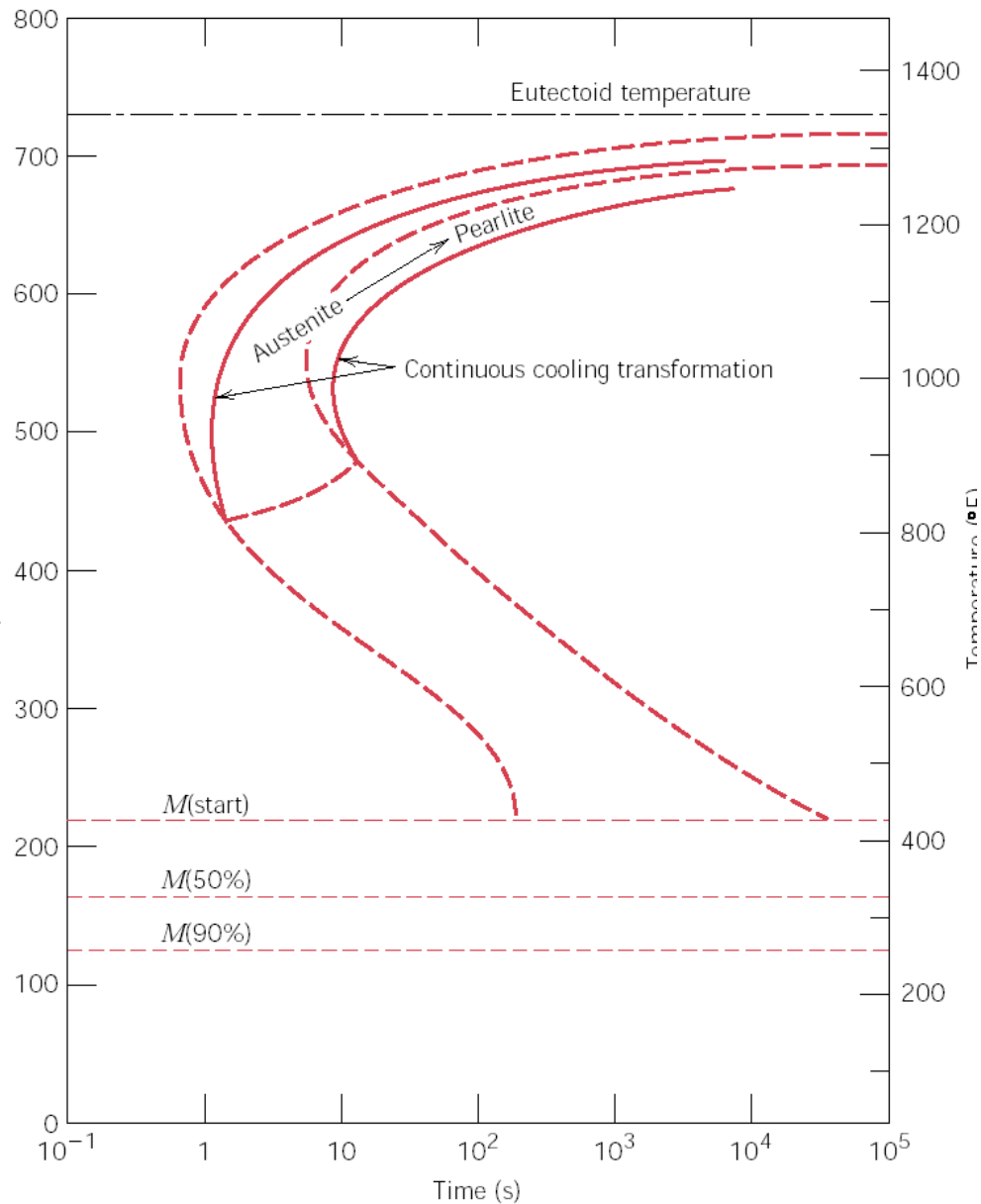


*photos under electron microscopy

Complete Isothermal Transformation Diagram for 4340 Steel Alloy

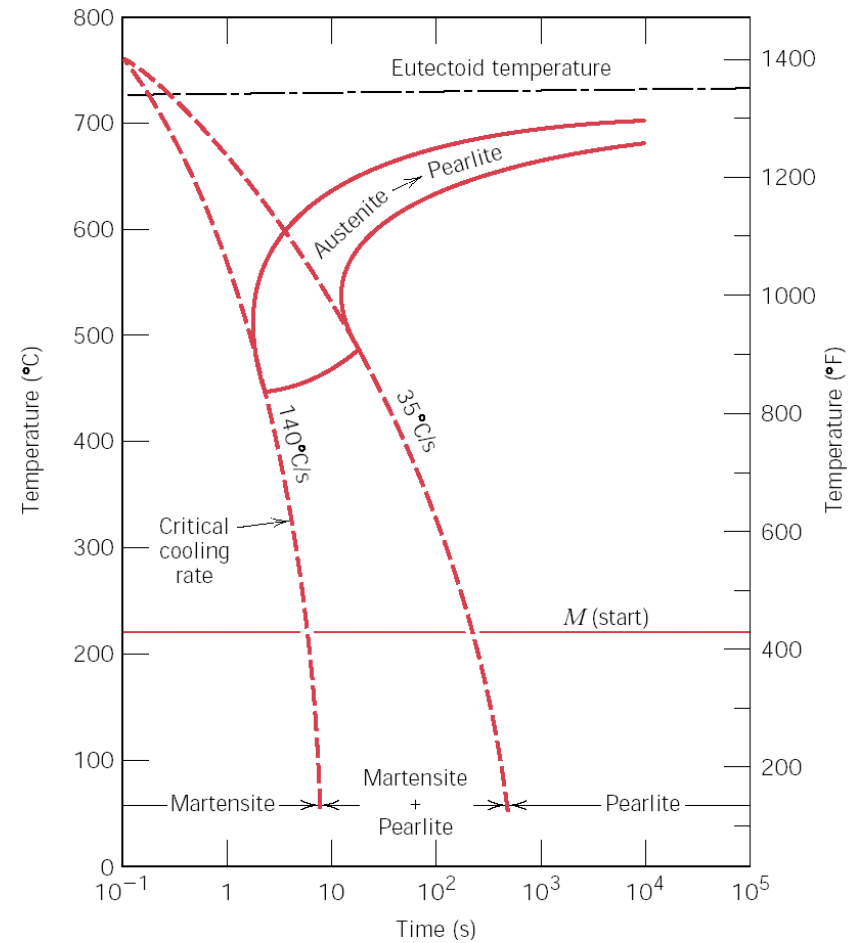
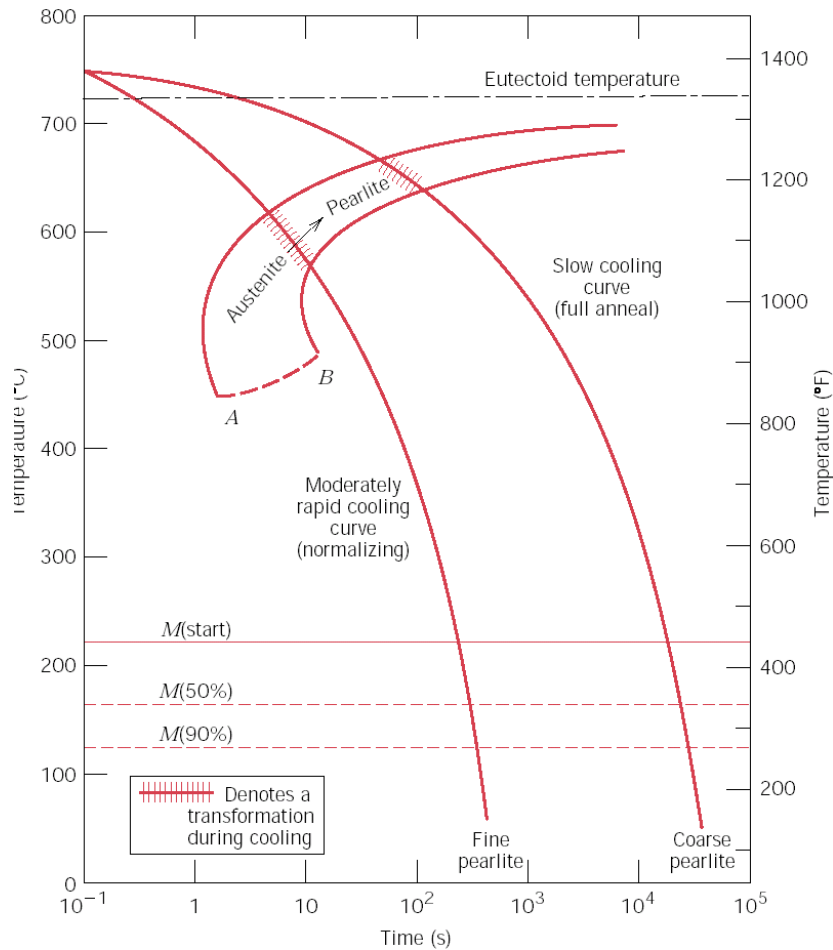


Continuous Cooling vs. Isothermal Diagrams

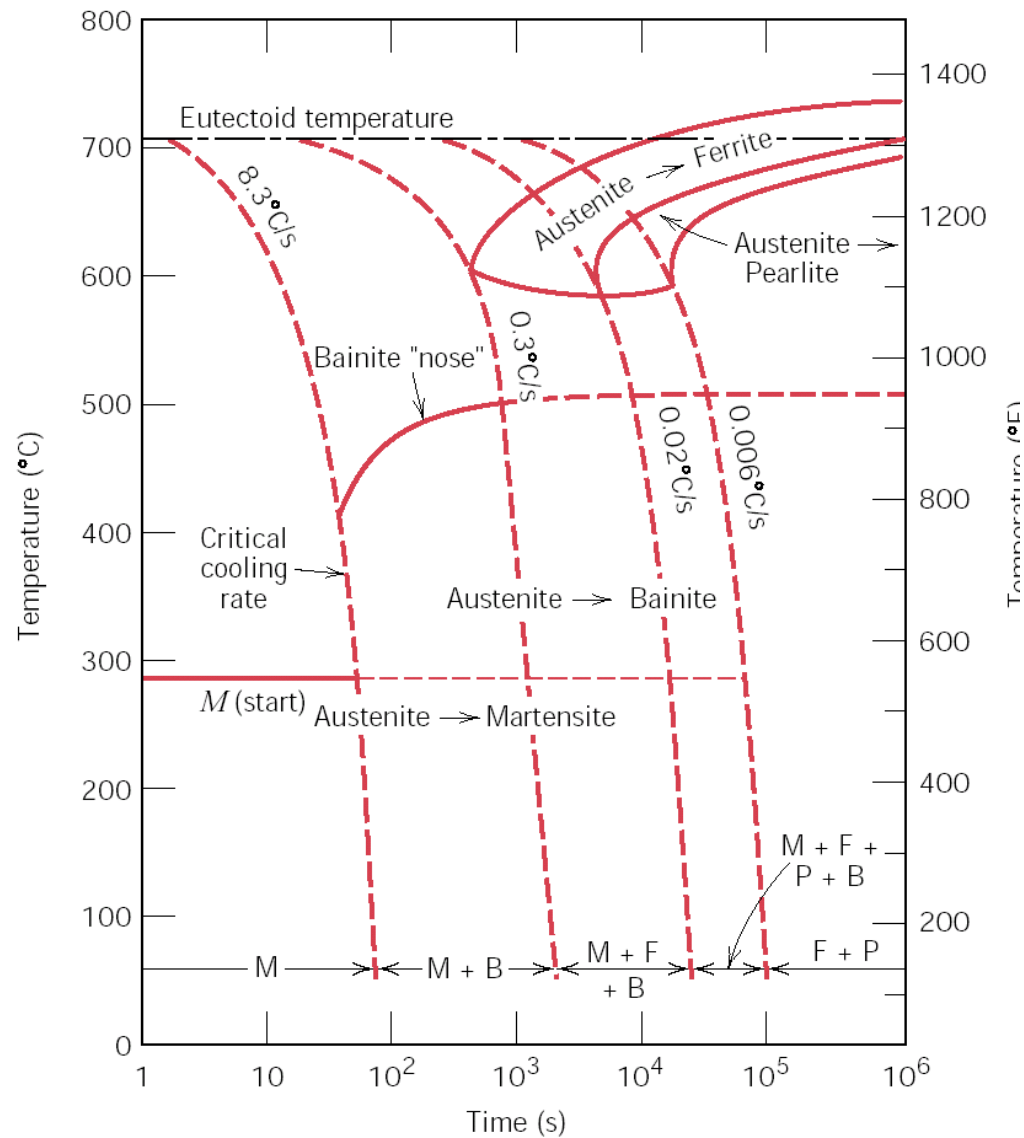


Effective shift in the start/stop times for the reaction

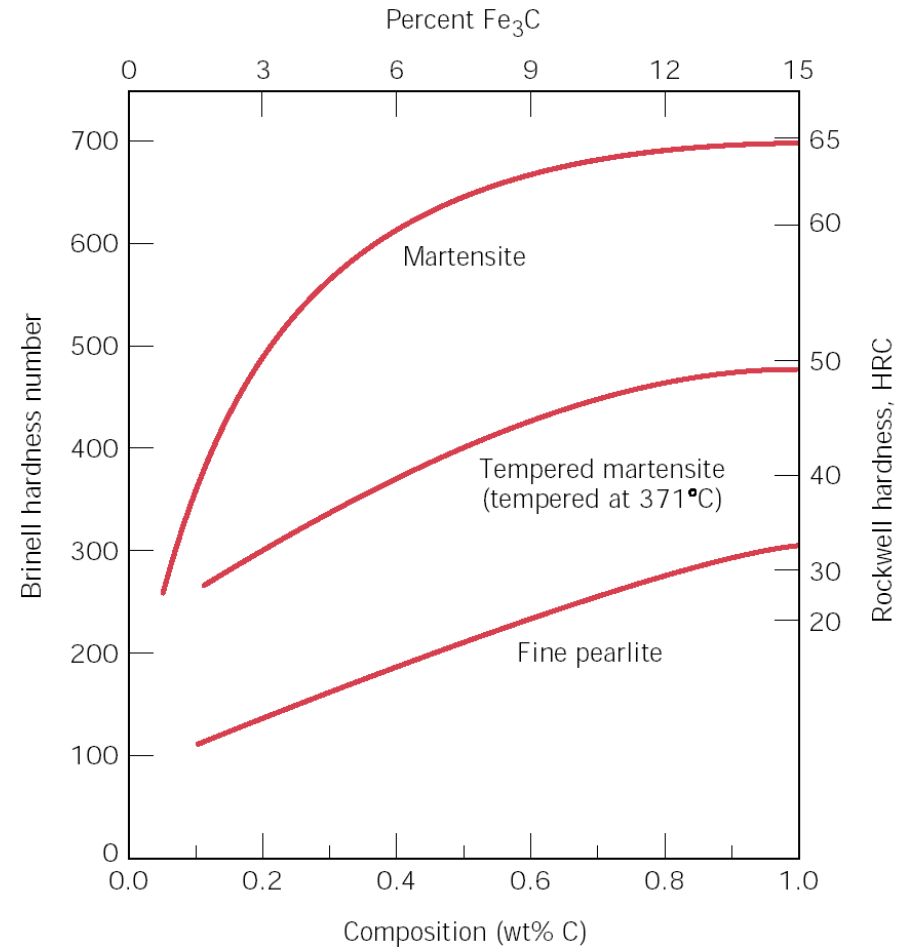
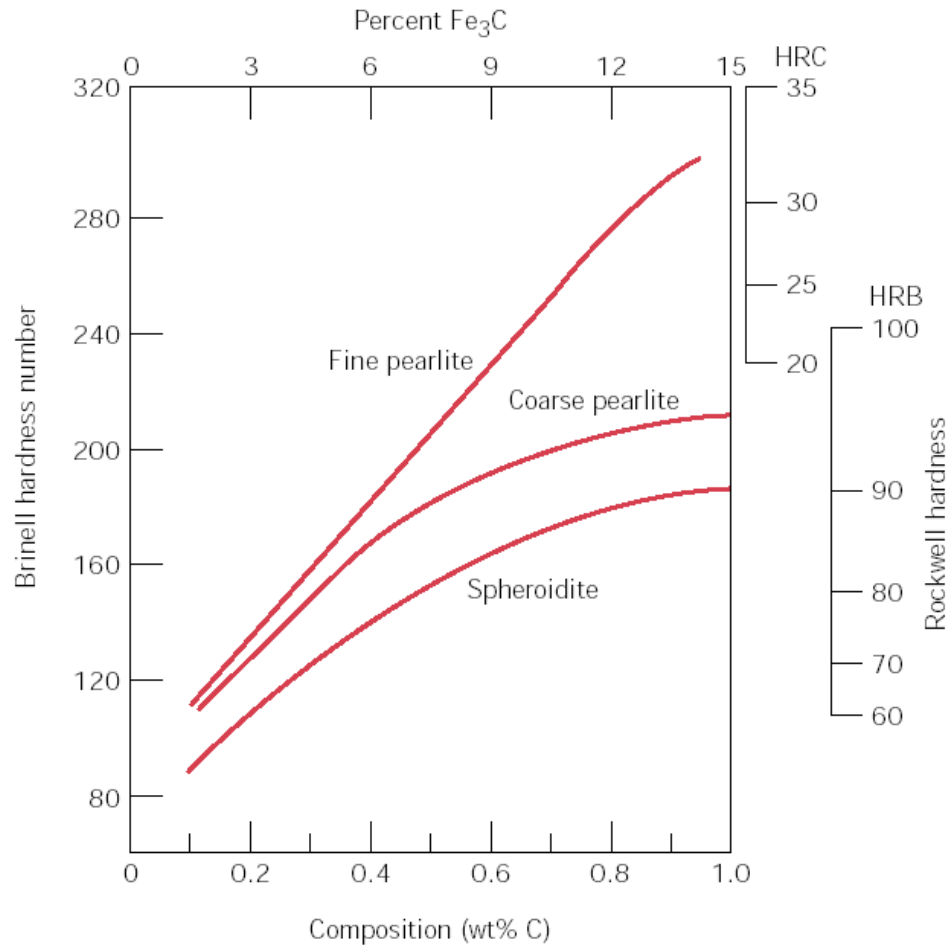
Continuous Cooling Diagrams and Microstructure (Eutectoid Steel)



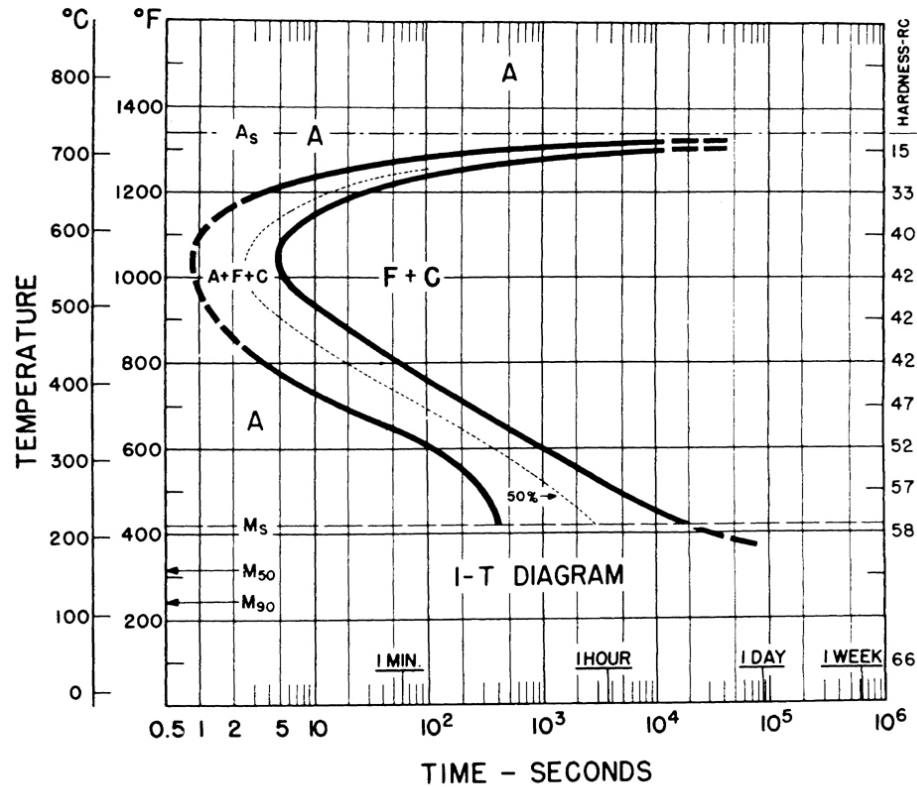
Continuous Cooling Diagrams and Microstructure – 4340 Steel Alloy



Hardness vs. Microstructure & Carbon Content

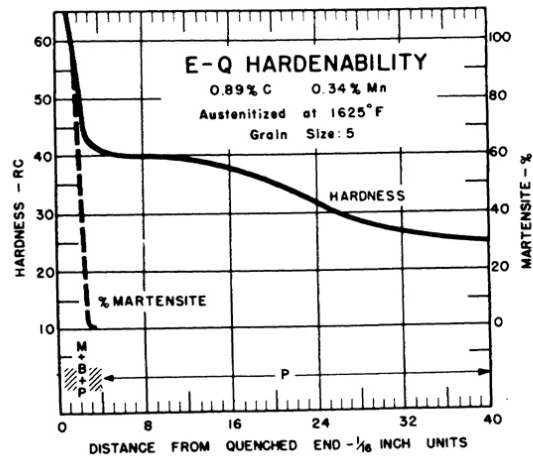


Carbon Steels: 1095



TTT Diagram and Hardenability

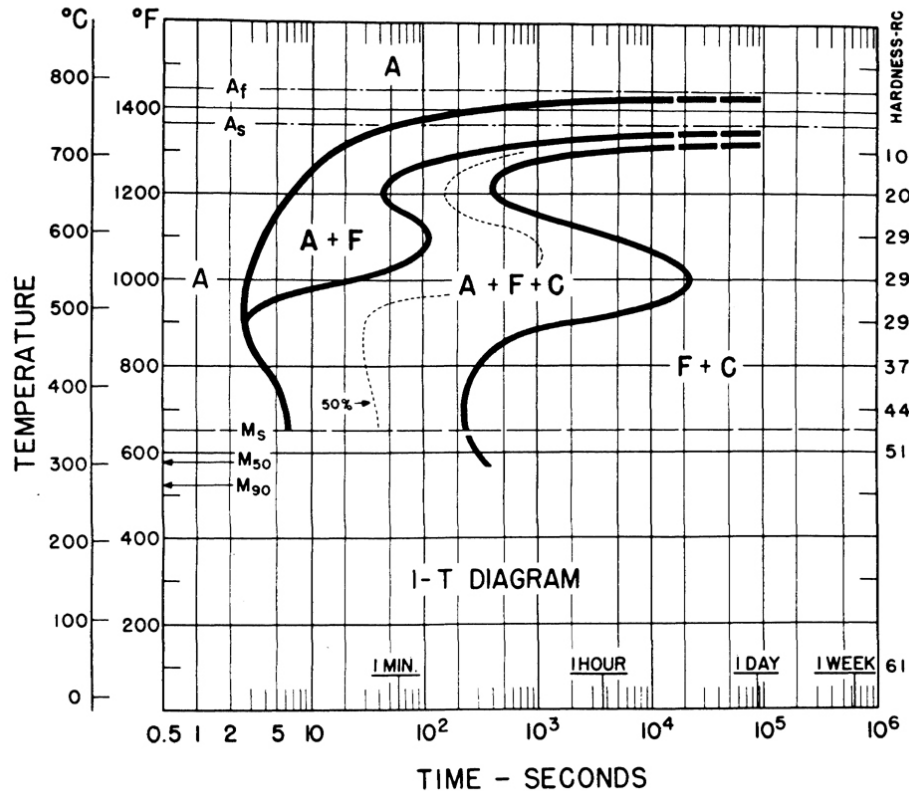
1095



LEGEND

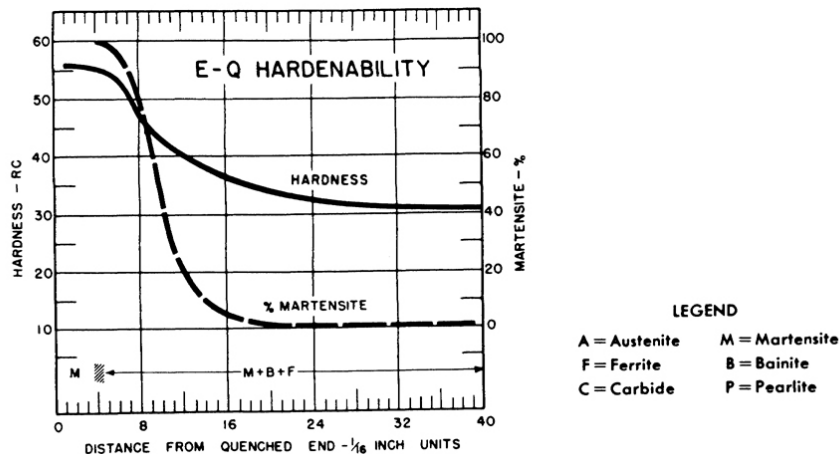
A = Austenite M = Martensite
F = Ferrite B = Bainite
C = Carbide P = Pearlite

Chromium-Molybdenum Steels: 4140

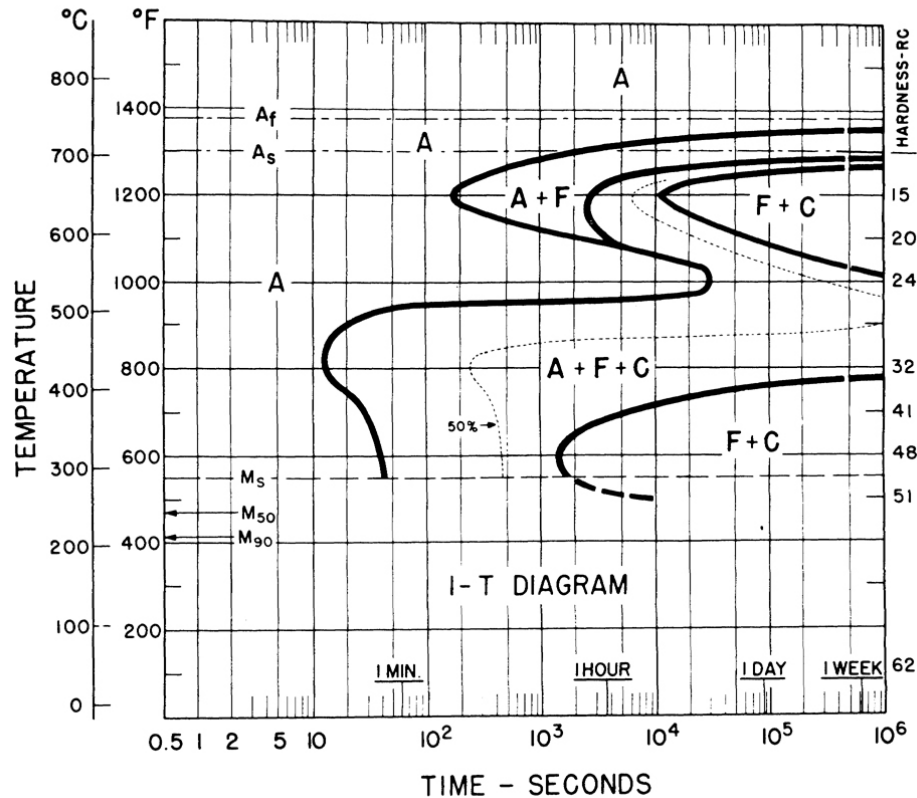


TTT Diagram and
Hardenability

4140

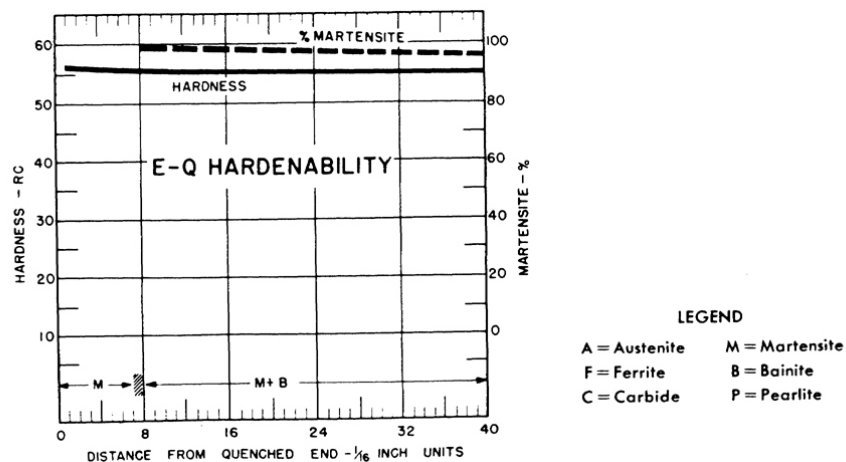


Ni-Cr-Mo Steels: 4340

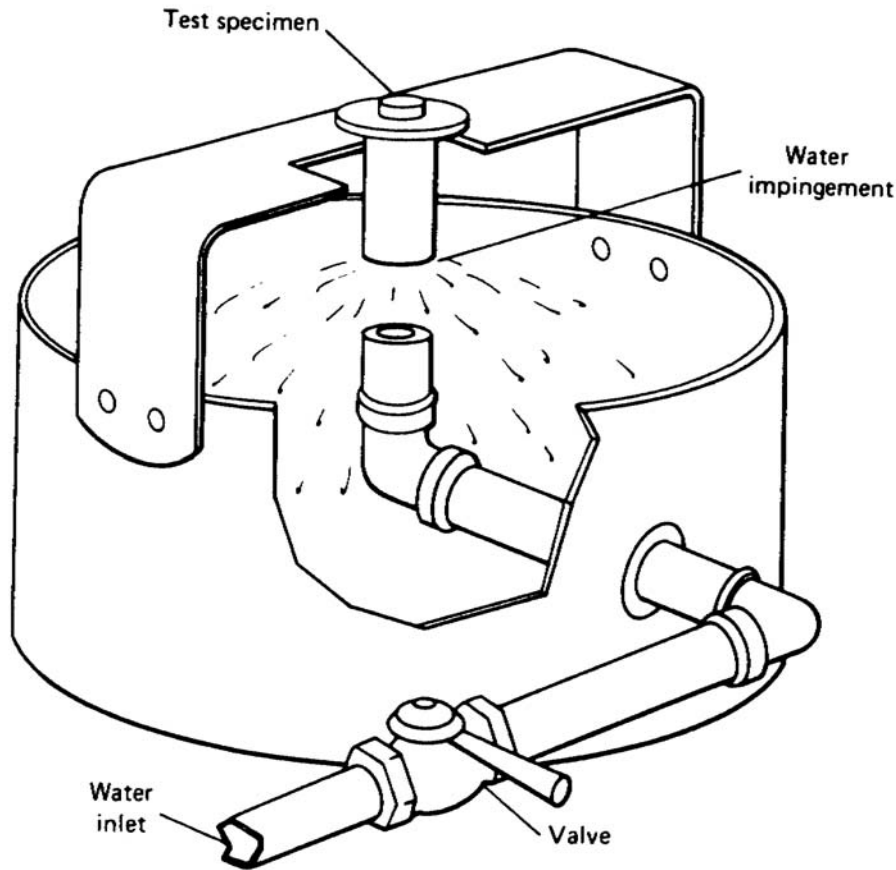


TTT Diagram and
Hardenability

4340



The ASTM Jominy Bar Test

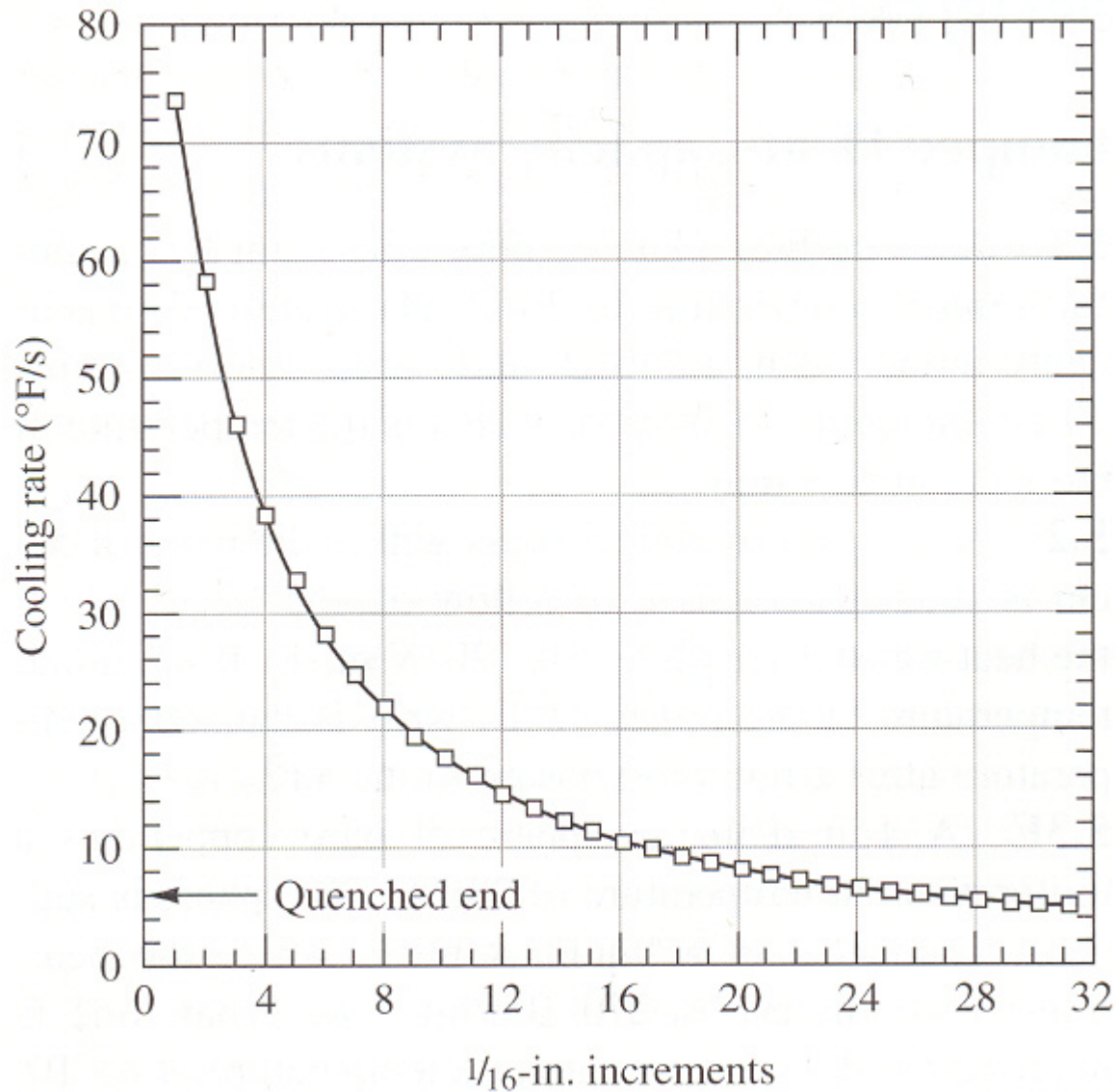


- ASTM Standard A255
- Standard measure for hardenability of steel
- 25.4mm Diameter, 100mm Long Test Specimen
- Specimen heated above austenitic temperature ($\sim 800^{\circ}\text{C}$) for > 1 hour
- Specimen end quenched with water jet



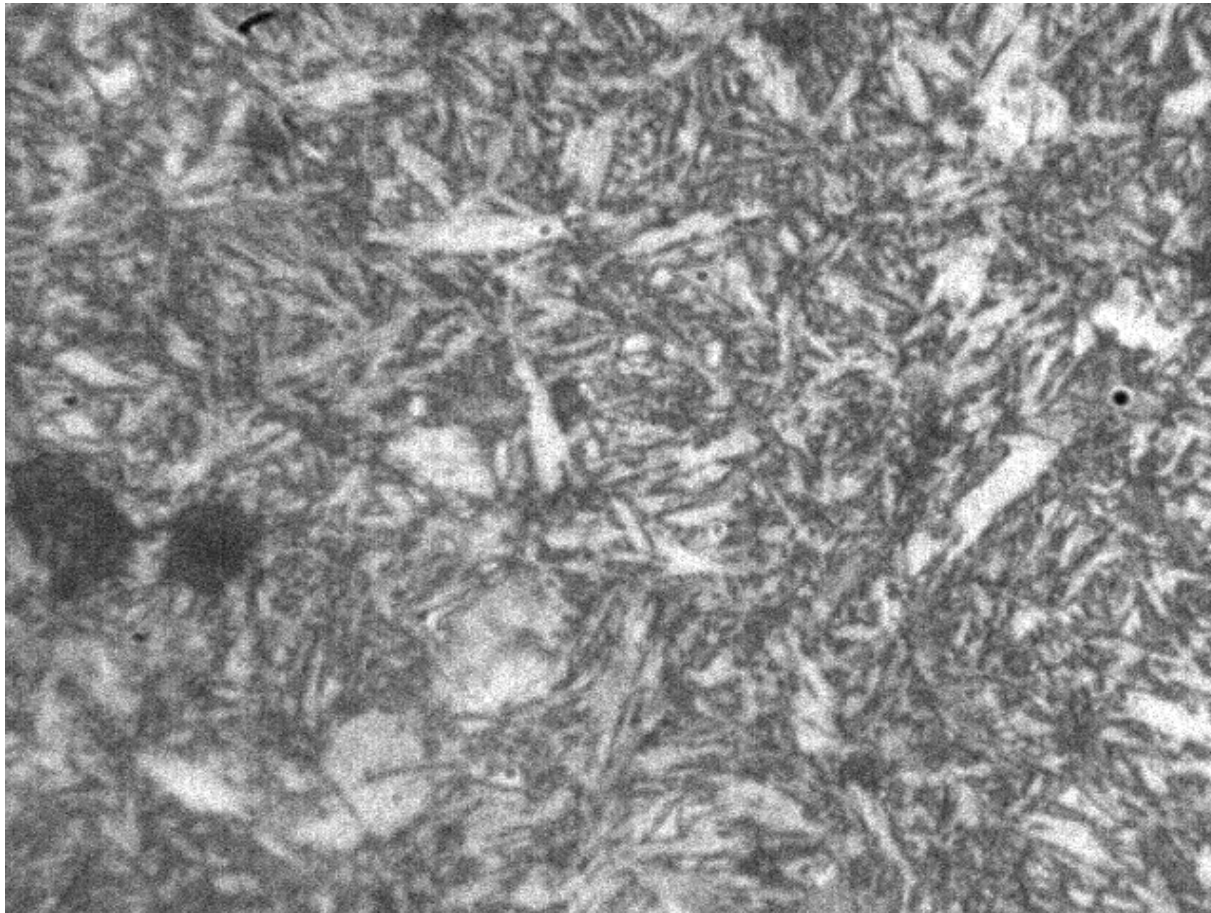


Estimated Cooling Rates within Jominy Bar



Experimental Results – Plumpton & Harris (2002)

Microstructure

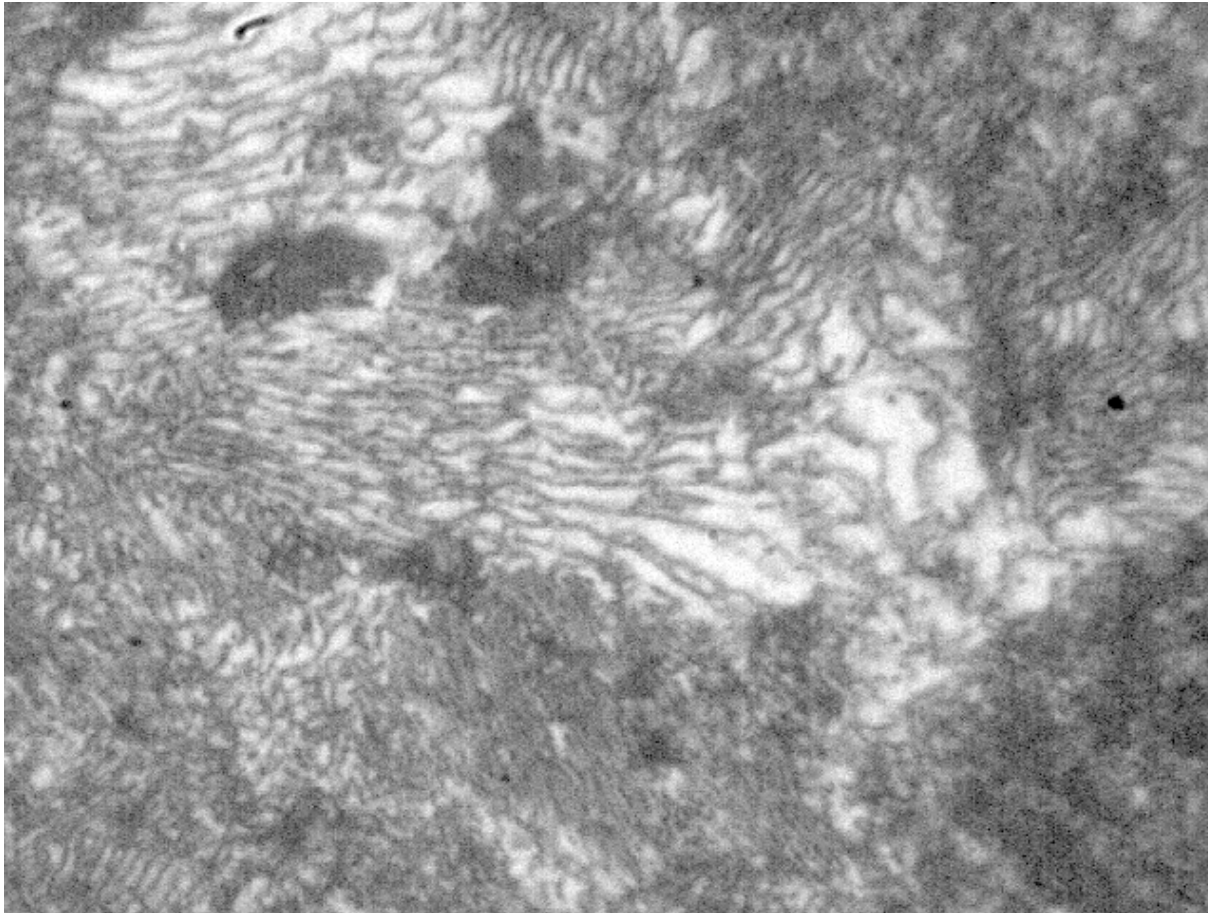


Quenched
End

~800x

Experimental Results - Plumpton & Harris (2002)

Microstructure



3/4L from
Quenched
End

~800x

Experimental Results - Plumpton & Harris (2002)

Hardness Curves

Rockwell C Hardness vs. Distance from Quenched End

