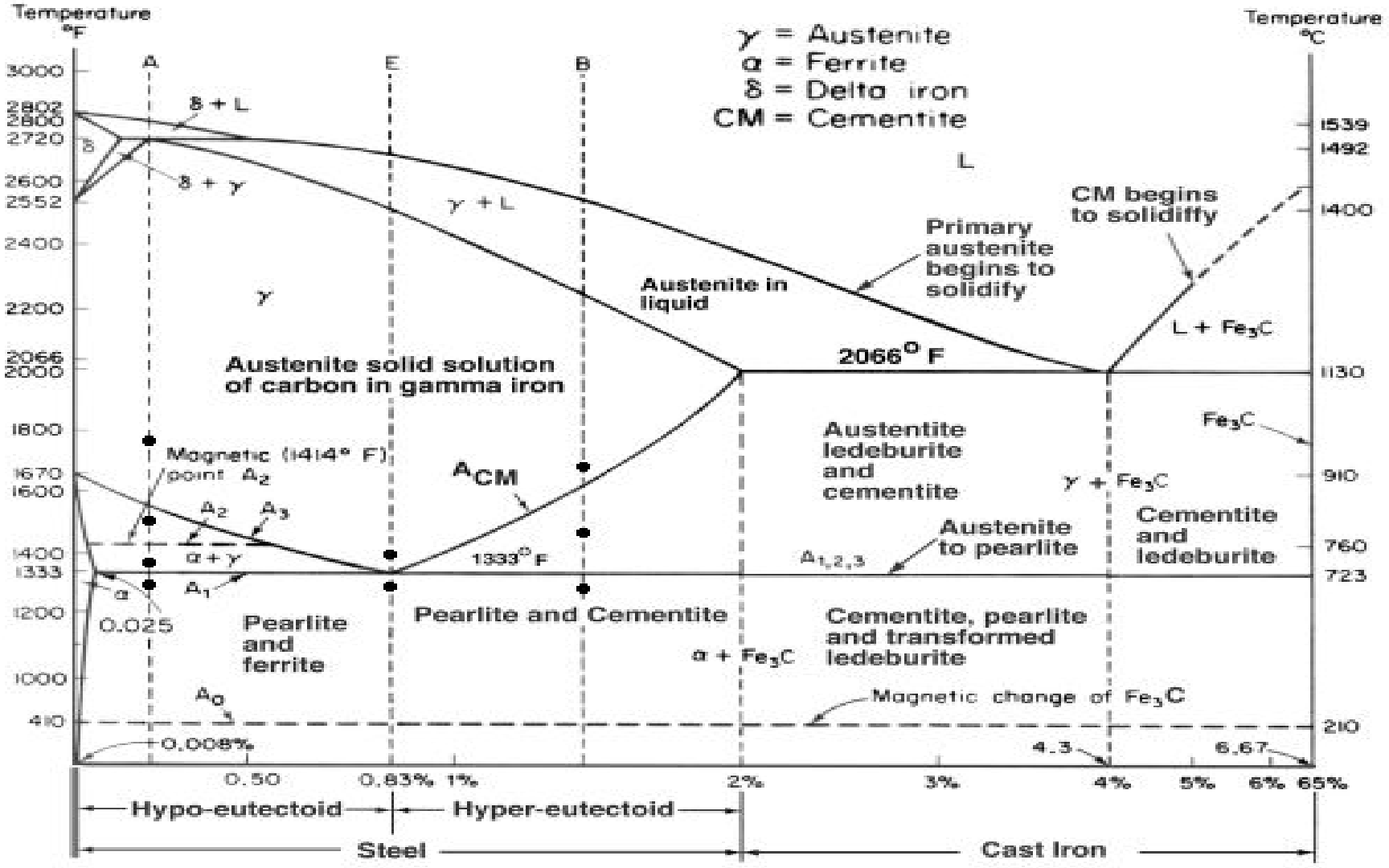

Temperature °F
Temperature °C
γ = Austenite
α = Ferrite
δ = Delta iron
CM = Cementite
3000
2802
2800
2720
2600
2552
2400
2200
2066
2000
1800
1670
1600
1400
1333
1200
1000
410
1539
1492
1400
1130
910
760
723
210
A
E
B
δ + L
δ
δ + γ
γ + L
L
CM begins to solidify
Primary austenite begins to solidify
Austenite in liquid
γ
L + Fe3C
2066° F
Austenite solid solution of carbon in gamma iron
Fe3C
Austentite ledeburite and cementite
γ + Fe3C
Magnetic (1414° F) point A2
ACM
A2
A3
α + γ
1333° F
A1,2,3
Austenite to pearlite
Cementite and ledeburite
α
A1
0.025
Pearlite and ferrite
Pearlite and Cementite
α + Fe3C
Cementite, pearlite and transformed ledeburite
A0
Magnetic change of Fe3C
0.008%
4.3
6.67
0.50
0.83% 1%
2%
3%
4%
5%
6%
65%
Hypo-eutectoid
Hyper-eutectoid
Steel
Cast Iron

Definition of structures

- **Austenite** is an interstitial solid solution of Carbon dissolved in γ(F.C.C.) iron.
- Maximum solubility is 2.0 % C at 1130°C.
- High formability, most of heat treatments begin with this single phase.
- It is normally not stable at room temperature. But, under certain conditions it is possible to obtain austenite at room temperature.

Definition of structures

- **Cementite** or iron carbide, is very hard, brittle intermetallic compound of iron & carbon, as Fe_3C, contains 6.67 % C.
- It is the hardest structure that appears on the diagram, exact melting point unknown.
- Its crystal structure is orthorhombic.
- It is has
  - low tensile strength (approx. 5,000 psi), but
  - high compressive strength.

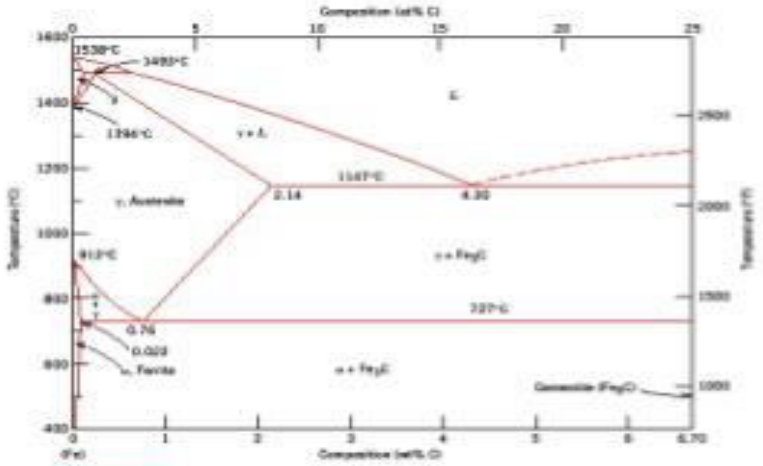
Definition of structures

- **Ferrite** is known as α solid solution.
- It is an interstitial solid solution of a small amount of carbon dissolved in α (BCC) iron.
- stable form of iron below 912 deg.C
- The maximum solubility is 0.025 % C at 723°C and it dissolves only 0.008 % C at room temperature.
- It is the softest structure that appears on the diagram.

Definition of structures

- **Pearlite** is the eutectoid mixture containing 0.80 % C and is formed at 723°C on very slow cooling.
- It is a very fine platelike or lamellar mixture of ferrite and cementite.
- The white ferritic background or matrix contains thin plates of cementite (dark).

Various Features of Fe-C diagram



The iron–iron carbide phase diagram. (Adapted from *Binary Alloy Phase Diagrams*, 2nd edition, Vol. 1, T. B. Massalski, Editor-in-Chief, 1990. Reprinted by permission of ASM International, Materials Park, OH.)

Phases present

L

δ
BCC structure
Paramagnetic

α ferrite
BCC structure
Ferromagnetic
Fairly ductile

γ austenite
FCC structure
Non-magnetic
ductile

Fe_3C cementite
Orthorhombic
Hard
brittle

Reactions

Peritectic $L + \delta = \gamma$

Eutectic $L = \gamma + Fe_3C$

Eutectoid $\gamma = \alpha + Fe_3C$

Max. solubility of C in ferrite=0.022%

Max. solubility of C in austenite=2.11%

Three Phase Reactions

- Peritectic, at 1490 deg.C, with low wt% C alloys (almost no engineering importance).
- Eutectic, at 1130 deg.C, with 4.3wt% C, alloys called cast irons.
- Eutectoid, at 723 deg.C with eutectoid composition of 0.8wt% C, two-phase mixture (ferrite & cementite). They are steels.

The Iron-Iron Carbide Diagram

The diagram shows three horizontal lines which indicate isothermal reactions (on cooling / heating):

- First horizontal line is at 1490°C, where peritectic reaction takes place:

  Liquid + δ $\leftrightarrow$ austenite

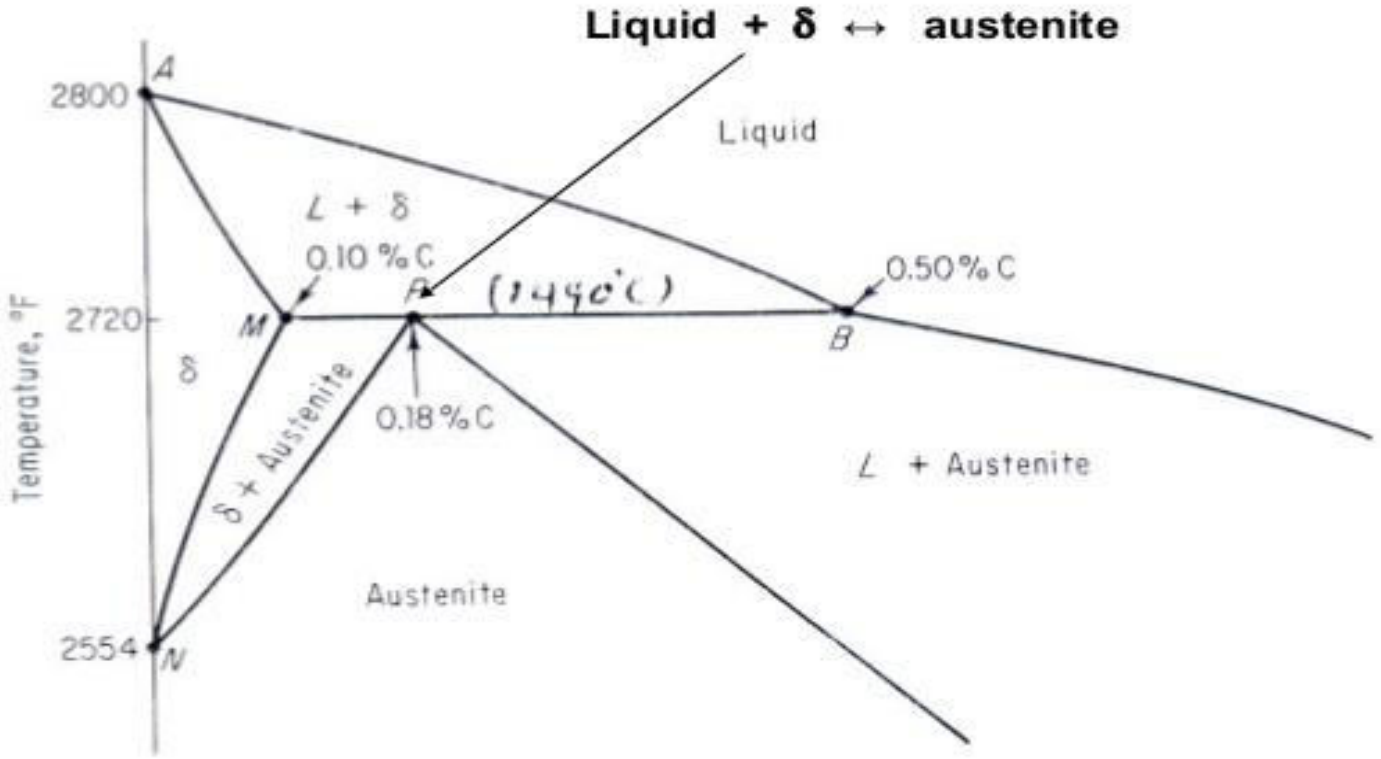
- Second horizontal line is at 1130°C, where eutectic reaction takes place:

  liquid $\leftrightarrow$ austenite + cementite

- Third horizontal line is at 723°C, where eutectoid reaction takes place:

  austenite $\leftrightarrow$ pearlite (mixture of ferrite & cementite)

Delta region of Fe-Fe carbide diagram



The Austenite to ferrite / cementite transformation in relation to Fe-C diagram

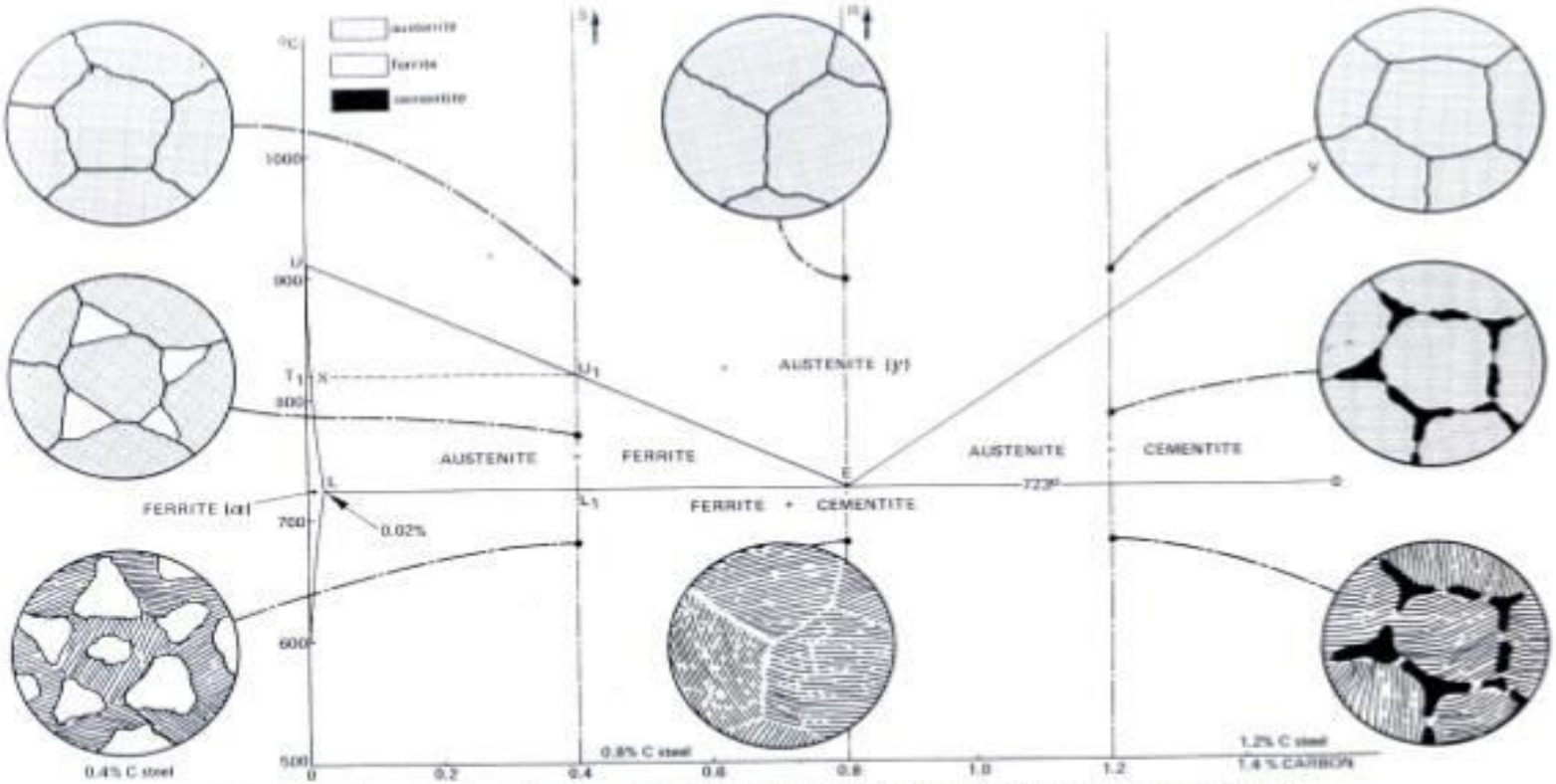
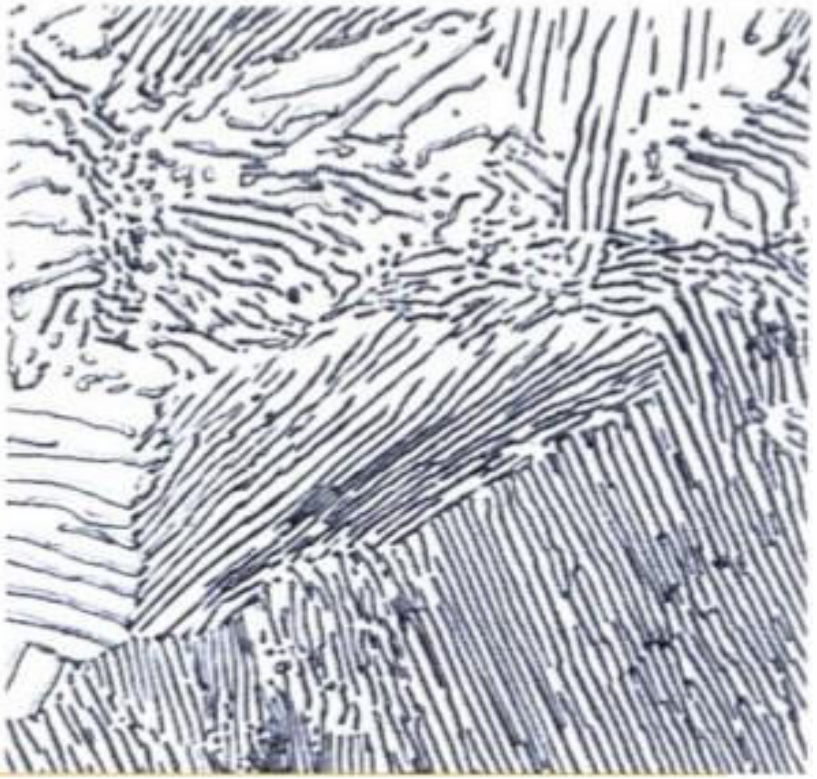


Fig. 9.3—The austenite → ferrite/cementite transformation in relation to the iron–carbon diagram.

Pearlitic structure

- The net reaction at the eutectoid is the formation of pearlitic structure.
- Since the chemical separation occurs entirely within crystalline solids, the resultant structure is a fine mixture of ferrite and cementite.

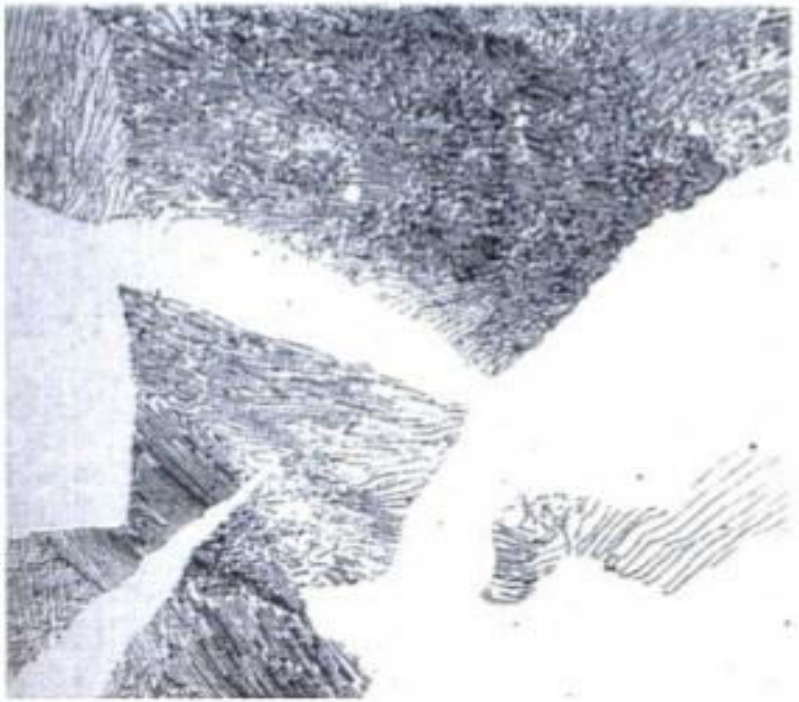


The Austenite to ferrite / cementite transformation in relation to Fe-C diagram

- **Hypo-eutectoid steels-**

  At *723°C*, the remaining austenite will have assumed the eutectoid composition *(0.8%* carbon), and further cooling transforms it to pearlite.

- The resulting structure, is a mixture of *primary* or *pro-eutectoid ferrite* (ferrite that forms before the eutectoid reaction) and regions of pearlite.



The Austenite to ferrite / cementite transformation in relation to Fe-C diagram

Hypo-eutectoid steel showing primary cementite along grain boundaries pearlite

Principal phases of steel and their Characteristics

Phase	Crystal structure	Characteristics
Ferrite	BCC	Soft, ductile, magnetic
Austenite	FCC	Soft, moderate strength, non-magnetic
Cementite	Compound of Iron & Carbon Fe_3C	Hard &brittle