Quiz 3  Phase Diagrams

You Should Be Able to:

- Define a phase and explain how the amount, nature, size, shape, distribution, and orientation of the phases affects the material properties.
- Given an equilibrium phase diagram,
  - identify the liquidus, solidus, or solvus lines, and state what they represent.
  - identify the eutectic or eutectoid point, composition, or temperature, and state what they represent.
  - find the number of phases present, name those phases, find their chemical compositions (phase analyses), and find in what proportions (amounts) the phases occur.
  - predict whether age hardening is possible for a given alloy.
- For Iron-Carbon alloys you should:
  - Label regions in Fe-Fe₃C equilibrium phase diagram
  - State the composition, structure, and properties of austenite, ferrite, cementite, and pearlite and explain how each is formed.
  - Sketch and label the equilibrium structure for hypo- and hyper-eutectoid steels and be able to determine the approximate weight percent pearlite present in a given alloy from a microphotograph

Vocabulary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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</thead>
<tbody>
<tr>
<td>Austenite</td>
<td>Liquidus Line</td>
</tr>
<tr>
<td>Cementite</td>
<td>Microconstituent</td>
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<tr>
<td>Equilibrium</td>
<td>Pearlite</td>
</tr>
<tr>
<td>Eutectic reaction</td>
<td>Phase</td>
</tr>
<tr>
<td>Eutectic structure</td>
<td>Phase Diagram</td>
</tr>
<tr>
<td>Eutectoid reaction</td>
<td>Primary Phase</td>
</tr>
<tr>
<td>Hypereutectoid</td>
<td>Proeutectoid</td>
</tr>
<tr>
<td>Hypoeutectoid</td>
<td>Solidus Line</td>
</tr>
<tr>
<td>Intermetallic Compound</td>
<td>Solvus Line</td>
</tr>
<tr>
<td>Lever Rule</td>
<td>Tie Line</td>
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</tbody>
</table>
Equilibrium Phase Diagrams
(Binary or Two Element)

Useful Information from a Phase diagram
- The phases present for any alloy at any temperature
- Chemical composition of each phase
- Relative amounts (weights of each phase)
- Melting/Solidification temperatures

Finding Chemical Composition
To find the chemical compositions of the phases, you first have to know
- the alloy you are using (defines location on the x-axis)
- the temperature of interest (defines location on the y axis)

If the intersection of the alloy line and the temperature line (point of interest) fall in a single phase region, there is only one phase present. The composition of the phase is the composition of the alloy.

If the point of interest falls in a two phase region, you will need to find the composition for each phase. To do this:
- draw a horizontal point thru the point of interest until it intersects with the boundaries of the closest single phase regions
- draw vertical lines to the x-axis and read the composition for each phase
Finding Composition of the Phases present in a Two Phase Region

Consider a 25% Sn, 75% Pb alloy at 230°C.

Point of Interest (Temperature and Composition):

Chemical composition of a is about: 15% Sn - 85% Pb
Chemical composition of L is about: 40% Sn - 60% Pb

Continuing with the same alloy at the same temperature

Finding Relative Amounts (proportions of the phases)

To find the weight percent of a phase, use the tie line as a lever with fulcrum at the point of interest and lever ends at the phase compositions.

\[
\%a = \frac{\text{opposite}}{\text{total length}} \times 100 = \frac{15}{25} \times 100 = 60\%
\]

\[
\%L = \frac{\text{opposite}}{\text{total length}} \times 100 = \frac{10}{25} \times 100 = 40\%
\]
Iron Carbon Phase Diagram (partial)

<table>
<thead>
<tr>
<th>Phase</th>
<th>Carbon</th>
<th>Name</th>
<th>Structure</th>
<th>Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferrite</td>
<td>&lt;0.02%</td>
<td>α-iron</td>
<td>BCC</td>
<td></td>
</tr>
<tr>
<td>Austenite</td>
<td>&lt;2.2%</td>
<td>γ-iron</td>
<td>FCC</td>
<td>&gt;727°C</td>
</tr>
<tr>
<td>Cementite</td>
<td>6.7%</td>
<td>Fe₃C</td>
<td>Intermetallic</td>
<td></td>
</tr>
<tr>
<td><strong>Structure</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pearlite</td>
<td>0.76%</td>
<td>layered α,Fe₃C</td>
<td>&lt;727°C</td>
<td></td>
</tr>
</tbody>
</table>

**Terms**

*Eutectoid point* - 3 phases (ferrite, austenite, cementite) in equilibrium at one temperature. All phases are solid, therefore this is a solid-solid transformation.

*Eutectoid composition* - 0.76% carbon (approximately a 1080 steel)

*Eutectoid Structure* - Pearlite

*Proeutectoid* - phase that forms at temps above the eutectoid temperature (727°C). For hypoeutectoid steels (steels with less than 0.76% C), ferrite is the proeutectoid phase. For hyper eutectoid steels (steels with more than 0.76% C, cementite is the proeutectoid phase.

*Hypoeutectoid* is an iron carbon ally