ES 202
Fluid and Thermal Systems

Lecture 17:
More on properties and phases
(1/21/2003)

Road Map of Lecture 17

• Continue exercise on property table (water)
• Common procedure in phase determination
  – saturation table
• More on Compressed Liquid Approximation
• Practice with data interpolation
  – linear
  – bi-linear
• Special models
  – constant pressure process
  – constant volume process
What is the common starting point?

• Review question: In the procedure of phase determination of a substance, what is the common starting point?
  – the saturation table

• It serves as a reference region which helps you to decide if you are in
  – compressed (subcooled) liquid region
  – two-phase region
  – superheated vapor region

• If the substance is in the two-phase region, the knowledge of quality (mass fraction of vapor in the mixture) is critical in completely identifying the state of the mixture.

More on Compressed Liquid Approximation

• As introduced yesterday, the compressed liquid approximation can be expressed as:
  \[ u(T, P) \approx u_f(T) \]
  \[ \nu(T, P) \approx \nu_f(T) \quad \text{(weak function of } T) \]
  \[ s(T, P) \approx s_f(T) \]
  \[ h(T, P) \approx u_f(T) + P\nu_f(T) = h_f(T) + [P - P_{sat}(T)]\nu_f(T) \]

• It can be interpreted as weak dependency of most properties on pressure in the compressed liquid region.

• Hence, most properties can be approximated by their saturated liquid values at the specified temperature.
Compressed Liquid Approximation on Phase Diagrams

\[ P-v \] diagram

\[ T-v \] diagram

Data Interpolation

- The property tables only tabulate discrete values for pressure or temperature as the independent property.

- If you are interested in values which do not fall on the tabulated data points, interpolation within the “sandwich” interval will be necessary.

- Since the property tables report data at small intervals, linear interpolation should be adequate for most purposes.
  - Example: specify \( T \) (not tabulated) and \( x \) in two-phase region

- If both independent, intensive thermodynamic properties do not fall on the tabulated data points, bi-linear interpolation is necessary to completely specify the thermodynamic states.
  - Example: specify \( P \) and \( T \) in superheated vapor region (both not tabulated)
Constant Pressure Process

- Imagine a heating process in a cylinder with a constant weight as a lid (closed system; control mass)

- Since pressure is constant, you only need one more independent, intensive property to specify the state.

- Trace the process on
  - $P-v$ diagram
  - $T-v$ diagram

Constant Volume Process

- Imagine a heating process in a rigid enclosure (closed system; control mass)

- Since volume is constant, specific volume is constant throughout the process.

- Trace the process on
  - $P-v$ diagram
  - $T-v$ diagram