Lecture notes week 10 (part b). Use of Thermodynamic Tables

Properties for saturation, superheat, and compressed states are available for many pure substances. Common property tables available in the back of Thermodynamic texts are for H_2O, Refrigerants 12, 22 and 124a, and Ammonia.

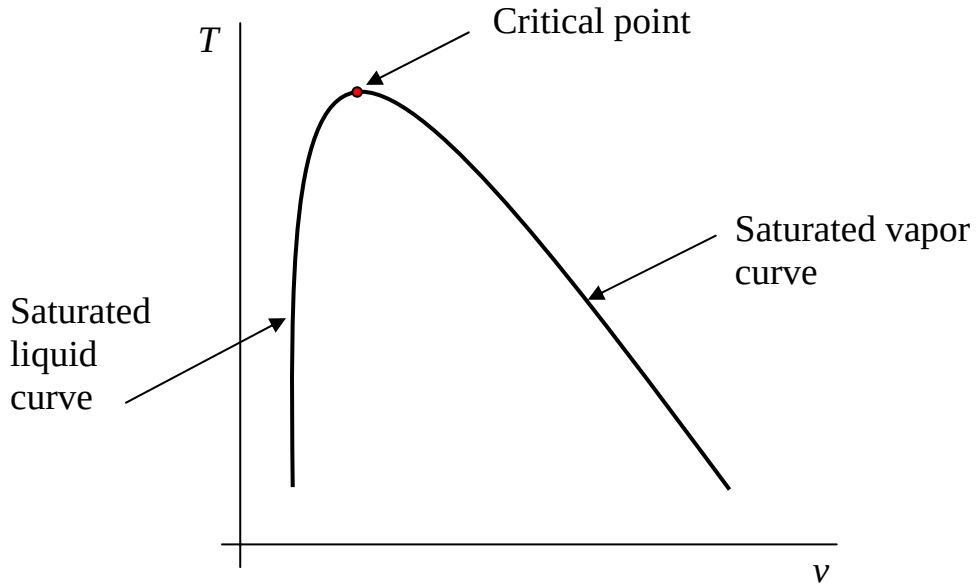
The physical property tables list sets of the *p*, *v*, *T* data as well as the specific internal energy (*u*), enthalpy (*h*) and entropy (*s*) data at convenient intervals of *T* or *p*. The intervals are spaced sufficiently close to allow linear interpolation between the listed data sets. For the time being let us focus on the *p, v, T* data.

The first step in the use of this data is to identify a given state so that we can use the appropriate table.

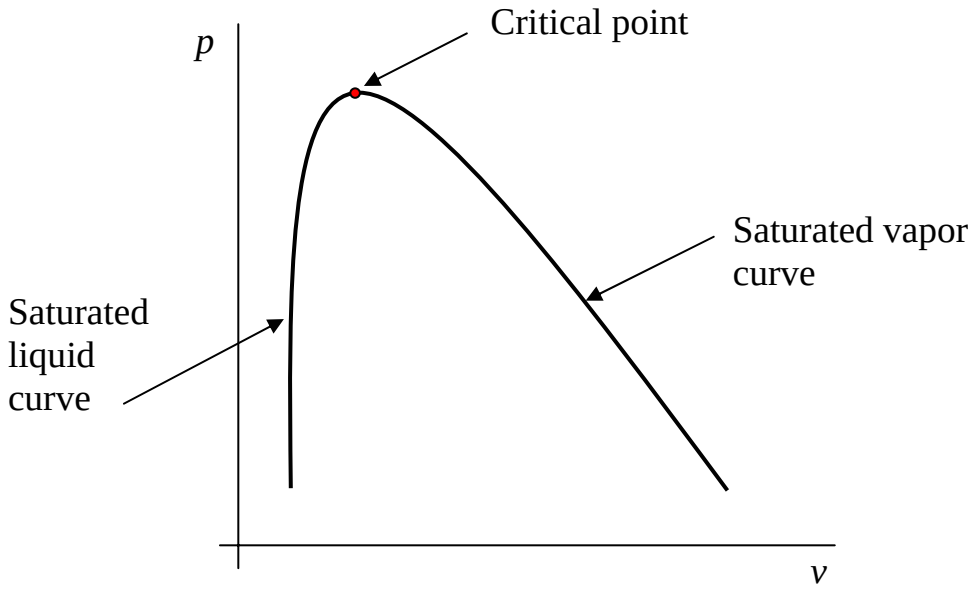
Note that:

- two independent properties are needed to define a state of a pure substance, and that any two such variables are sufficient.
- in the saturation region (inside the saturation dome) , *T* and *p* are not independent.

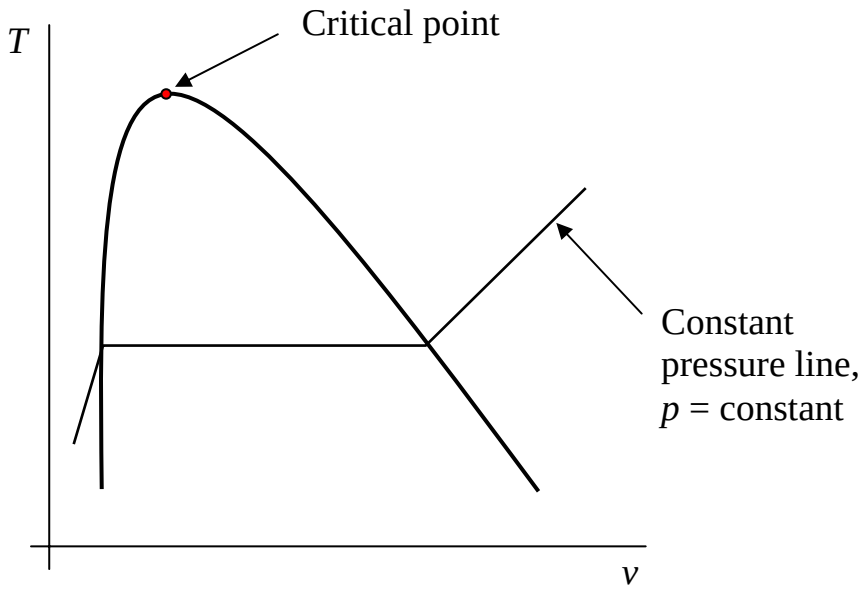
To use these tables effectively, it is helpful to sketch *T*–*v* diagram or a *p*–*v* diagram with the saturation dome clearly shown, as below:



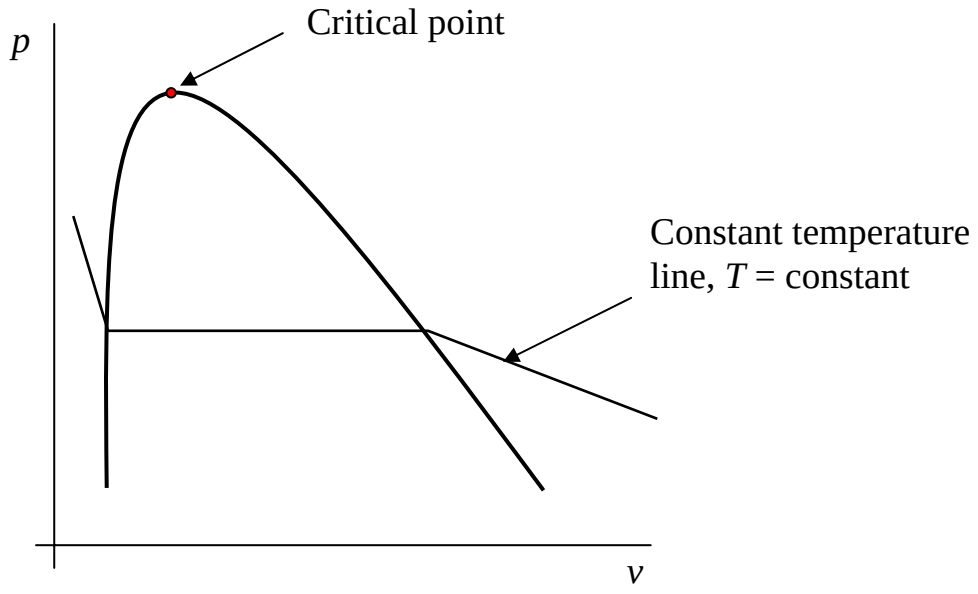
The *p*-*v* diagram:



On the *T*-*v* diagram, draw an arbitrary constant pressure, *p*, line. Note the positive slope of the constant pressure line.



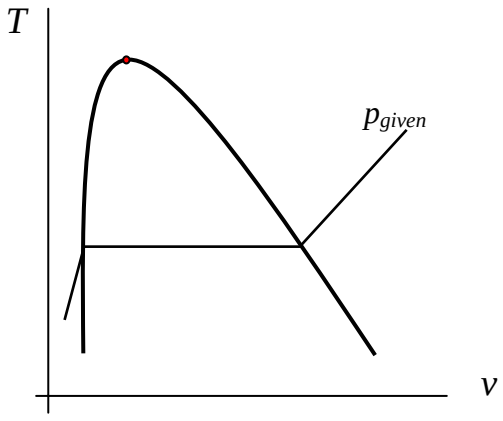
On the *p*-*v* diagram, draw an arbitrary constant temperature, *T*, line. Note the negative slope of the constant temperature line.



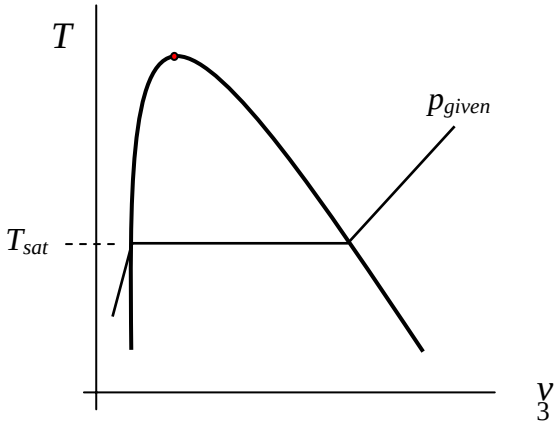
<u>Consider some typical situations:</u>

1. Given *T* and *p*, determine the State, and find *v* and *u*.

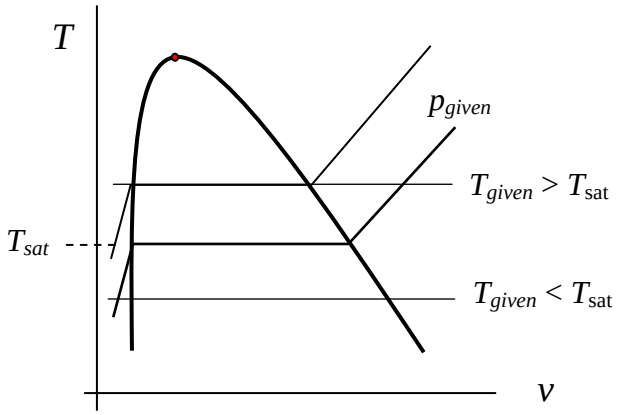
To find the state draw an arbitrary constant *p* line on a *T*-*v* diagram to represent the given *p* value.



Look up the saturation temperature value, T_{sat}, corresponding to the given pressure in the Saturated Pressure Table, and mark it on the diagram.

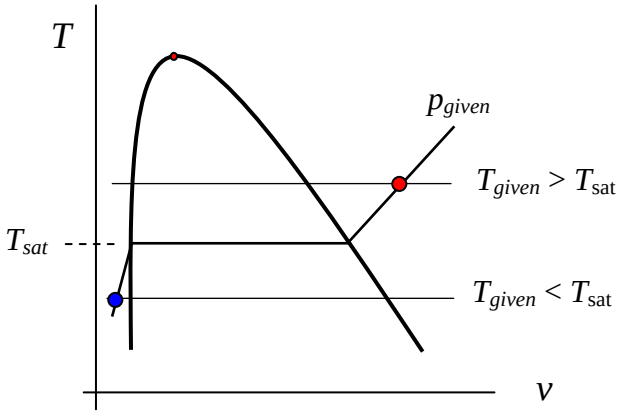


Now compare the given T with the T_{sat} marked on the diagram. The given T value will lie either above or below the T_{sat} line as shown in the diagram.



The intersection between the given T_{given} line and the given p_{given} line denotes the given state.

The upper intersection indicates a superheated vapor state. Look up the v and u values in the superheated tables. In general, interpolation will be needed to obtain the corresponding v and u.



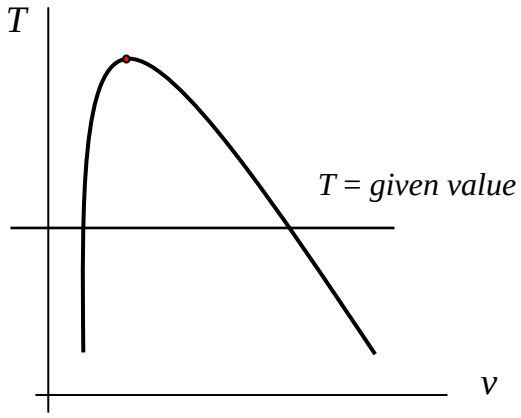
The lower intersection represents a compressed liquid state. Look up the v and u values in the compressed liquid tables. In general, interpolation will be needed to obtain the corresponding v and u. In the compressed liquid region we can also use the assumption that the v and u are independent of pressure and approximately equal to the v_{sat} and u_{sat} at the given T, i. e.

$$v(T, p) \approx v_f(T)$$
$$u(T, p) \approx u_f(T)$$

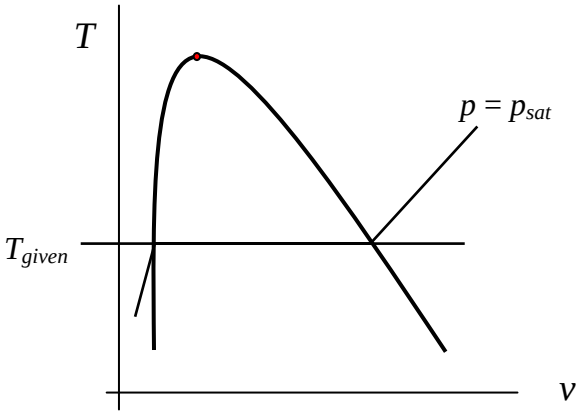
More on this approximation later.

An alternative determination of the state can also be made starting with the given temperature on the *T*-*v* diagram.

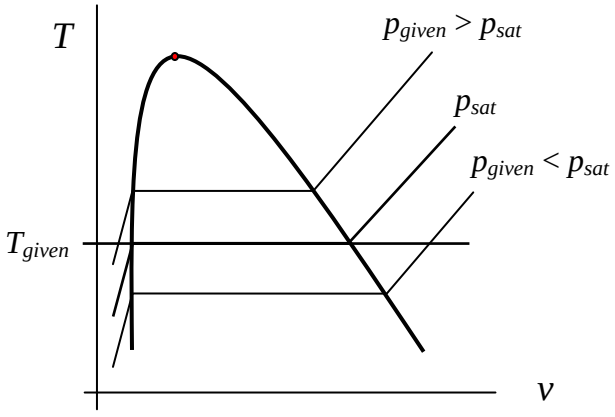
Draw an arbitrary constant *T* line on a *T*-*v* diagram to represent the given *T* value.



Look up the saturation pressure value, p_{sat}, corresponding to the given temperature in the Saturated Temperature Table, and mark it on the diagram.

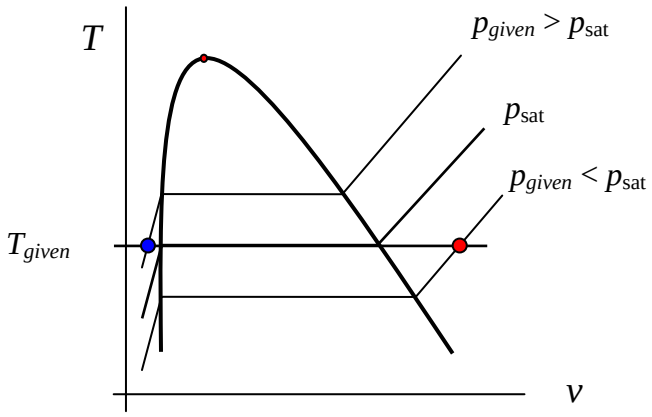


Now compare the given *p* with the p_{sat} marked on the diagram. The given *p* value will lie either above or below the p_{sat} line as shown in the diagram.



The intersection between the T_{given} line and the given p_{given} line denotes the given state.

The intersection on the right side indicates a superheated vapor state. Look up the v and u values in the superheated tables. In general, interpolation will be needed to obtain the corresponding v and u.



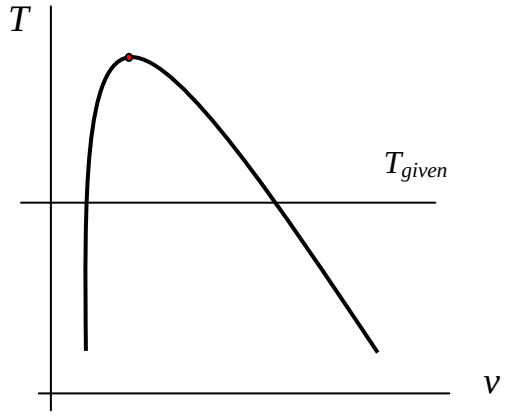
The intersection on the left side represents a compressed liquid state. Look up the v and u values in the compressed liquid tables. In general, interpolation will be needed to obtain the corresponding v and u. In the compressed liquid region we can also use the assumption that the v and u are independent of pressure and approximately equal to the v_{sat} and u_{sat} at the given T, i. e.

$$v(T, p) \approx v_f(T)$$
$$u(T, p) \approx u_f(T)$$

An equivalent procedure can also be used on a p-v diagram to determine the corresponding state for the given p and T values.

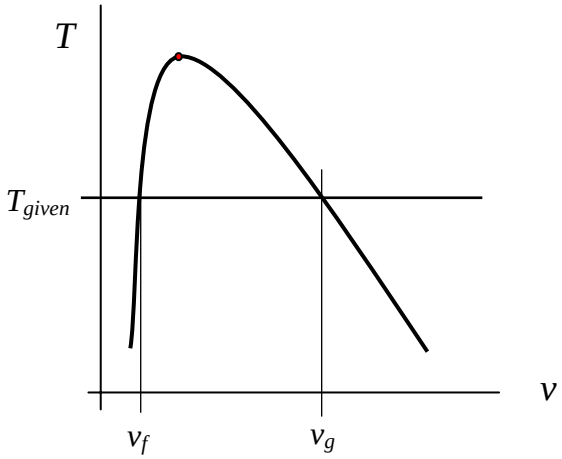
2. Consider next the situation where T and v are given and p and u are the values to be determined. Use a similar procedure to the above example. Start with the given T and use the T-v diagram this time (a p-v diagram is equally suitable). The procedure is as follows:

To find the state draw an arbitrary constant T line on a T-v diagram to represent the given T value.

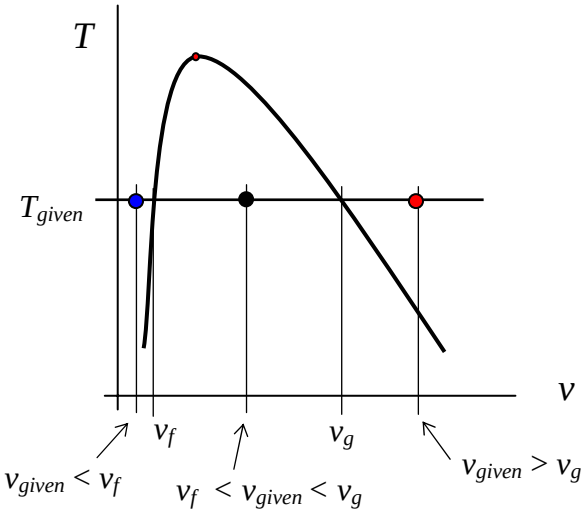


Draw vertical lines to represent the saturated liquid and saturated vapor states at the given temperature.

Look up the saturation liquid, v_f, and saturation vapor, v_g, values corresponding to the given temperature value and mark it on the diagram.



Now compare the given v with the v_f and v_g marked on the diagram. The given v value will be in one of three possible places. If it is to the left of v_f it represents a compressed liquid state, if it is between v_f and v_g it represents a saturated liquid-vapor state, and if it is to the right of v_g it is in the superheated state.



If the given value was pressure instead of temperature, follow the same procedure as above on a p-v diagram. Clearly, the same state determination can be made using either a T-v or a p-v diagram.