Let Your Gases Lead the Way: Stock Tank Vapors
VRU Best Practices Series

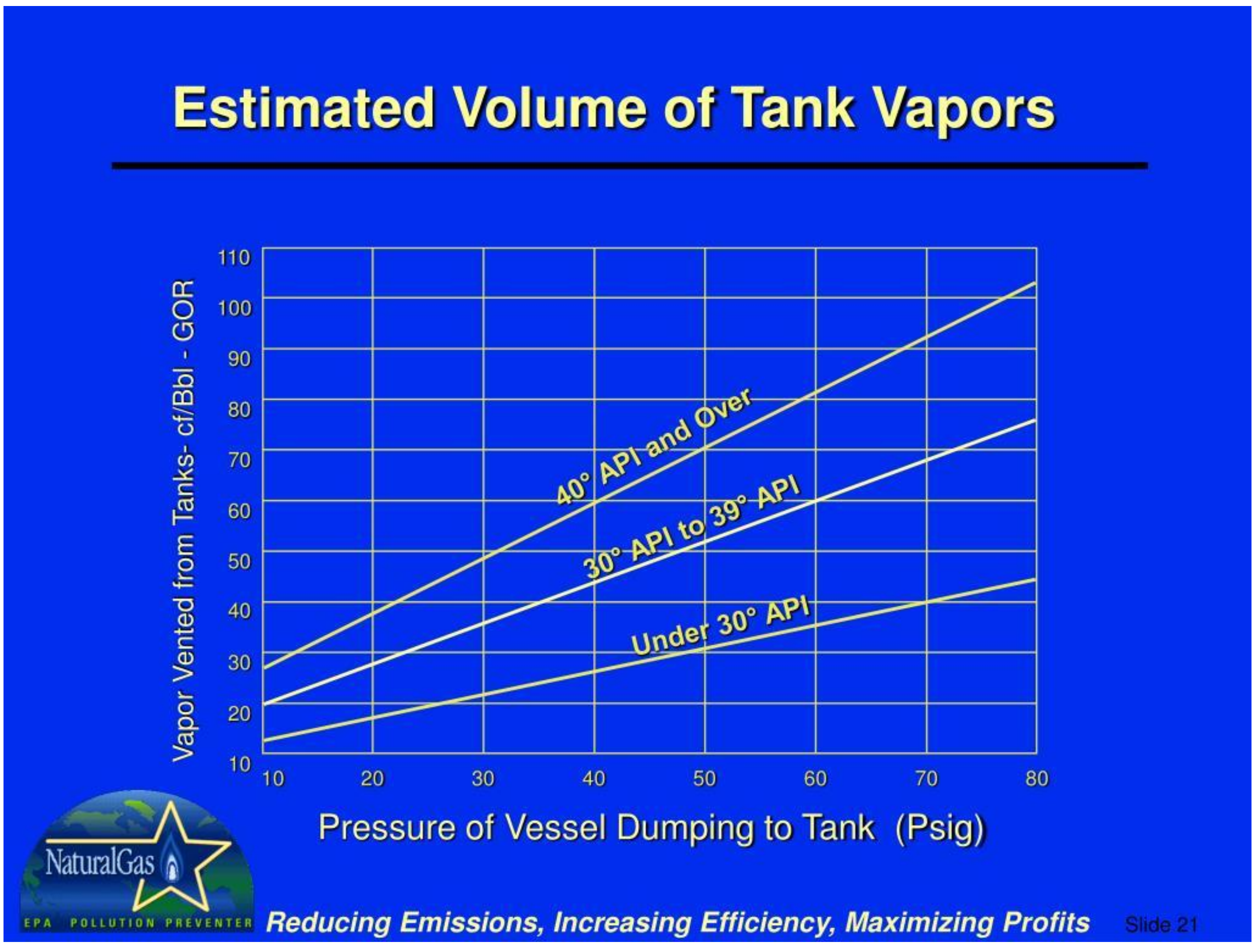
We left off in our first post in the *VRU Best Practices series* – The Dynamics of the Vapor Gas Stream - with the concept there is no common stock tank gas composition. Following are just a few brief highlights to kick off our follow-up conversation about Stock Tank Vapors.

1. Crude oils vary dramatically in their composition throughout the country and the world. These variances in composition occur due to the following criteria.
   - Crude oil composition varies throughout the various fields and production zones based upon the maturity of the product and the downhole pressures and temperatures.
2. Since all crude oils vary in composition, all associated off-gases vary in composition.
3. Gaseous phases within the crude oil vary with pressures and temperatures.
4. No two crude oil storage tanks contain the same liquid composition.
   - Variations in Crude Oil: Crude oils vary and are rated by their “API” Gravity.
   - Different API Gravities have different off-gases.

API Gravity	Liquid	Relative Density
0 thru 10	Extra Heavy Crude (Tar Sands / Bitumen)	Heaviest
10	Water	Water
10 thru 22	Heavy Crude Oil	
22 thru 38	Medium Crude Oil	
> 38	Light Crude Oil	
>55	Condensates	Lightest

Figure 1 API Gravity is based upon the specific gravity of the oil in comparison to that of water. Oils with a number less than 10 are heavier than water and are considered "Heavy" crude. Oil that is lighter than water has a rating above 10.

<u>Different API Gravities have different off-gas vent volumes.</u>



There may be slight variances within an area processing a common zone, but each source should be considered before applying to a Vapor Recovery Unit. Here, we'll be addressing the issues of working with and compressing these gases.

Stock Tank Vapors

Stock tank vapors are comprised of gases that are heavy in their molecular weight and have low vapor pressures. Therefore, these gases have a high weight mass flow, a low C_p / C_v (specific heat ratio) and are quite condensable into a liquid state when temperatures and pressures equal the "dewpoint" of some or all of the gas components. Special consideration should be applied to the choice of compression type, and the amount of condensate condensing between stages.

In-order to properly elevate (compress) these gases to pressures and temperature that meet a required system parameter, the Vapor Recovery Unit must comply with the following process requirements:

- The vapors must have excess temperature above the pressure dewpoint of all the gas components for the pressures achieved or condensing can occur within the compressor.
- This usually results in catastrophic compressor failure, as most compressors are not designed for compression of liquids.
- When staging with intercooling of the vapors, condensing occurs between stages and a reduction of volume occurs. This must be considered in the application and sizing of the compressor and specifically the displacement of the 2nd + stages.
- In single-stage compression the final gas volume is usually reduced from the inlet volume.
    - The reduction in the volume is the result of some of vapor components condensing at the discharge pressures and temperatures and being returned to the process as a liquid.
    - This results in a different (leaner) gas composition and a reduced gas flow rate to that of the inlet stream at the discharge into the sales line.
- In multi-stage compression cycles, there is condensing at each inter-stage and again at the final discharge (post after-cooler).
    - Condensed liquids of varying composition are returned back to the process at each of the inter-stage(s) and final discharge by means of gas/liquid separators.
    - Each of these condensate stream has a different vapor pressure.
    - When returned to the process, they may again flash (evaporate) back into the inlet gas stream and be again recompressed in the compressor gas stream.
- Produced condensates are valuable products that must be separated from the gas stream, collected and returned to the users process for sales.
    - It is important to understand that since all vapors are at their "Dewpoint", then all produced condensates from these vapors are at their "Bubble Point"
    - Liquids at Bubble Point have zero net positive suction pressure avaliable (NPSHA)
    - All pumps have a minimum positive suction pressure required ("NPSHR") inorder to operate without cavitation
    - The only NPSH available is the elevation ("Head") of the liquid column above the pump inlet

- A very low NPSHR pump and added Head must be designed into the system to properly work with and pump the produced condensates back into the process

Note: As explained, the gas composition does dramatically vary by the type of crude oil, down hole pressures and temperatures and the site environment and elevation. Therefore, it has to be assumed that the flow volumes into the Vapor Recovery Unit can vary dramatically throught the area, during the day and by the seasons.

And, that the gas as processed within the system will see changes of state (condensation) as they reach dew point(s) and condense. This condensation within the system does change the flow volumes and in some cases condense almost all of the product with little gas to sales and more important little flow capacity control utilizing recycle gas.

Therefore, the following design considerations must be considered:

- A Vapor Recovery System should always be oversized.
  - A flow stated in volume per day may actually not be evenly distributed throughout the day. This is usually a cummulative flow that is calculated on a GOR and crude oil throughput. In reality, the production may be intermittant with the separator dumping to the crude oil stock tank, sporatically. Upon dumping the crude oil from the separator, the vapors are suddenly emitted and then tapor off as those highr vapor pressure components flash out of the crude.
  - This sporatic nature of vapor production should be considered when sizing a VRU. Its flow rate should be able to handle the flush of initial vapor rate in order that no emissions from the stock tank enter the environment.

- Vapor flow rates of the system are based upon the bubble point(s) of the entrained condensates and therefore are totally contingent upon the ambient temperatures and atmospheric pressures that are current at this time.
  - Day, night, hot sun and seasonal changes all affect the flow rates of gases from the stock tanks into the Vapor Recovery system.
  - Discharged flows of gases can vary dramatically as gas condenses with in the system as different component pressure dew points are reached changing a gas to a liquid. There can be significant change in flows during the day by ambient temperaturtes alone. Higher flows during daylight and reduced during the night.

In Summary:
A Vapor Recovery System is not a generic gas compression system as is normally applied to dry gas applications. It is a complex system that must address the various gas compositions, varying gas flows, varying gas dewpoint(s) as well as that of the produced condensates with varying bubble points.

All design considerations start with the crude oil processed and the produced vapor that will be emitted from the crude at various pressure & temperature conditions.

-President and Founder, Vince Thomas