BLOG POST

Let Your Gases Lead the Way: The Dynamics of the Vapor Gas Stream
VRU Best Practices Series

Choosing the right machine starts with the gas at hand

With a personal history of designing and manufacturing Vapor Recovery Systems since 1976, and specifically creating TESCORP, a company dedicated to vapor emission recovery technology in 1987, I have seen many applications and as many misapplications of Vapor Recovery Units due to the lack of focus on the produced gas and conditions of service.

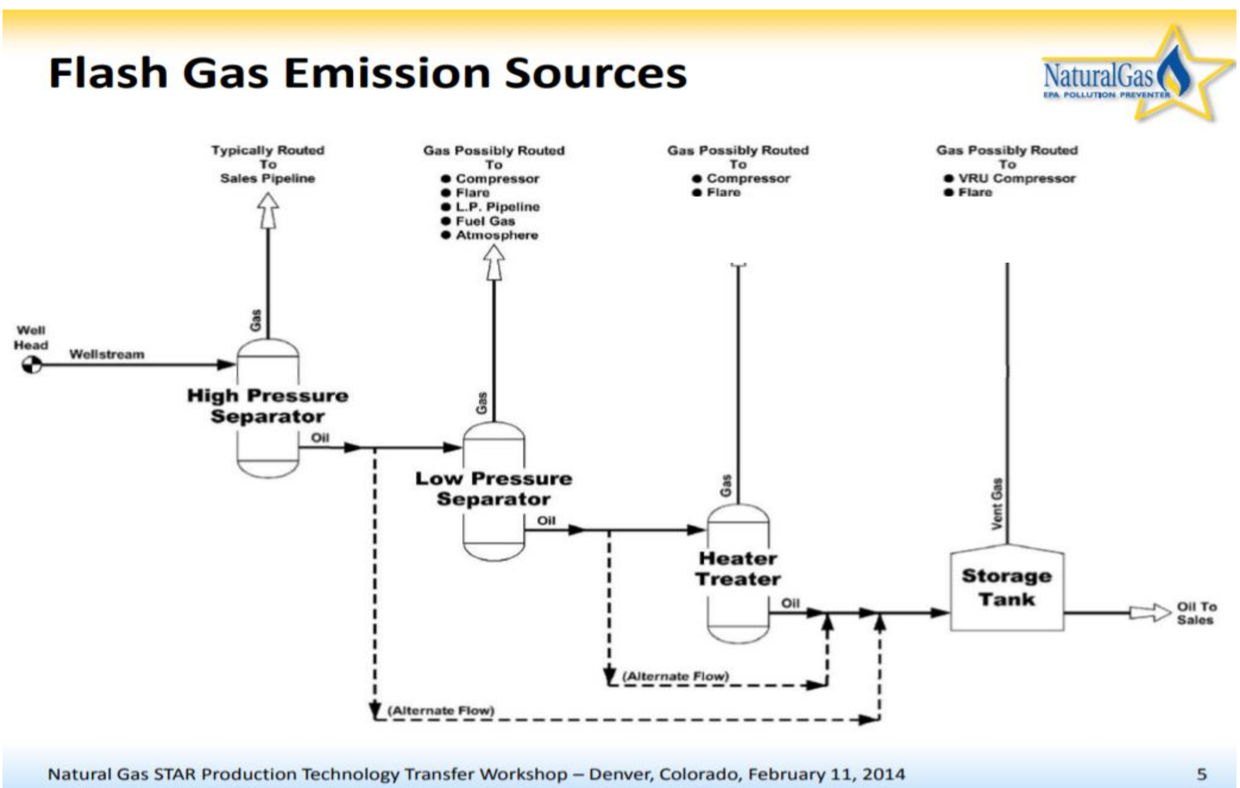
There are many conversations proliferating within the industry that often imply that one type of compressor or system fits all. This is a huge misnomer. The application process and component selection are not that simple. There are many variables associated in the proper selection of components for the gases, process requirements for pressures, temperatures and "dew points' within the actual process. Unlike "dry gas' applications, stock tank vapors are "wet" and "unstable" gases that have associated design considerations that must be addressed to properly design a good working Vapor Recovery Unit. It is more than just a type of unit; it is a process.

The Dynamics of the Vapor Gas Stream

In order to discuss the application and function of a Vapor Recovery Unit, it is important to first define and understand the source of these gases - their origin and composition. The following is a very brief explanation of the petroleum crude oil origins and composition that is the basic source for the off gases that are the feed stock of vapor recovery systems.

The feed source for the stock tank vapor recovery units is a mix of hydrocarbon components that are released from the petroleum crude oil when the pressure(s) are relieved on the oil at different process points. These components vary in composition and vapor pressures. When this crude oil is under pressure as found in the reservoirs, these components are in a liquid state or a solid. Once the pressure is relieved to that of the "Flash Gas Separator" pressure and again to the "Stock Tank" pressure that is equal to the site atmospheric pressure, these components evaporate into gases that vary in their composition. These are normally heavy gases with high economic value that if not captured would enter the atmosphere as pollutants. These gases vary in composition at each phase and pressure.
The Vapor Recovery Unit is the applicable technology to capture these vapor emissions and send them onto a process or market.

Throughout the process from wellhead to sales, the crude oil and its entrained components go through pressure/temperature changes that create "thermally unstable" to "stable" and then "unstable" conditions at various pressure points. At each "thermally unstable" condition, different entrained components within the crude oil vaporize to create an off gas.



The onsite crude oil stock tank is the final storage and liquid/gas separator prior to the crude oil being shipped for sale. At this point, the final "thermal stabilization" of this product occurs. The entering oil product does still have entrained hydrocarbon condensates in solution with the oil. These entrained components were stabilized at separator pressure and temperature. But again, at this point the pressure is reduced to near atmospheric pressure where the "decanting" process occurs again with those components that have a vapor pressure greater than that of the site atmospheric pressure becoming unstable. This instability creates a heavy gas product that is a saturated wet gas very near/at dewpoint. This volume of gas in comparison to the oil flow is the "Gas Oil Ratio" (GOR) and the feedstock for the Vapor Recovery Unit (VRU).

It is not often noted or understood that the gases vary greatly in their composition. And variances also greatly affect the types of compressors and their ancillary components that may be required to properly design, construct, and operate a good working Vapor Recovery System. To properly compensate for these gas variances is to understand their impact to the compressor and the system required to properly recover and transport them. That is why we focus on and specialize in saturated "wet" gases associated with stock tank and flash gas vapor emissions and the problems and idiosyncrasies in working with those gases.

There are some basic facts concerning crude oil and their associated gases that must be considered in the application of a "Stock Tank Vapor Recovery System". They are:

1. **<u>Crude oils vary dramatically in their composition throughout the country and the world.</u>** These variances in composition occur due to the following criteria:
    - Crude oil composition varies throughout the different 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.**
    - All hydrocarbon components have specific "Vapor Pressures".
        - The volatility of a liquid is quantified by its vapor pressure. The vapor pressure of a hydrocarbon component is its pressure of its gaseous phase when in equilibrium with its liquid phase.
        - The higher the vapor pressure of a liquid, the more volatile the product is. Therefore, the higher its tendency to evaporate.
    - Lighter hydrocarbons may exist as gases in the form of methane, ethane, propane and some butane. These are the predominate gases found in the "casinghead" or at the "flash gas separator".
    - Often this gas is classified as "Dry Gas".

4. **<u>No two crude oil storage tanks contain the same liquid composition.</u>** The variances in composition are due to:
    - Initial crude oil composition as explained in item #1.
    - Initial oil/gas separator pressures and temperatures.
        - At higher pressure, heavier entrained condensates remain contained in the crude oil as liquids as opposed to at lower pressures.
        - At lower temperatures, heavier entrained condensates remain contained in the crude oil as liquids than at higher temperatures.
        - While in the separator, the excess gases are released, and the crude oil is now in a "stable" state for both its pressure and temperature.

- The predominate gas released is methane, ethane and propane.

- **Environmental conditions.**
    - Ambient temperatures from maximum to minimum and the seasonal and daily variances. Stock tank "decanting" is a variable of its present temperature(s).
    - Altitude. A site located near sea-level would have a lower decant volume and a different (leaner) gas composition than one located in a high elevation with the same crude oil composition.
- **When the crude oil is released to the stock tank, the crude oil once again becomes "unstable".**
    - Heavier hydrocarbon components such as butanes, pentanes, hexanes and heavier remained in a liquid state while at separator pressures and temperatures, now at atmospheric pressures ambient temperatures start to decant (evaporate).
    - The evaporation process releases all of the unstable gases from the stock tank until the crude oil once again becomes "stable".
- The gases that are released in the "decant" process vary in composition due to all the previously discussed variables. The composition of these gases can vary during the day and seasons by changes in ambient temperatures as the crude must continually stabilize to meet these changes.
    - *No matter what is the exact composition of the stock tank vapors, they are at "bubble point" and "dew point".*

      "Bubble Point" = the temperature and pressure where the first drop of liquid mixture begins to vaporize.

      "Dew Point" = the temperature and pressure where the first drop of gaseous mixture begins to condense.

Water to steam back to water is an example of the change of state achieved by temperature or pressure changes.

An example of pressure dewpoint would be a steam kettle. Water boils at: 212°F @ Sea level =14.7 Psia
203°F @ 5,000 ft. = 12.2 Psia
32°F (freezing) @ a vacuum of 29.7 in-Hg
Inversely, it condenses just below these same temperatures or when the pressures are slightly elevated.

All natural gas components have specific boiling and condensing pressures & temperatures. All vary in both. The stock tank vapors are a combination of these components that exist in a vapor state at the site pressure & temperature. As conditions change i.e. temperature or back pressure, this composition may change.

This same effect of evaporation and condensing continues throughout the compression process. Therefore, the stock tank vapors must be monitored as pressures and temperatures of the compression cycle may achieve the dewpoint of some of the components in that process.

The stock tank vapors are comprised of gases that are heavy in their molecular weight and have low vapor pressures. Therefore, this gas has a high weight flow and is 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 Summary:

There is no common stock tank gas composition. There may be slight variances within an area processing a common zone, but each should source be considered before applying a Vapor Recovery Unit. In a follow-up post, the issues of working with and compressing of these gases will be discussed.