CLEARSTONE ENGINEERING

Tanks BMP Development: Prediction of Evaporation Losses & Rationale for Improvements to Existing Tools

Methane to Markets Partnership
Lake Louise, Alberta, Canada
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Study Details

- Objective:
  - Develop improved methods for assessing and monitoring emissions from storage tanks.
- Sponsors:
  - NRCan's Program of Energy Research and Development (PERD) /Upstream Petroleum Air Issues Research Initiative (UPAIRI)
  - CAPP
- Project Team:
  - Clearstone Engineering Ltd.
  - Carleton University (Dr. Matt Johnson)
- Start date and duration: 2008 (3 years)

Background

- Reliable emissions assessment techniques are needed to evaluate vapor control opportunities, design solutions and justify capital & operating expenditures.

- Emissions from storage tanks contribute 2.2% of GHG emissions and 31.5% of VOC emissions by the upstream oil and gas industry in Canada.

- Vapor composition:
  - Greenhouse gases (CH_4 and CO_2).
  - Reduced sulphur compounds (H_2S and mercaptans).
  - C_2H_6 and heavier hydrocarbons (including BTEX).

Potential Emissions

- Breathing, working and flashing losses.
  - Flashing losses occur primarily at production facilities:
    - Boil-off of dissolved gas absorbed by the product during contact with natural gas at elevated pressures (e.g., in separators and scrubbers).
  - Breathing and working losses are most important in applications involving storage of stabilized or weathered product:
    - Breathing losses attributed to diurnal temperature changes causing expansion and contraction of the volume gas in the vapor space.
    - Working losses are physical displacement of accumulated evaporation losses (e.g., evaporation of product residue on the tank walls and from the exposed liquid surface).

Potential Emissions

- Unintentional gas carry-through to storage tanks:
  - Inefficient upstream gas/liquid separation (e.g., due to increased water production).
  - Leakage past the seats of drain and dump valves.
  - Malfunctioning level controllers.
  - Piping changes resulting in unstable product going to tanks.

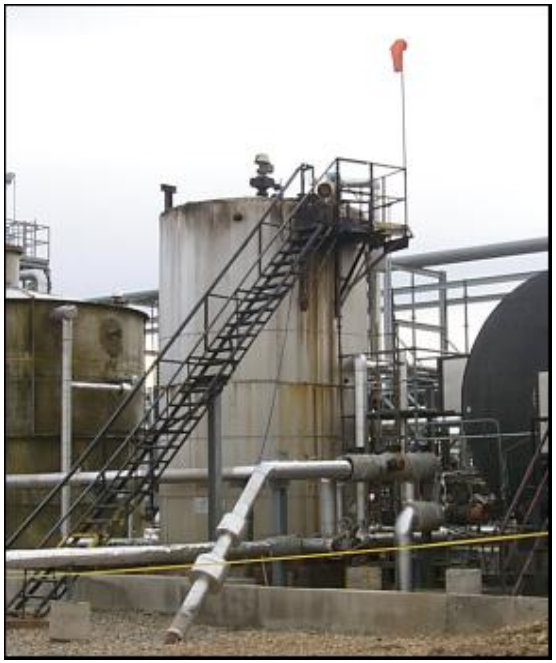
- Malfunctioning vapor recovery or control systems:
  - Faulty blanket gas regulators or pressure controllers.
  - Fouled vapor collection lines.
  - Leaking pressure-vacuum valves and thief hatches.
  - Undersized of systems (e.g., neglect of diurnal temperature effects).
  - Damaged floating roofs and seals.
  - DI&M.

Storage Tank Emissions

- Field measurement results for 9 gas plants.

Facility	THC Emissions ($10^3 m^3/y$)	CH4 Emissions ($10^3 m^3/y$)	Value of Lost Product ($/y)
Plant 3	1,663	57	441,370
Plant 5	95	93	24,559
Plant 8	4,469	2,651	1,880,267
Total	6,227	2,801	2,346,197

•Value of emissions based on a $6.78/GJ for natural, $8.13/GJ for propane, and $9.63/GJ for butane and condensate.



Needs

- Lack of a clear protocol for assessing flashing losses from production tanks.
  - Significantly different results depending on the assumptions made when applying E&P TANKS or process simulators.
    - TVP weathers down to values less than local atmospheric pressure but flash calculations are often only taken to atmospheric pressure.
    - Lack of metering to show liquid flows from each individual separator and scrubber at a facility:
      - Assuming all liquids come from the lowest pressure source may underestimate emissions.
      - Assuming all liquids come from the highest pressure source may overstate emissions.
  - Lack of guidance on measurement techniques that can be used to verify predicted emission estimates.

Needs

- Need to know instantaneous emissions, not average values, to assess potential air quality impacts.
  - US EPA TANKS is intended for predicting annual average emissions for inventorying purposes, not instantaneous emissions for VRU sizing or air quality predictions.
- Lack of data available to predict emissions of trace constituents, such as reduced sulphur compounds and potentially CH_4, that do not show up in typical liquid analyses but are of an air quality or emissions concern.
- Generally increasing levels of H_2S and mercaptans in crude oil streams resulting in odor concerns.

Needs

- Current US EPA TANKS model does not account for continuous convective breathing losses that occur during cold weather (i.e., periods when the ambient air is colder than the temperature of the stored product and the ullage space):
  - Stratification in the vapor space inhibits evaporation losses (summer).
  - Continuous convective mixing in the ambient air (winter) promotes greatly increased breathing losses:
    - Dense (cold) ambient air continuously flows into the ullage spaced displacing the lighter (warm) air-vapor mixture and promotes further evaporation due to the dilution effect.

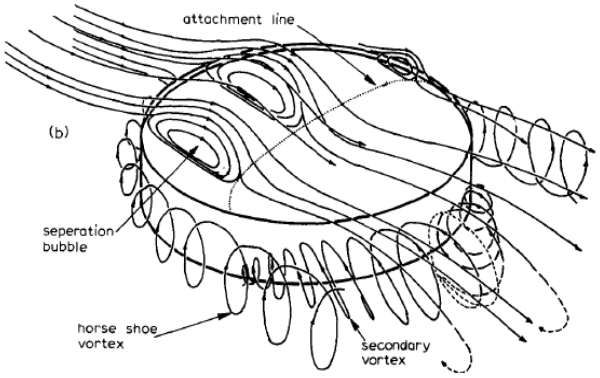
Needs

- Lack of methods and related guidance to regular monitoring of tanks for emissions upsets or deteriorated emissions control (especially for floating roof tanks):
  - Downwind air quality monitoring tends to identify problems after the fact and does not necessary pinpoint the source.
  - Headspace monitoring not widely used.
  - DIAL used in Europe but at infrequent intervals (e.g., once every 5 years) due to the high expensive.
  - Roof-top vapor sensors (usually only used after issues arise).

Deliverables

- Enhanced methodology for estimating average and instantaneous emission rates.
- Database of physical properties and vapor compositions for Canadian crude oils.
- Best management practice for measurement and estimation of storage losses.
- Improved systems or methodologies for monitoring emissions from storage tanks.

Work Done to Date



Wind profile for an empty tank (Holroyd, 1983)

- Initial Literature Review
  - Estimation and measurement techniques.
  - Wind effects.
- Initiated sampling program:
  - Crude Oil:
    - Physical properties (density, RVP).
    - Detailed liquid compositions (C_1 to C_{30+} and sulphur content).
  - Vapors:
    - C_1 to C_{12+} and reduced sulphur compounds (GC/TCD, GC/FID, GC/MS and GC/SCD).
  - Measurement of vertical concentration profiles in the ullage space to examine stratification and mixing.

Next Steps

- Continued testing program:
  - Flashing losses.
  - Floating roof tanks.
  - Emissions during landing and re-floating of floating roofs.
- Development of monitoring systems.


Thank you!