Tank Vapor Recovery Safety in Design

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Overview

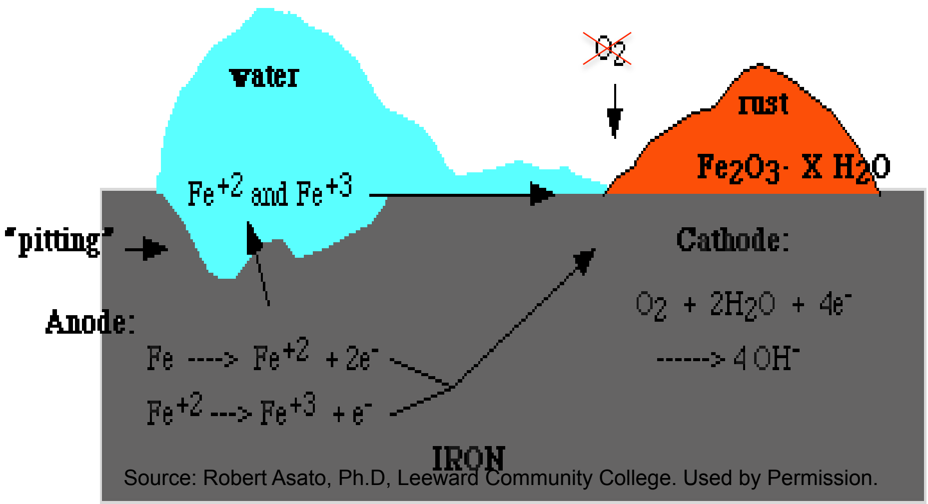
- Assess Common Tank Failure Mechanisms
- Review Best Practices in Design of VRU Systems
  - Piping Considerations
  - System Design Considerations
  - Operation of the Stack Valve
- Make Gas Concerns
  - Make up or Make Worse!!!
- Suction Design Best Practices
- Compressor Design for VRU Service

Safety Considerations
Tank Failure Modes

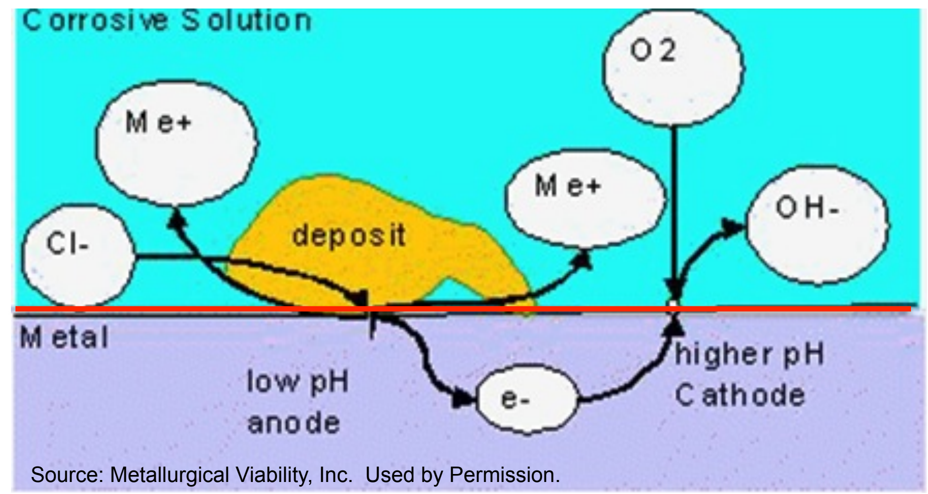
- Corrosion – Roof and Floor
- Collapse – Vacuum
- Hydraulic Failure – Closed System Overflow
- BLEVE – Boiling Liquid Expanding Vapor Explosion
- Over-pressure - Frangible Joint vs. External Rafters

Tank Corrosion

Roof Corrosion



Floor Under Deposit Corrosion



Solution - Seal tank.
- Operate TVRU system at positive pressure.
- Avoid installing TVRU Drain Tanks

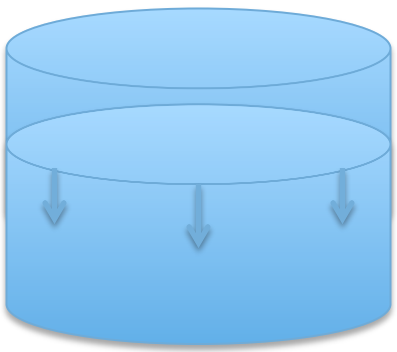
Solution – Inspect, Prep, and Coat floor and shell three feet up from the tank bottom

Tank Vacuum Collapse

Simultaneous Operations

Painters on Roof

Hydrotest Crew on Ground

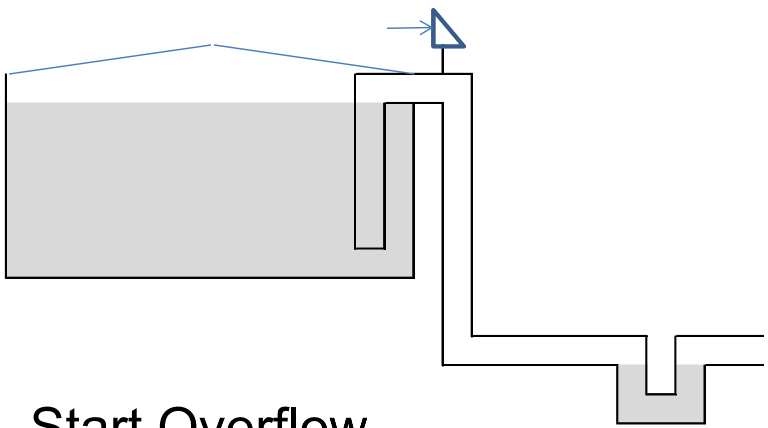


Source: Walter Driedger – is not the photographer, he credits API

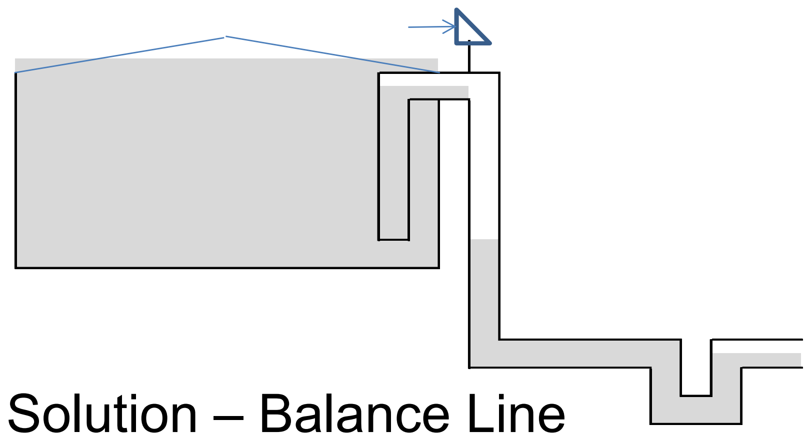
Solution - Communicate

Tank Hydraulic Rupture
Closed Overflow System

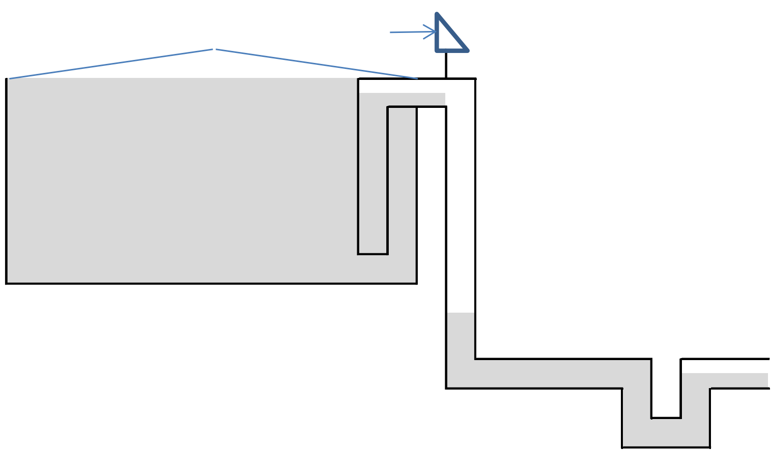
Normal Operation



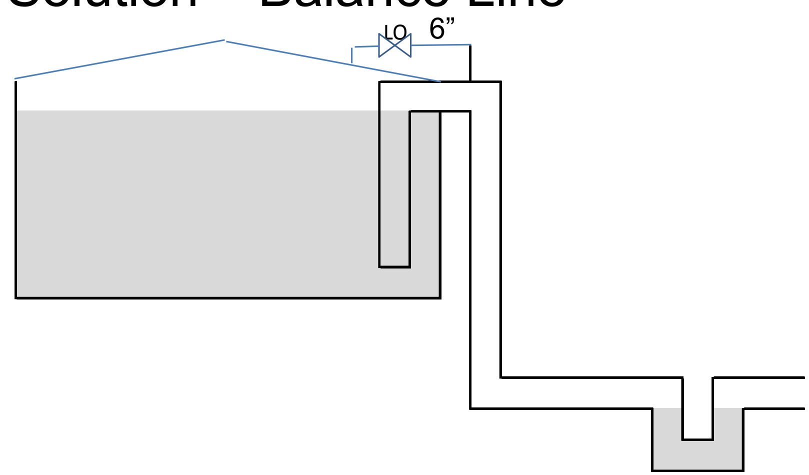
Roof Hydraulic Rupture



Start Overflow

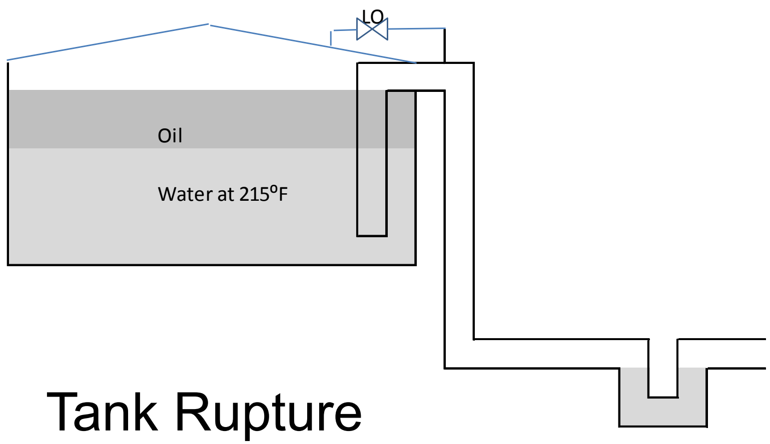


Solution – Balance Line

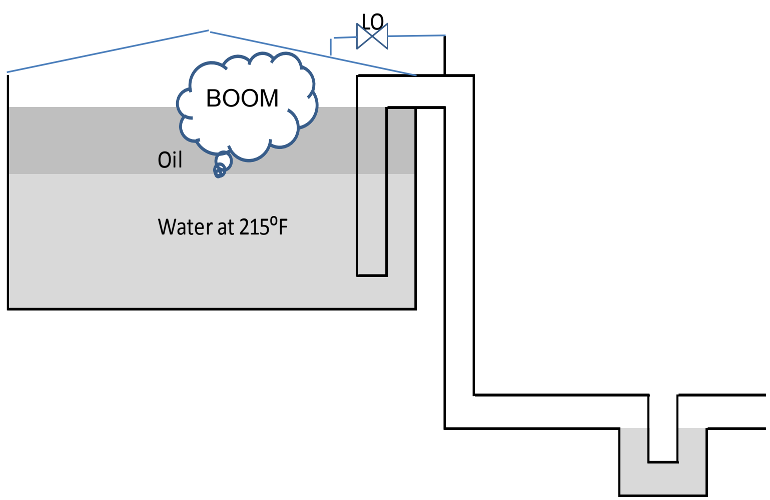


Tank Boiling Liquid Expanding Vapor Explosion (BLEVE)

Steam Heater TCV fails open or Coil Ruptures



Tank Rupture

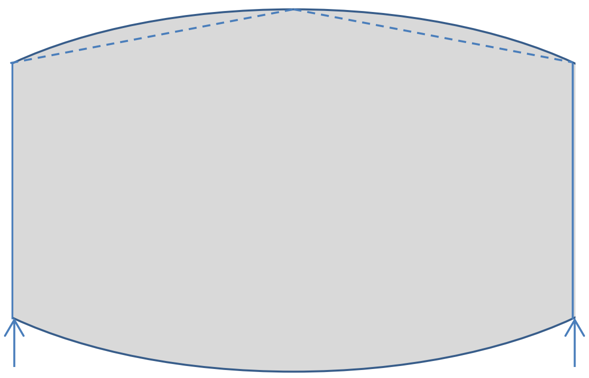


Solution:

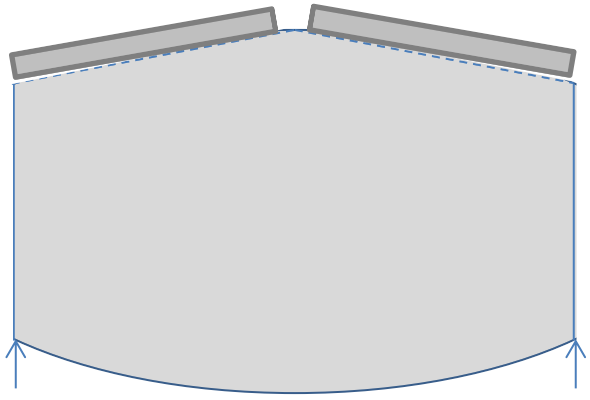
- Steam Shutdown Valve (fail close) on inlet to tank coils or thermo panes
- High temperature shutdown monitoring temperature located high in water phase, not oil emulsion

Tank Over-pressure

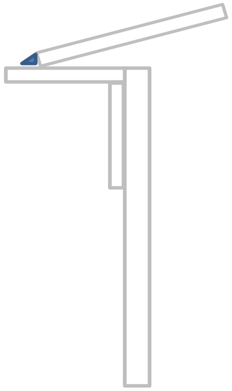
Frangible Roof Joint



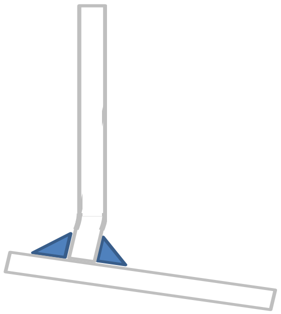
External Rafters



Shell to Roof Failure



Shell to Floor Failure



Typical VRU Design in an OCP

- Large pipe sizing and 316L Stainless Steel
- Long piping support spans with min deflection
- Eliminate sources of Oxygen IGF & Drain Tanks
- Press transmitter near furthest large gas source
- Oxygen sensor to mitigate corrosion and HEL
- Stack valve to mitigate Varec reseating leaks
- Cooling with cold potable water atomizer
- Make-up gas at inlet of compressor
- Oil-flooded rotary screw compressor
- More than one destination for TVRU gas

Vapor Recovery System Key Considerations

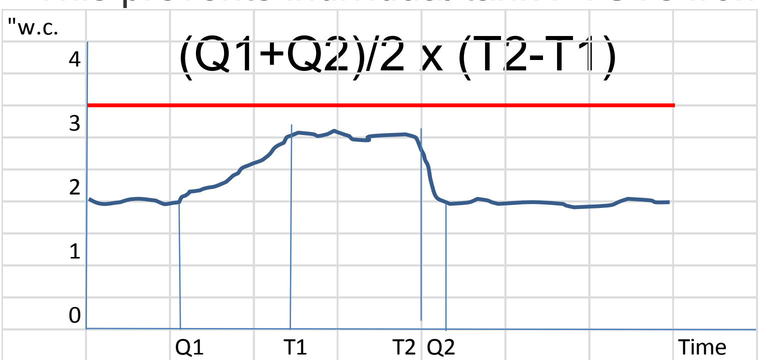
- VRU System Should be Plant Specific
  - One Size **does not** “fit All”
- Prioritize Recommendations based on
  - Tank Permit Requirements
  - Location of Flare or Export Gas System
  - Toxic Gas Release Mitigation – Ultrafab/Sulfatreat
  - Resources, Cost and Schedule
- Provide Training Pertaining to the Proper Design and Operation
  - Only as Good as the Operators
- Majority of VRU related deficiencies are the result of Poor Design

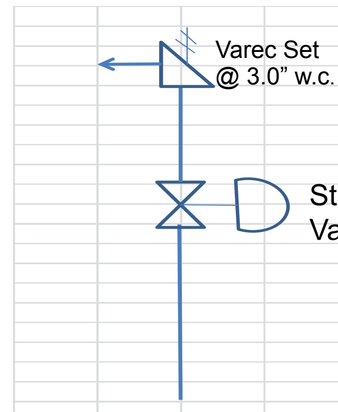
VRU Piping Design Best Practices

- Design Piping to Minimize Pressure Drop
  - Max Pressure Drop from Furthest or Largest Producing Gas Source should be <= 0.5'' W.C at twice the maximum flow.
- Construct system piping from 316L stainless steel thin wall schedule 10 piping,
  - Large diameter 316L sch 10 is light weight with large section modulus allowing for 50 ft pipe support spans with minimal deflection/pocketing.
  - No need to design pipe support spacing for hydrotest loads, instead use low pressure (30 psig) service test with nitrogen and soap bubble test.
- Concerns With Using Carbon Steel Piping
  - Oxygen can form Iron Oxide Scale
  - Hydrogen sulfide can form Iron Sulfide Scale
  - Carbon Dioxide and Water can cause pitting corrosion.

VRU Stack Valve Design

- Stack valve should be centrally located
  - This will allow venting at one safe location that can be controlled and measured for reporting purposes.
  - This prevents individual tank PVSVs from opening.





- Stack Valve should be a tight shut-off high performance butterfly Valve
  - PVSV sealing surfaces do not seal tight after relieving which is the purpose of having a Valve upstream of the Varec.
- Stack Valve opens under the following conditions:
  - VRU Shutdown and/or pressure reaches 3.0" w.c.
  - VRU Discharge pressure is high due to no VRU gas outlet
  - Oxygen content in VRU gas is at 10% of the HEL
- Stack Valve assists operations with recording of deviation

VRU System Design Best Practices

- Piping should be sized to limit pressure drop to 0.5” w.c. between compressor suction and all equipment connections, at a minimum of two times nominal flow

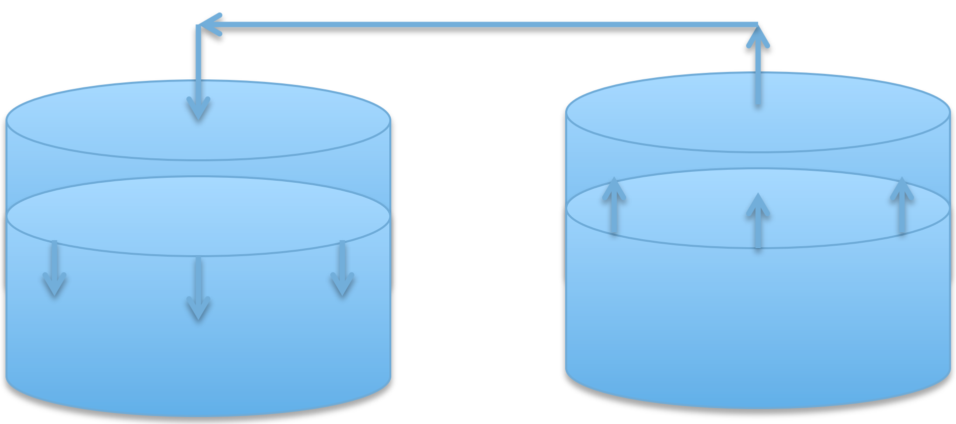
	in W.C	psig
Tank Design Pressure	**3.5**	**0.13**
Stack Valve Relief Pressure	**3.0**	**0.11**
VRU Suction Pressure	**2.0**	**0.07**
VRU Recycle Valve Pressure	**1.0**	**0.04**
VRU Make Up Gas Valve Pressure	**0.5**	**0.02**
Tank Design Vacuum Valve	**-0.8**	**-0.03**

- Gas rate fluctuations from field due to POP’s and terrain induced slugging, day-to-night and seasonal temperature changes must be considered in the design.

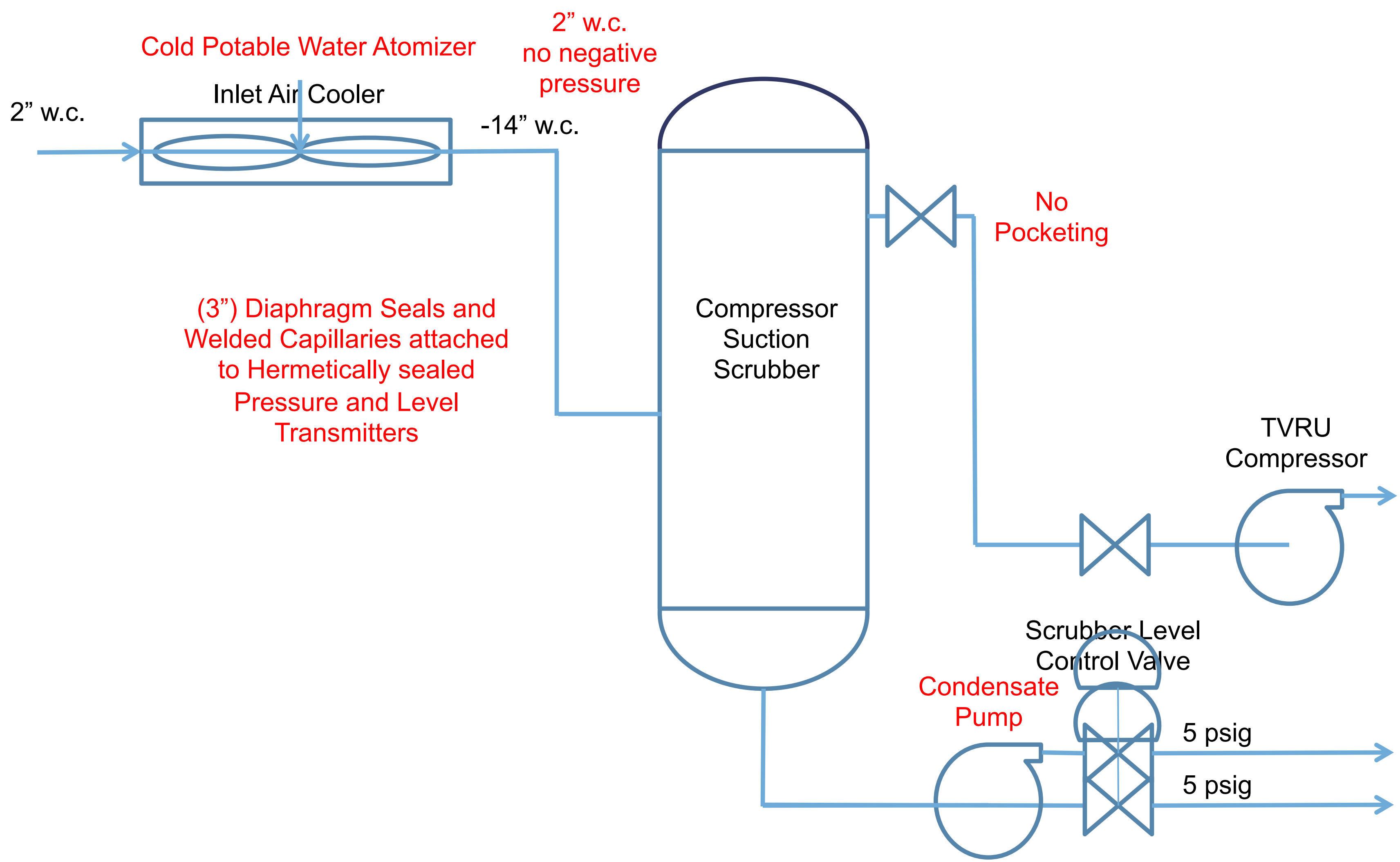
*Note: Compressor Capacity Control, Recycle Valve, and Make-up Gas are all trying to control pressure at their set-points based on a **single pressure transmitter** located at the furthest tank and/or the largest gas source.

VRU Make-up Gas Considerations

- Make-up Gas helps to maintain positive pressure on tanks when the tank liquid level drops.
- Assuming that the piping system is sized properly, produced gas from one tank can serve as make-up gas to another tank.
- Make-up Gas competes with Produced Gas for capacity in the VRU piping system and Compressor.
- Make-up Gas is only required at the inlet of the VRU compressor suction scrubber



VRU Typical Suction Design Deficiencies



TVRU Compressor Design Recommendations

- VRU compressors Not Ideal
  - Sliding vane, liquid ring, and Reciprocating are
  - Limited to a single stage compression ratio of 3.0 (30 psig discharge pressure) due to heat of compression
  - Compressor will shutdown on high discharge temperature.
  - More Staged Will Require Larger Foot print.

VRU Compressor Recommended

Oil-flooded Rotary Screw Compressor

Single stage compression ratio of 8.0 (100 psig discharge pressure) due to the heat of compression being absorbed in the oil.

Minimized Leaks – Less Moving Parts

Liquid Flooded – Can Tolerate some Liquid Carry over.

Other Considerations

- Consideration must be given to downstream pressure drops on equipment such as coolers, sulfa-scrub columns, sulfa-treat columns, iron sulfide blockage, and the final pressure at the destination such as steam generators, casing gas collection system, disposal wells, or flare.
- Ensure more than one destination for VRU discharge gas such as steam generator, disposal well, flare, etc.

Key Considerations for VRU System

- Pipe sizing and materials
- Large piping support spans with minimal deflection
- No pocketing of piping
- Stack valve centrally located to mitigate tank Varec re-seating leaks
- Eliminate sources of Oxygen to VRU (ie: Flotation Cells and Drain Tanks)
- Oxygen sensor to mitigate corrosion and address higher explosion limit
- Pressure transmitter located on furthest and/or largest gas source
- Make-up gas at inlet of compressor
- Cooling with cold potable water atomizer
- Scrubber Condensate pump with level control valve
- Large diaphragm seals and welded capillaries
- Oil-flooded rotary screw compressor– high compression ratio
- More than one destination for TVRU gas

Questions or Comments?