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Regulator Freeze Protection

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Regulator Freeze Protection

> Introduction to Regulator Freeze Protection

- Why does Freezing Occur?
  - Freeze off
  - Chemical related freezing
- What are Problems Caused by Freezing?
  - Service disruptions
  - Physical damage to equipment
- How to Prevent Freezing?
  - Dehydration
  - Heating the gas source
  - Chemical injections

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> Why Does Freezing Occur?

- There are four main contributors to regulator freezing problems.
  - Pressure drop
  - Presence of water
  - Hydrocarbon liquids
  - Ambient Temperature

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> Pressure Drop

- Joule-Thompson(JT) effect is the thermodynamic principle that describes temperature change as it relates to pressure changes.
  - As the pressure of a gas drops, so does the temperature. For every 100 psi of pressure drop, the temperature of natural gas will drop approximately 7 degrees F as a good rule of thumb.

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> Joule-Thompson Effect

- At room temperatures, all compounds have a positive JT coefficient except hydrogen and helium.
- Each component of natural gas has a significantly different effect from pressure cuts

$$\mu_{JT} = \left(\frac{\partial T}{\partial P}\right)_H = \frac{V}{C_p}(\alpha T - 1)$$

If the gas temperature is	then μ_{JT} is	since ∂P is	thus ∂T must be	so the gas
below the inversion temperature	positive	always negative	negative	cools
above the inversion temperature	negative	always negative	positive	heats

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> JT Effect on Common Natural Gas Components

Component	Inlet Pressure	Outlet Pressure	Inlet Temperature	Outlet Temperature
100% Methane	1000 psi	100 psi	100 Deg F	47 Deg F
100% Ethane	1000 psi	100 psi	100 Deg F	-39 Deg F
100% Propane	1000 psi	100 psi	100 Deg F	64 Deg F
100% Butane	1000 psi	100 psi	100 Deg F	102 Deg F
100% CO2	1000 psi	100 psi	100 Deg F	-51 Deg F
100% Pentane	1000 psi	100 psi	100 Deg F	104 Deg F
50% Methane, 50% Ethane	1000 psi	100 psi	100 Deg F	0.4 Deg F

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> Presence of Water

- Typical pipeline water tariff is 7 lbs per million standard cubic feet. Processing plants may have upset conditions where the water level can spike.
  - High velocities can sweep water into city gate stations
  - Piping configurations can also concentrate the problems
  - Improper pigging or maintenance activities can introduce water

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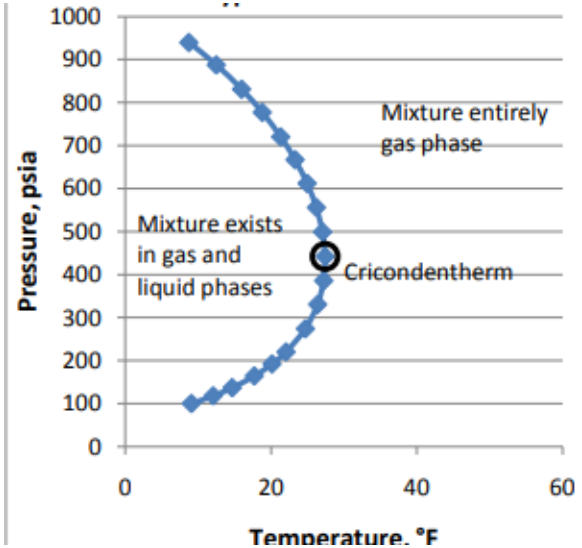
> Hydrocarbon liquids

– What are hydrocarbon liquids and how are they formed?

- Hydrocarbon dew point shifts can cause the formation of hydrocarbon liquids within the pipeline.
- When hydrocarbons go through a phase change liquids drop out.
- Both temperature shifts and pressure shifts effect the hydrocarbon dew point (HDP) as shown in figure to the right.
- Higher BTU gas is generally more likely to have liquid drop-out and form hydrates.



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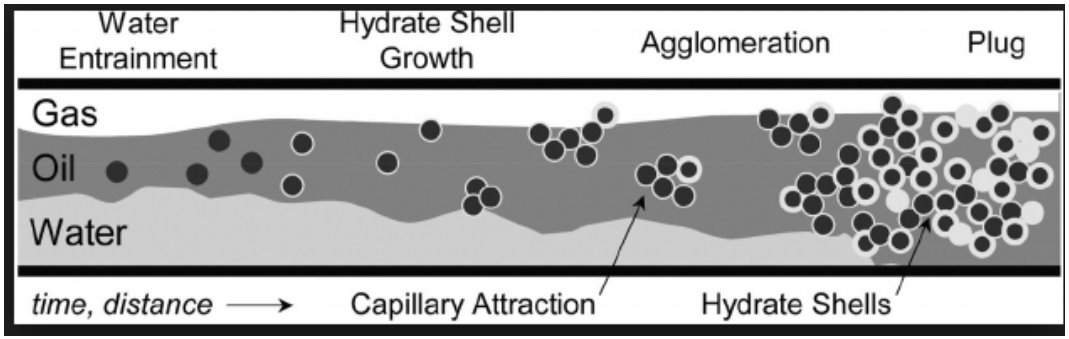
> Hydrocarbon Liquids/Hydrates

- Hydrocarbon freezing can cause a physical barrier within the pipeline.
  - The freezing can cause damage to regulators, control valves, and other pressure control equipment.



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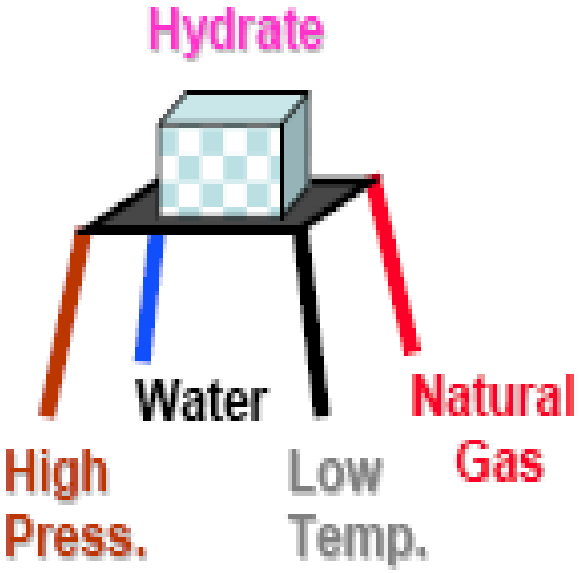
> Hydrate Characteristics

- Formed when water and hydrocarbons are present, usually under high pressure and low temperature
- Can form well above the freezing point of water
- Common formation due to cooling effects from ambient temperatures



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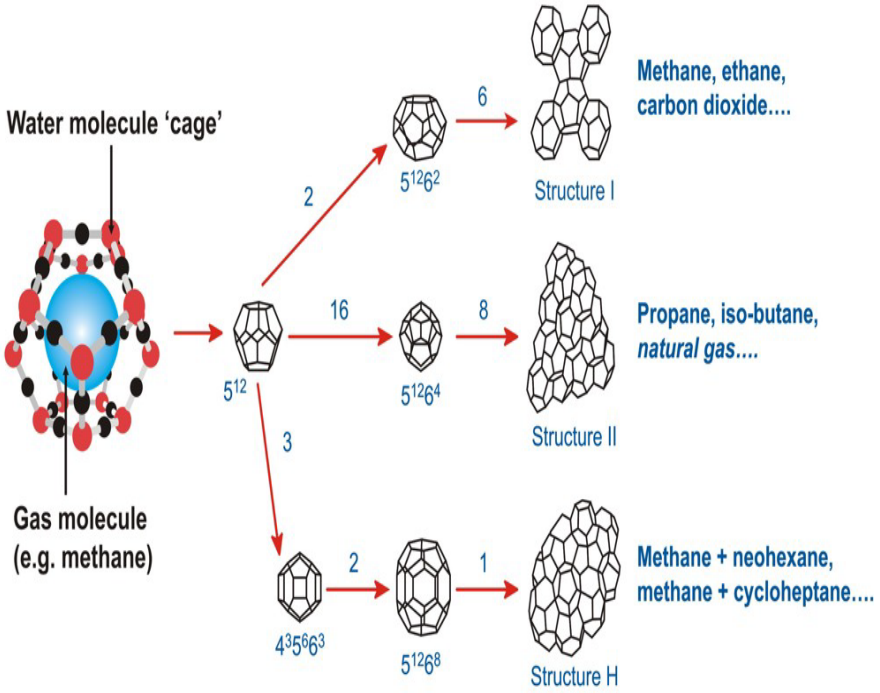

Water Molecule cage is not chemically bonded to the hydrocarbon.

Different hydrocarbon chains have different tightness and density.

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> Hydrate Properties

- Density similar to ice, will settle to the bottom of a pipe or vessel during a shut in.
- Mechanical strength about 20 times that of ice.
- Requires approximately 6 times the amount of heat to dissociate hydrates compared to the same amount of ice.

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> Ambient Temperature

- Ambient Temperature also plays a role in freezing.
- Typically the pipeline temperature follows the ground temperature.
- Gate station piping is above ground and can be exposed to subfreezing temperatures
- Cold day with the regulators taking a pressure cut cause external freezing

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> Chemical Freezing

- Sulfur vapor is present within the gas stream and drops out at pressure cuts.
- Sulfur levels within pipelines are typically with in tariff limits, usually less than analyzer detection limits.
- Sulfur dropout occurs typically after a pressure cut.
- Sulfur build-up prevents regulators from locking up. Deposits within the pilot prevent the pilot from controlling or even locking into a fixed position.

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> Chemical Freezing

- Dithiazine issues are a newer problem within our industry. Dithiazine is a byproduct of sulfur scavenger process.
- Currently no real time analyzers can detect dithiazine
- It prevents regulators from working properly. It prevents positive lockup
- It prevents regulator pilots from functioning properly
- It can build-up and physically block piping.

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> Internal Freezing

- Internal freezing may be caused by the following: water, hydrocarbons, hydrates, and chemicals.
- Regulators and control valves may not be able to control pressures and volume correctly due to ice buildup on the internal sealing surfaces.
- Flexible element regulators can be damaged from ice cutting soft goods.
- Ice may block the regulators, regulator run piping and not allow gas to flow.

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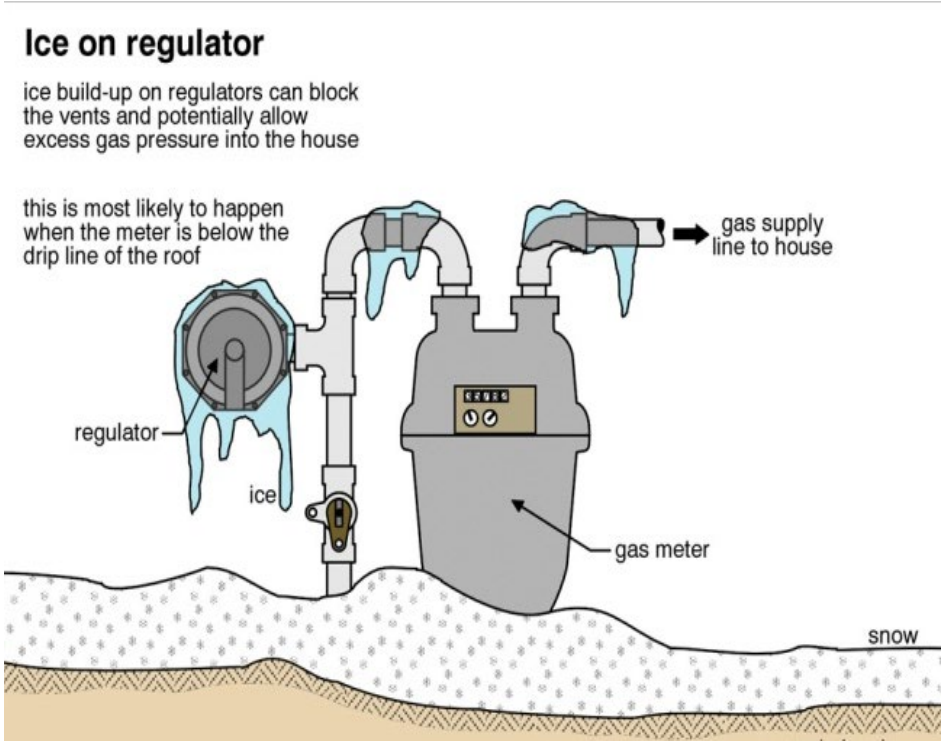
> External Freezing

- External freezing of the regulator can cause issues on both direct acting and pilot operated regulators.
- The picture to the right shows ice over the regulator. If the vent port gets blocked the regulator set point can shift.



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> External Freezing

- External freezing can cause issues with operating equipment. The downstream valves are frozen over in this picture.
- Meters can freeze over and not function
- Frost heave between flanges can cause leak.

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> How to Prevent Freezing

- There are several options available to prevent freezing when implemented correct can work effectively.
  - Dehydration
  - Heating the gas stream
  - Chemical Injections

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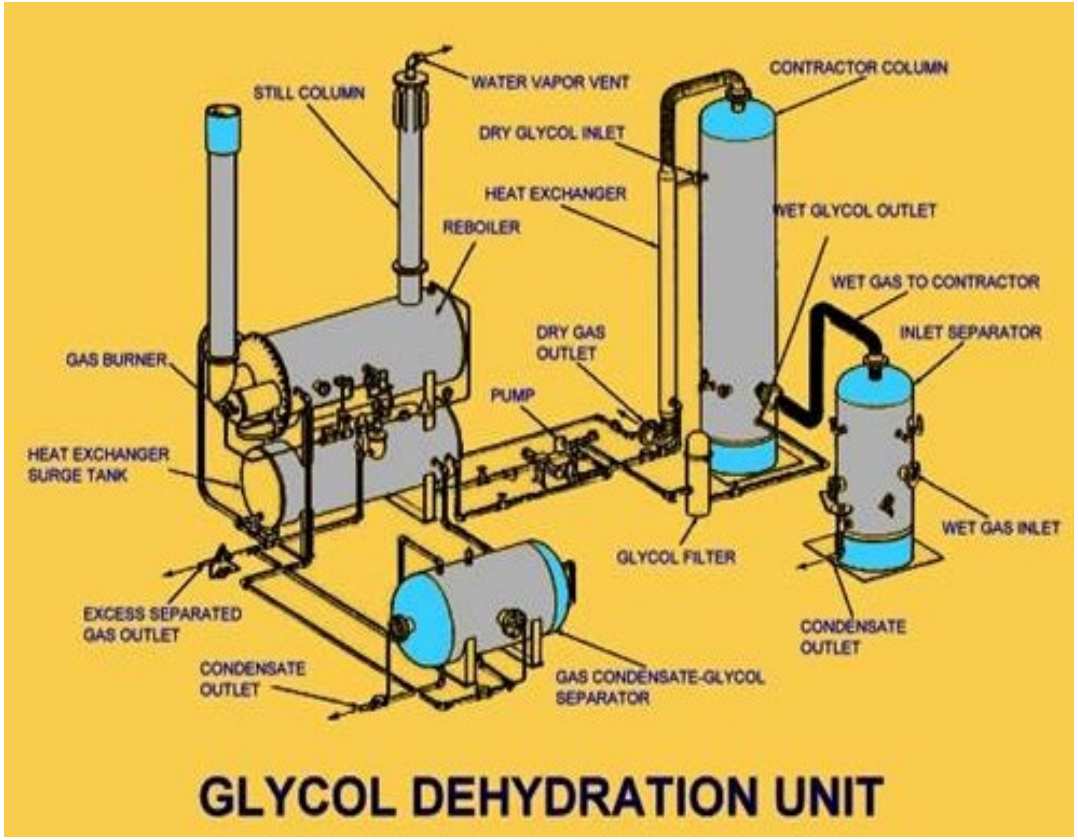
> Dehydration

- Glycol dehydration units remove the water from the gas stream.
- As gas passes through the glycol the water and the glycol will combine. The gas continues through the process making dry gas on the outlet side.
- The water is byproduct and the glycol is used again within the process.



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> Heat

- Heating the gas above the freezing point of water and above the hydrocarbon dew point is also an effective method.

- This is a basic math problem. (Inlet gas temperature) – (temperature loss from JT effect) > freezing temperature.

- There are several heating options available to Operators.
  - Pilot and instrument gas heaters
  - Station heaters

- Section of what heating options to be used depends of the amount of heat required to prevent freezing from the JT effect.

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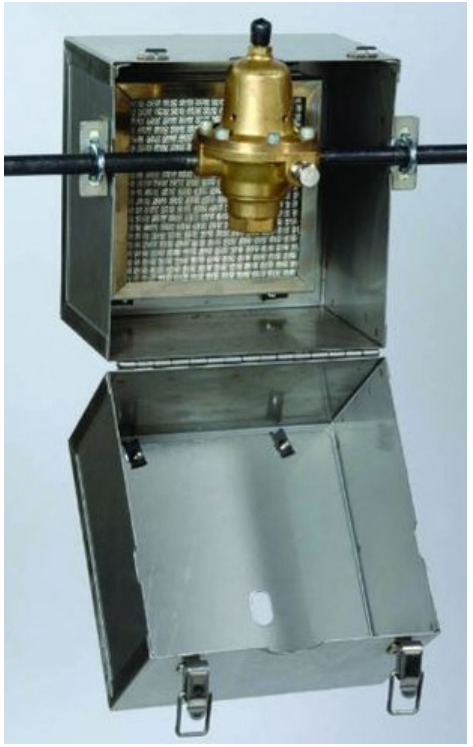
> Pilot & Instrument gas heaters

- Typically a catalytic heater that is lit to heat an enclosure.
- Pilot lines or regulator are routed through heated enclosures.
- Pros: low cost option with minimal maintenance. Burns pipeline gas.
- Cons: require external power to start. Limited feedback and control.



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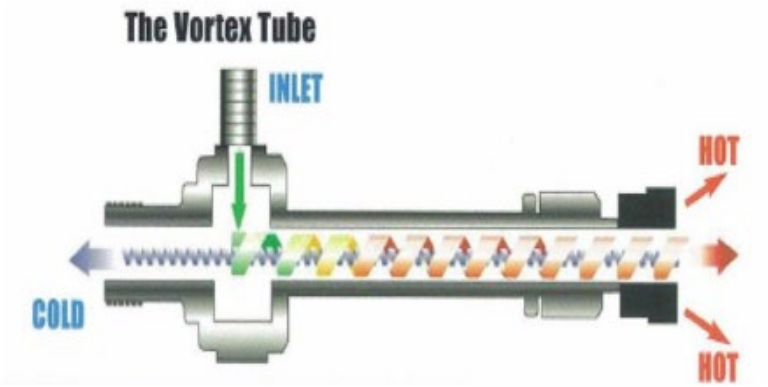
> Pilot & Instrument gas heaters

- Vortex heaters use the kinetic energy of one gas stream to heat another gas stream.
- The high pressure gas passes through special designed inlet nozzle that cuts the pressure and increase the velocity of the gas. This creates a high and low temperature vortex currents.
- The pilot gas is then heated by the hotter gas stream.
- Pros: No operating cost, no real maintenance
- Cons: Requires OPP for instrument line and has minimal DP requirements. Not commonly used.



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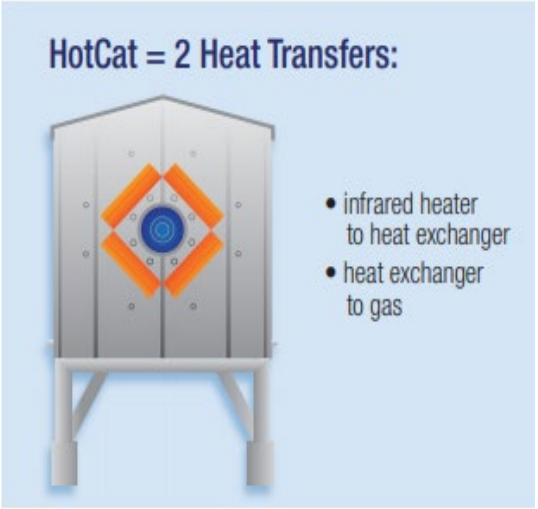
> Line Heaters

- There are three common used line heaters in gas Transmission and Distribution today: Catalytic heaters, Indirect fired water bath heaters, and Heat driven loop system.
- The pictures on the right are catalytic heater style line heater. They are larger version of the instrument gas catalytic heaters.
- Pros: Low operating cost, no glycol, no flame, no noise, can be installed in Class 1 Div 1 areas. Only 2 heat transfers.
- Cons: Catalytic elements will degrade overtime. Temperature control can be harder than water bath heater. Requires onsite power for automated system. Upfront capital cost.



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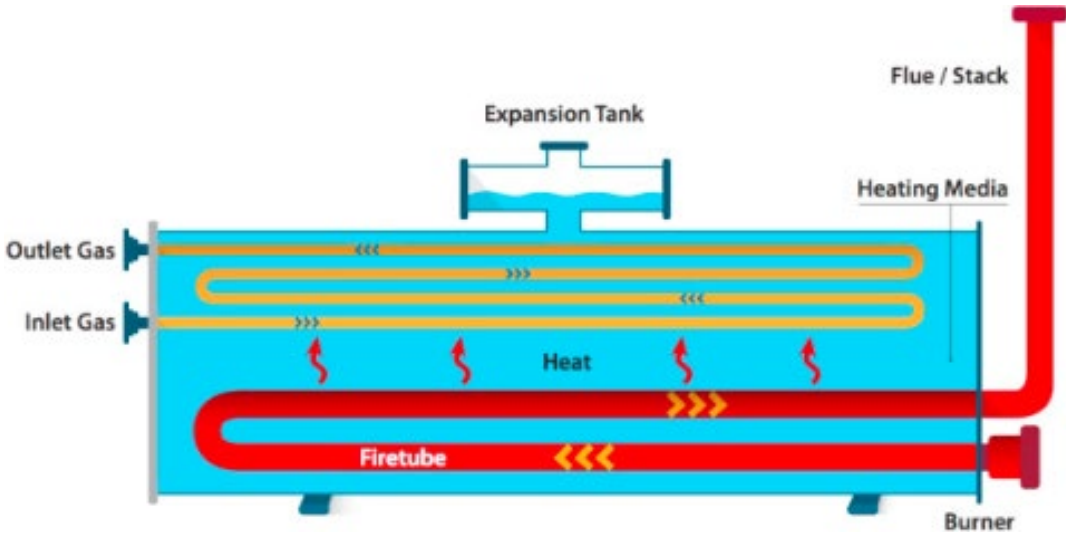
> Line Heaters

- Indirect fired water bath line heaters. Heats the gas stream by heating the bath media.
- The heater consists of five main parts: burner, fire tube, process coil, shell, and fluid. The burner box is where the pilot flame and burner is contained.
- Pros: Easy to understand, provide uniform heating, reliable
- Cons: Only about 50% energy efficiency, maintenance required on fuel and burner systems, pH testing for corrosion.



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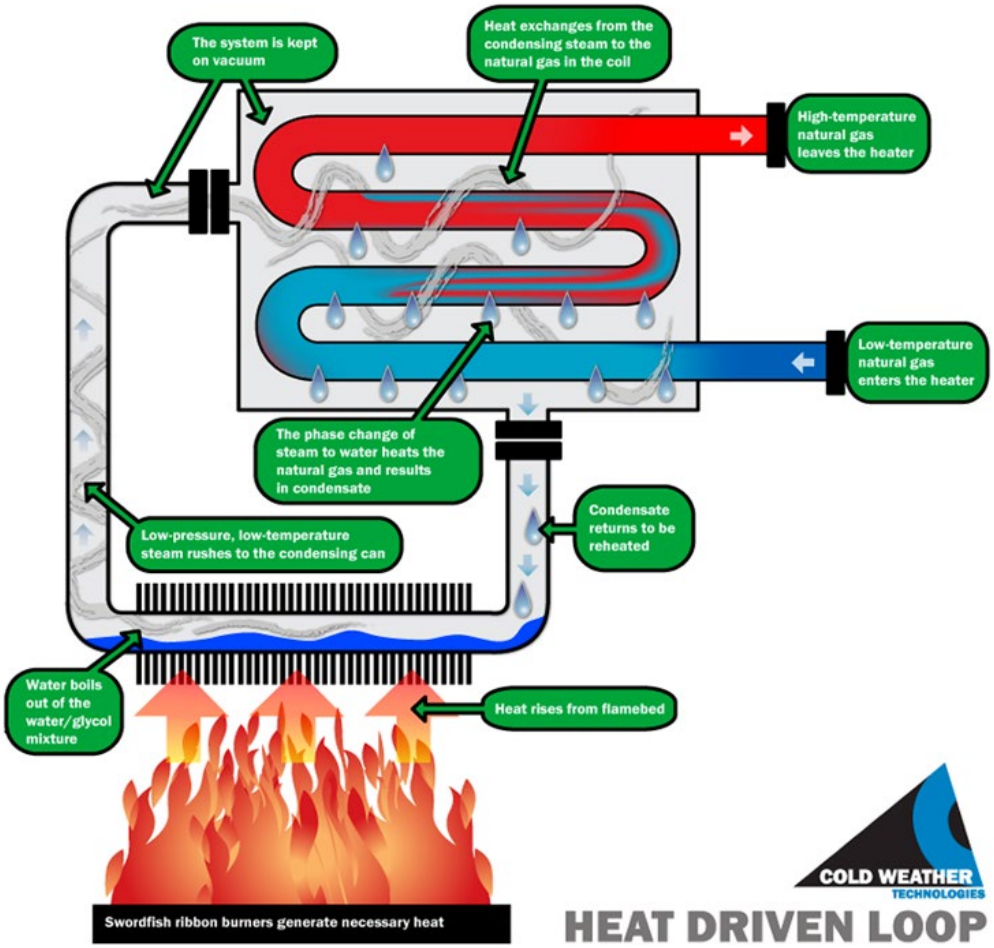
> Line Heaters

- Heat driven loop system work also by heating the bath media.
- The heater consists of five main parts: burner tray, condenser, process coil, safety and control devices. The burner tray is where the pilot flame and burner is contained.
- Pros: More efficient than traditional water bath heater, provide uniform heating, reliable, BMS incorporated into the design
- Cons: Maintenance required on fuel and burner systems, glycol testing, upfront capital cost.



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> Line Heaters

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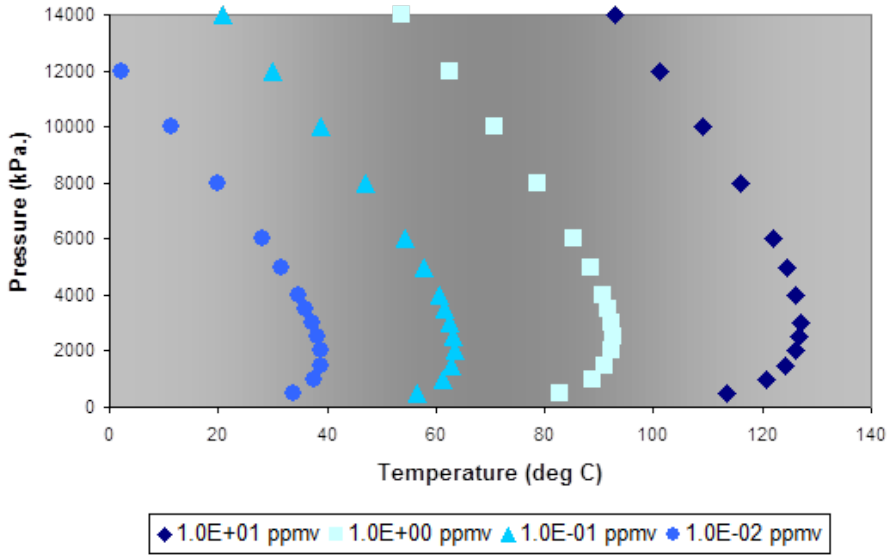
> Dithiazine and Sulfur

- Adding heat the process fluid.
  1. Line Heater
  2. Pilot Gas Heater
  - The heat added to the process keeps phase envelope of the sulfur in the gas stage. The sulfur will still be present but will just not fall out of the gas stream.
  - Heat also seems to be effective for dithiazine drop out too.



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> Chemical Injections

- Thermodynamic hydrate inhibitor- Shifts the hydrate curve toward lower temperature and higher pressure
  - Methanol
    - Relatively Inexpensive $4-5/gal, have to watch downstream BTU value
  - MX 5-4143
    - More expensive than methanol, maintains BTU better,
  - FB75
    - Expensive but uses about half the dosage of methanol, maintains BTU better
- Kinetic hydrate inhibitor- Does not affect hydrate formation temperature or pressure, it decreases the rate of reaction to form hydrates
  1. Adds as a small dose to methanol (95% methanol solution)
  2. Not nearly as effective as THI's in continuous, long term production