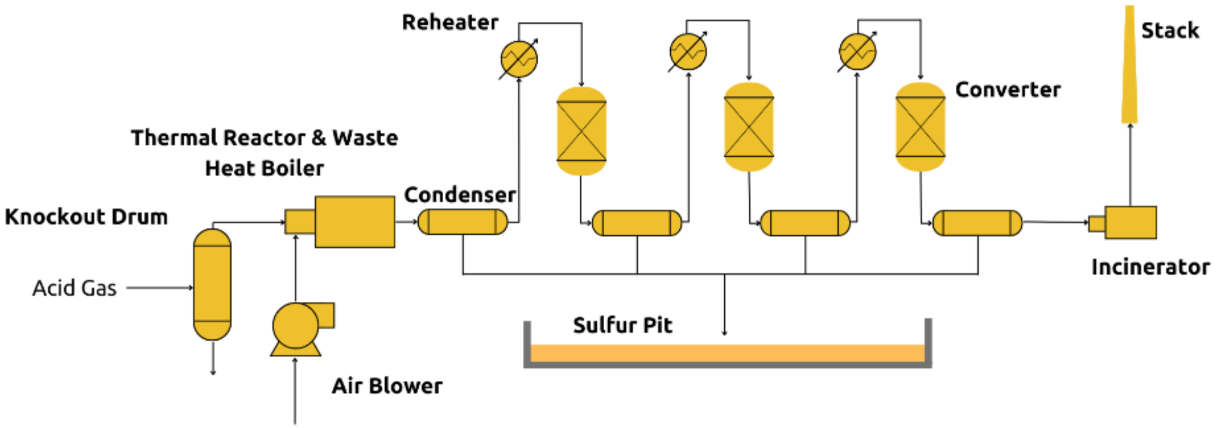

The Claus Sulfur Recovery Process

Courtesy of Sulfur Recovery Engineering

QMAX™

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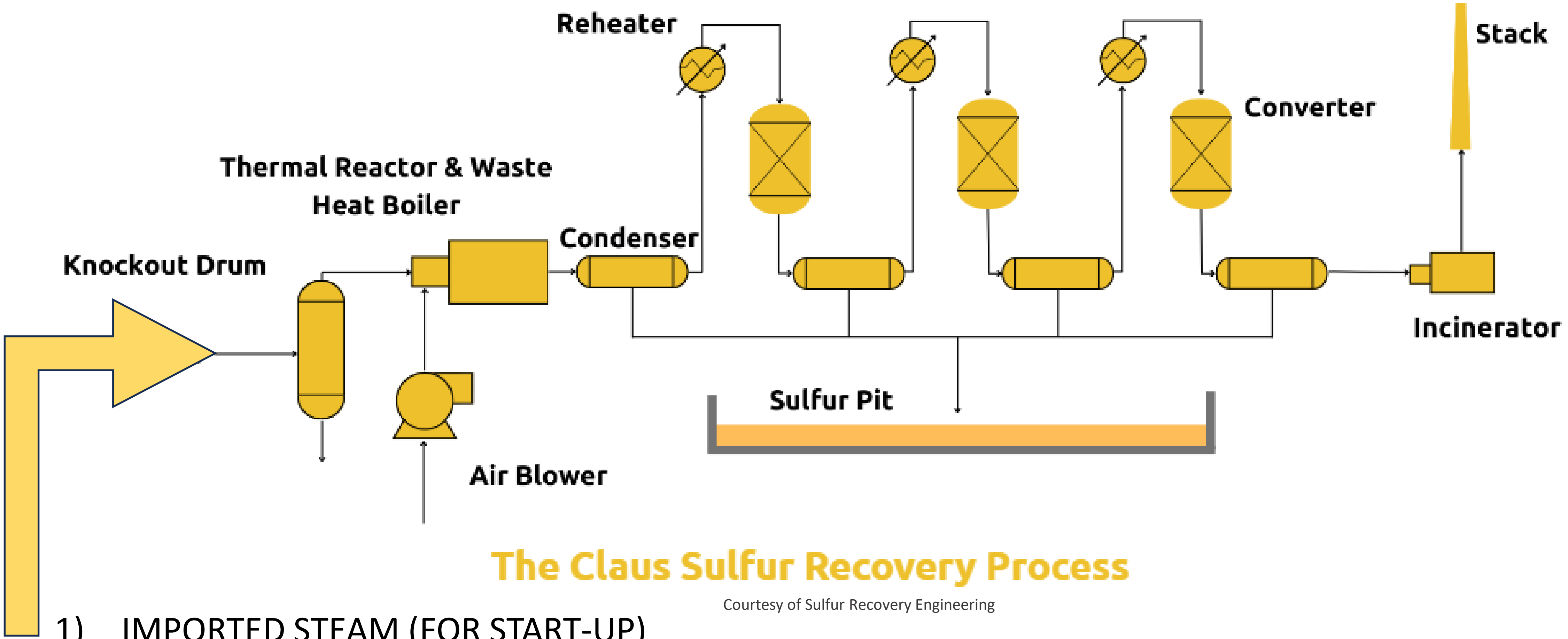
One BTU at a Time

Steam and Condensate Handling in

Sulfur Recovery Units



The Claus Sulfur Recovery Process

Courtesy of Sulfur Recovery Engineering

1) IMPORTED STEAM (FOR START-UP)
2) FUEL GAS
3) FEEDSTOCK (USUALLY ACID GAS)
4) MONEY!

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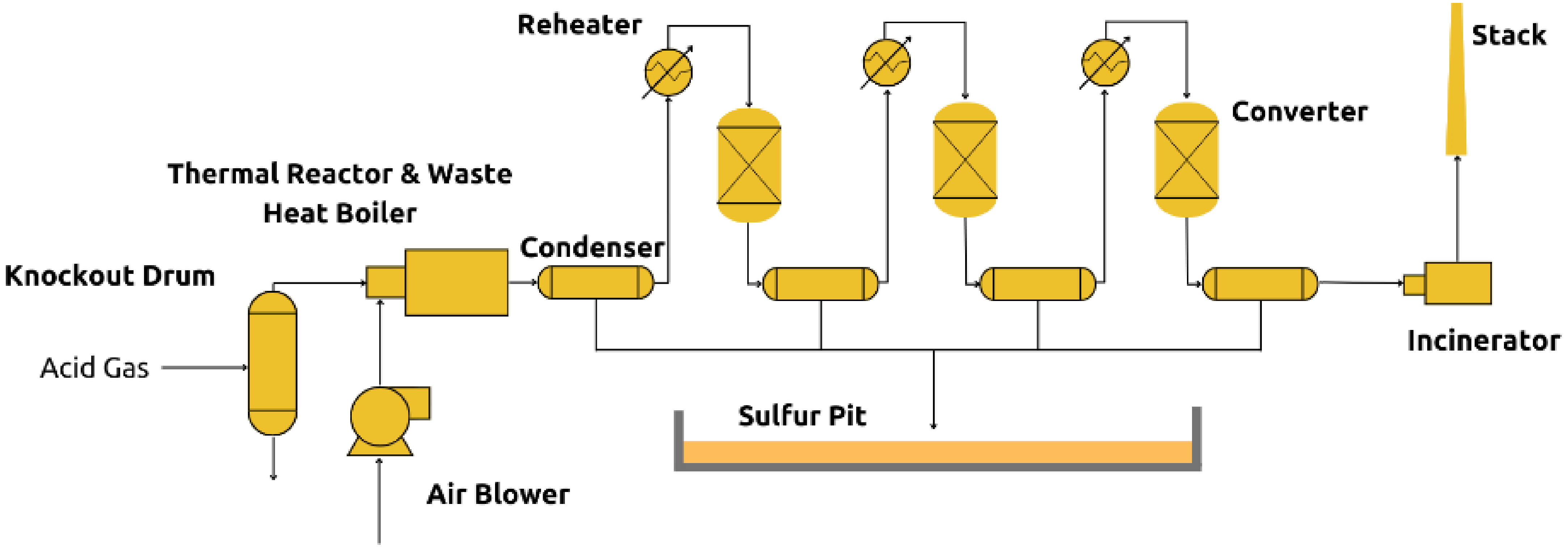
SRU INPUTS



The Claus Sulfur Recovery Process

Courtesy of Sulfur Recovery Engineering

Sulfur

Heartburn

Steam

SRU OUTPUTS

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Why do we use steam in SRUs?

1) It’s available (byproduct of process)
2) It’s “free”
3) The Claus process generates steam at pressures that are ideal for re-use within the unit
4) Steam is predictable
5) Has fantastic energy density

Absolute Pressure $p_{steam,abs}$ psia	Gauge Pressure p_{steam} psig	Temperature T_{steam} °F	Heat of Saturated Liquid h_f Btu/lb	Latent Heat of Evaporation h_e Btu/lb	Total Heat of Steam h_g Btu/lb	Specific Volume of Water v_{H2O} ft^3/lb	Specific Volume of Steam v_s ft^3/lb	Steam Dynamic Viscosity μ_s cP
60	45	292.71	262.2	915.4	1177.6	0.01738	7.1736	0.013
61	46	293.79	263.3	914.6	1177.9	0.01739	7.063	0.013
62	47	294.86	264.4	913.8	1178.2	0.0174	6.9558	0.013
63	48	295.91	265.5	913	1178.6	0.01741	6.8519	0.013
64	49	296.95	266.6	912.3	1178.9	0.01742	6.7511	0.013
65	50	297.98	267.6	911.5	1179.1	0.01743	6.6533	0.013
66	51	298.99	268.7	910.8	1179.4	0.01744	6.5584	0.013
67	52	299.99	269.7	910	1179.7	0.01745	6.4662	0.013
68	53	300.99	270.7	909.3	1180	0.01746	6.3767	0.013
69	54	301.96	271.7	908.5	1180.3	0.01747	6.2896	0.013
70	55	302.93	272.7	907.8	1180.6	0.01748	6.205	0.013
71	56	303.89	273.7	907.1	1180.8	0.01749	6.1226	0.013
72	57	304.83	274.7	906.4	1181.1	0.0175	6.0425	0.013
73	58	305.77	275.7	905.7	1181.4	0.01751	5.9645	0.013
74	59	306.69	276.6	905	1181.6	0.01752	5.8885	0.013
75	60	307.61	277.6	904.3	1181.9	0.01753	5.8144	0.013
76	61	308.51	278.5	903.6	1182.1	0.01754	5.7423	0.013
77	62	309.41	279.4	902.9	1182.4	0.01755	5.672	0.013
78	63	310.29	280.3	902.3	1182.6	0.01756	5.6034	0.013
79	64	311.17	281.3	901.6	1182.8	0.01757	5.5364	0.013
80	65	312.04	282.1	900.9	1183.1	0.01757	5.4711	0.013
81	66	312.9	283	900.3	1183.3	0.01758	5.4074	0.013
82	67	313.75	283.9	899.6	1183.5	0.01759	5.3451	0.013
83	68	314.6	284.8	899	1183.8	0.0176	5.2843	0.013
84	69	315.43	285.7	898.3	1184	0.01761	5.2249	0.013
85	70	316.26	286.5	897.7	1184.2	0.01762	5.1669	0.013

STEAM UTILITY

SIMPLIFYING OUR WORLD
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STEAM TRAPS

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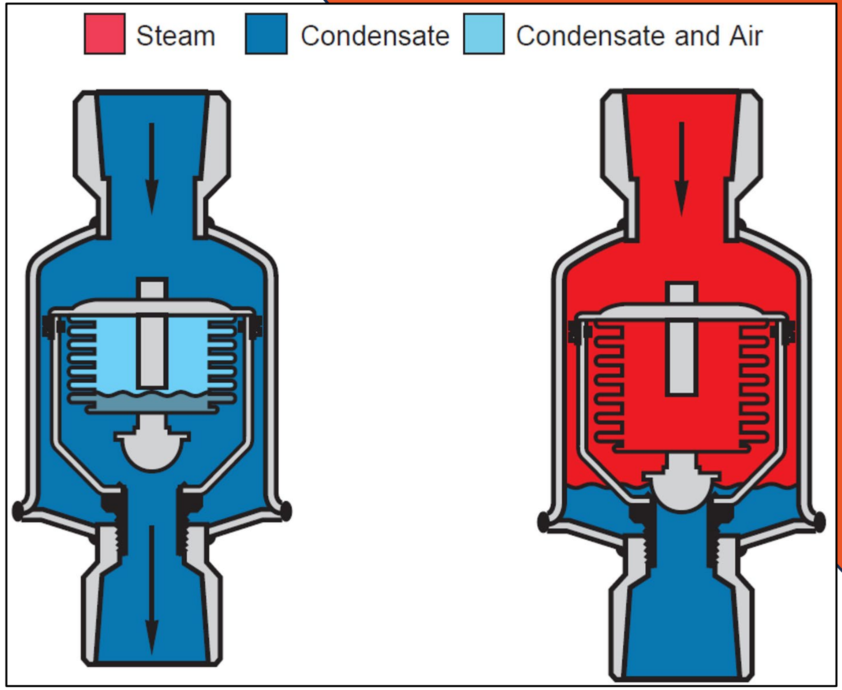
Steam Trap "Groups":

- **Temperature Actuated**

Thermostatic:
- Element opens/closes valve based on phase change or thermal expansion of fluid in the element
- Saturated steam only



Intermittent Flow
Intermittent Discharge

STEAM TRAPS

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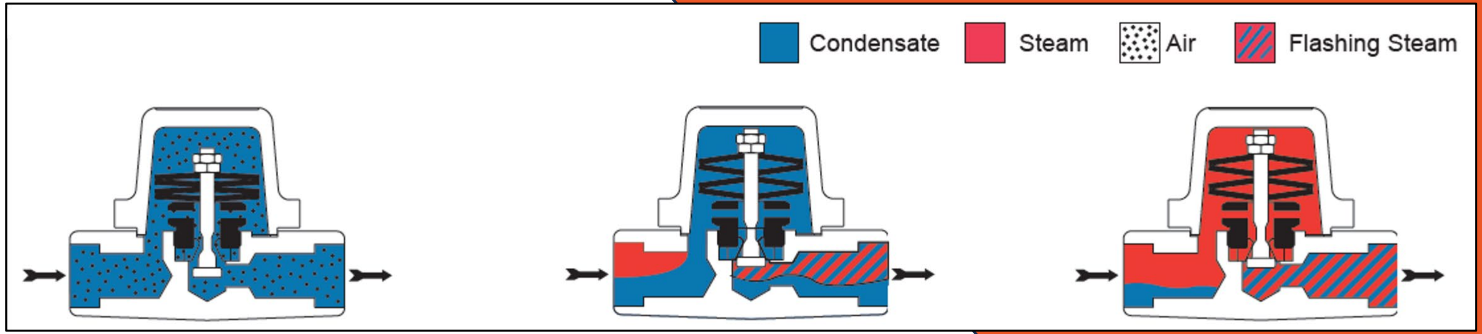
Steam Trap "Groups":

- Temperature Actuated



Bi-Metallic:

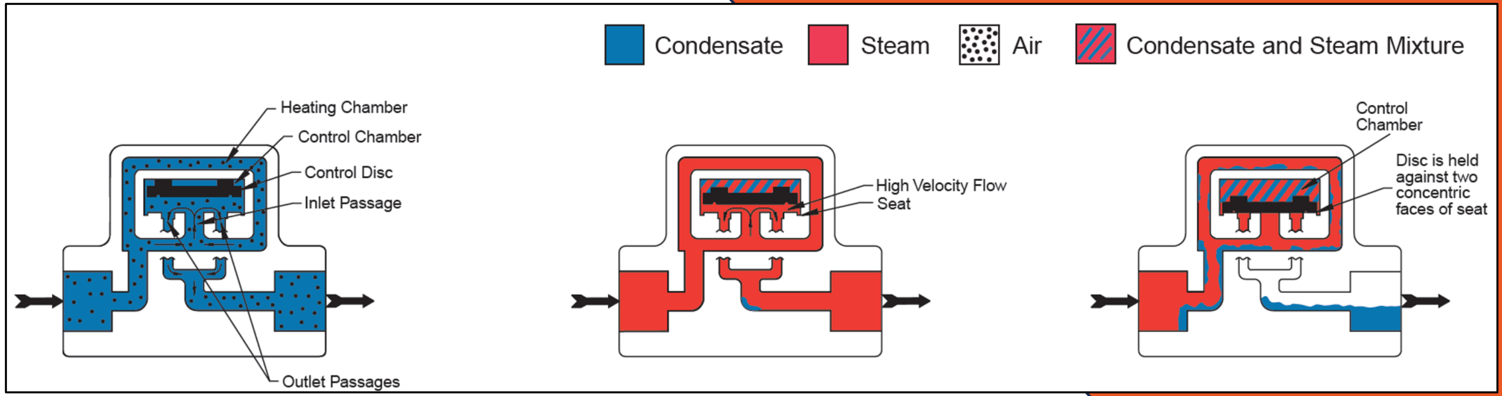
- Element opens/closes valve based on differing thermal expansion of two dissimilar materials
- Suitable for saturated and superheated steam

Intermittent Flow
Intermittent Discharge

STEAM TRAPS

Steam Trap "Groups":

- Temperature Actuated
- **Thermodynamically Actuated**



Thermodynamic:

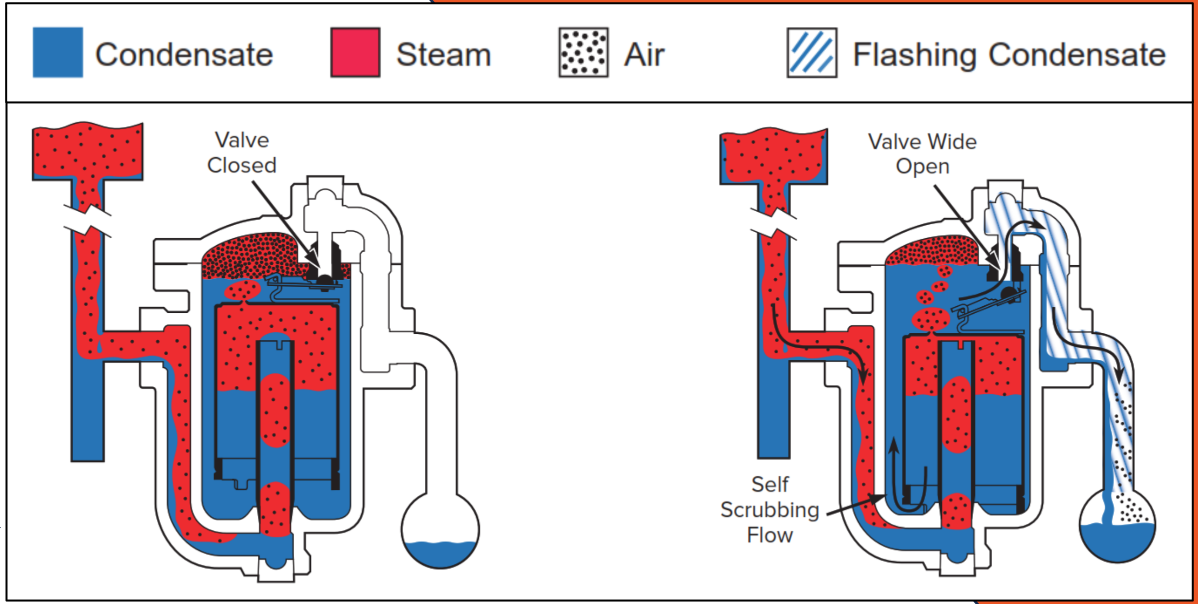
- Velocity + temperature actuated
- Floating "disc" allows lower velocity condensate to escape
- Bernoulli effect of high velocity steam causes trap to shut
- Suitable for saturated and superheated steam

Intermittent Flow
Intermittent Discharge

STEAM TRAPS

Steam Trap "Groups":

- Temperature Actuated
- Thermodynamically Actuated
- **Presence of Condensate**



Inverted Bucket:

- Mechanical-type trap
- Floating "bucket" operates on buoyancy (presence of condensate)
- Suitable for saturated steam

Continuous Flow

Intermittent Discharge

STEAM TRAPS

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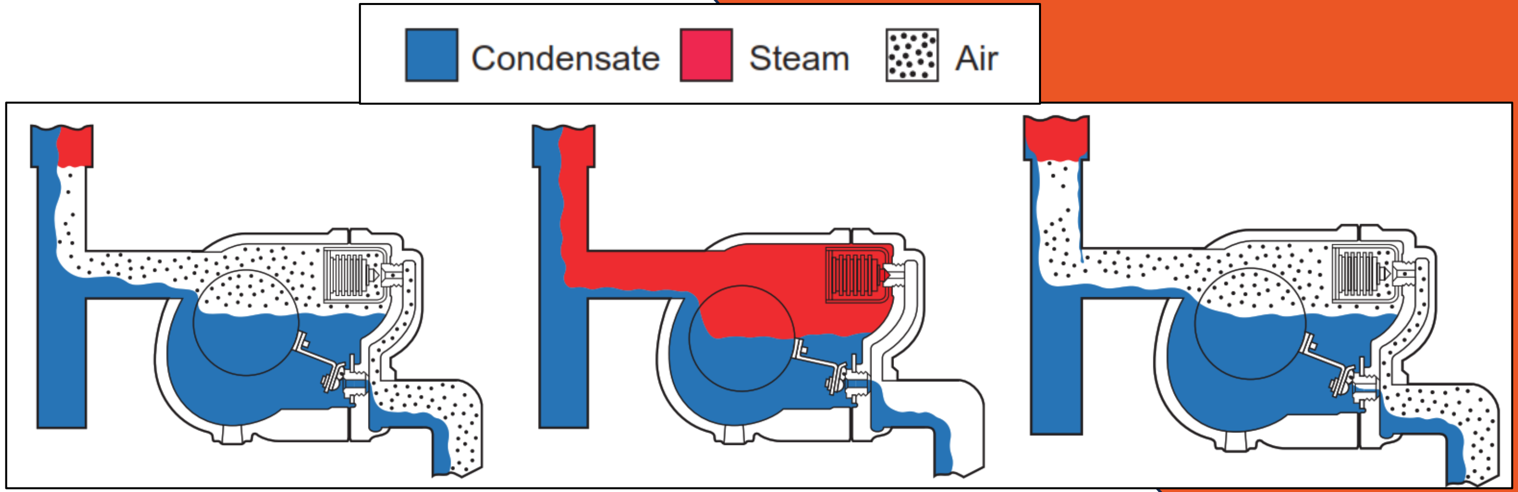
One BTU at a Time

Steam Trap “Groups”:

- Temperature Actuated
- Thermodynamically Actuated
- **Presence of Condensate**



Float (& Thermostatic):

- Mechanical-type trap
- Closed float and thermostatic element actuate to discharge condensate and non-condensable gasses
- Suitable for saturated and superheated steam

Continuous Flow
Continuous Discharge

STEAM TRAPS

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Steam Traps Summary

- **3 main "Actuation Triggers":**
  - Temperature Actuated
  - Thermodynamically Actuated
  - Presence of Condensate Actuated

- **4 Total Flow/Discharge Conditions**
  - Intermittent/Continuous Flow
  - Intermittent/Continuous Discharge

- **Relevance to Sulfur Applications**
  - Continuous flow is preferred/recommended to avoid condensate backup
  - High discharge rates across low differential pressures ensure adaptability to different operating conditions.

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STEAM TRAPS

STEAM GENERATORS

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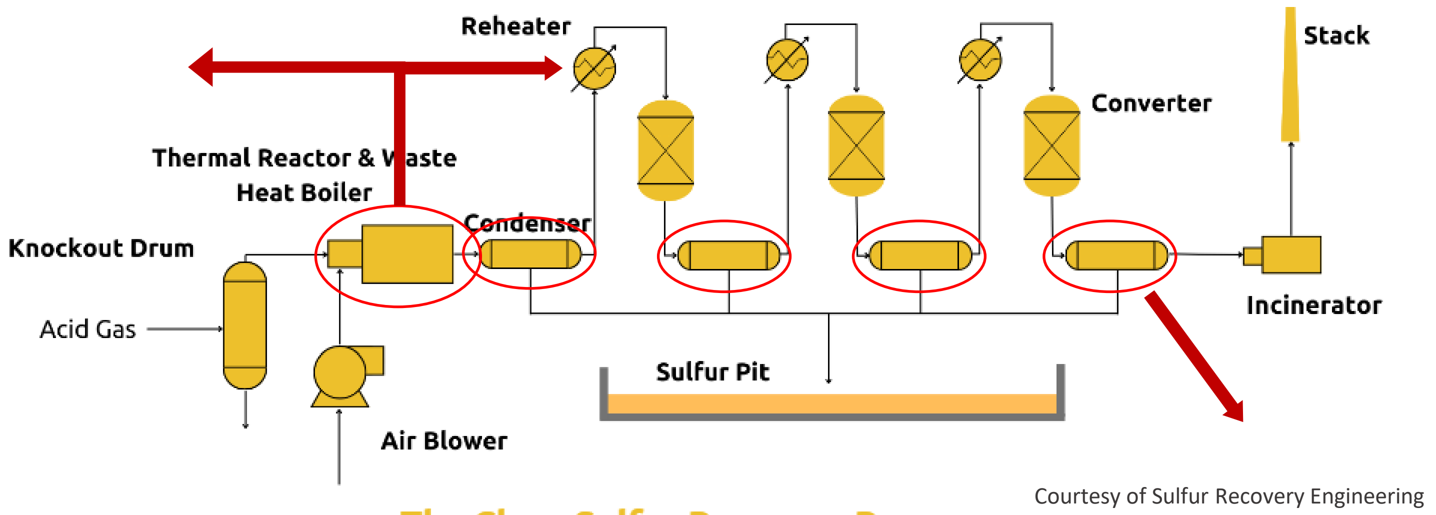
Thermal Reactor/Waste Heat Boiler (WHB)

- 450-600-psig saturated steam generated by Waste Heat Boiler
- Sent to heat Reheaters as required
- Sent to combustion air and/or acid gas pre-heater(s)
- Surplus sent to other units

Condensers

- 50-70-psig saturated steam generated by condensers
- Supplied to Steam Tracing, Jacketing and Pit Coils
- 95% surplus sent to other units



The Claus Sulfur Recovery Process

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STEAM GENERATORS

STEAM USERS

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Combustion Air and/or Acid Gas Pre-Heater(s)

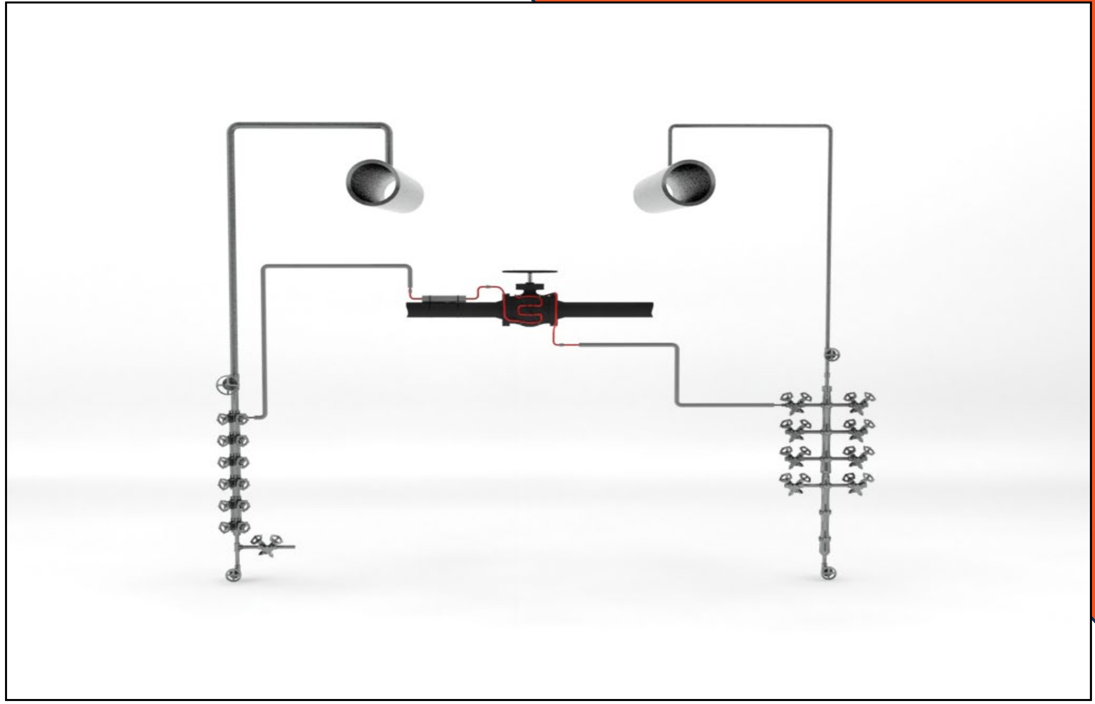
- Increases Performance & Flame Stability
- 450-600-psig sat. steam from WHB
- Bucket or Float Trap

Reheaters

- Increase gas temp to converters
- 450-600-psig sat. steam from WHB
- Bucket or Float Trap

Pit/Collection Vessel

- Coils keep sulfur molten
- 50-70-psig sat. steam from condensers
- Bucket or Float Trap with control/bypass orifice to prevent steam locking during vertical condensate lift



Tracing/Jacketing

- Keeps sulfur molten and walls above dew points in rundown, seals, transfer lines, and vessels. Protects knockout/separators from freezing
- 50-70-psig sat. steam from condensers
- Thermodynamic, Bucket or Float Trap

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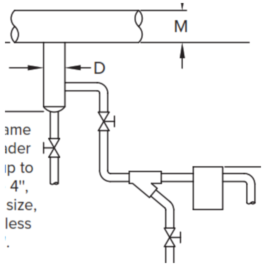
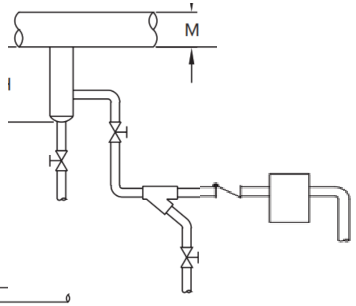
STEAM USERS

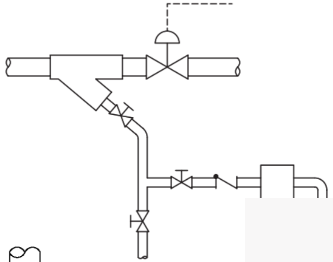
CRITICAL PRACTICES

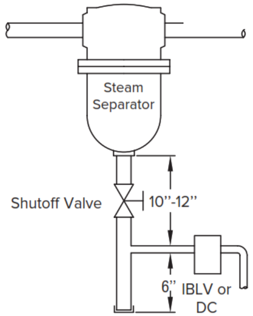
General Steam Distribution

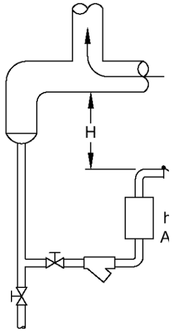
- Size headers appropriately and insulate
- Drip legs
  - Mitigate water hammer and corrosion
  - Dry, quality steam supply to equipment
  - Saturated steam- All trap types
  - Superheated Steam- Bimetallic, Float & Thermostatic, Thermodynamic

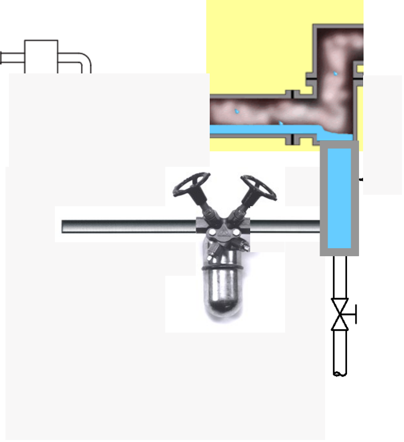












SIMPLIFYING OUR WORLD
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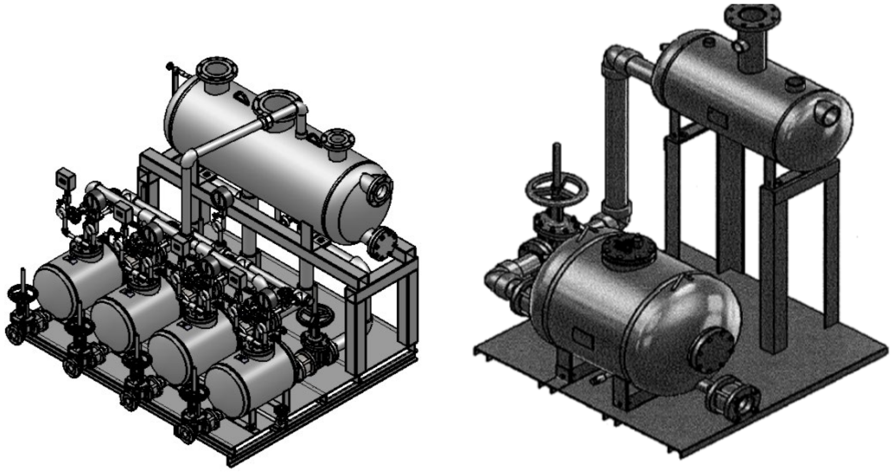
CRITICAL PRACTICES

General Condensate Collection

- Size headers appropriately and insulate
- Use traps fit for service
- Gravity Drain where possible
  - Mitigate water hammer and corrosion
- Pump if necessary
  - Low differential pressure systems
  - Long return distances
  - Large vertical lifts

Electric Pump System



Mechanical Pump System

CRITICAL PRACTICES

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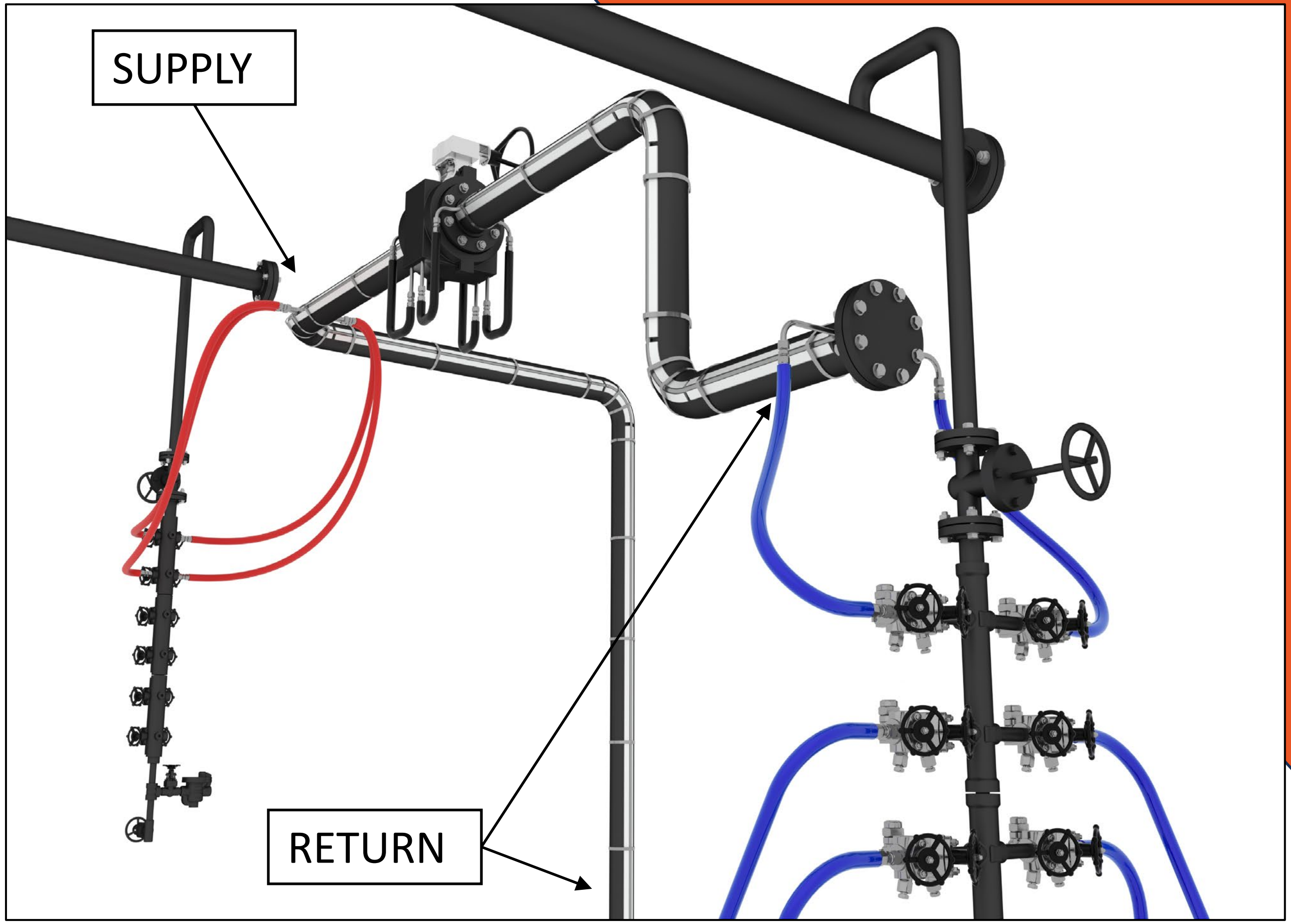
Tracing & Jacketed Pipe

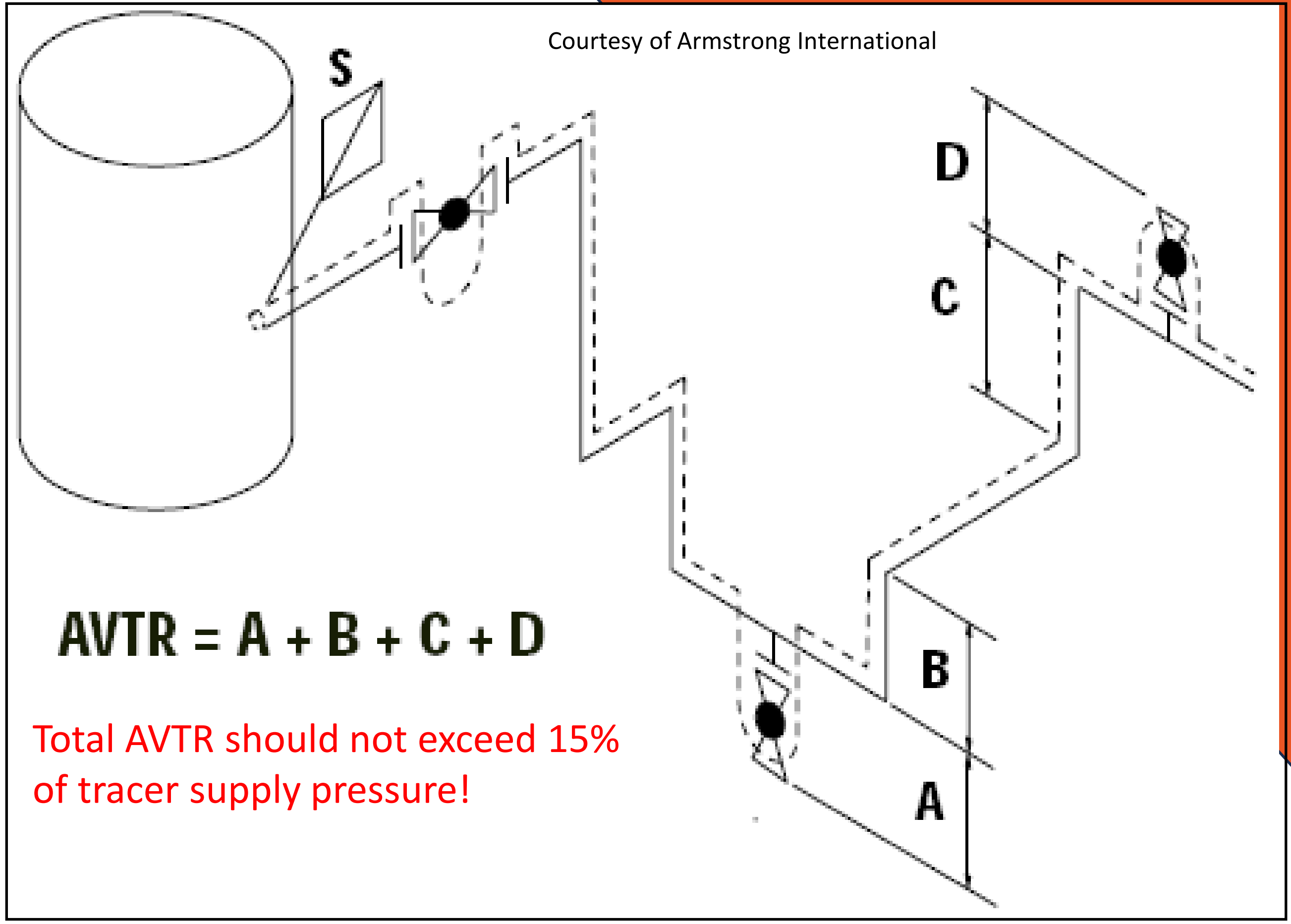
- Supply High/Return Low/minimize vertical lift



CRITICAL PRACTICES

Tracing & Jacketed Pipe

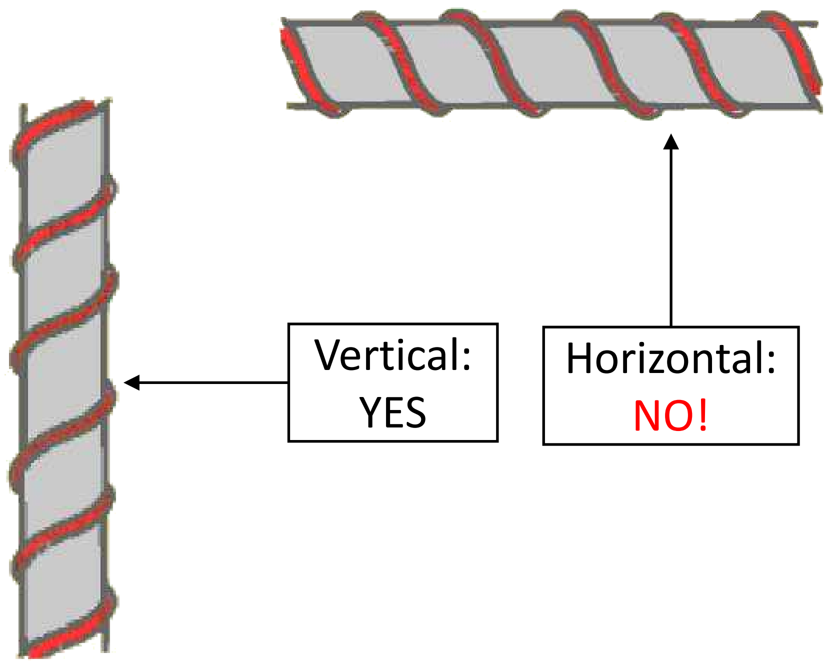
- Supply High/Return Low/minimize vertical lift
- Consider Accumulated Vertical Tracer Rise (AVTR)



CRITICAL PRACTICES

Tracing & Jacketed Pipe

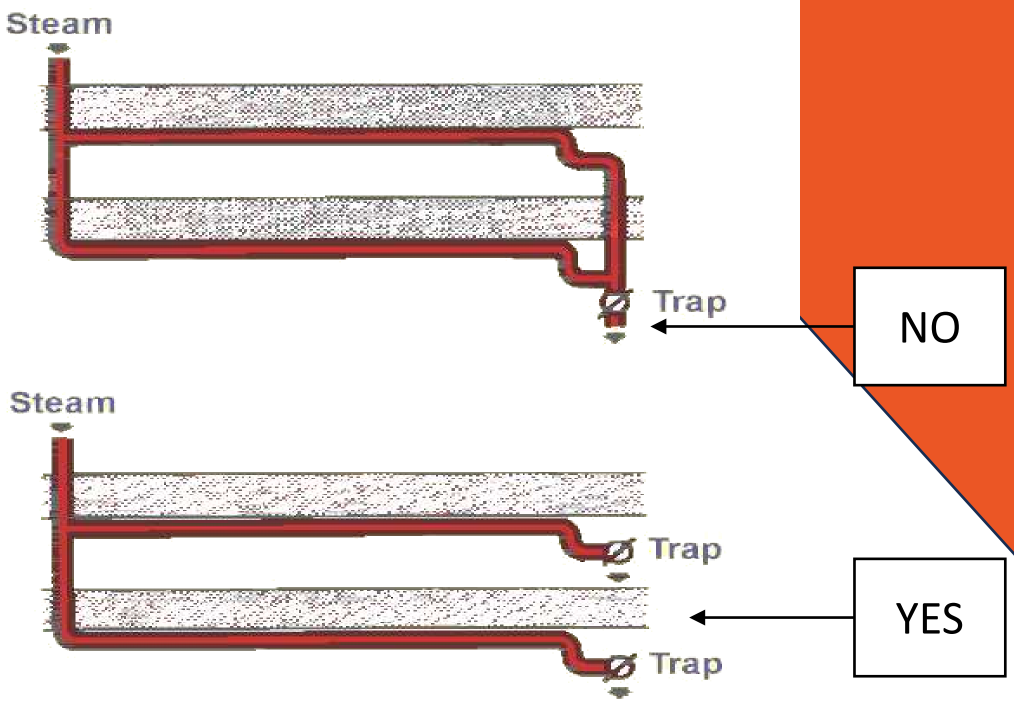
- Be cautious when tube wrapping



CRITICAL PRACTICES

Tracing & Jacketed Pipe

- Be cautious when tube wrapping
- Do not permit group trapping



CRITICAL PRACTICES

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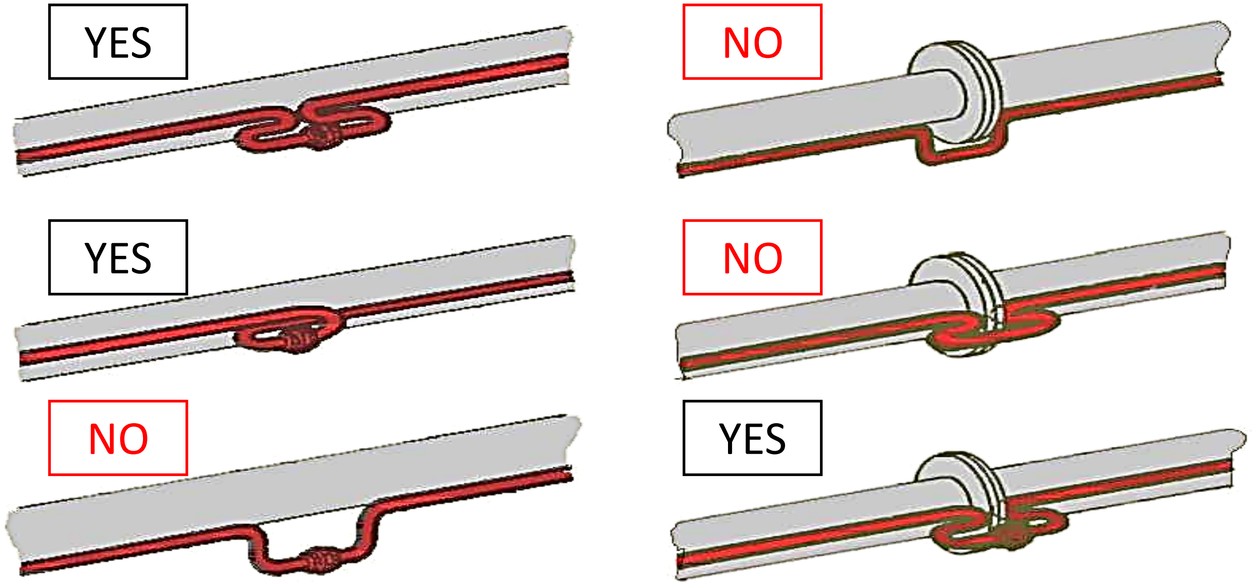
Tracing & Jacketed Pipe

- Be cautious when tube wrapping
- Do not permit group trapping
- Use proper expansion loops



CRITICAL PRACTICES

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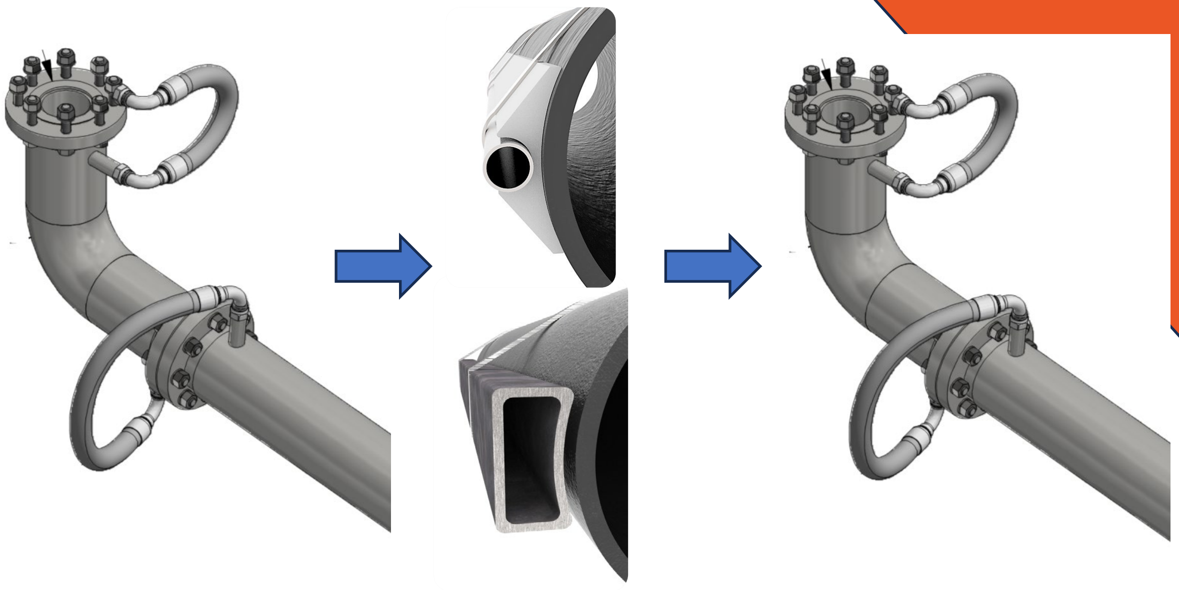
Tracing & Jacketed Pipe

- Be cautious when tube wrapping
- Do not permit group trapping
- Use proper expansion loops
    - Consult manufacturers when combining/mixing heating technologies

Section of tracing in middle of jacketed pipe run



CRITICAL PRACTICES

And Finally:

- Invest in steam/condensate system training and education for engineers and operators
  - Share knowledge
    - Encourage questions
      - When in doubt: reach out. Your vendors want to help!

THANK YOU!

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CRITICAL PRACTICES