Low Charge NH_3 Evaporators

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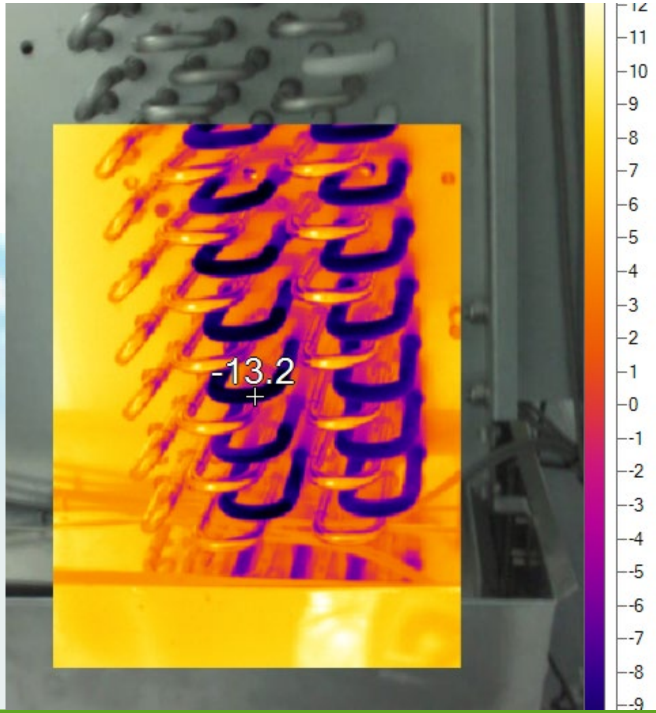

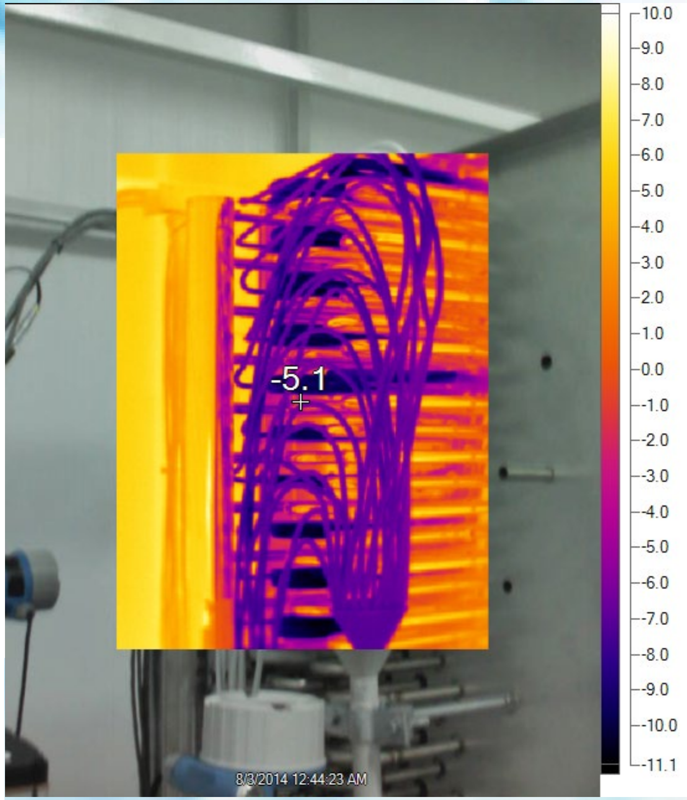

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refrigerants delivered by mother nature

What is “Low Charge NH_3”?

Definition: Any NH_3 system which requires a specific system charge of less than (1.3kg / kW)

- Conventional LR system ~ 2.0 – 3.5kg / kW
- Presently Low Charge systems are between 65g – 1.0 kg / kW
- Possible reductions of up to 50 times the currently installed scenario
- Achievable with either reduced recirculation rates or DX feed

- *Definition should be reconsidered as 1.3kg / kW, is now actually fairly high*

- Opportunities exist not only for Industrial Refrigeration, but also for HVAC and Commercial Refrigeration

What is “Low Charge NH_3”?

What is a “Low Charge Evaporator?”

- There is no such thing!

- Essentially we are only talking about the mass flow through the evaporator
- For low recirculation rates – this is less than “historical values”

- As a manufacturer this is our concern
- Coil circuiting is unlike a traditional LR evaporator

- DX remains “unchanged”
- Feed type, or the rate into the coil will determine residence mass in coil

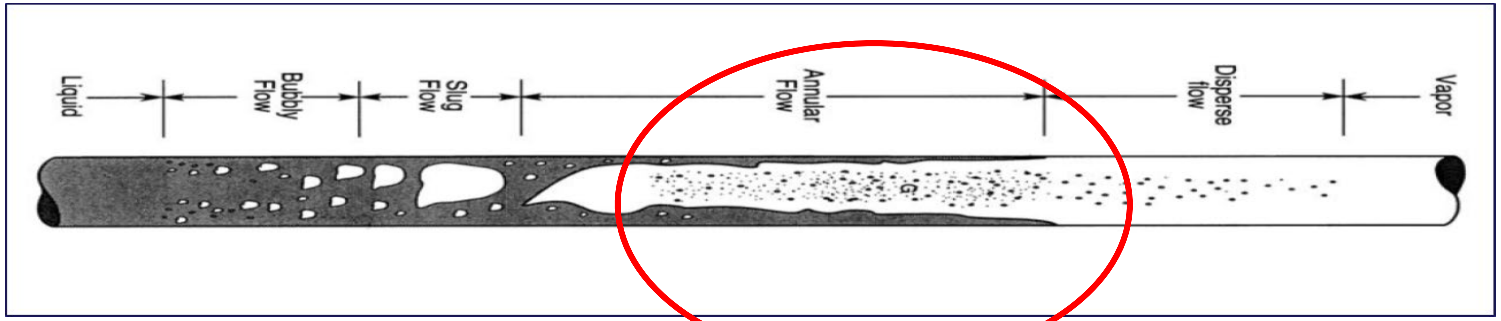
Evaporator Design for Low Charge Systems;

- Ammonia has unique thermophysical properties, combined with a high latent heat of vaporization (= relatively low mass flows)

- Separation of the liquid and vapor phases can occur at low fluid velocities due to the high ratio of vapor to liquid specific volume

- Coil circuiting (fluid velocities) – if not correct – will cause liquid to settle on lower portion of tubes and render upper portions “dry” resulting in poor evaporator performance (stratified, slug, wavy flow)

Evaporator Design for Low Charge Systems;



Two Phase Flow regimes

- Annular flow is the coil designer's goal – in order to:
  - Maintain inner tube walls wetted
  - Maximize the coil performance…

  - …Fluid velocities / coil circuiting (heat flux) are critical to achieve maximum coil thermal performance

Evaporator Design for Low Charge Systems – Low RR;

Effects of Mass Specific Vapor Quality in Coil;

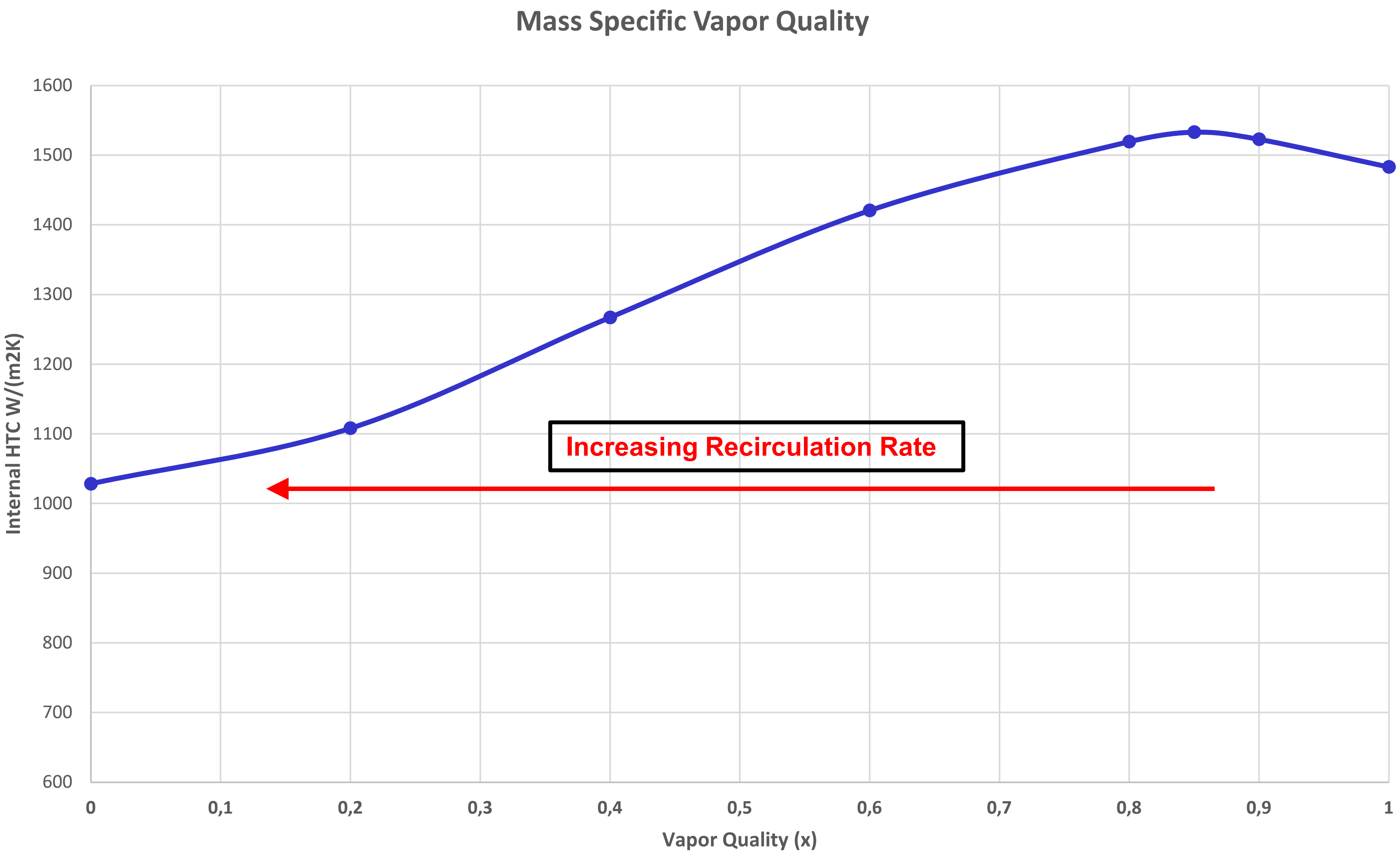
- If the recirculation rate (RR) is 1:1 all the refrigerant evaporates, and vapor quality (x) at exit is 1.0 [NOT superheated]

- When the recirculated rate is > 1.0 not all the refrigerant is evaporated, only the portion = 1/RR;
  - 2:1 RR = 1/2 = 50% (x = 0.5)
  - 3:1 RR = 1/3 = 33.33% (x = 0.33)

- Therefore: as RR is increased, the vapor quality decreases…

- …AND internal heat transfer co-efficient decreases

Evaporator Design for Low Charge Systems – Low RR;



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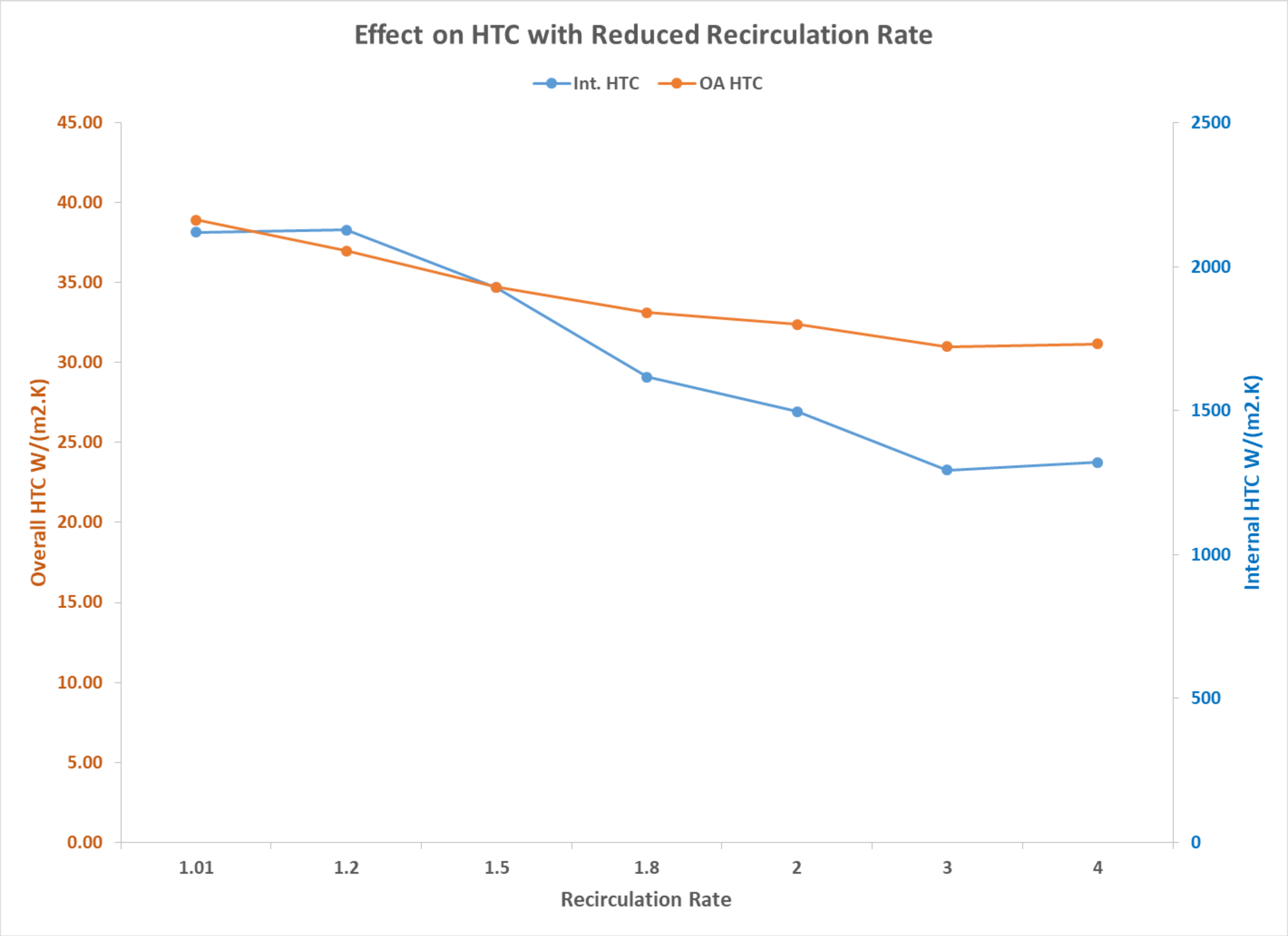

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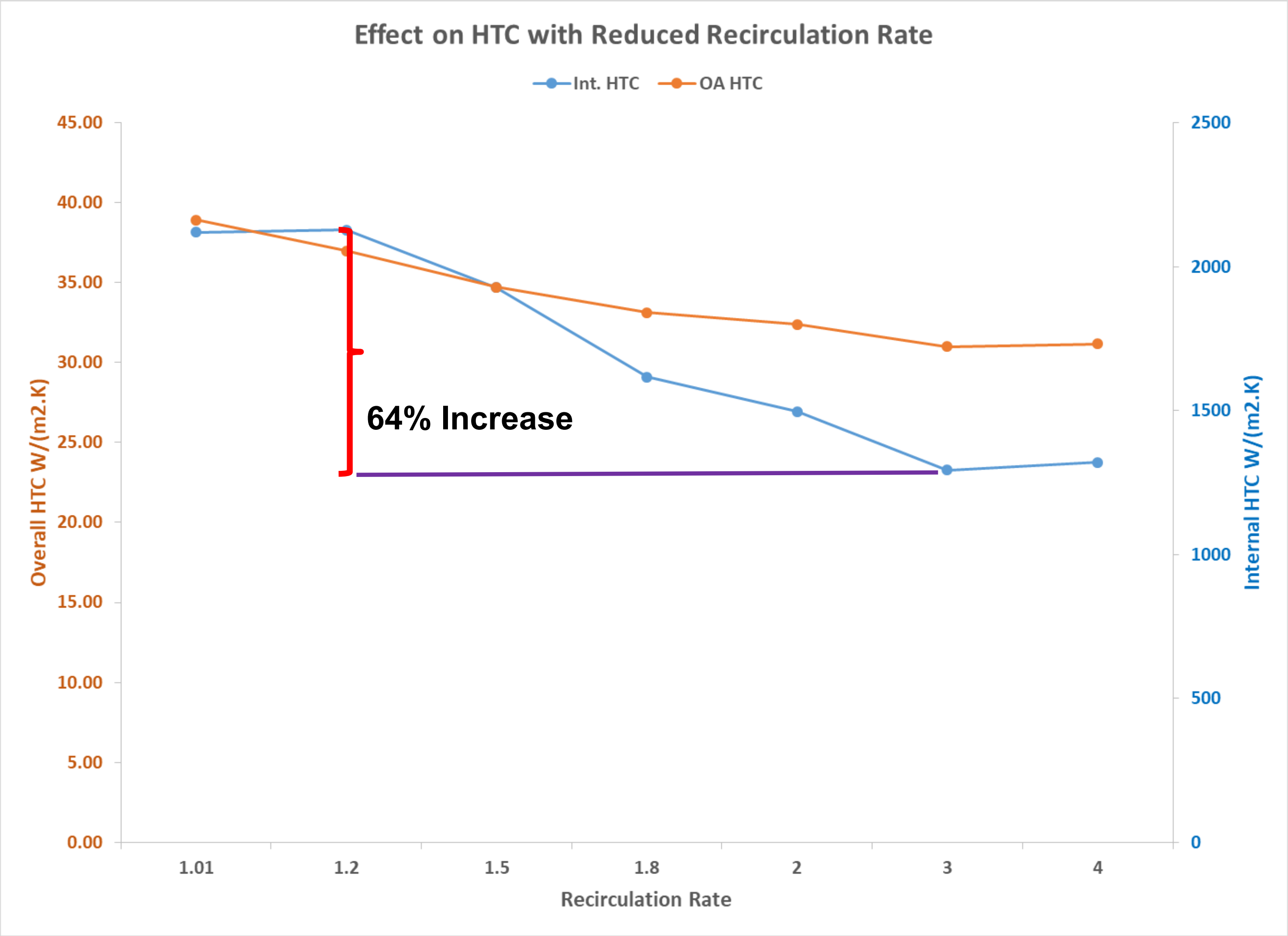

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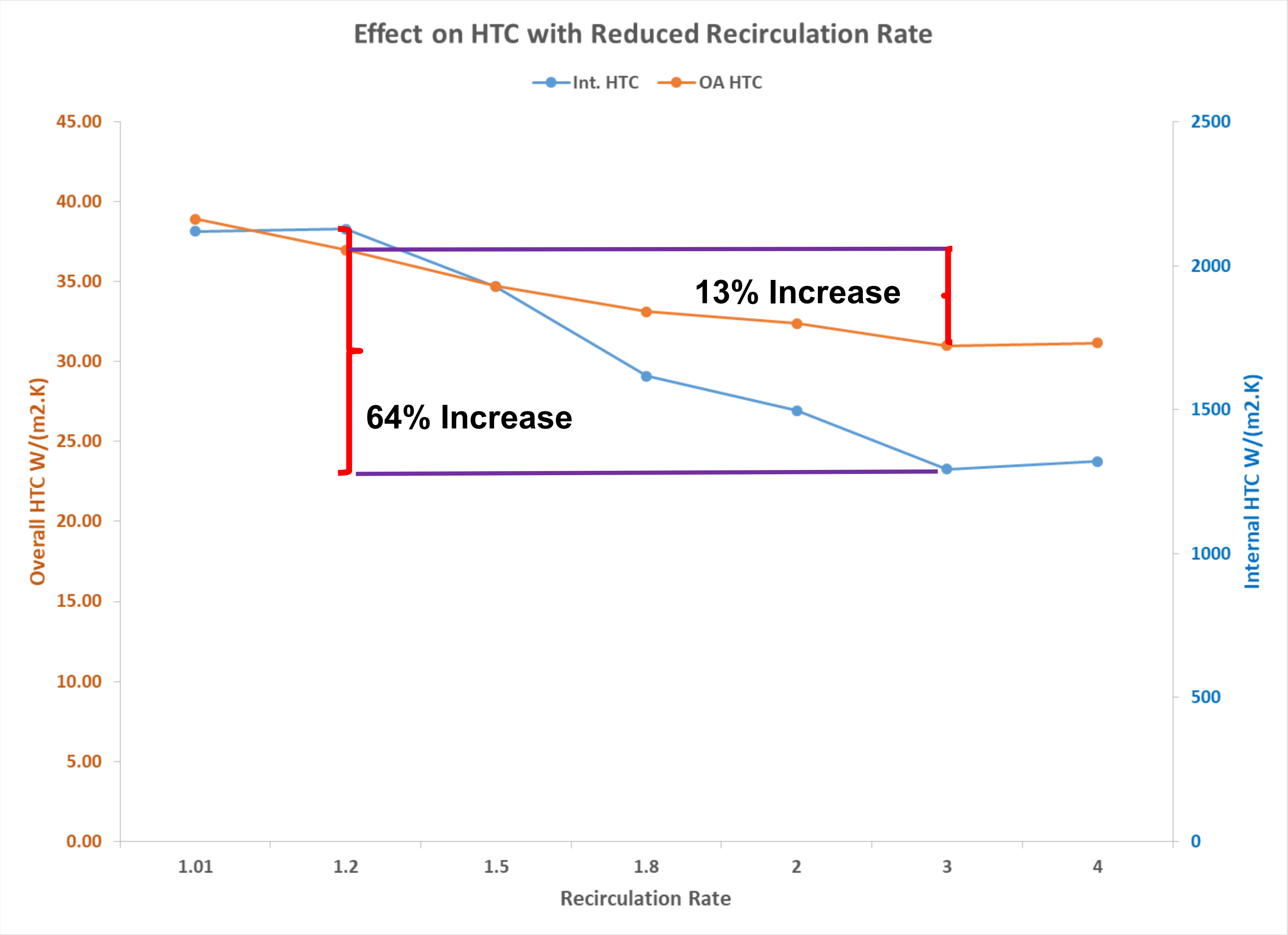

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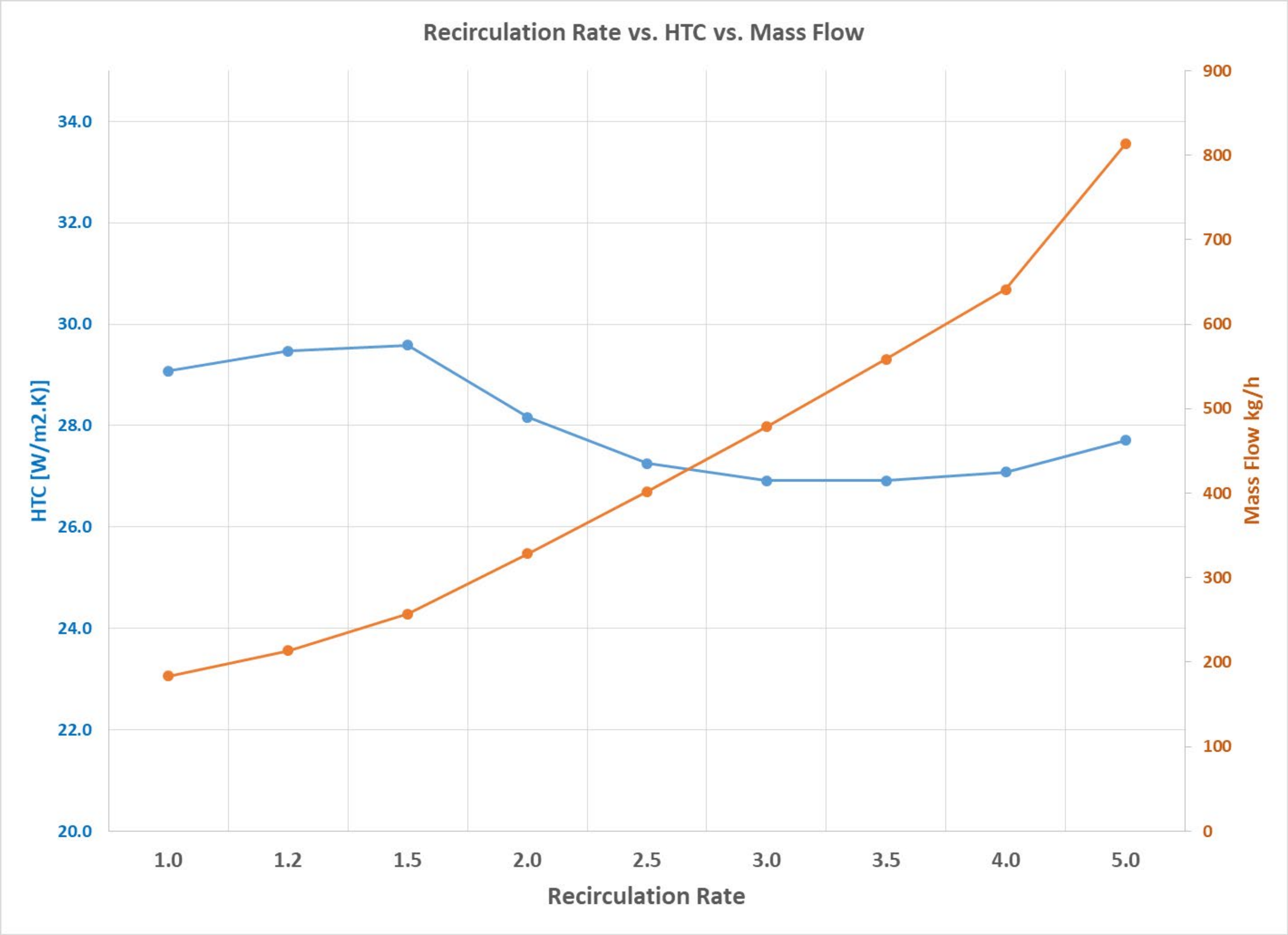

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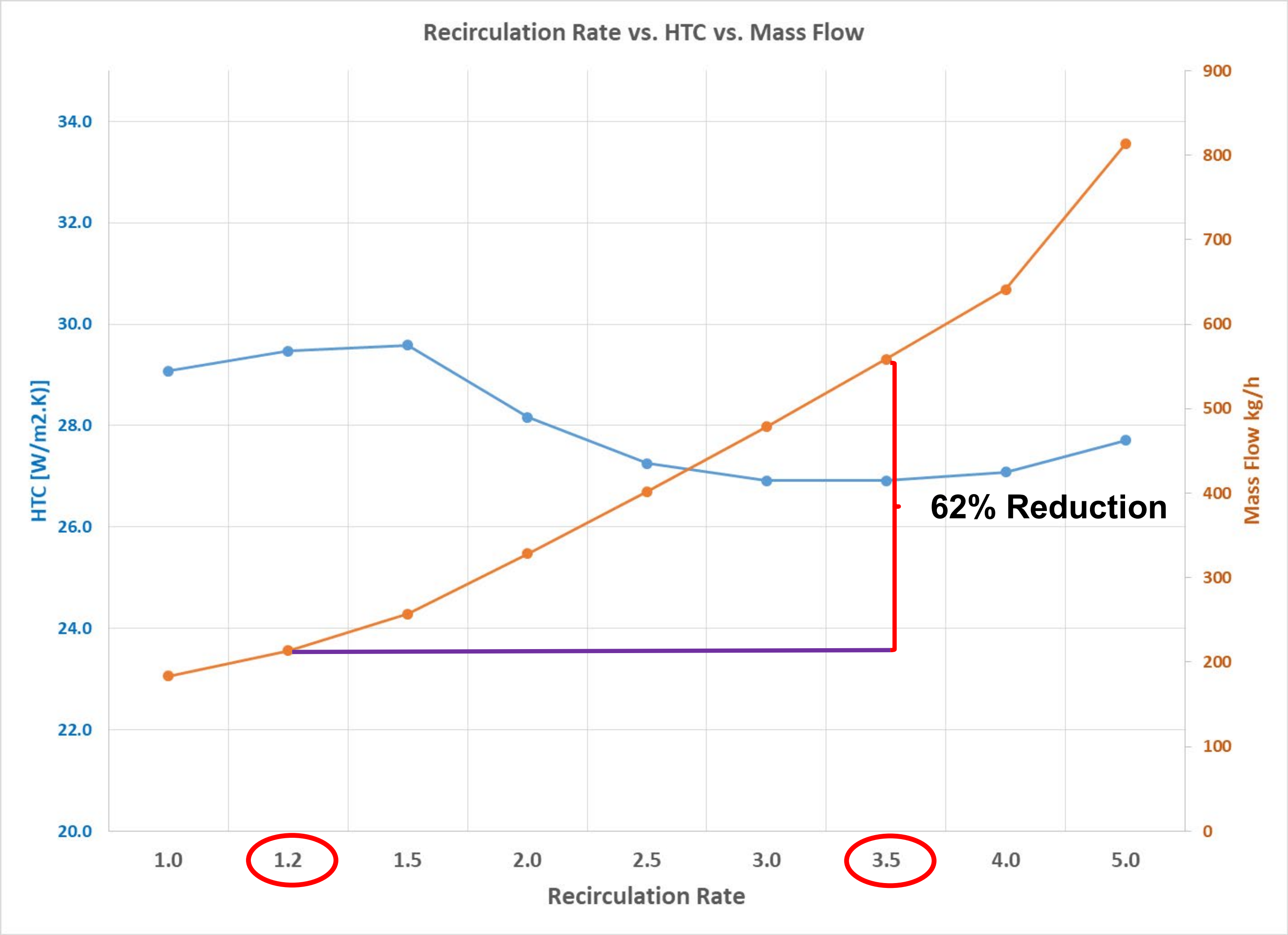

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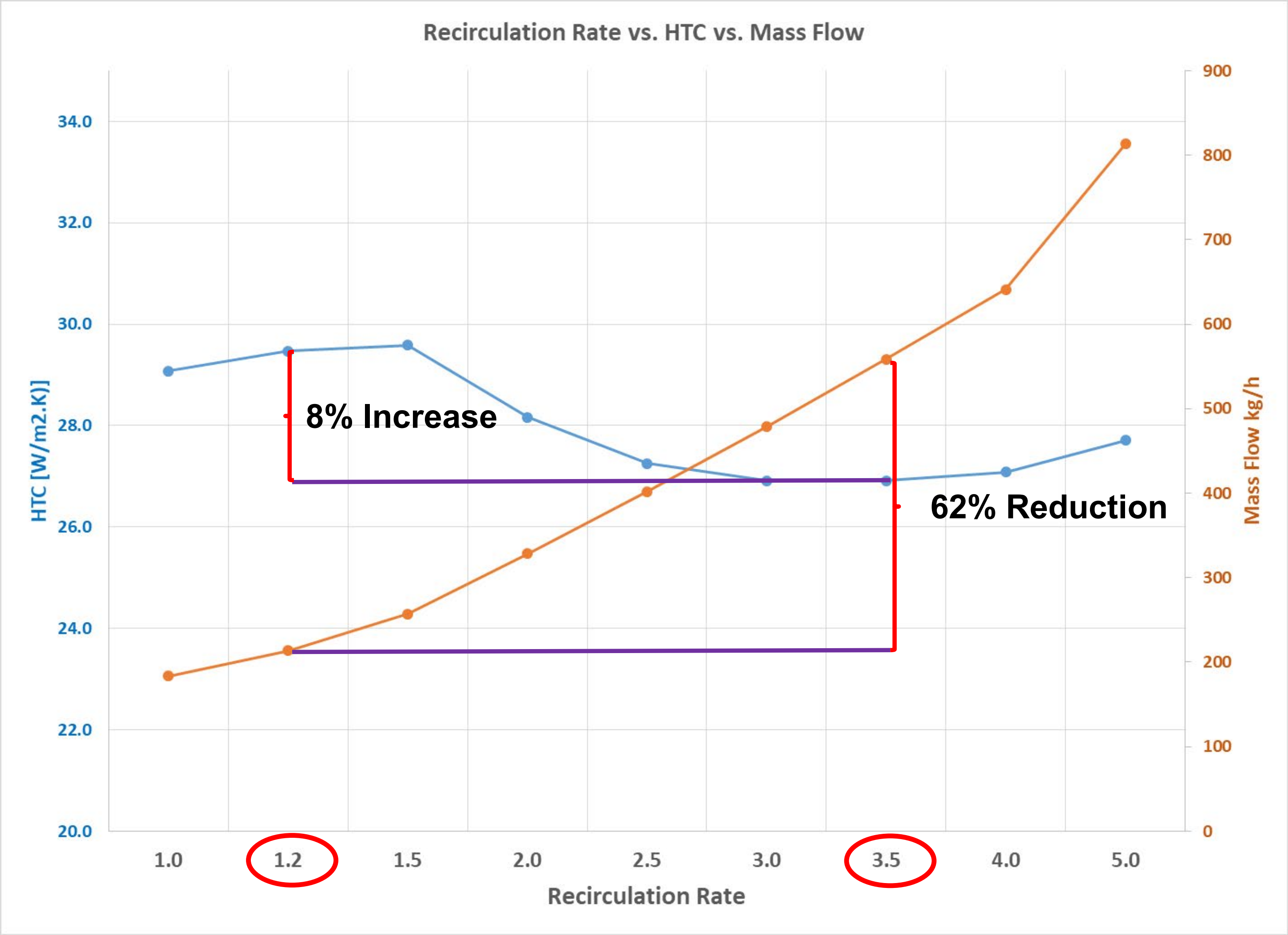


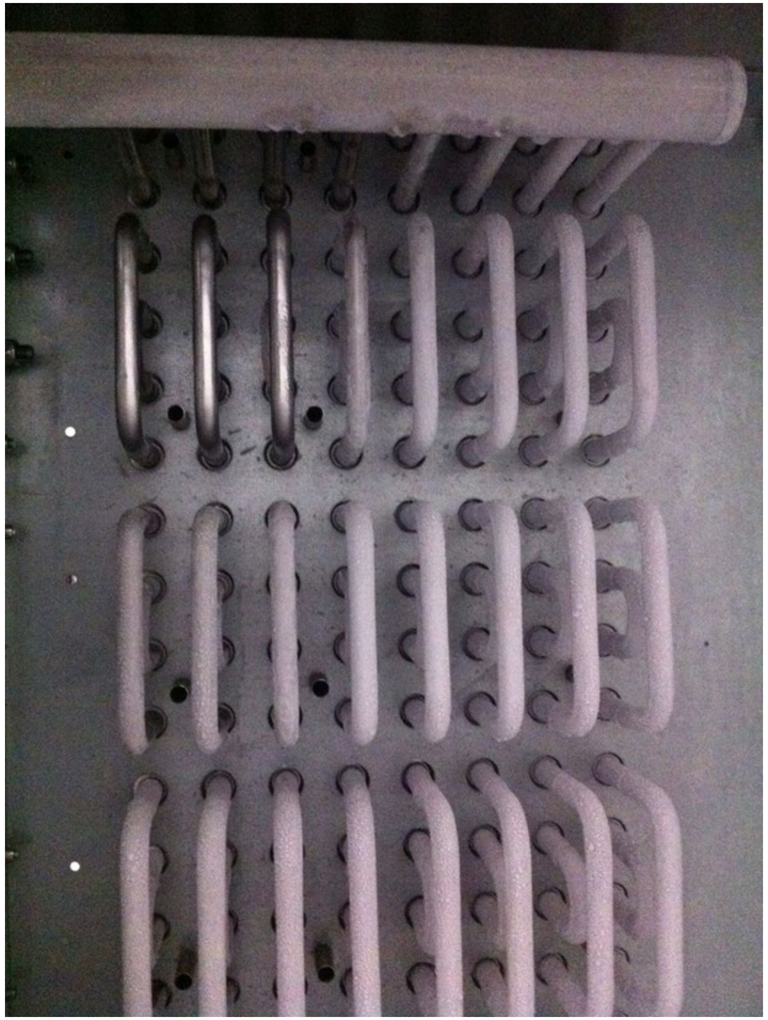
Evaporator Design for Low Charge Systems – Low RR;

Effects of Reduced Recirculation Rates;

- As can be seen in previous slides the HTC value increases considerably when going from 4:1 to ~1.2:1
- 1:1 is very unlikely, and almost impossible to maintain
- Fluctuations in load will have an impact on coil performance
- However, 1.2:1 is realistic and fairly easy to achieve
- This "minimum" recirculation rate is dependent on tube diameter / geometry
- *Coil circuiting, and liquid feed into coil, is different for these reduced rates, and unique for each coil*
- Bottom line though, is that on average 5 – 10% increase in coil performance can be achieved with a 1.2:1 vs. 3.5:1 recirculation rate

Evaporator Design for Low Charge Systems – Low RR;

Traditional horizontal headers;
“Superheated region ” is visibly noticeable.
(RR = 1.5:1)



Evaporator Design for Low Charge Systems - DX;

Direct Expansion considerations;

- Traditionally DX coils have always been superheat controlled
- Thermal expansion valves are “history” and have been replaced with Electronic expansion valves
- Superheat values have never been less than ~ 6K
- The superheated vapor portion of the coil surface area provides negligible refrigeration effect (essentially “wasted” surface area) [5 – 15%]
- Advancements to control(s) and metering devices has changed this landscape

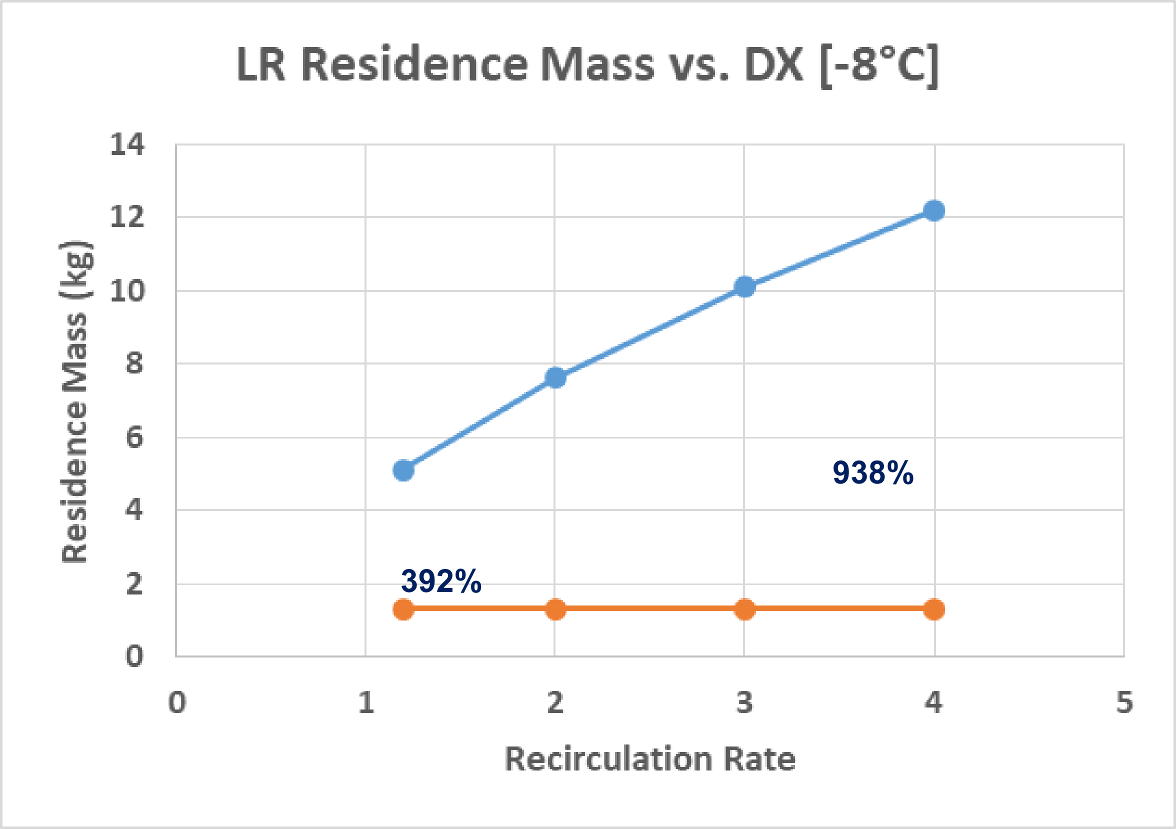
Evaporator Design for Low Charge Systems - DX;

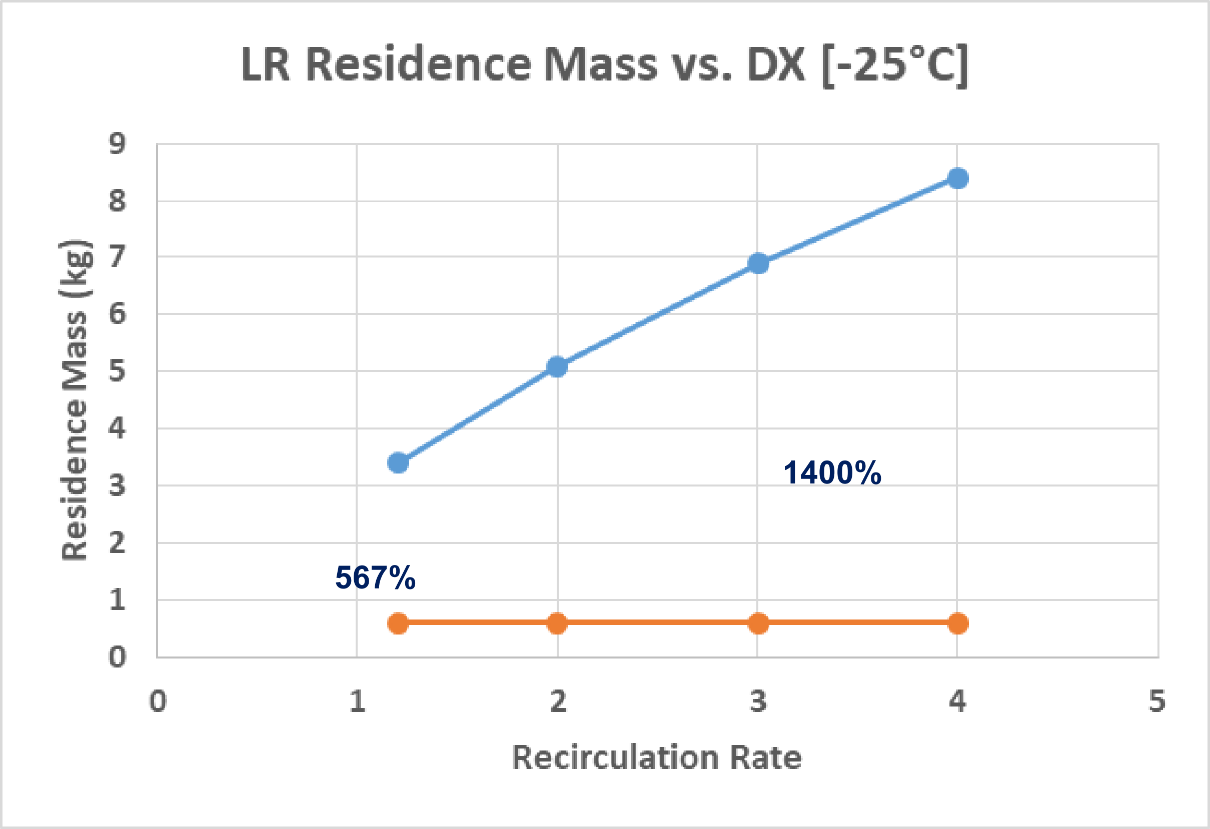
Direct Expansion considerations;

- Significantly reduces the refrigerant charge
- No mechanical pumps
- Smaller pipe diameters
- Reduced insulation costs
- No separation vessels, but…
- Suction accumulator is recommended

Evaporator Design for Low Charge Systems - DX;

Residence Mass in Evaporator Coil;





Evaporator Design for Low Charge Systems - DX;

“New” Controls Available for DX Applications?

- Vapor Quality sensor, for
  - DX applications, and
  - Low recirculated rate liquid metering
- Measures vapor quality [Void Fraction] – NOT a superheat controller
- Built in microprocessor which sends a 4 – 20mA signal proportional to sensor’s determined measurement area
- Advancements to controls and technologies have changed this landscape

Evaporator Design for Low Charge Systems - DX;

Direct Expansion Considerations;

- Having refrigerant leave coil at vapor quality of 1.0 would be “optimum” >>> zero superheat
- With Superheat control this is not possible
  - Even with Electronic valves
- With Vapor quality control this is possible
- However, with vapor quality control consideration should be allowed for “some” liquid carry over (suction accumulator)

Summary;

- The Industrial Refrigeration Landscape – as we once knew it – has changed!

- End Users and Owners are Striving for;
  - ✓ Reduced Energy Usage
  - ✓ Lower Initial Investment
  - ✓ Reduced Life Cycle Running Costs
  - ✓ Reduced Regulatory Requirements
  - ✓ Inherently Safer NH_3 Systems Installed

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Summary – Low RR vs. DX;

Pros – Low RR

- Less coil surface area
- Water in system – minimal effect
- Lower operating costs

Cons – Low RR

- Vessels are still required
- Pumping power
- Larger pipe diameters (vs. DX)
- Feed rate control - questionable
- Orifice diameters (hot gas defrost)

Pros – DX

- Reduced refrigerant inventory
- Precise feed control
- Suction accumulator – only vessel
- No pumps
- Smaller pipe sizes

Cons – DX

- More coil surface area (cost)
- Coil circuiting on large evaporators
- Liquid carry over
- Water (or oil) in the system – unstable operation

Summary;

- Lower Recirculation rates are possible, and more advantageous
- NH_3 DX systems today are now reliable due to the advancements in controls and technology
- *NH_3 DX is certainly the preferred direction to take*

- ➢ Güntner is committed to continued research and development to meet the requirements of this changing landscape
- ➢ Güntner is committed to being a front-runner in low charge refrigeration systems

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