ASHRAE October Meeting

VRF Indoor Unit Control

Presenter: Marty Brinton

LG Electronics US, Inc.

Sr. Applications Engineer

Overview of todays seminar

- VRF 3-pipe system
  Refrigeration Cycle
  - Heating
  - Cooling

- 3-Pipe Heat Recovery:
  How is Heat Recovered?

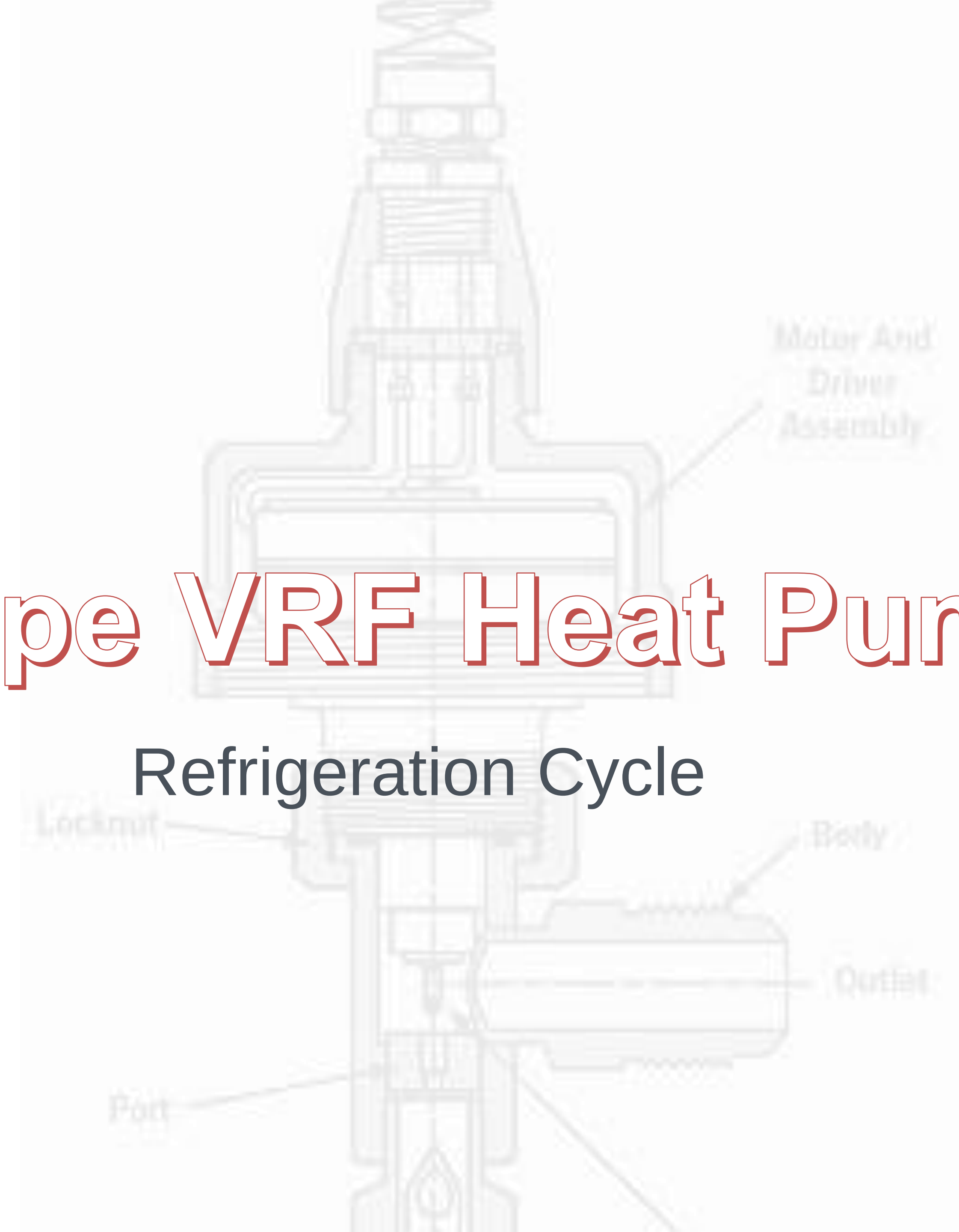
- VRF Indoor Unit Operation:
  DX EEV Coil Control

- Indoor unit fan control:
  Airflow rate = capacity

- Future Refrigerants Update

3-Pipe VRF Heat Pump

Refrigeration Cycle



3-Pipe VRF Heating Cycle

Subcooling

Pressure does not change in the condensing process.

As hot vapor passes through the tubes, the airflow extracts heat from the refrigerant gas.

Near the end of the tube, the refrigerant vapor turns to liquid (condenses) depicted as red to gold.

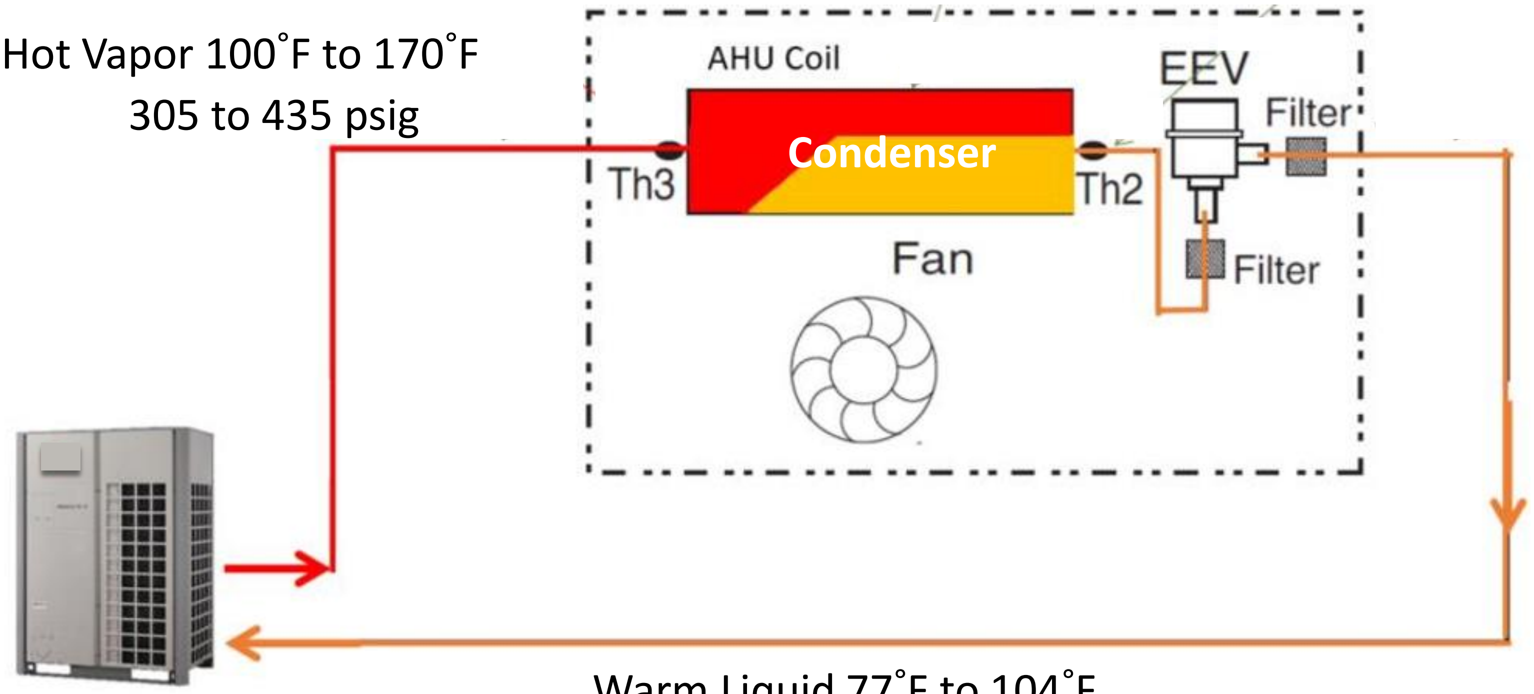
As the liquid continues through the tubes it gives up more heat and is further cooled below saturation, thus the term “sub-cooled liquid.

Default subcooling target is 18-25˚F

Target value can be adjusted on a IDU by IDU basis at commissioning to achieve desired leaving air temperature.

EEV regulates IDU coil subcooling (no pressure drop)

Hot Vapor 100˚F to 170˚F
305 to 435 psig



Warm Liquid 77˚F to 104˚F
305 to 435 psig

ODU coil is the refrigerant Evaporator

3-Pipe VRF Cooling Cycle

Superheat

After liquid flashes to vapor caused by pressure drop at EEV, refrigerant temperature instantly drops. Mixed state liquid/vapor refrigerant enter coil.

Refrigerant absorbs heat from air and somewhere close to the end of the tube length all refrigerant liquid boils off to vapor state.

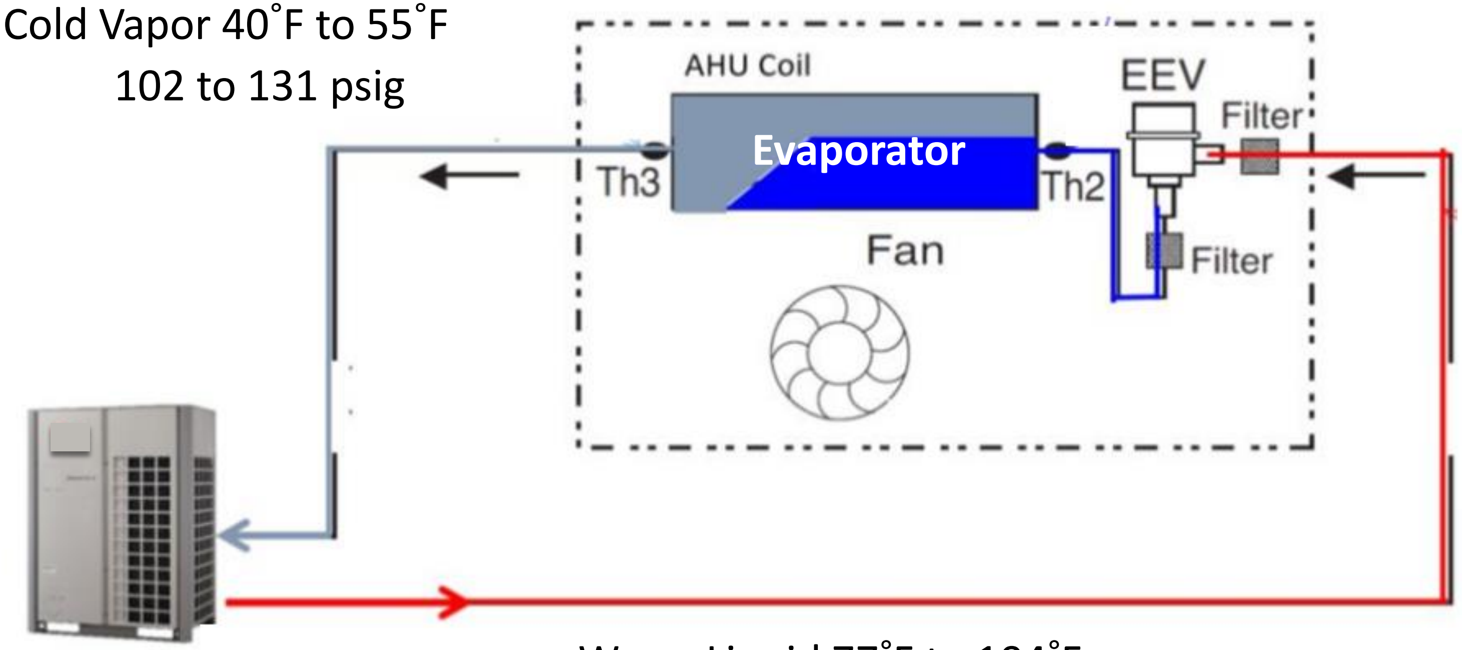
Vapor continues to absorb more heat before leaving the coil. Thus the term “super-heat”

Default superheat target is 7.9F

Target superheat value can be adjusted on a IDU by IDU basis at commissioning to achieve desired leaving air temperature.

EEV regulates IDU coil superheat
(large pressure drop)

Cold Vapor 40˚F to 55˚F
102 to 131 psig

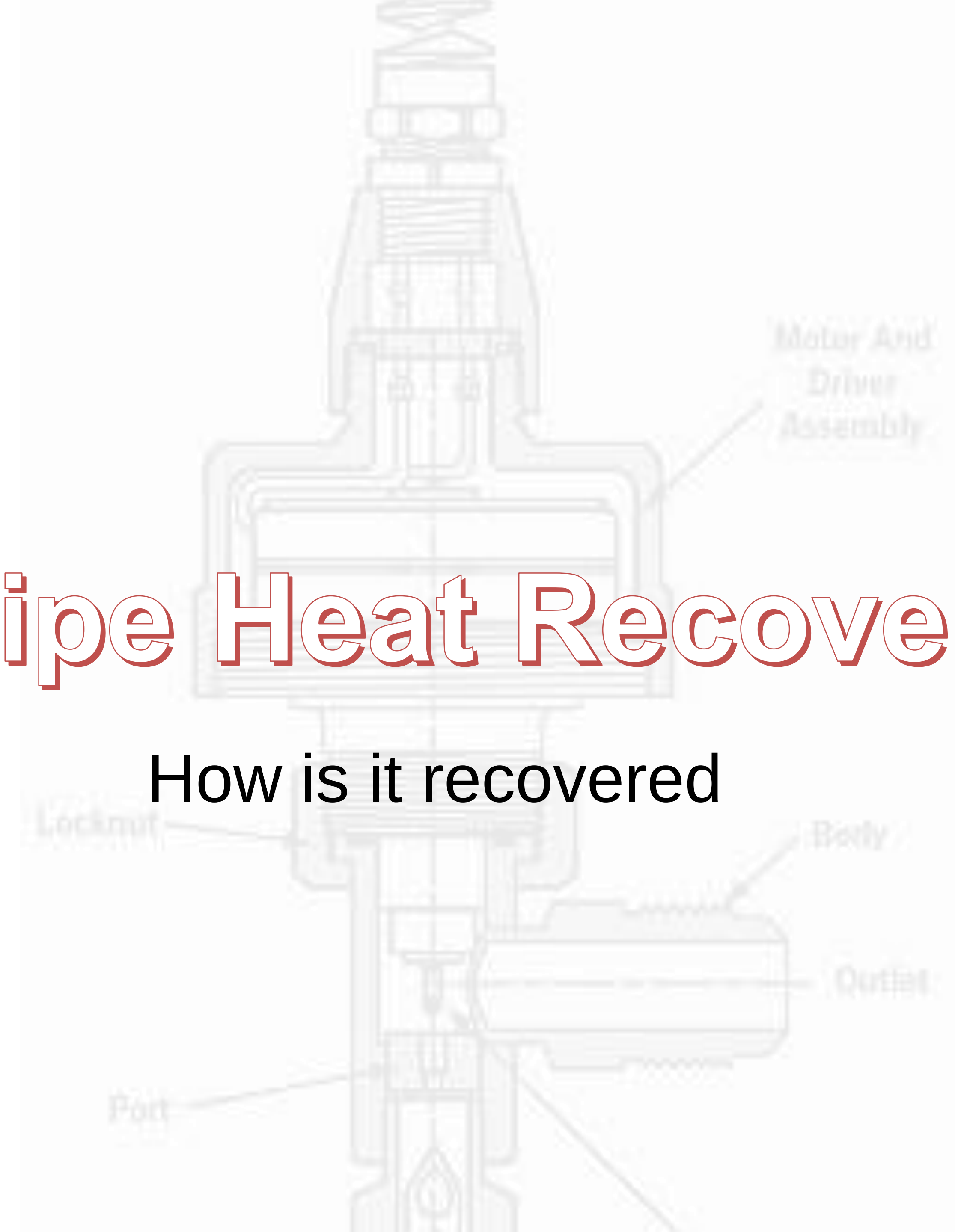


Warm Liquid 77˚F to 104˚F
305 to 435 psig

ODU coil is the
refrigerant Condenser

3-Pipe Heat Recovery

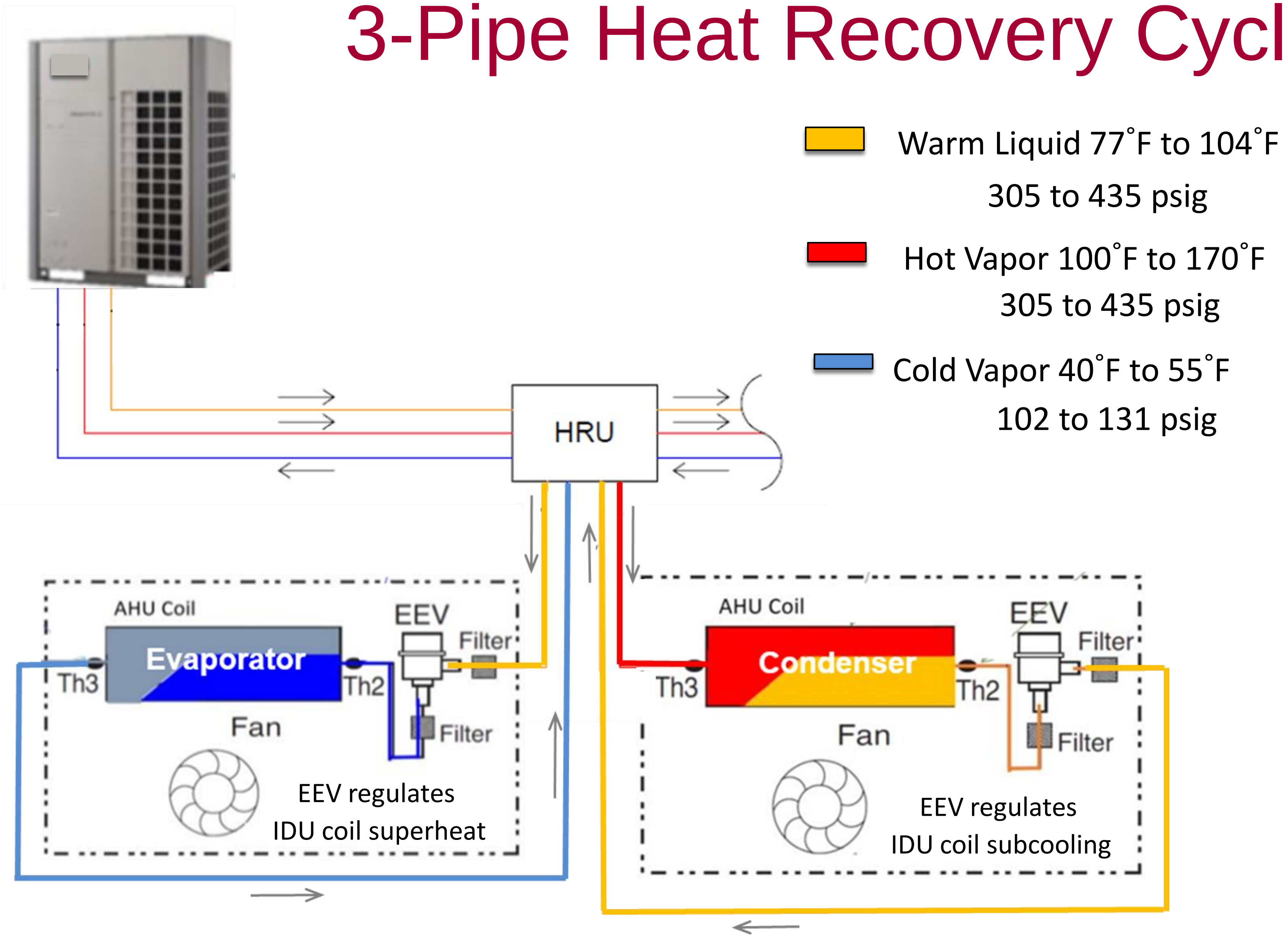
How is it recovered



3-Pipe Heat Recovery Cycle

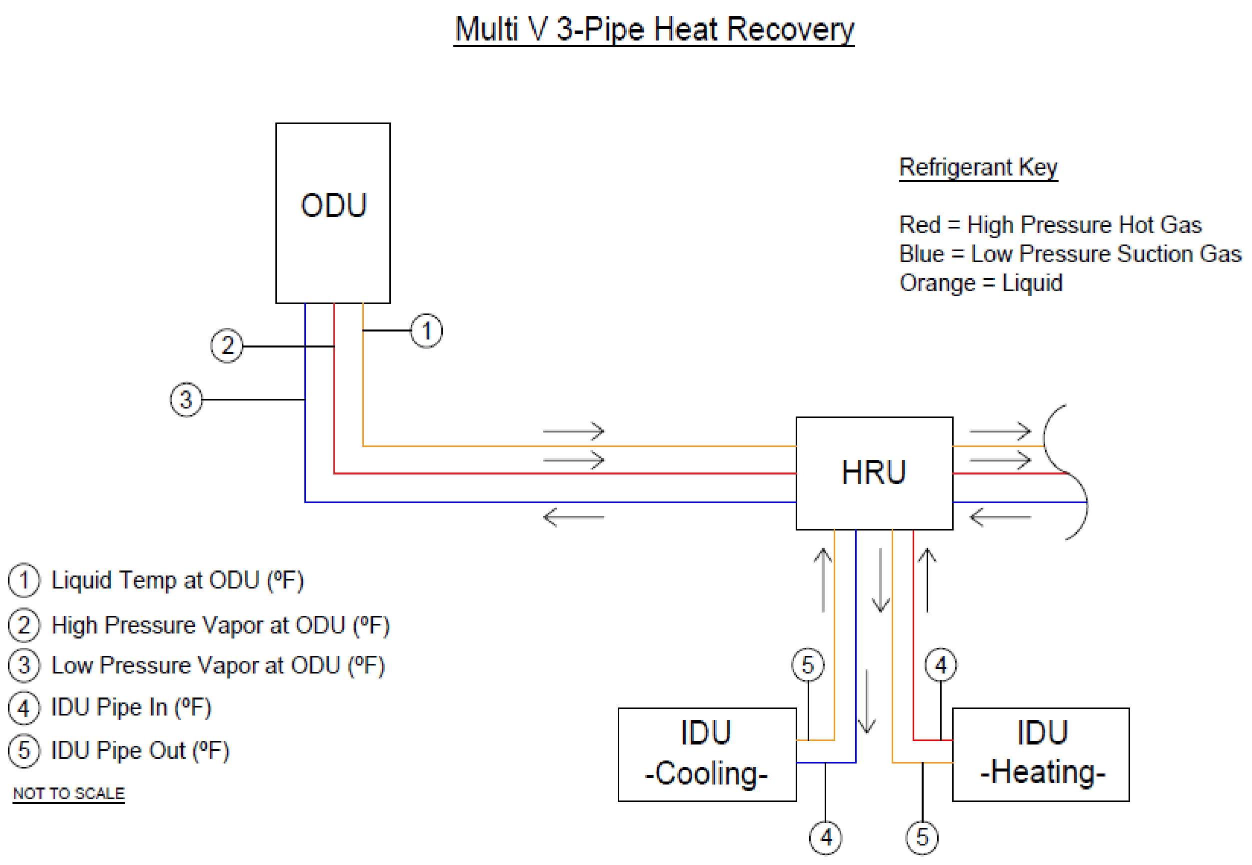
Flow Dynamics:

- High pressure, hot vapor always flows from ODU to IDUs and either direction between HRUs.
- Low pressure, cold vapor always flows from IDUs to ODU.
- High pressure, liquid could be flowing either direction between HRUs and IDUs to ODU.
- If ODU reversing valve is in cooling position, flow is from ODU to IDU. When valve is in heating position, flow is from IDU to ODU.
- ODU coil could be functioning as a condenser or an evaporator during simultaneous heating and cooling operation depending on reversing valve position



VRF Operating Conditions

Pipe Insulation Engineering



Normal sustained operating temperature range

P1 = 77˚F to 104˚F

P2 = 100˚F to 170˚F

P3 = 40˚F to 55˚F

P4 vapor = 40˚F to 160˚F

P5 liquid = 77˚F to 104˚F

Normal sustained operating pressure (psig)

P1 = 305 to 435

P2 = 305 to 435

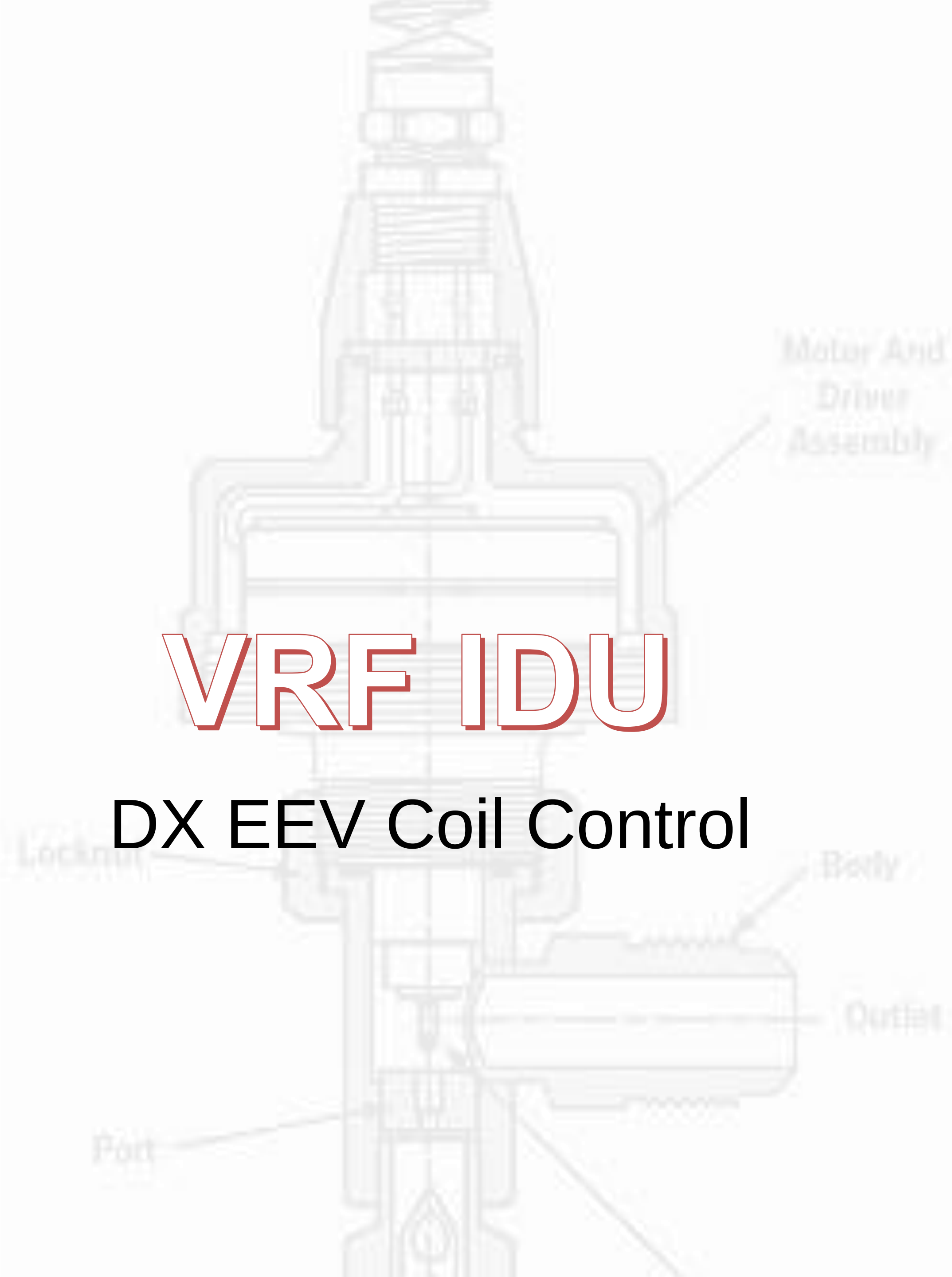
P3 = 102 to 131

P4 vapor = 102 to 435

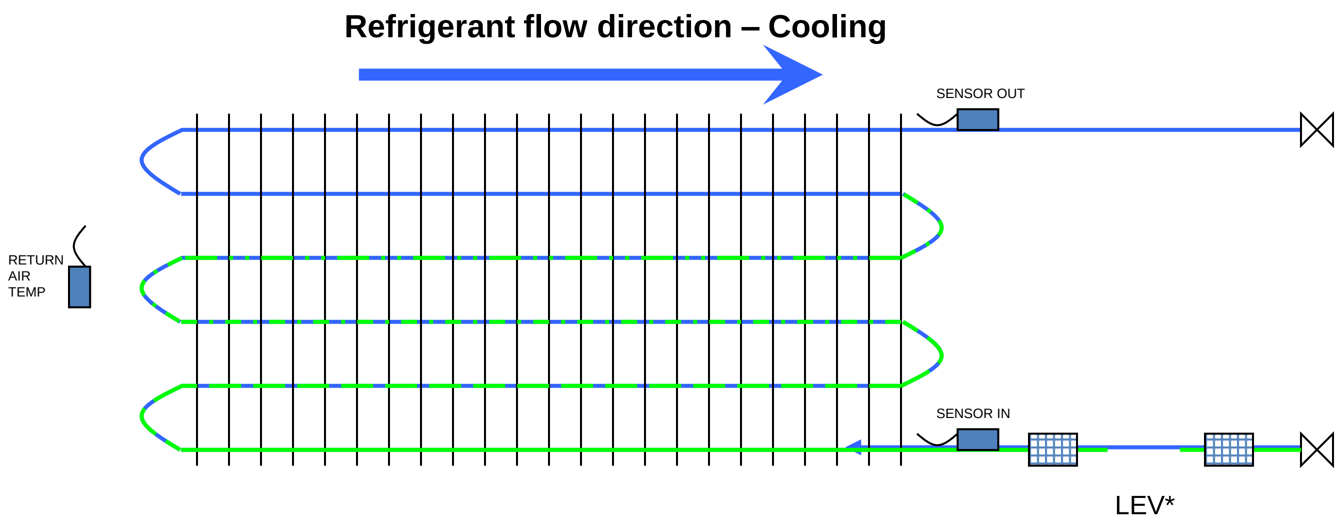
P5 liquid = 305 to 435

VRF IDU

DX EEV Coil Control



Indoor EEV (Cooling)

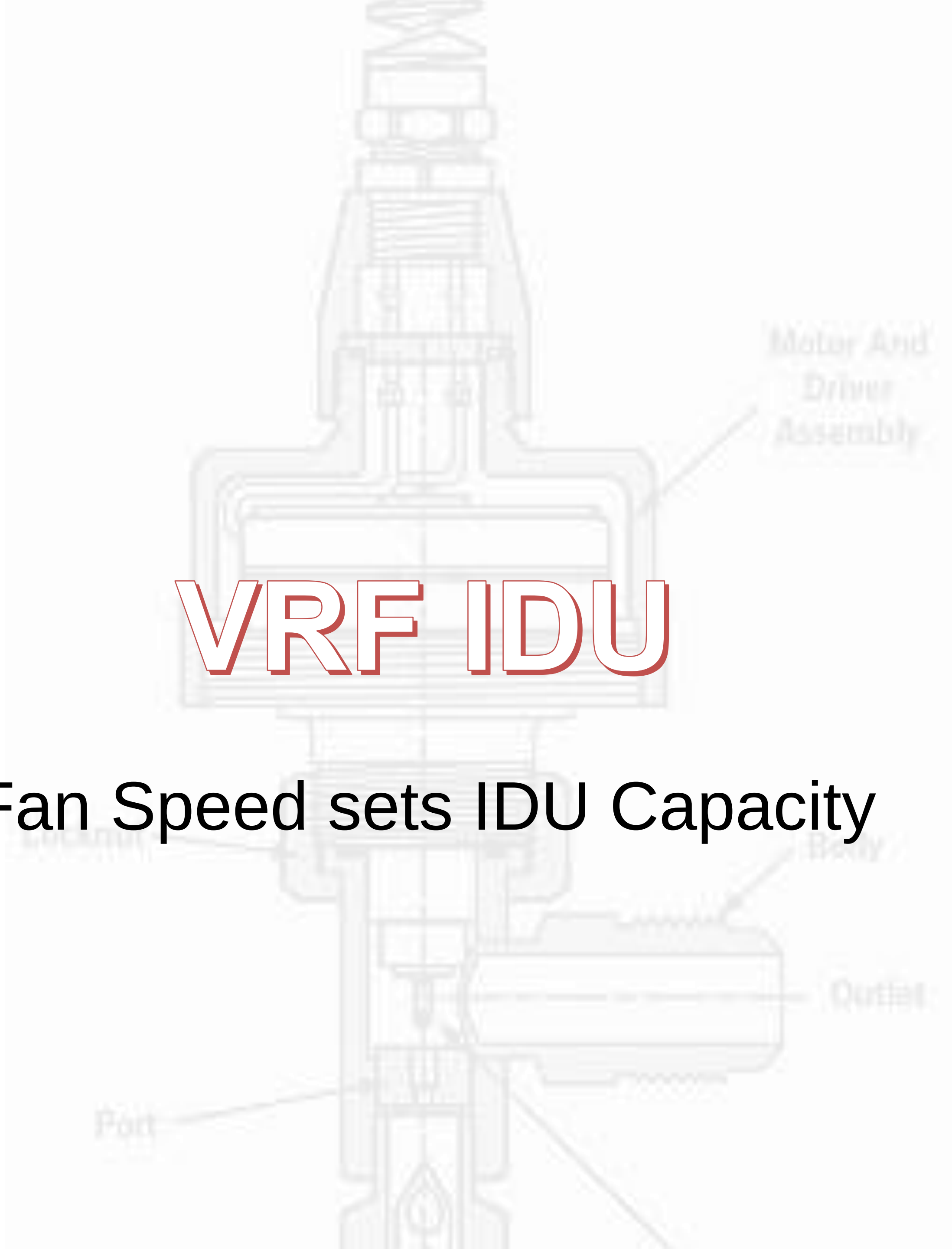


The EEV pulses to maintain a constant superheat across the Indoor coil. Depending on model of the Indoor units connected and ambient conditions, the superheat target may change. Factory default target value is 7.9˚F.

Target value can be adjusted on a IDU by IDU basis at commissioning to achieve desired leaving air temperature.

VRF IDU

Fan Speed sets IDU Capacity



IDU Fan Control

Airflow Rate Determines Sensible Capacity

Maintain leaving air temperature well below dew-point

- Use the sensible heat equation to estimate capacity
- IDU Coil Cap (sens) = 1.085 * CFM * ΔT (°F)

Note: the constant 1.085 assumes sea level air density at ~ 60˚F

What capacity will the IDU produce at a modified airflow rate?

1. Use published capacity and airflow to calculate coil Delta-T
   - *Key: Delta-T won't change as airflow rate changes

2. Use Delta T calculated and the new airflow rate, calculate the IDU sensible capacity using the same equation.

**Note: Latent capacity remains nearly constant as long as coil remains wet, that is leaving air temperature comfortably below room dew-point.*

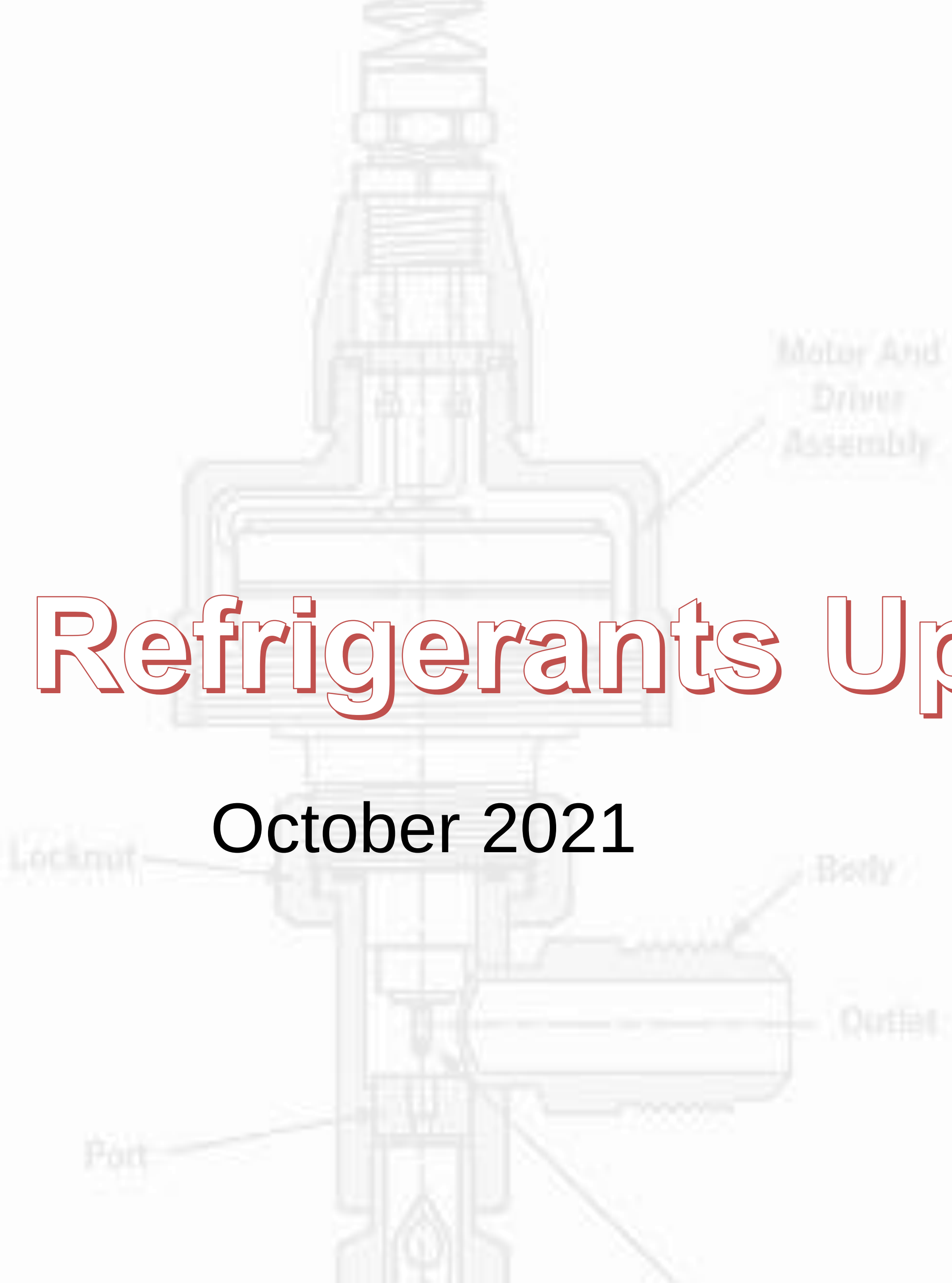
Summary Review | VRF IDU Coil/Fan Control

Cooling Mode Operation assuming LAT is below dewpoint

- Typical VRF cooling IDU LAT = 52°F
- At 80°F DB /67°F WB (RH=50%), dewpoint ~ 58°F
- EEV position changes to hold target coil superheat (SH) at 7.9°F
- Coil LAT held steady as airflow rate changes.
- Airflow drops, EEV orifice size reduced to reduce refrigerant flow, maintain (SH), and hold LAT constant.
- Opposite action also true.
- IDU coil sensible capacity = 1.085 * CFM * ΔT (°F)
- CFM changes = cooling/heating capacity changes.

Future Refrigerants Update

October 2021

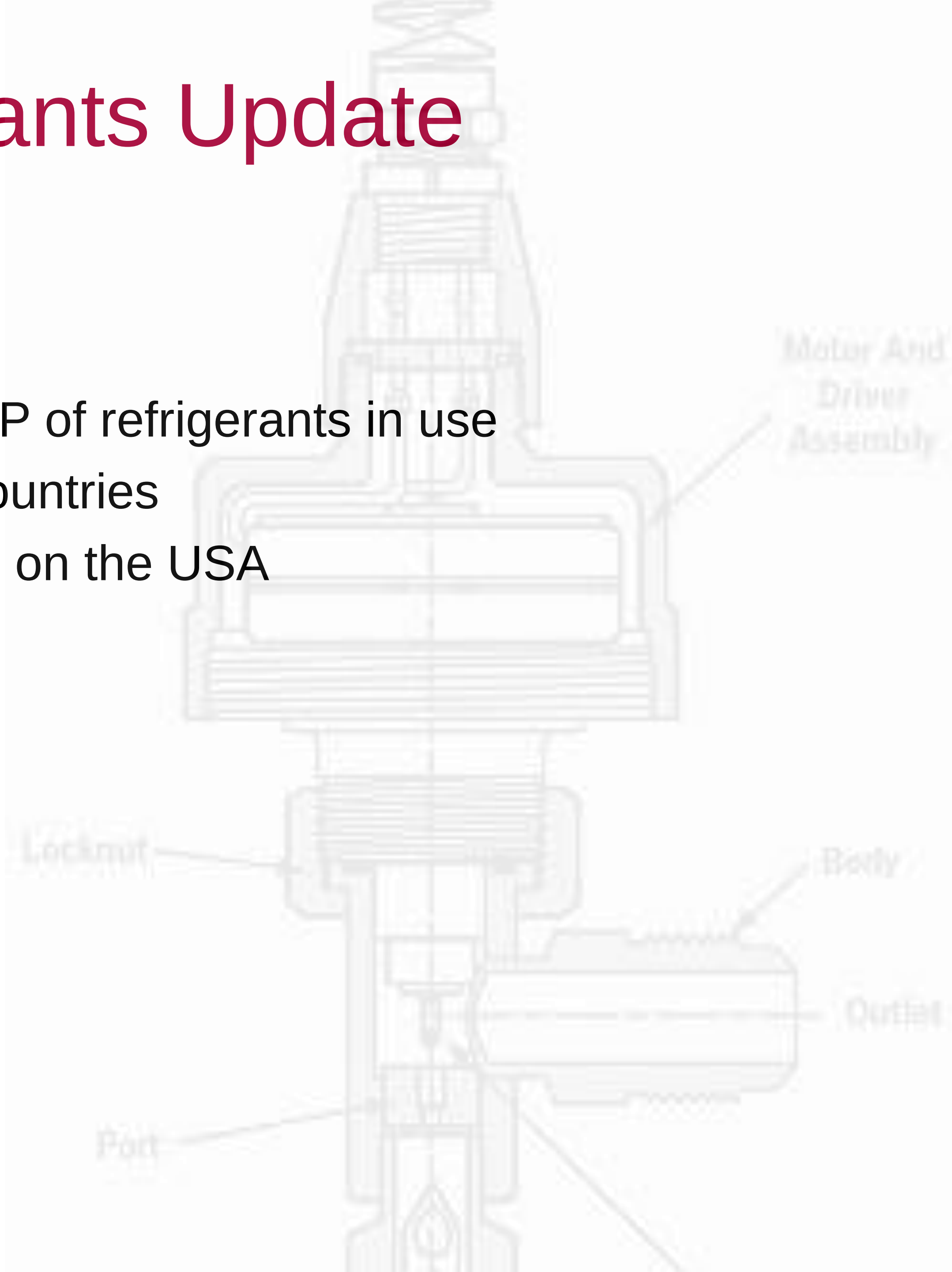


Future Refrigerants Update

Global

Kigali Agreement

- Agenda: Reduce GWP of refrigerants in use
- Multiple developed countries
- Not ratified or binding on the USA



Future Refrigerants Update

USA - Federal

1. DOE (Department of Energy)
   - Policy never allow “industry backsliding” (lowering efficiency)
   - Note: In general - low GWP refrigerants provide higher energy efficiency than R410A
   - Made no movement toward more stringent regulation since 2016. Review/update policy every 6 years.
   - AHRI 1230 changes | Goal make AHRI 1230 more real world. Controls verification process added to test. Effective 2024.
   - DOE Appendix M1 Standard | test procedure for < 65k cap effective Jan 1 2023 (ARI 210-240 is same)
2. EPA (Environmental Protection Agency)
   - SNAP documents
     - ➢ Agenda: Define refrigerant alternatives
     - ➢ No new documents since 2012
   - 608 Certification Program
     - ➢ Agenda: Licenses mechanical installers to work with refrigerants
3. US Congress
   - Writes Federal Law
   - AIM Legislation Bill 2754 in process
     - ➢ Balanced approach: Efficiency, global warming, ozone depletion
     - ➢ May 2021 - American Innovation and Manufacturing (AIM) Act of 2020. The AIM Act directs EPA to sharply reduce production and consumption of HFCs in the United States by 85% over the next 15 years.
     - ➢ AHRI public link > https://www.ahrinet.org/policy/call-to-action-center

Future Refrigerants Update

States & Local Authority

1. CARB (California Air Resource Board)
   - Mandate refrigerants must have a GWP <750 by Jan 2023
     - AC/HP <65k cooling - effective Jan 1, 2025
     - VRF > 65k cooling effective Jan 1, 2026
   - Currently 16 states are aligned with CARB
   - Policy conflicts with Federal AIM 2020 legislation
   - Violating federal pre-emption law. Lawsuits probable.
2. CEC (California Energy Commission
   - Agenda: Write the building code that’s legally enacted before 2026 deadline
   - Currently no alternative refrigerants are in code
3. California Fire Marshall
   - Regulates the use of refrigerants
   - Have not accepted refrigerants with an A2L rating, possibilities are….
     - R32 [charge of 6 lbs]
     - R454B, R454C, possibilities to replace R410a,
     - R1234ze [automotive]
4. Legal
   - Pacific Gas Electric (PGE) and S, California Edison (SCE) lawsuits around wildfires
5. Insurance industry risk
   - Rates and risk assessment

Future Refrigerants Update

HVAC Industry

AHRI

- Supports Kigali Agreement
- Aligned with federal AIM 2020 legislation
- AHRI Webinar link: https://www.ahrinet.org/news-events/webinars

Future Refrigerants Update

Once Alternative Refrigerant is accepted

1. SNAP
   - Publish definition (1 year)
2. Refrigerant Manufacturer
   - Write MSDS documents
3. ASHRAE
   - Update Standards 15, 34 and 90.1
     - Create refrigerant concentration limits (RCL) tables
     - Define safety categories based on refrigerant system charge
     - Update 90.1 minimum efficiency tables for VRF systems
4. UL
   - Update safety code for manufacturing of HVAC equipment (60335-2-40)
   - Define requirements for refrigerant detection sensors and emergency exhaust ventilation
5. NFPA
   - Write code concerning use of refrigerant
6. HVAC equipment manufacturers
   - Develop new product (2+1/2 years)
   - OSHPD Seismic Certification testing (1+1/2 years)
7. EPA
   - 608 technician certification program developed (1 year)
   - Train technicians and installers
   - Note: A bi-product of combustion of low GWP A2L refrigerants is acid which requires the use of personal protective equipment (PPE)

Future Refrigerants Summary

VRF Manufacturers Are Ready

- This decision making and code implementations process moves SLOWLY
- The future refrigerant choice for use in VRF is currently unknown
- All viable alternatives have been tested in R&D
- A solution is ready