



NATE (Heat Pump)

Instructor
Technical Service Trainer

Monday, July 20, 2026



DISCLAIMER

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This training seminar is dedicated to Bill “The Professor” Doster for the many years he devoted to passing his knowledge to the HVAC industry and beyond.

Bill “The Professor” Doster
January 3, 1943 – May 23, 2026



SERVICE TECH APP

Carrier Service Technician

- Carrier Google Play



- Carrier App Store



Bryant® Service Technician

- Bryant Google Play



- Bryant App Store



RC Mobile Technician

- RC Google Play



- RC App Store



CAFFEINE & COILS PODCAST



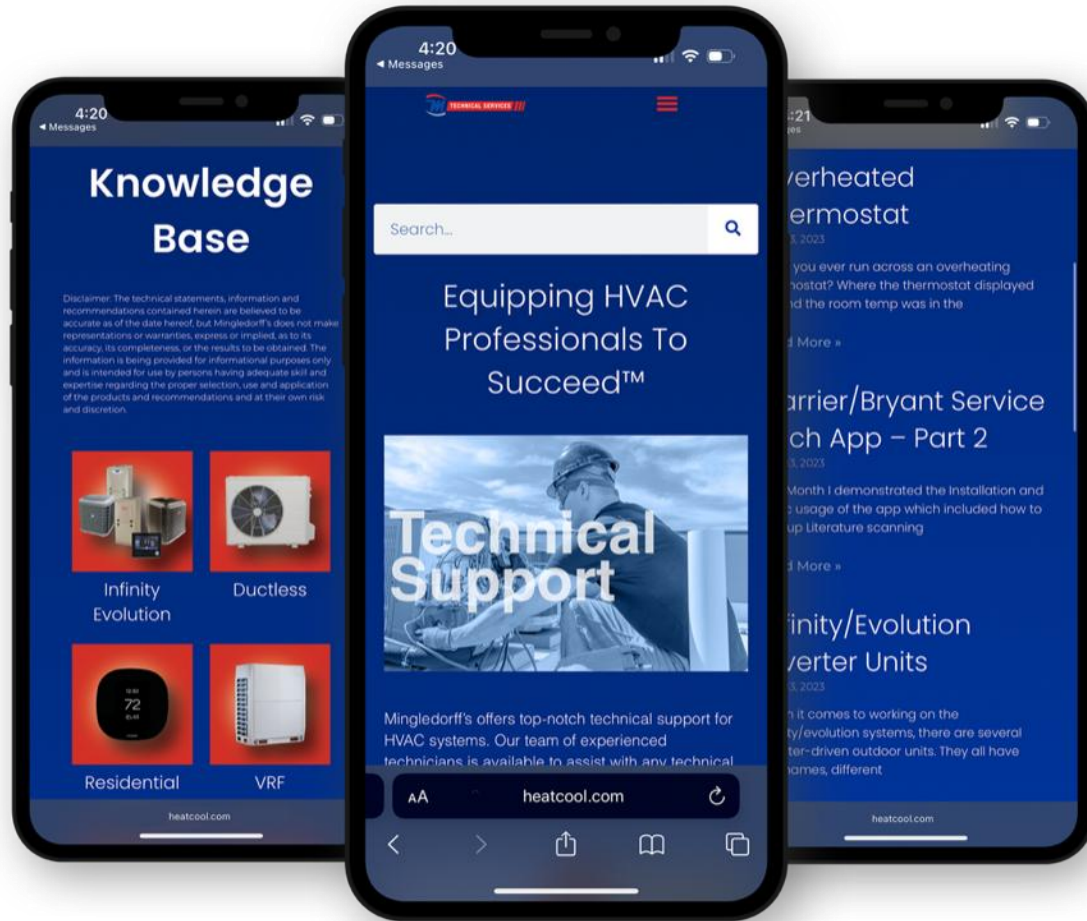
- Mingledorff's new podcast featuring Jenny Brown and Deanna Lassiter
- This podcast is your go-to source for valuable insights, expert interviews, and cutting-edge industry trends.



LIKE US ON FACEBOOK



An improved digital experience for those in the field



HEATCOOL.COM



INTRODUCING MINGLEDORFF'S NEWEST TECHNICAL AND WARRANTY RESOURCE! EVERYTHING TECHNICAL AND WARRANTY RELATED UNDER A SIMPLE URL – HEATCOOL.COM.

- **TECHNICAL SUPPORT**
 - Product Knowledgebase
 - Access to Factory Manuals
 - Technical Services Contacts
- **WARRANTY SUPPORT**
 - Helpful Links & Resources
 - Online Warranty Tips
 - Warranty Experts Contacts
- **TECH TIPS – MONTHLY NEWS ARTICLES**
- **TRAINING CALENDAR AND ONLINE LEARNING**
- **MANAGED BY TECHS FOR TECHS**



TECH TIPS AND TRAINING INFORMATION



Ecobee Setup

Ecobee thermostats provide multi-speed fan control to work with 2/4-pipe fan coil units with/without pipe sensors (24V systems only) and multi-speed PTAC units. These settings are accessed through the "I'm a Pro" setup flow. Many of the same first-run configuration steps apply as described in the "I'm a homeowner" section, however this section will callout and describe the key screens and settings.

First step is to determine the correct configuration for the application the ecobee is going to be controlling.



Servicing Carrier VRF Part 2

As service and installation technicians we need to be able to figure out problems or ensure a system is running as it should. Are VRF systems serviced like a residential split system? The simple answer is no. VRF contains many more moving parts and electronics depending on what you're looking at.

Last month we covered how to get the software and your service computer hooked to a system. If you need a refresher or missed that portion you can find it here: [\(PLEASE INSERT LINK TO ARTICLE HERE\)](#). When first opening STT (Service Technical Tool) it can be a little confusing how to get started and figure out what exactly you're looking at or looking for. Today we will be exploring this software.

Monthly **REAL** “how too technical tips.”
Upcoming Training Seminars & link to registration of those seminars.
Consistent & accurate technical information.
View articles that have been archived.
If you are not receiving the newsletter, contact Erin at: Erin.Turner@mingleodrffs.com

Spring Service Update

MingleDorff's Spring Service Update class focuses on the latest techniques and best practices for maintaining HVAC systems during the spring season. The class covers a range of topics related to seasonal system checks, preventative maintenance, and troubleshooting common issues that arise.

- Earn 4 FAD distributor hours, 4 NATE hours and 4 State CEU's
- Topics to be covered:
 - A/C Refrigerant
 - IntelliSense
 - Replacement VFD Update
 - SystemW
 - Quality Update

REGISTER NOW

or click to register

*Vacuum pump clinic available

Location	Date / Time
MingleDorff's - Atlanta 1402 Jackson Dr. Atlanta, GA 30318	3/9/ 8am-12pm
MingleDorff's - Newnan 20 Enterprise Ct. Newnan, GA 30285	3/11/ 5pm-9pm
MingleDorff's - Norcross 6675 Jones Mill Ct Peachtree Corners, GA 30092	3/12/ 5pm-9pm
MEC - Braselton 5455 Dutton Ct Braselton, GA 30017	3/13/ 10am-2pm
MingleDorff's - Forest Park 2138 Kennedy Rd, Suite D Forest Park, GA 30297	3/13/ 5pm-9pm
LOCA - Live Oak Room 2718 Jamming Creek Road Lawrenceville, GA 30045	3/14/ 5pm-9pm
MingleDorff's - Marietta 6665-D Trail Ct. Marietta, GA 30063	3/18/ 5pm-9pm
VFW - Conyers 1422 VFW Drive SW Conyers, GA 30212	3/19/ 5pm-9pm
Gwinnett Tech - Banquet Hall Rm 1309 1100 Sugarloaf Parkway Lawrenceville, GA 30043	3/20/ 5pm-9pm
Comfort Inn - Blue Ridge 63 Blue Ridge Overlook Blue Ridge, GA 30715	3/20/ 5pm-9pm
GNTO - Building H, Room 101 1 Maurice Outberson Dr. SW Rome, GA 30161	3/25/ 5pm-9pm
MingleDorff's - Lithia Springs 302 Thompson Rd Suite 106 Lithia Springs, GA 30122	3/26/ 5pm-9pm
Athens Technical College Building T Rm 108 605 1st St. Athens, GA 30601	3/28/ 5pm-9pm

Upcoming Training Information

EPA 608 Online

Become EPA 608 certified online with our EPA 608 Review & Test sessions via Zoom!

- Each technician must have a computer with a camera and the exam will be recorded
- Only one student per computer is allowed
- The technician must be in view of the camera at all times during the exam
- Due to online proctoring regulations, space is extremely limited. When you register, you will receive instructions on how to get to the study guide and practice test.

Register Now



OBSERVE ALL SAFETY MEASURES



- Remove Jewelry Before Servicing



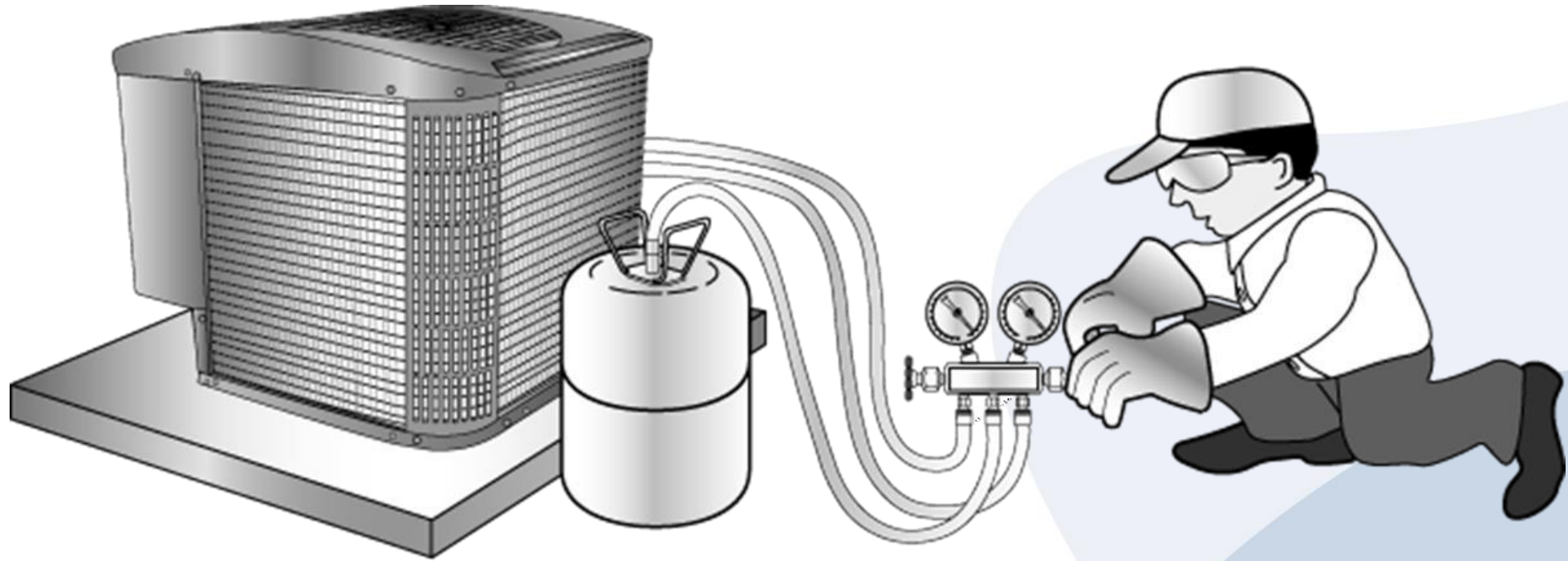
Lock out/tag out equipment disconnect switch



Gas pipe leak testing



SAFETY REVIEW



Use Safety Equipment

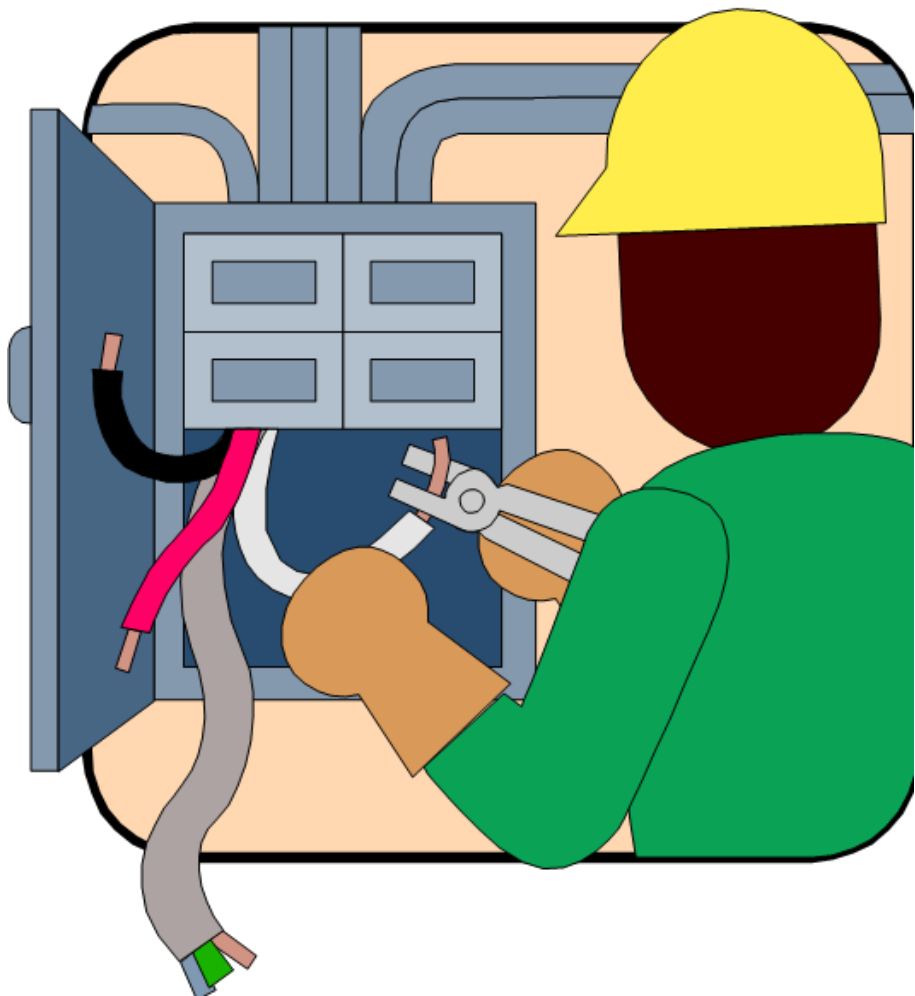


SAFETY REVIEW



Lift and Move Correctly

- High voltage is always dangerous.
- Even 40 volts can be lethal if skin is wet or damaged.



- Do not wear rings or jewelry when working on electrical circuits.
- Never use screwdrivers or other conductive tools in an electrical panel when the power is on.



GENERAL SAFETY

- *Use two hands to grasp the ladder*
- *Observe the type of roof material you may walk on. Slate roofs are extremely slippery at all times*
- **Observe safety rating on each ladder**
- **Extend ladder past roof line (36 in.)**
- **Never stand on top of A-frame ladder**
- *Seat belts should be worn at all times*
- *Never use oxygen to pressurize a system to check for leaks in a refrigeration system*
- *Never start a hermetic compressor while in a vacuum*



EPA REGULATIONS

Federal regulation requires anyone servicing, repairing or disposing of any equipment containing a controlled refrigerant to have in his/her possession a card certifying that he/she has obtained the proper level of certification for the work he/she is performing.

THIS MEANS YOU CANNOT WORK UNDER ANOTHER PERSON'S CERTIFICATION.



EPA REGULATIONS

EPA regulations require that hoses be equipped with low-loss fittings.

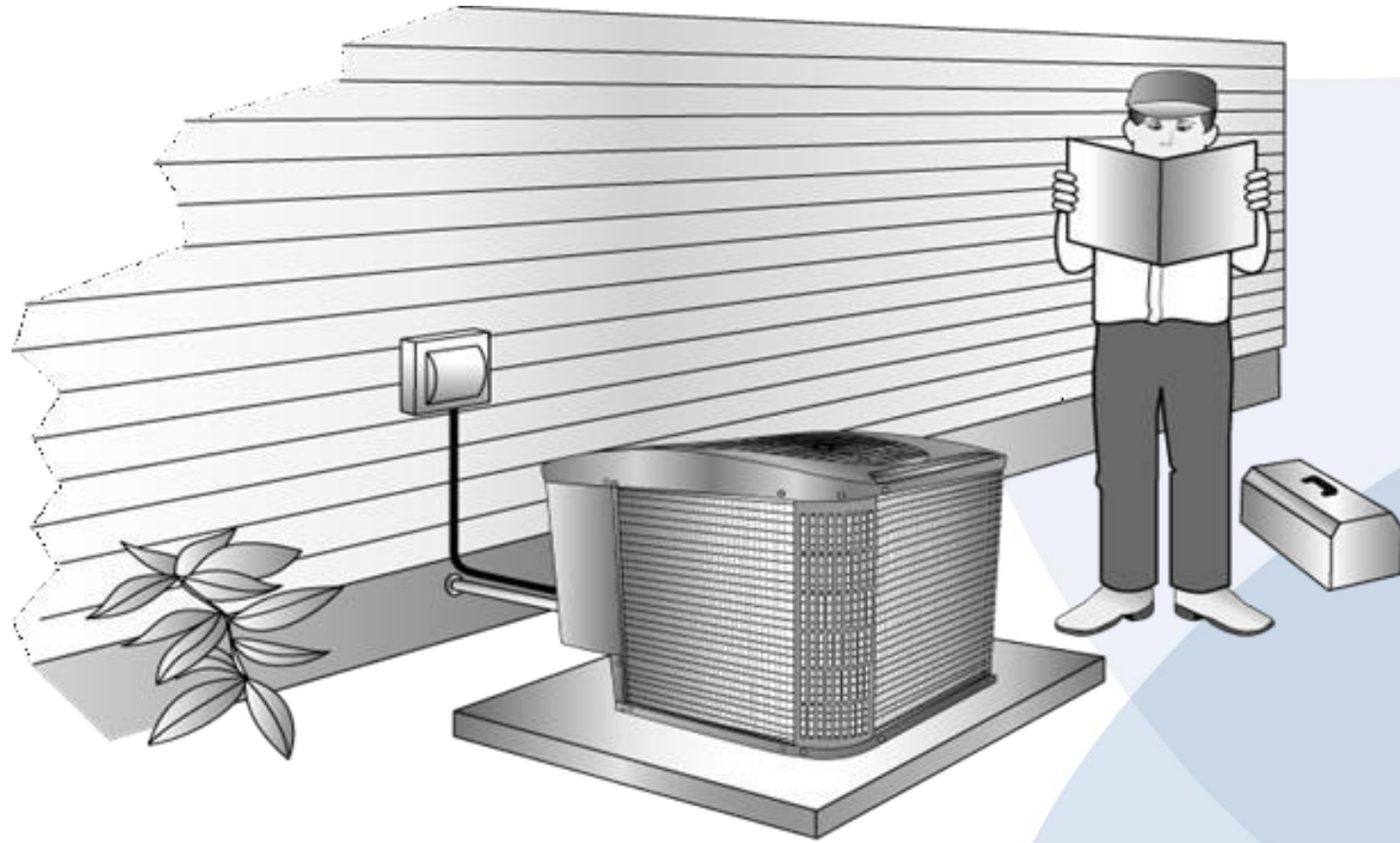




EPA REGULATIONS

- Require a red color marking on all process tubes and other pipes through which a flammable refrigerant passes and at the service connection.
- The color marking must extend one inch in both directions from service locations.

Wingledorff's FOLLOW SERVICE, INSTALLATION AND START-UP INSTRUCTIONS



- High voltage is always dangerous.
- Even 40 volts can be lethal if skin is wet or damaged.

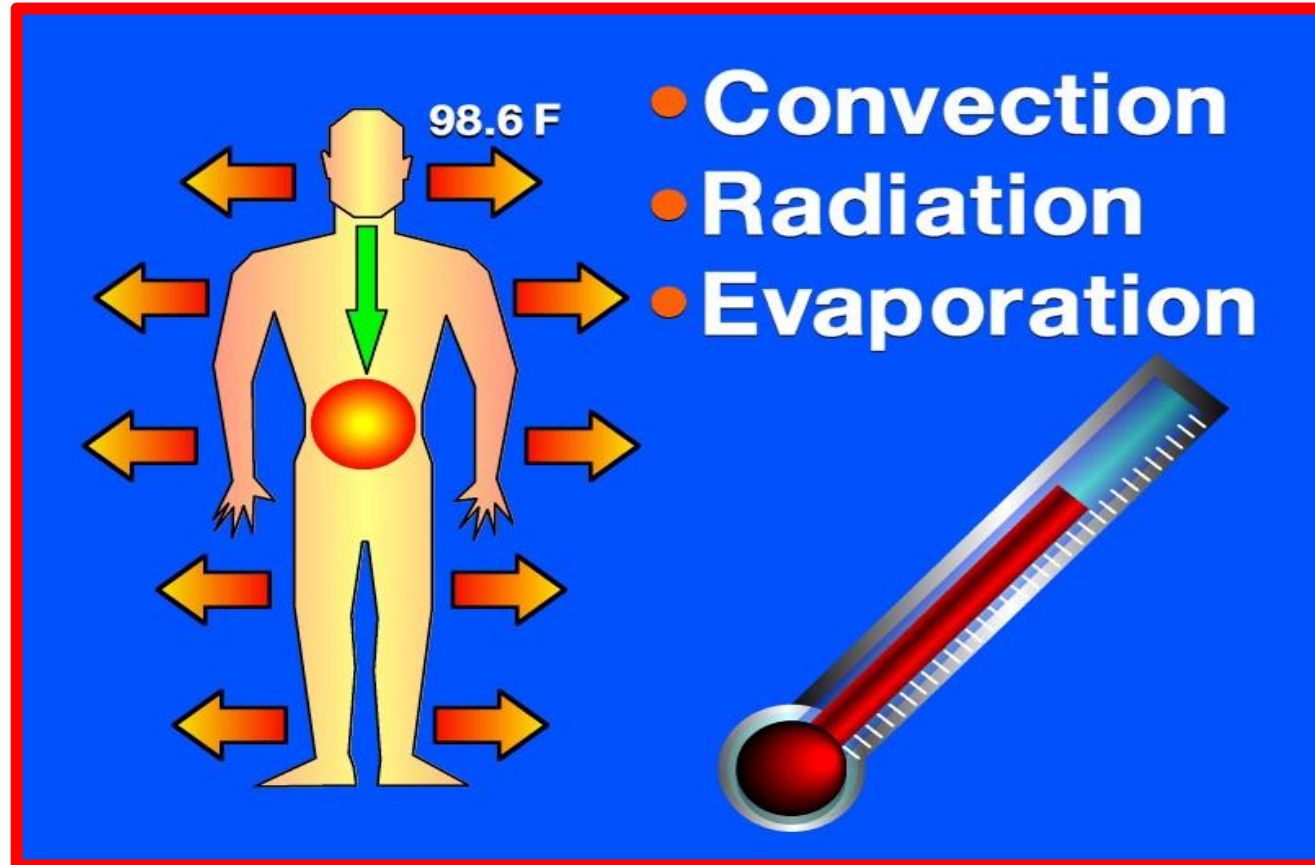
AIR CONDITIONING

“The process of treating air so as to control simultaneously its temperature, humidity, cleanliness and distribution to meet the requirements of the conditioned space.”

-ASHRAE



**AIR CONDITIONING IS USED TO
IMPROVE AN INDUSTRIAL PROCESS
OR TO MAINTAIN HUMAN COMFORT**



**THE BODY GIVES OFF EXCESS HEAT IN
THREE WAYS TO MAINTAIN NORMAL BODY
COMFORT**

TEMPERATURE

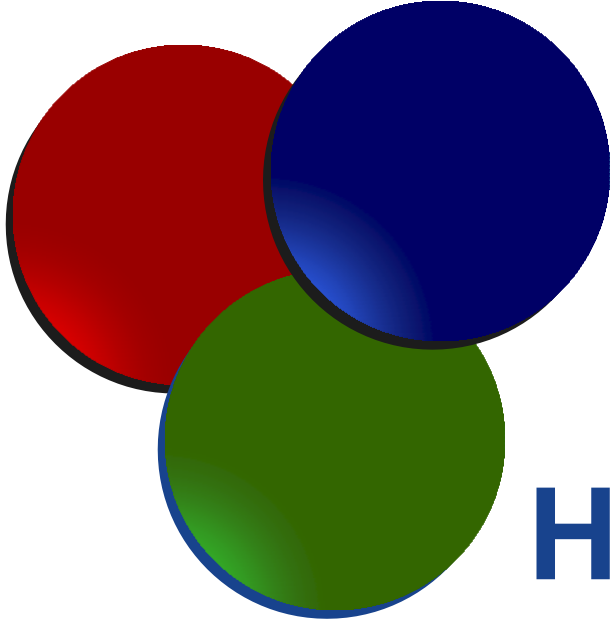
- Heat always flows from higher to lower temperature.
- The greater the temperature difference, the faster the flow of heat.
- The higher the air temperature, the slower the rate of heat transfer.
- Lower surrounding surface temperature, increases the cooling effect the body feels through radiation.
- Higher surrounding surface temperature, increases the warming effect by reversing the radiation process.

RELATIVE HUMIDITY

- A measure of how much moisture is in the air and an indication of how much moisture the air can absorb.
- Affects the amount of heat the body can give off through evaporation.
- There is a direct correlation between relative humidity and temperature.
- Cool air has less capacity to hold moisture than does warm air and changing temperature affects humidity.
- The higher the relative humidity, the less able the body is to give off heat through evaporation.

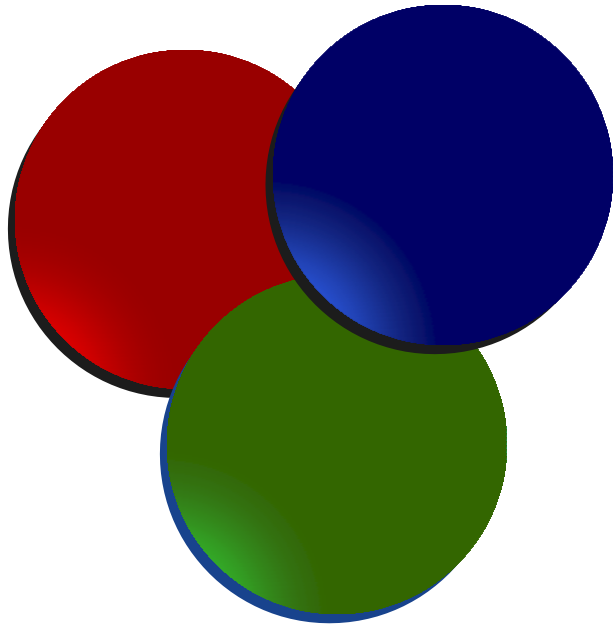
AIR CIRCULATION

- Increases the rate of evaporation.
- Air moving across the body forces away saturated air, allowing moisture to evaporate.
- Decreasing relative humidity through air circulation increases body comfort.
- Air motion speeds up convection by removing warm air close to the body and carrying away the heat.
- Air in motion can also remove heat from surfaces surrounding the body, like walls and ceilings.



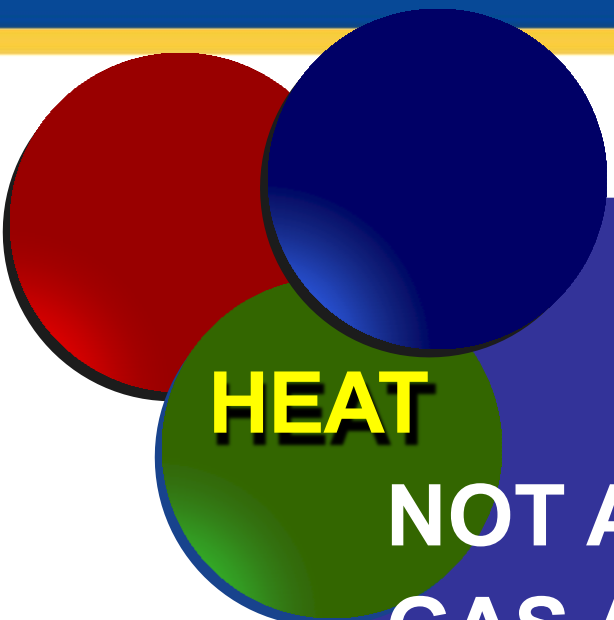
LAW #1

**Heat is a form of energy
and cannot be created
or destroyed**



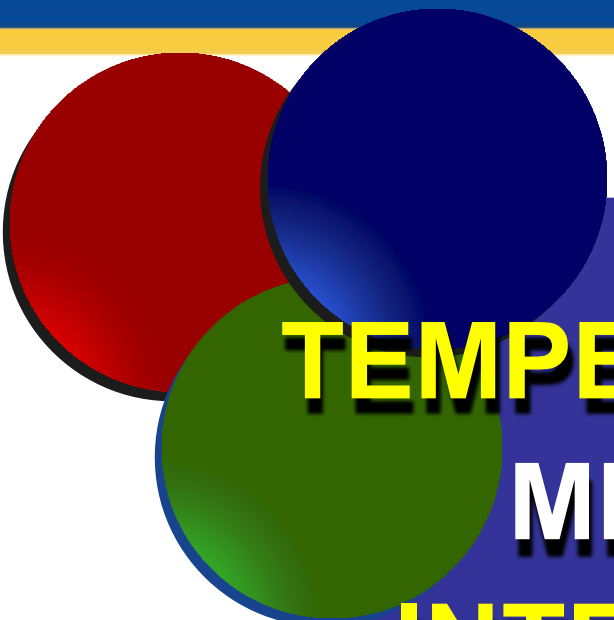
LAW #2

**Heat flows from
hot to cold and
seeks equilibrium**

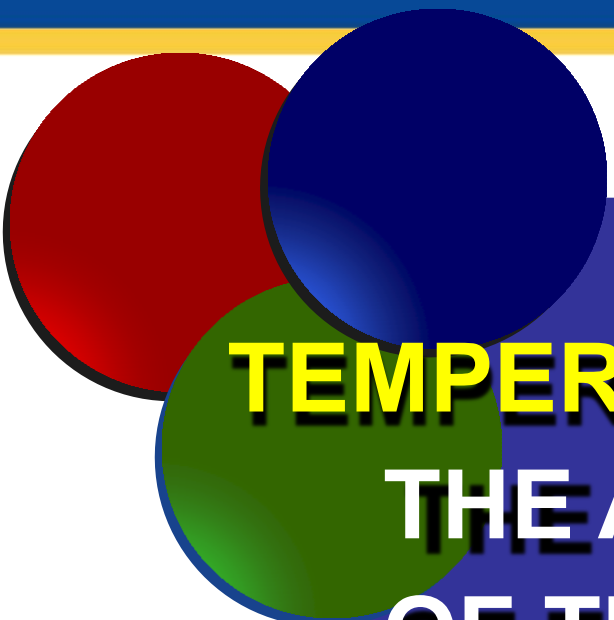


HEAT

IS A FORM OF **ENERGY**,
NOT A SOLID, OR LIQUID OR
GAS AND NOT MEASURABLE
BY WEIGHT OR VOLUME.



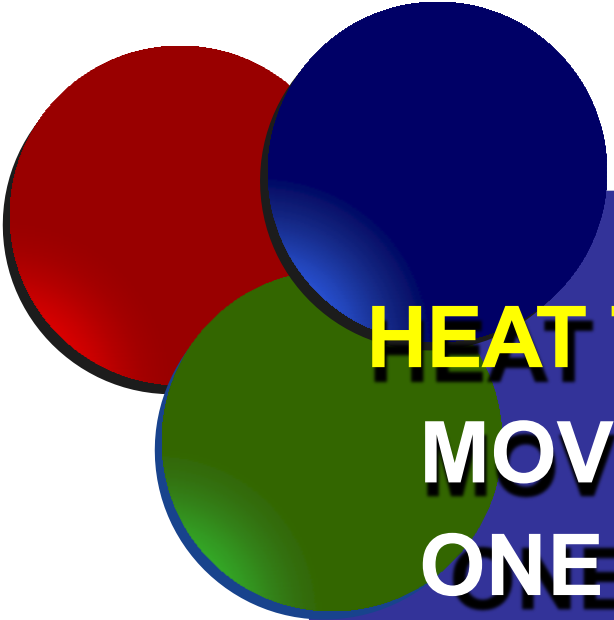
TEMPERATURE IS THE
MEASURE OF THE
INTENSITY OF HEAT IN
A SUBSTANCE.



TEMPERATURE INDICATES
THE AVERAGE **VELOCITY**
OF THE MOLECULES OF A
SUBSTANCE.



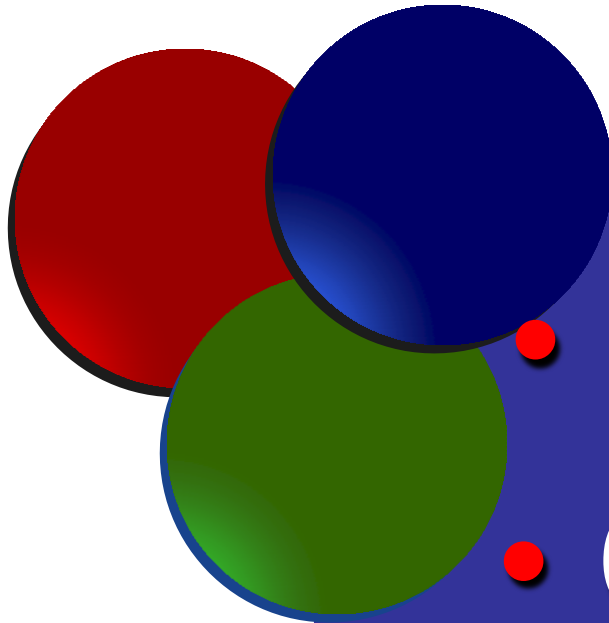
REFRIGERATION IS
COOLING BY THE
REMOVAL OF HEAT.



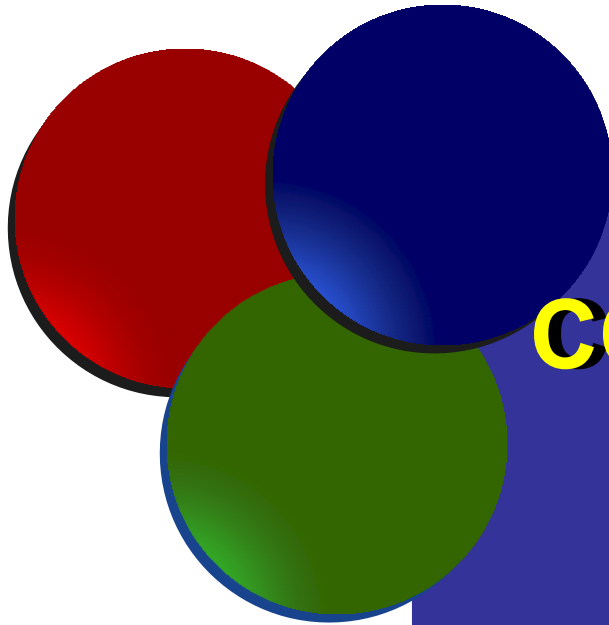
HEAT TRANSFER IS THE
MOVEMENT OF HEAT FROM
ONE PLACE TO ANOTHER,
EITHER WITHIN A SUBSTANCE
OR BETWEEN SUBSTANCES.



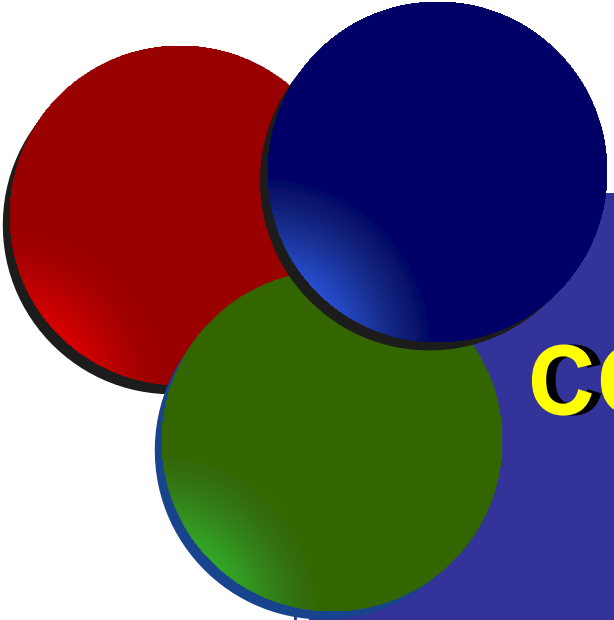
HEAT IS TRANSFERRED IN THREE WAYS:



- **Conduction**
- **Convection**
- **Radiation**



CONDUCTION IS THE
TRANSFER OF HEAT
FROM MOLECULE-TO-
MOLECULE THROUGH A
SUBSTANCE BY CHAIN
COLLISION.

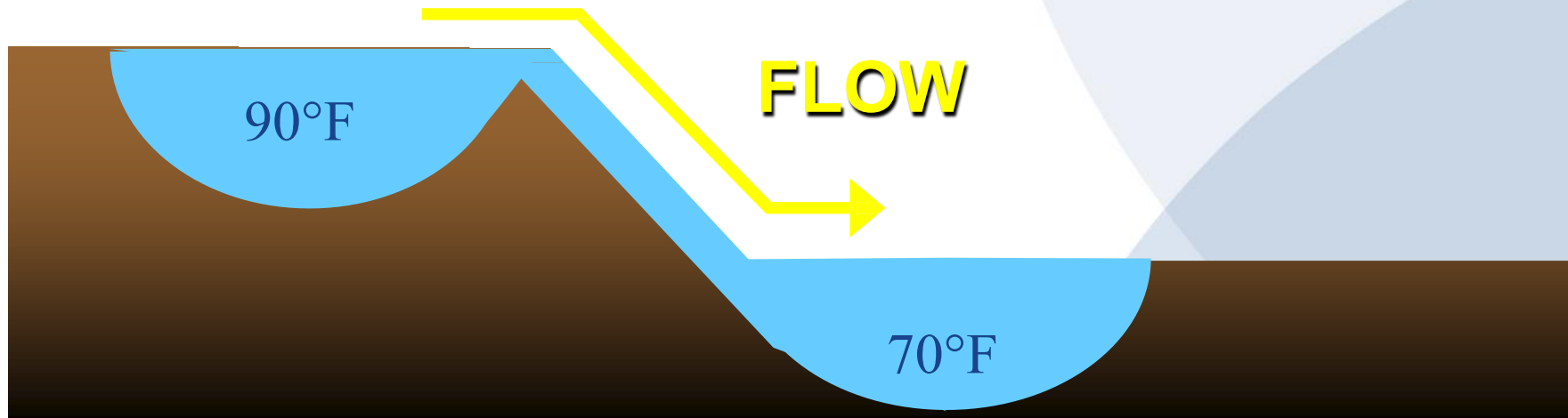
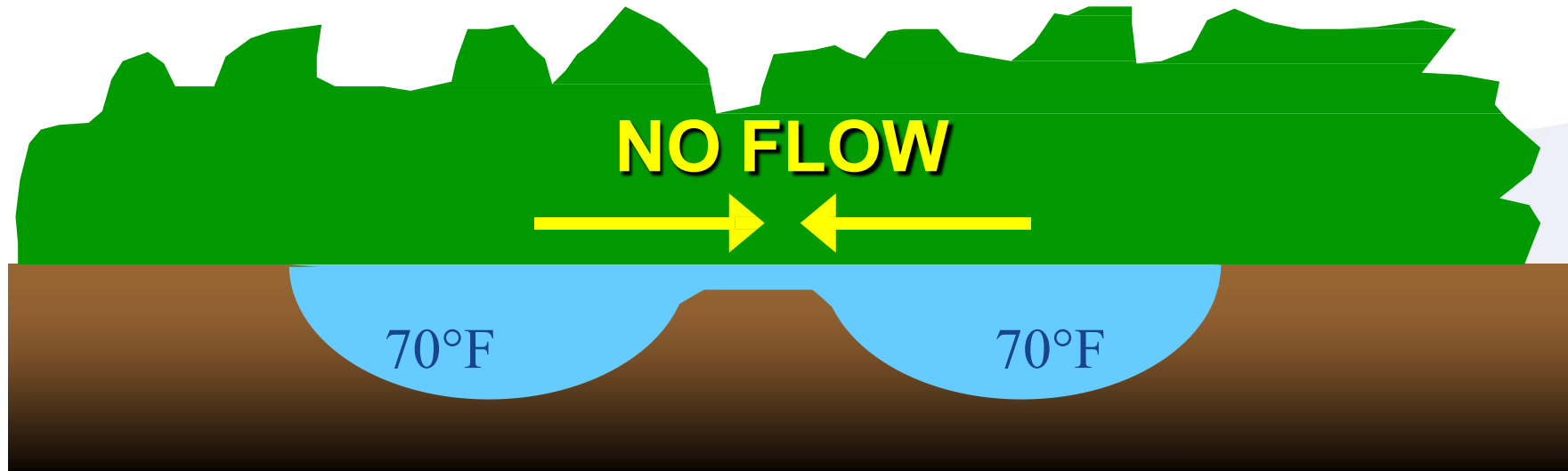


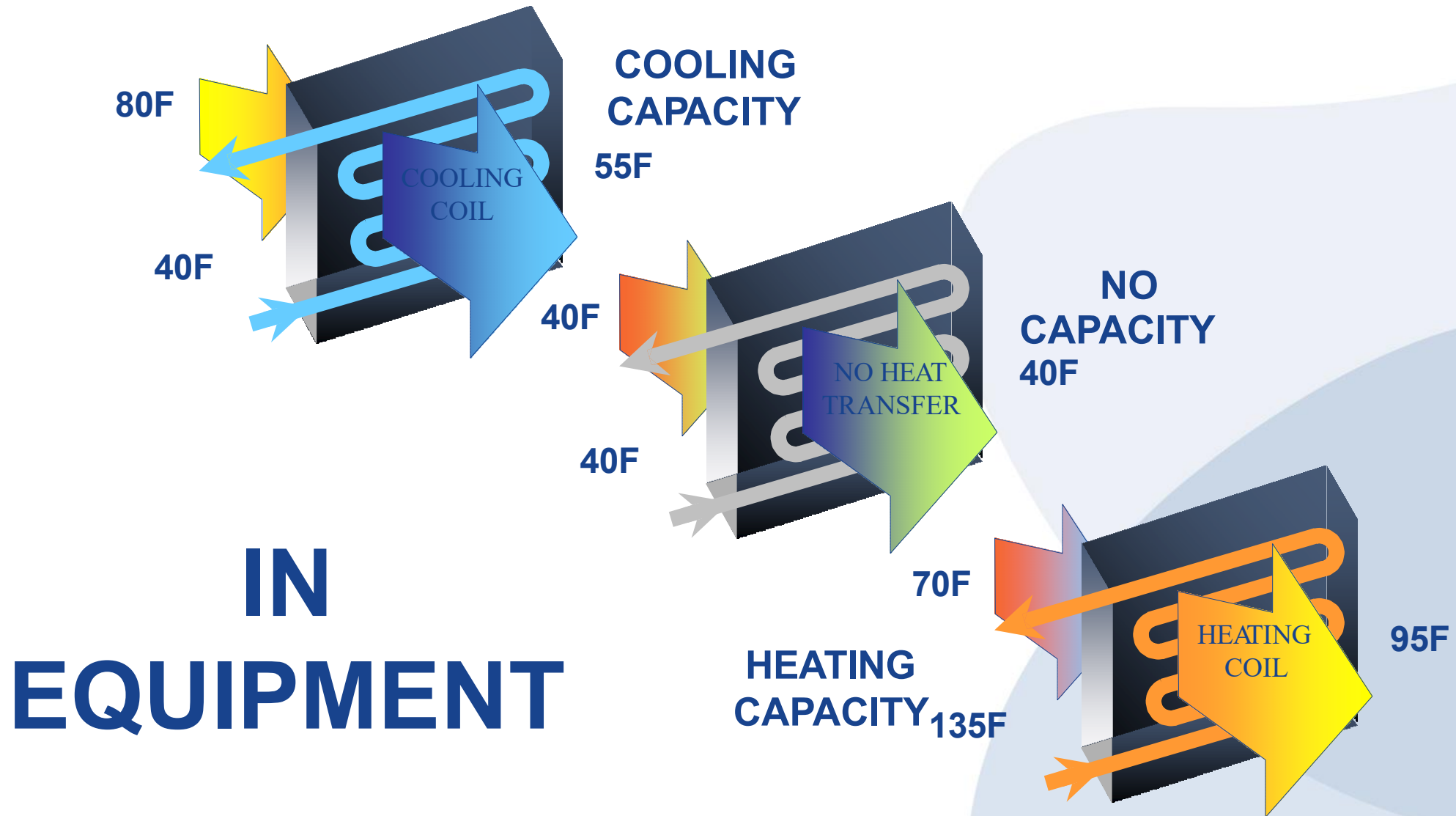
CONVECTION IS HEAT
TRANSFER BY THE
MOVEMENT OF
MOLECULES FROM ONE
PLACE TO ANOTHER.



RADIATION TRANSFERS
HEAT BY PASSING
FROM A SOURCE TO AN
ABSORBENT SURFACE
WITHOUT HEATING THE
SPACE IN BETWEEN.

ENERGY FLOWS “DOWNHILL”

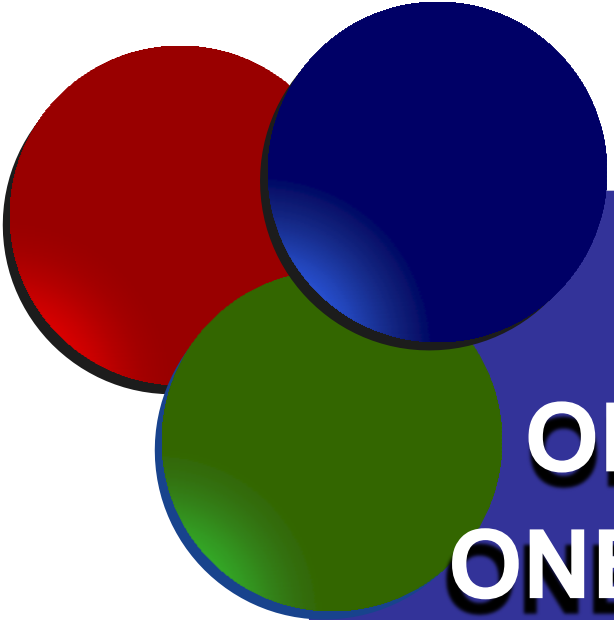






BTU MEASURES:

- **Heat Content**
- **Heat Transfer**
- **Heating and Cooling Capacity**
- **Heating and Cooling Load**
- **Heat Content of Refrigerant**

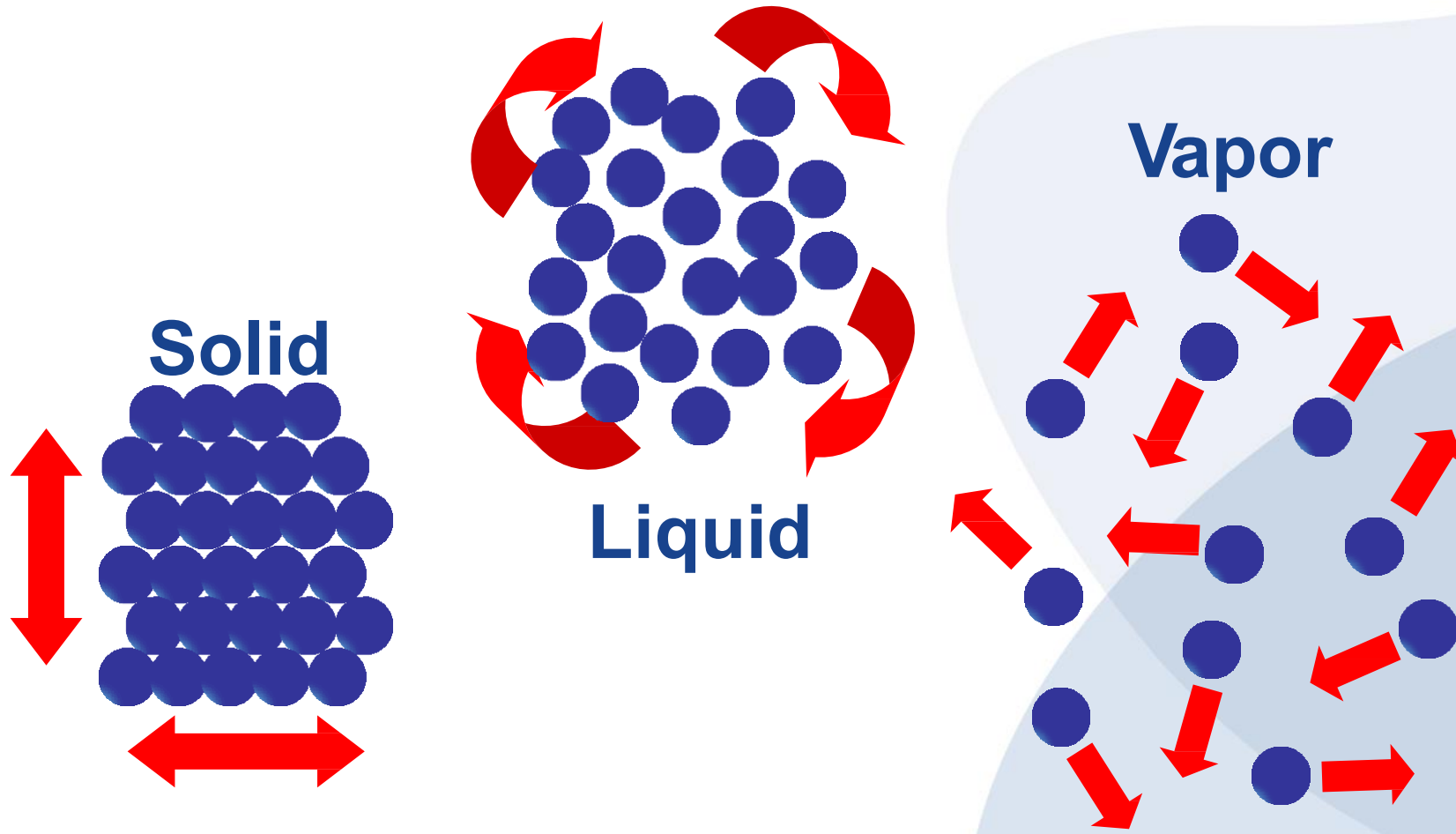


**ONE BTU CHANGES
ONE POUND OF WATER
ONE DEGREE FAHRENHEIT**



**1 TON = 12,000 Btu/h
(CAPACITY LOAD)**

Exists in Solid, Liquid or Vapor Form



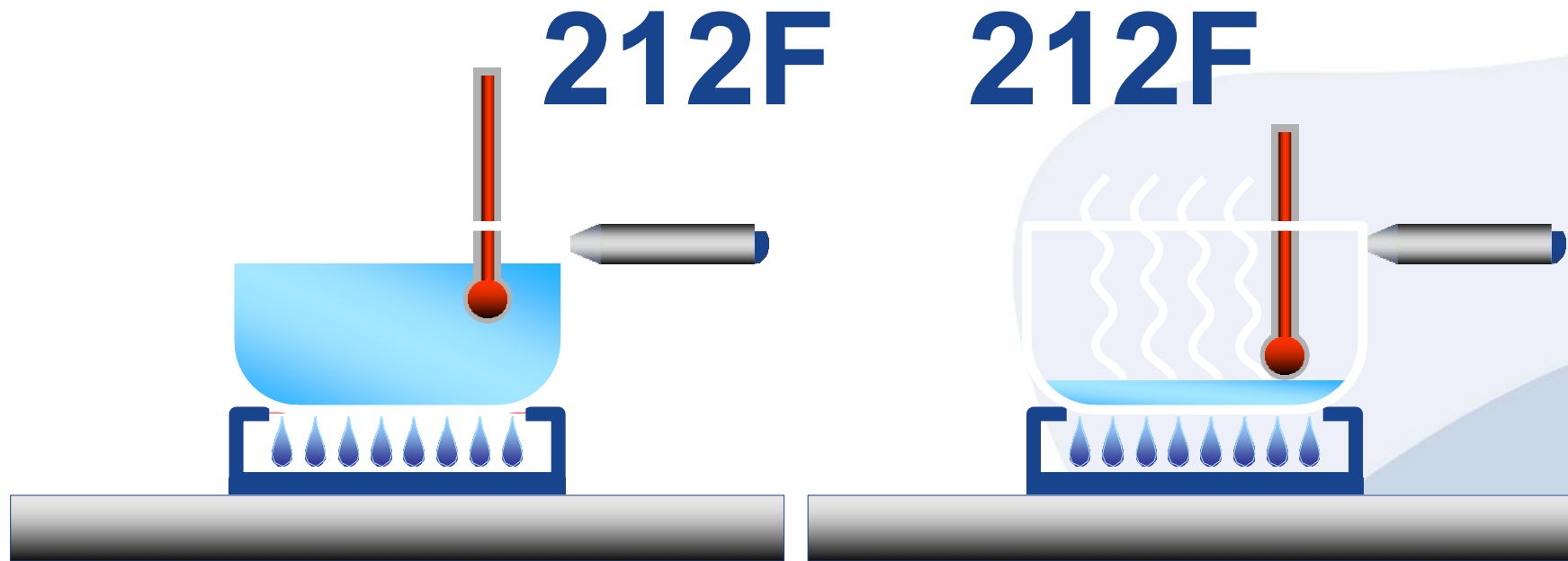


SENSIBLE HEAT

**IS THE ENERGY OF
MOLECULAR MOTION: IT CAN
BE MEASURED WITH
A THERMOMETER.**

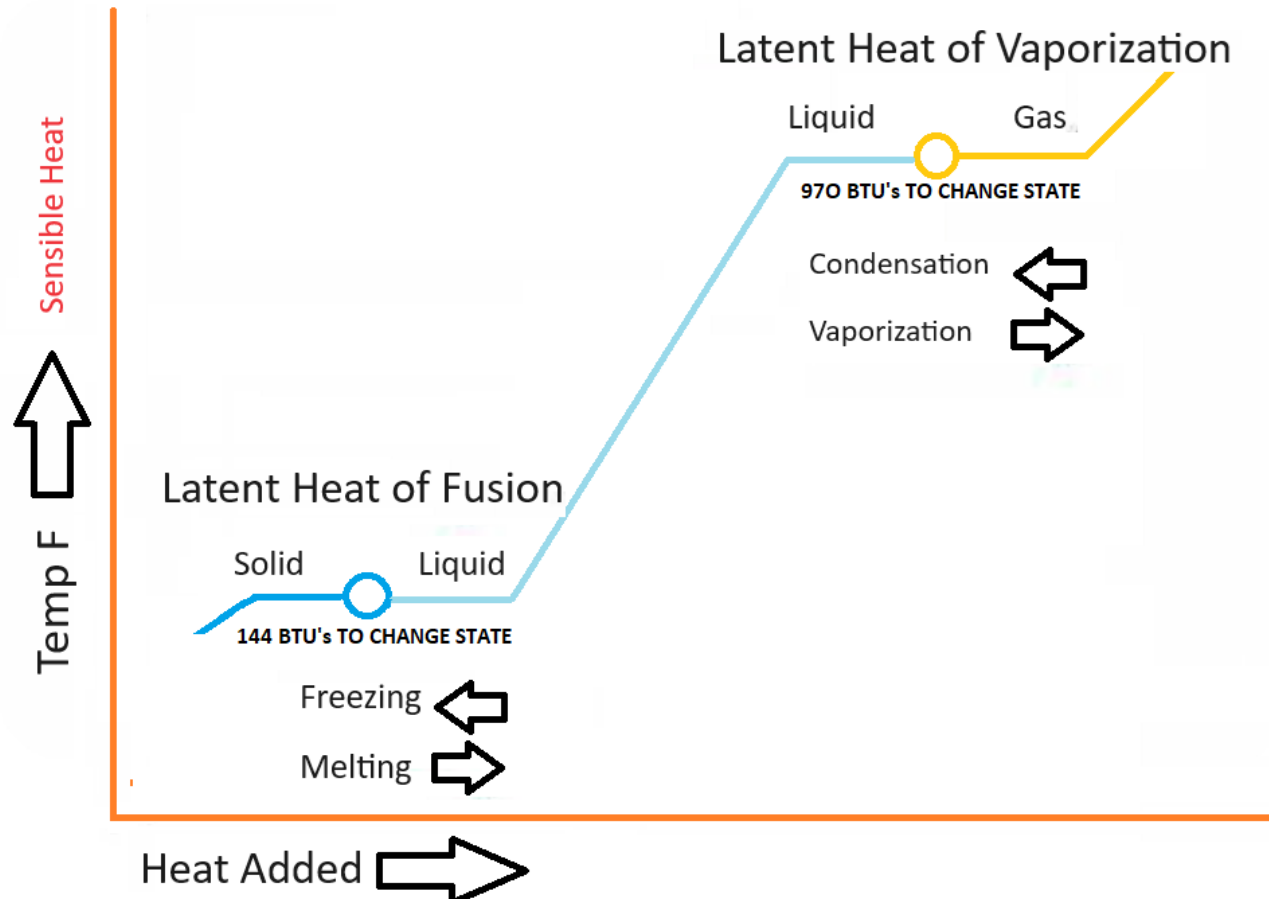


**IS THE ENERGY OF
MOLECULAR SEPARATION
AND ARRANGEMENT.
IT CANNOT BE MEASURED
BY A THERMOMETER.**



As heat is added, the temperature causes the liquid to continue to boil and change state (gas).

LATENT HEAT





LATENT HEAT

One Ton of refrigeration:

$(2000 \text{ pounds of ice} \times 144 \text{ BTU's per pound} \div 24 \text{ hrs})$

Amount of heat energy absorbed when a ton of ice melts back to water during one 24-hour day

Ice absorbs 12,000 BTU's per hour or 12000 Btu/H.



TOTAL HEAT IS
EQUAL TO SENSIBLE
PLUS LATENT HEAT.



MEASURING PRESSURE

Gauge Pressure

Service Work

Permanently Installed System Refrigeration Gauges

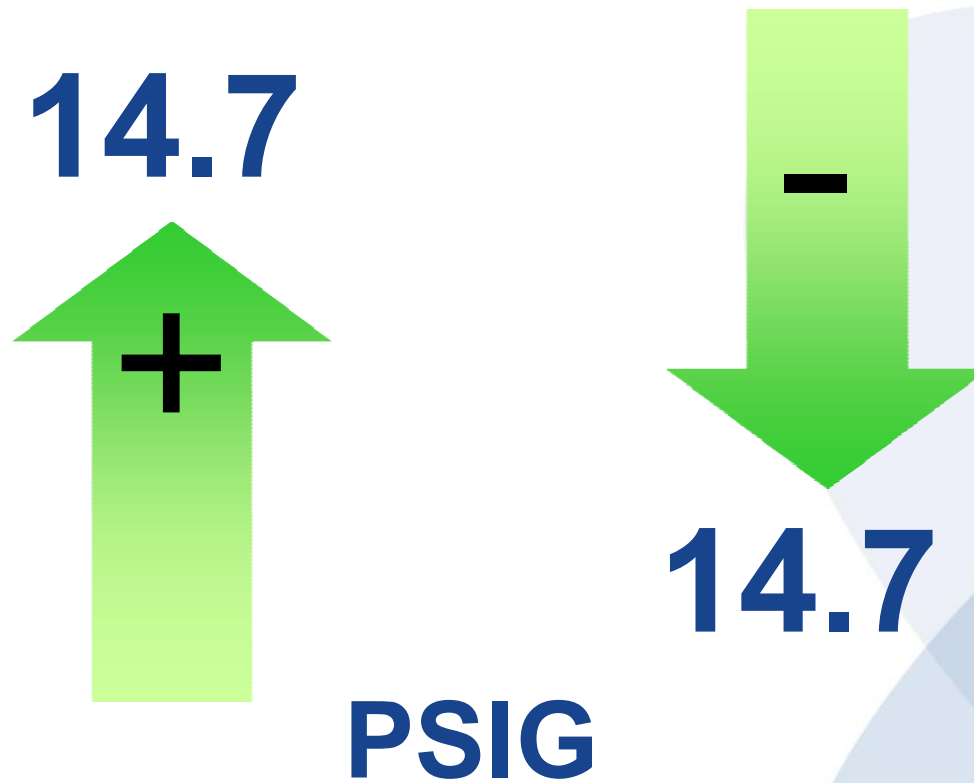
Absolute Pressure

Weather Reporting & Forecasting

System Engineering



CONVERTING PSIA TO PSIG





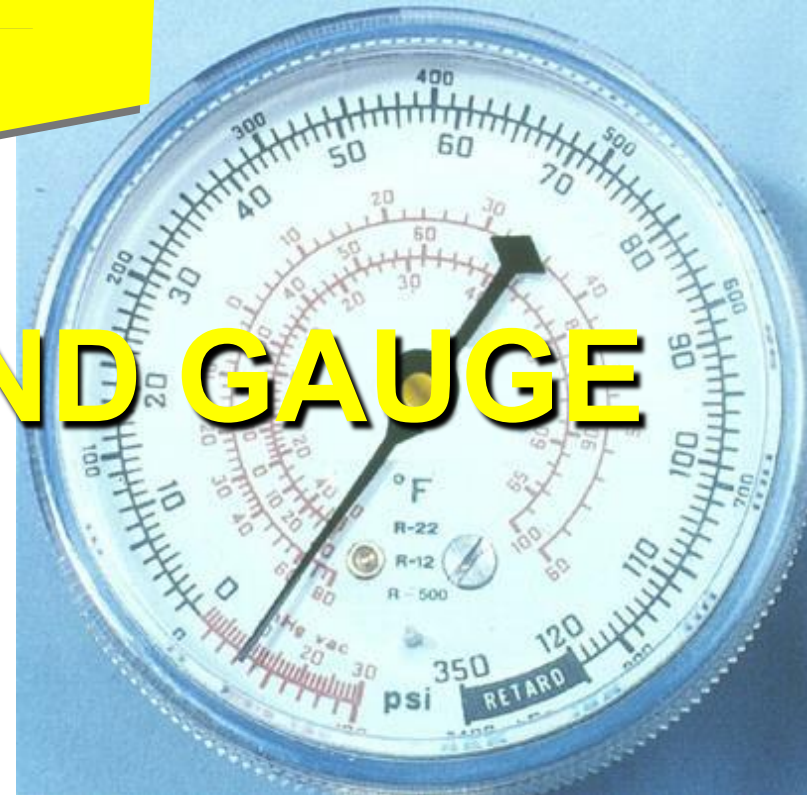
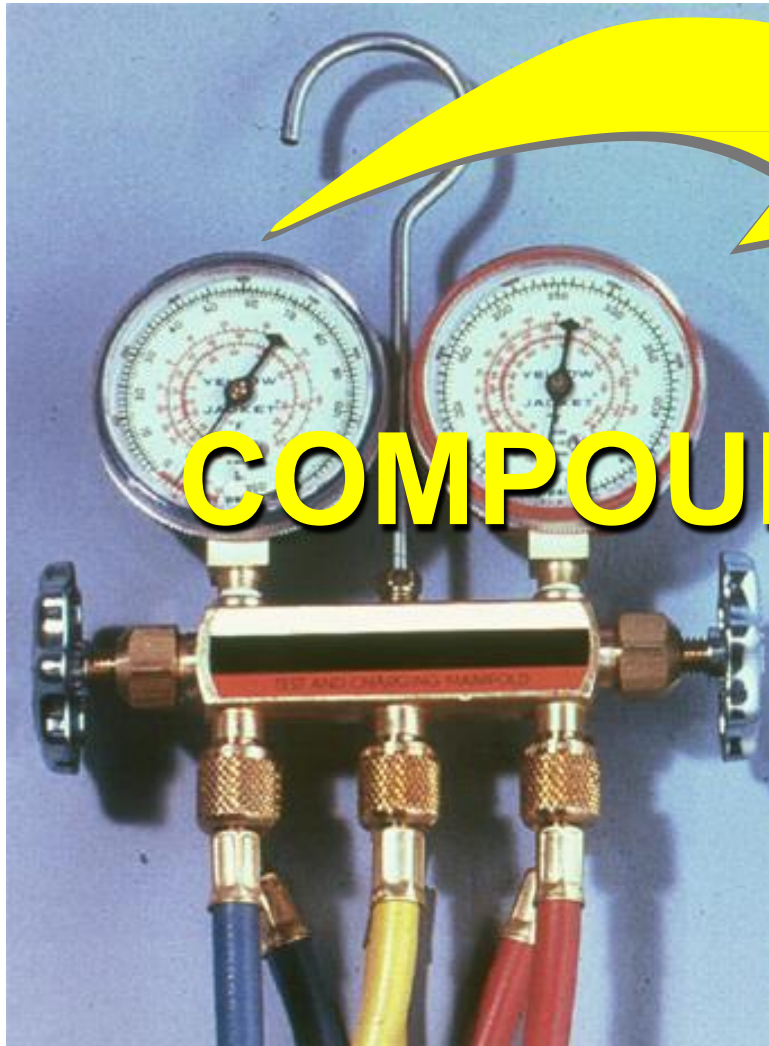
PRESSURE/TEMPERATURE CHART FOR R-22

CFC REFRIGERANTS			TEMPERATURE PRESSURE CHART		NON-CFC REFRIGERANTS		
TEMP (°F)	Vapor Pressure (PSIG) *		TEMP (°F)	HCFC 22	Vapor Pressure (PSIG) *		
	CFC 11	CFC 12			HCFC 22	HCFC 123	HFC 134a
-100.00	29.7	29.7	-20.00	10.2	25.0	29.9	27.9
-90.00	29.6	29.6			22.9	29.7	27.0
-80.00	29.5	29.5			20.1	29.6	25.7
-70.00	29.4	29.4			16.5	29.5	23.9
-60.00	29.1	29.1			11.9	29.3	21.6
-50.00	28.8	28.8	-15.00	13.2	6.1	29.1	18.5
-40.00	28.3	28.3			0.6	28.7	14.6
-35.00	28.1	28.1			2.6	28.5	12.3
-30.00	27.7	27.7			4.9	28.3	9.7
-25.00	27.4	27.4			7.4	28.0	6.7
-20.00	26.9	26.9	-10.00	16.5	10.2	27.6	3.5
-15.00	26.5	26.5			13.2	27.3	0.1
-10.00	25.9	25.9			16.5	26.8	2.0
-5.00	25.3	25.3			20.1	26.3	4.2
0.00	24.6	24.6			24.0	25.8	6.5
5.00	23.9	23.9	-5.00	20.1	28.2	25.1	9.2
10.00	23.0	23.0			32.8	24.4	12.0
15.00	22.1	22.1			37.7	23.6	15.1
20.00	21.0	21.0			43.1	22.7	18.5
25.00	19.8	19.8			48.8	21.7	22.2
30.00	18.5	18.5	0.00	24.0	54.9	20.6	26.1
35.00	17.1	17.1			61.5	19.4	30.4
40.00	15.6	15.6			68.5	18.0	35.1
45.00	13.8	13.8			76.0	16.5	40.1
50.00	12.0	12.0			84.0	14.9	45.5
55.00	9.9	9.9	5.00	28.2	92.6	13.1	51.2
60.00	7.7	7.7			101.6	11.1	57.4
65.00	5.3	5.3			111.2	8.9	64.1
70.00	2.7	2.7			121.4	6.6	71.1
75.00	0.1	0.1			132.2	4.0	78.7
80.00	1.6	1.6	10.00	32.8	143.6	1.2	86.7
85.00	3.2	3.2			155.7	0.9	95.3
90.00	4.9	4.9			168.4	2.5	104.3
95.00	6.8	6.8			181.8	4.2	114.0
100.00	8.8	8.8			195.9	6.1	124.2
105.00	10.9	10.9	15.00	37.7	210.7	8.1	135.0
110.00	13.2	13.2			226.3	10.3	146.4
115.00	15.7	15.7			242.7	12.6	158.4
120.00	18.3	18.3			259.9	15.1	171.2
125.00	21.1	21.1			277.9	17.7	184.6
130.00	24.0	24.0	20.00	42.1	296.8	20.6	198.7
135.00	27.1	27.1			316.5	23.6	213.6
140.00	30.5	30.5			337.2	26.8	229.2
145.00	34.0	34.0			358.8	30.2	245.6
150.00	37.7	37.7			381.4	33.8	262.9

Vapor pressures are shown as PSIG. Bold figures are shown as inches of mercury vacuum.

* Data supplied by Allied-Signal Inc.

Vapor pressures are shown as PSIG. Bold figures are shown as inches of mercury vacuum.



COMPOUND GAUGE

GAUGE MANIFOLD SET

Different refrigerants may require different gauge manifold sets.

Refrigerant R-22 has a maximum gauge pressure of 500 PSIG (pounds per square inch gauge).

Refrigerant R-410, on the other hand, has a maximum pressure of 800 PSIG and requires a different gauge manifold set.



GAUGE MANIFOLD SET

CAUTION!

- With the use of self-sealing fittings, high pressure refrigerant can be trapped and remain in the service hoses after they have been disconnected from the equipment, causing possible injury or burns.
- Do not over-tighten the valves on the gauge manifold set when closing (front-seating) the valves. Over-tightening the valves may damage the manifold.



TYPICAL COMFORT AIR CONDITIONING COMPRESSOR READINGS

	@ Compressor Suction	@ Compressor Discharge	
Coil temperature	Saturation Temperature (F)	40	120
Gas Leaving temp.	Actual Gas Temperature	50	165
	Superheat (F)	10	45
	Pressure (PSIA)	83.7	277.7
	Pressure (PSIG)	69.0	263.0
	Enthalpy (Btu/Lb.)	110	125

95°F OUTSIDE TEMPERATURE



COMPRESSORS

	@ Compressor Suction	@ Compressor Discharge
Saturation Temperature (F)	40	120
Actual Gas Temperature	50	165
Superheat (F)	10	45
Pressure (PSIA)	83.7	277.7
Pressure (PSIG)	69.0	263.0
Enthalpy (Btu/Lb.)	110	125

COMPRESSION RATIO

277.7 PSIA Absolute Discharge Pressure

83.7 PSIA Absolute Suction Pressure

$$277.7 \text{ PSIA} \div 83.7 \text{ PSIA} = 3.32$$



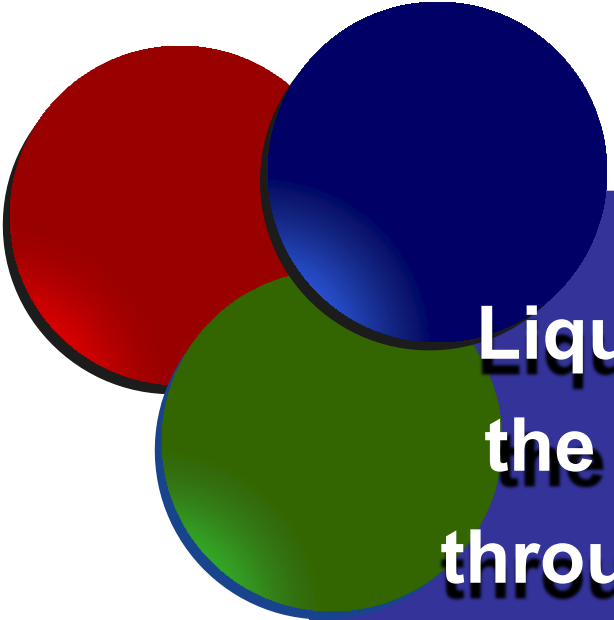
COMPRESSION RATIO PURON

	@ Compressor Suction	@ Compressor Discharge
Saturation Temperature (F)	40	120
Actual Gas Temperature	50	165
Superheat (F)	10	45
Pressure (PSIA)	132.7	431.7
Pressure (PSIG)	118	417.0
Enthalpy (Btu/Lb.)	110	125

431.7 PSIA Absolute Discharge Pressure

132.7 PSIA Absolute Suction Pressure

$$431.7 \text{ PSIA} \div 132.7 \text{ PSIA} = 3.26$$



Liquid **slugging** occurs when the amount of liquid passing through the compressor grows large enough to restrict the internal motion of the compressor.



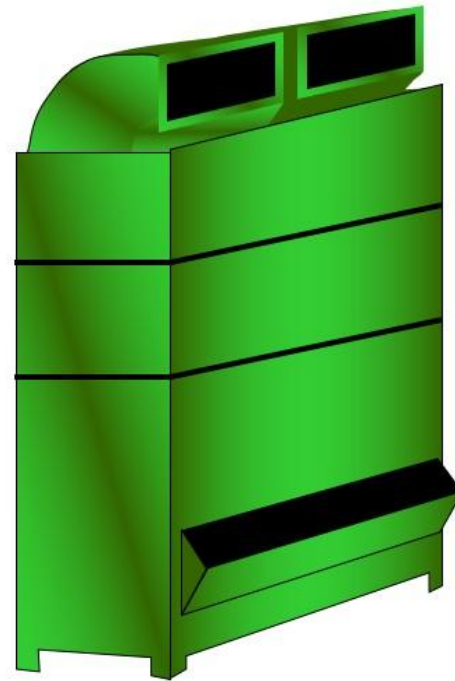
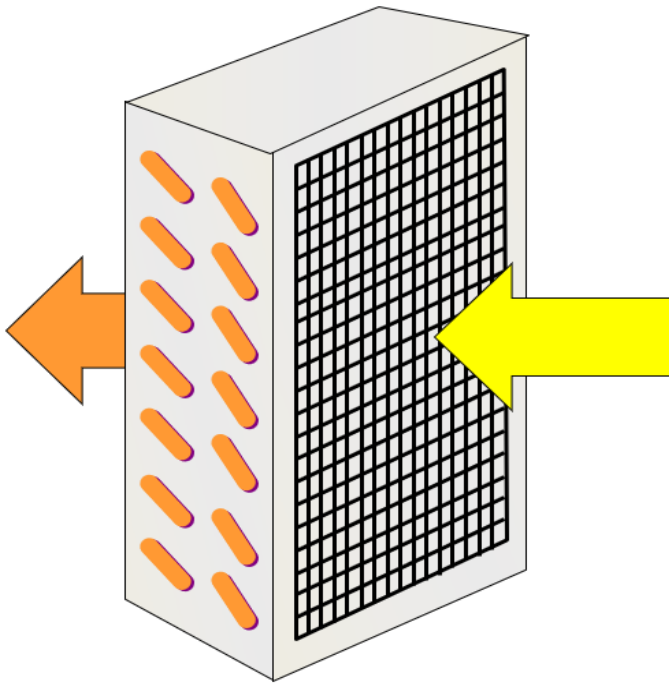
LIQUIDS IN COMPRESSORS CAUSE:

- 1. HIGH POWER USAGE**
- 2. MOTOR OVERHEATING**
- 3. COMPRESSOR OVERHEATING**
- 4. OIL BREAKDOWN**
- 5. IMPROPER COMPRESSOR LUBRICATION**
- 6. NOISY OPERATION**
- 7. VIBRATION**
- 8. COMPRESSOR DAMAGE THROUGH
DEFORMITY AND BREAKAGE**
- 9. INADEQUATE CAPACITY**



THE CONDENSER
IS A DEVICE
FOR REMOVING HEAT
FROM THE
REFRIGERATION SYSTEM

AIR COOLED



EVAPORATIVE



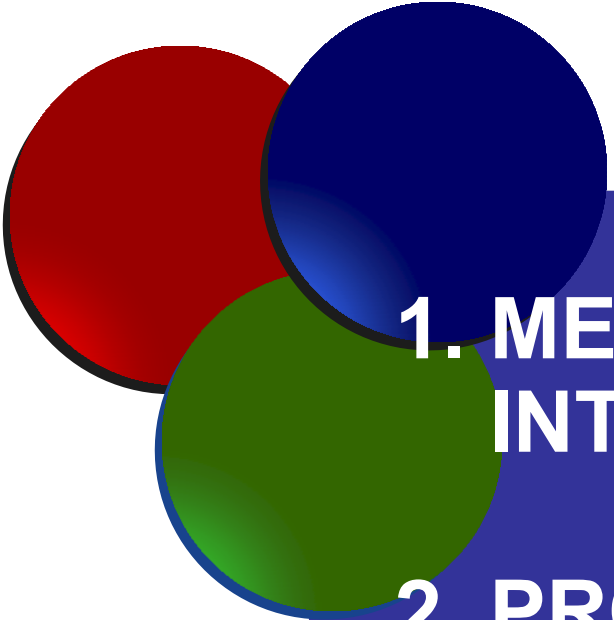
WATER COOLED



COMMON CONDENSER PROBLEMS

- **DIRTY COIL**
- **RESTRICTED AIR FLOW**
- **DIRTY FAN BLADES**
- **FAN MOTOR FAILURE**

THE METERING DEVICE:

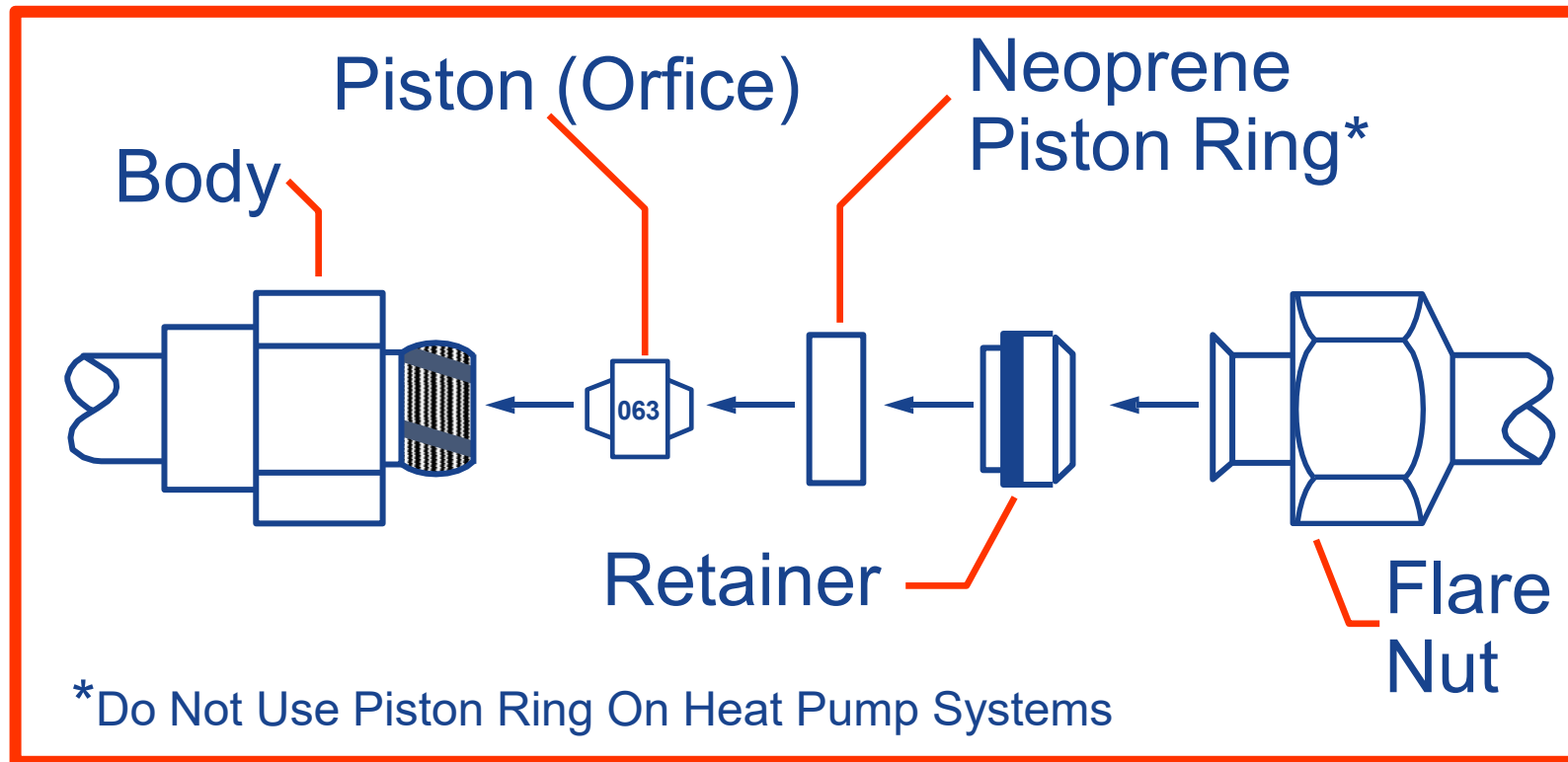
- 
1. METERS REFRIGERANT INTO THE EVAPORATOR
 2. PROVIDES A PRESSURE DROP WHICH SEPARATES THE HIGH SIDE FROM THE LOW SIDE OF THE SYSTEM



METERING DEVICES

FIXED	ADJUSTABLE
CAPILLARY TUBE	HAND EXPANSION VALVE
FIXED ORIFICE	LOWSIDE FLOAT VALVE
	HIGHSIDE FLOAT VALVE
	AUTOMATIC EXPANSION VALVE
	THERMOSTATIC EXPANSION VALVE
	ELECTRIC / ELECTRONIC EXPANSION VALVE

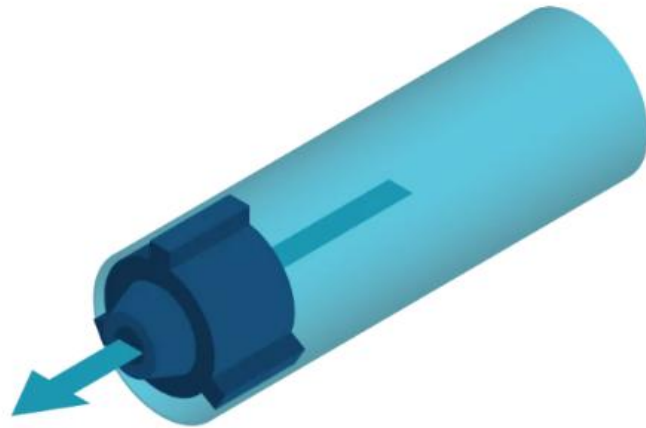
FIXED ORFICE DEVICES



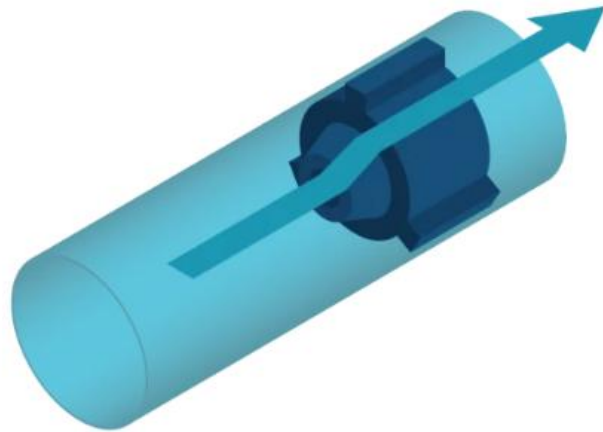
The Fixed Orifice Device accomplishes the same thing as the Capillary Tube Assembly but in a more compact and rugged design



FIXED ORFICE DEVICES



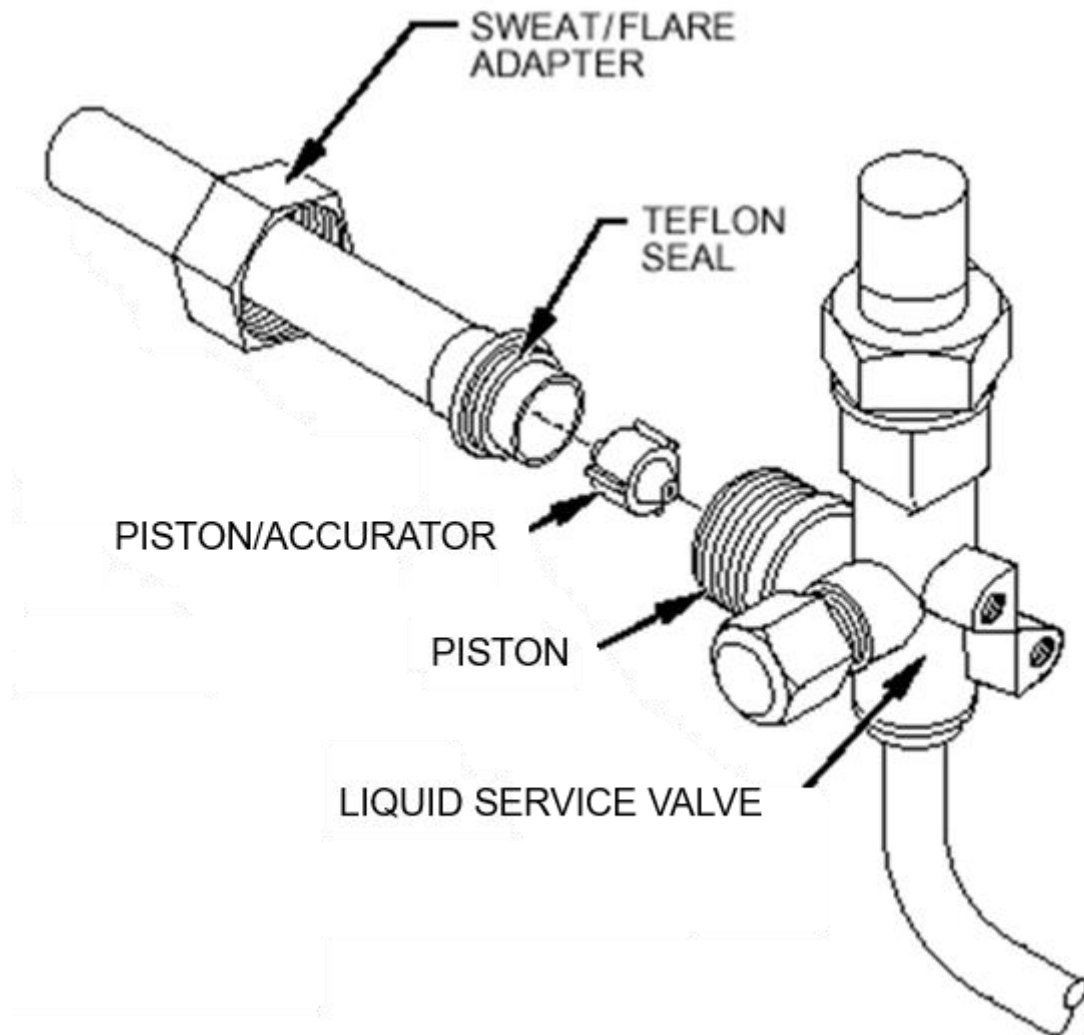
Metering Forced
through Piston



Flow Bypassed
around Piston

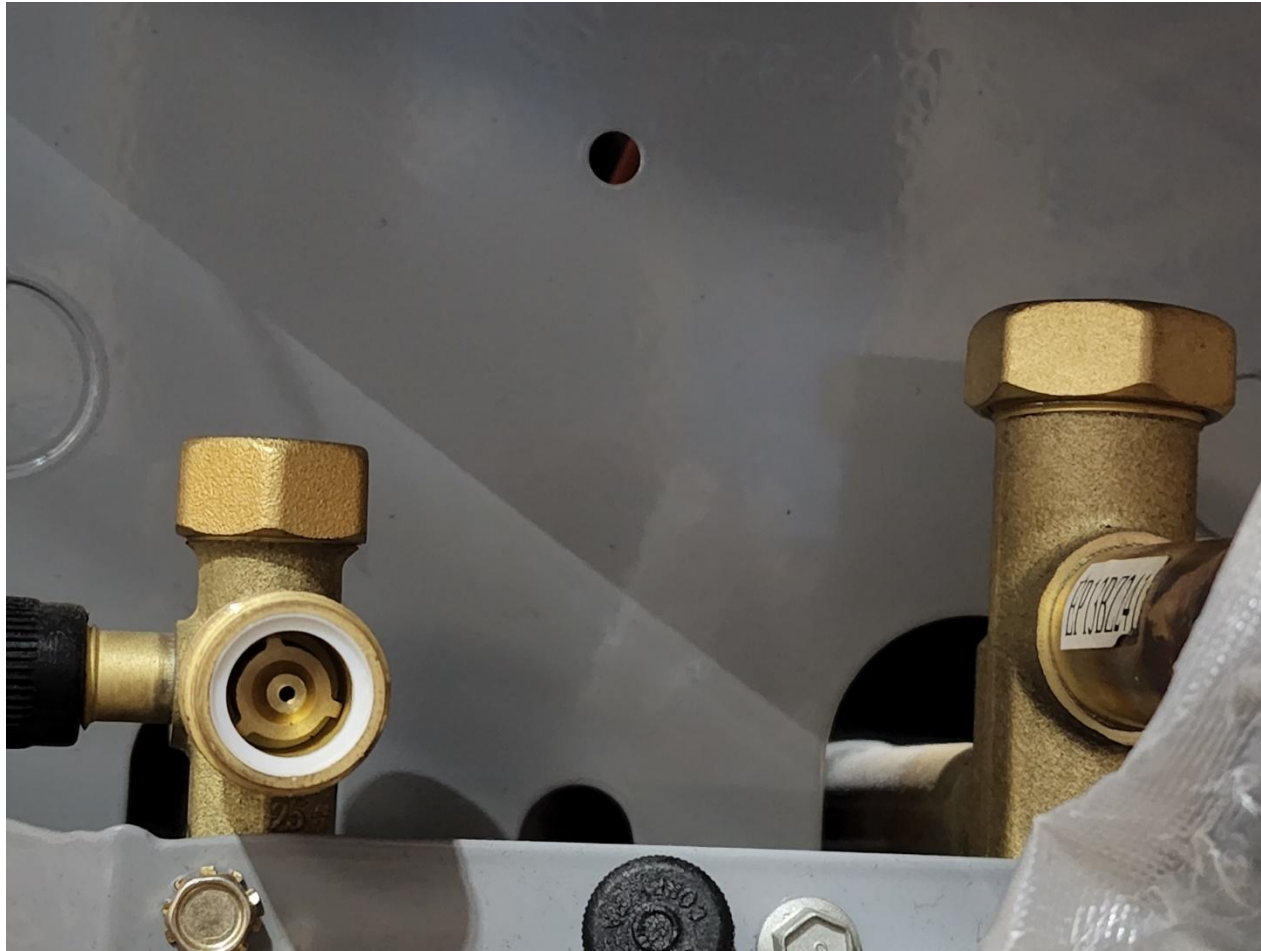


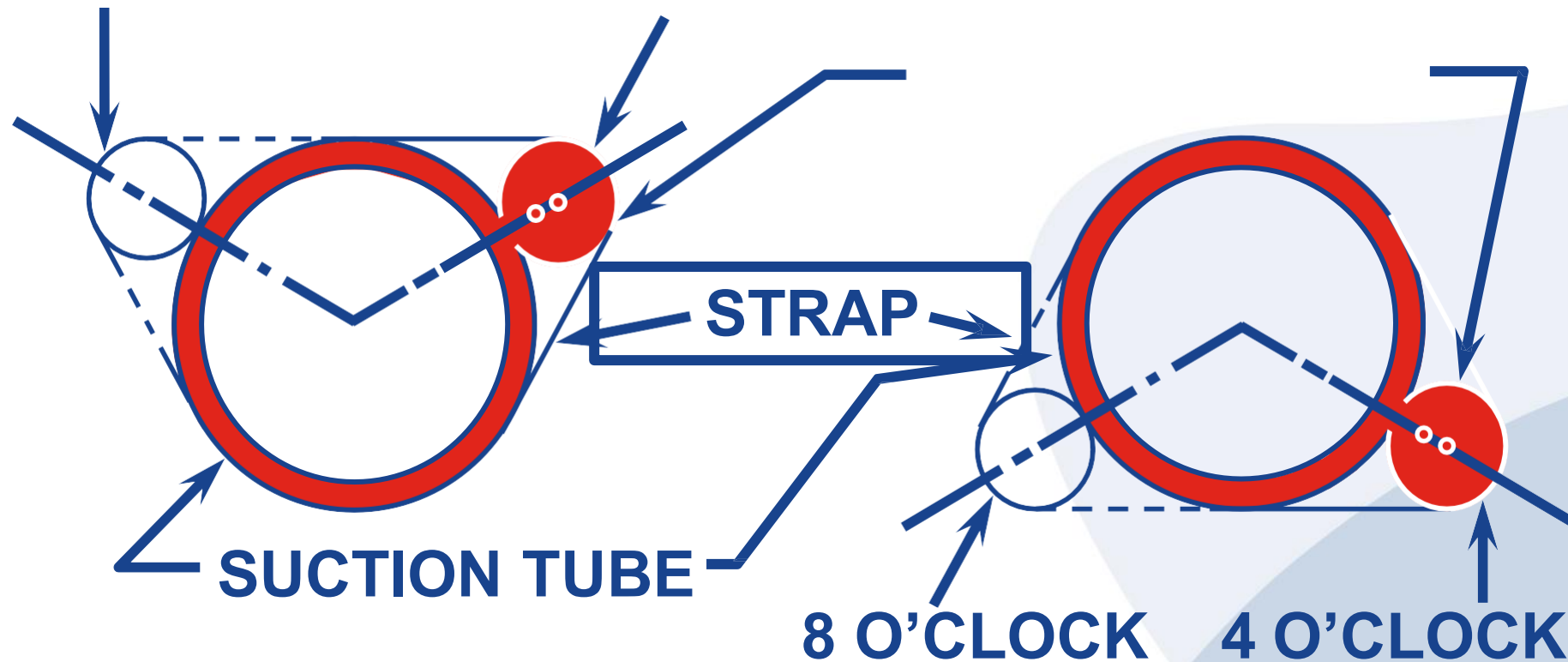
HEAT PUMP LIQUID LINE SERVICE VALVES





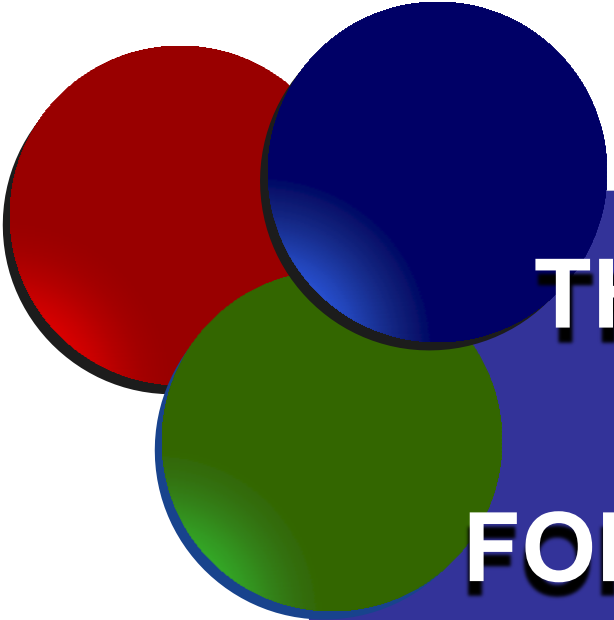
HEAT PUMP LIQUID LINE SERVICE VALVE ON LEFT





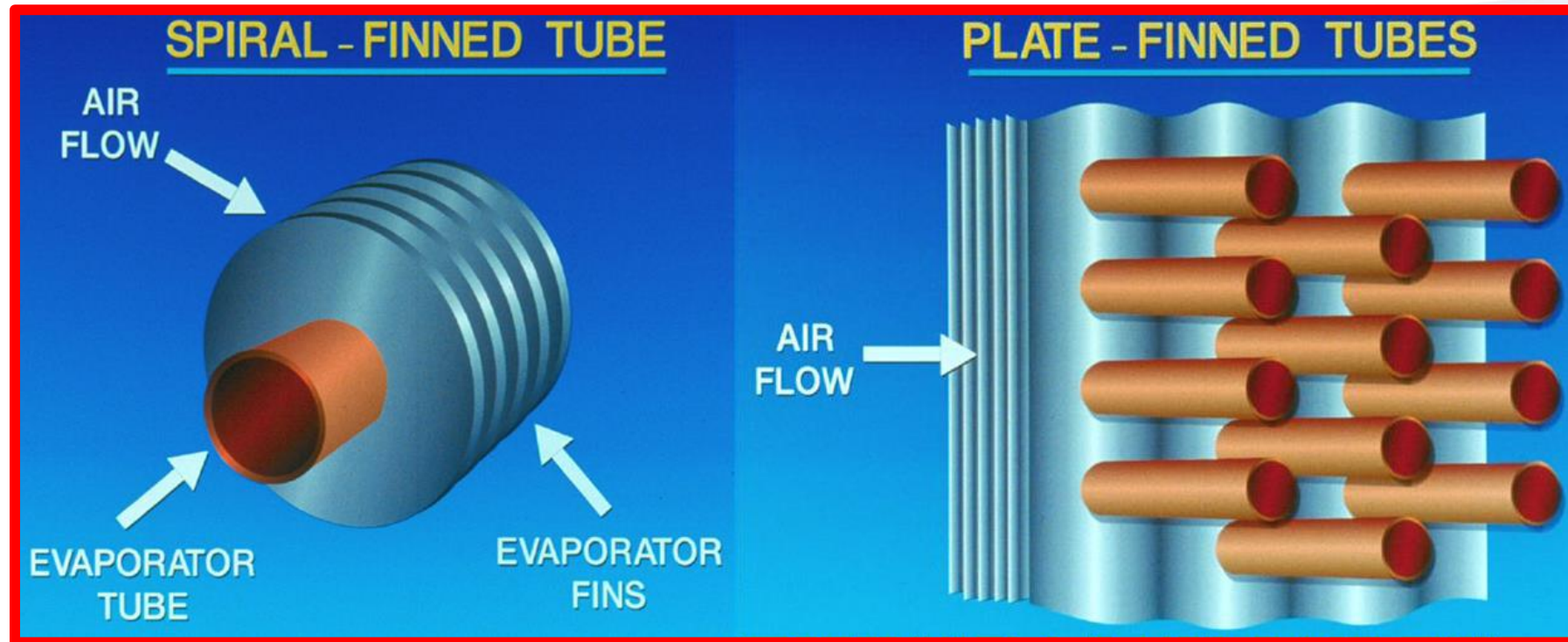
**7/8-IN. O.D. &
SMALLER**

**LARGER THAN
7/8-IN. O.D.**



THE EVAPORATOR
IS A DEVICE
FOR ABSORBING HEAT
INTO THE
REFRIGERATION SYSTEM

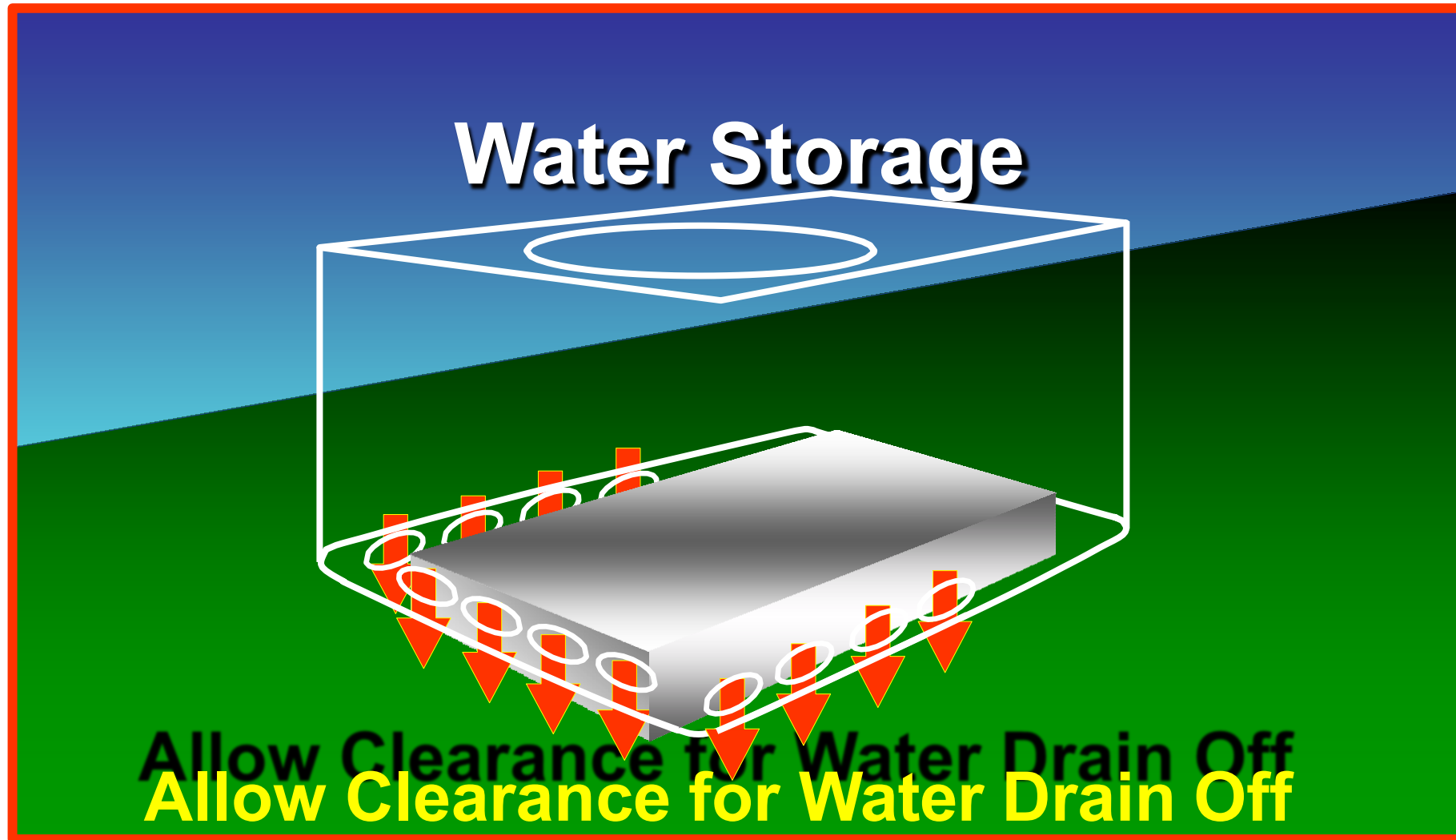
FINNED-TUBE EVAPORATORS





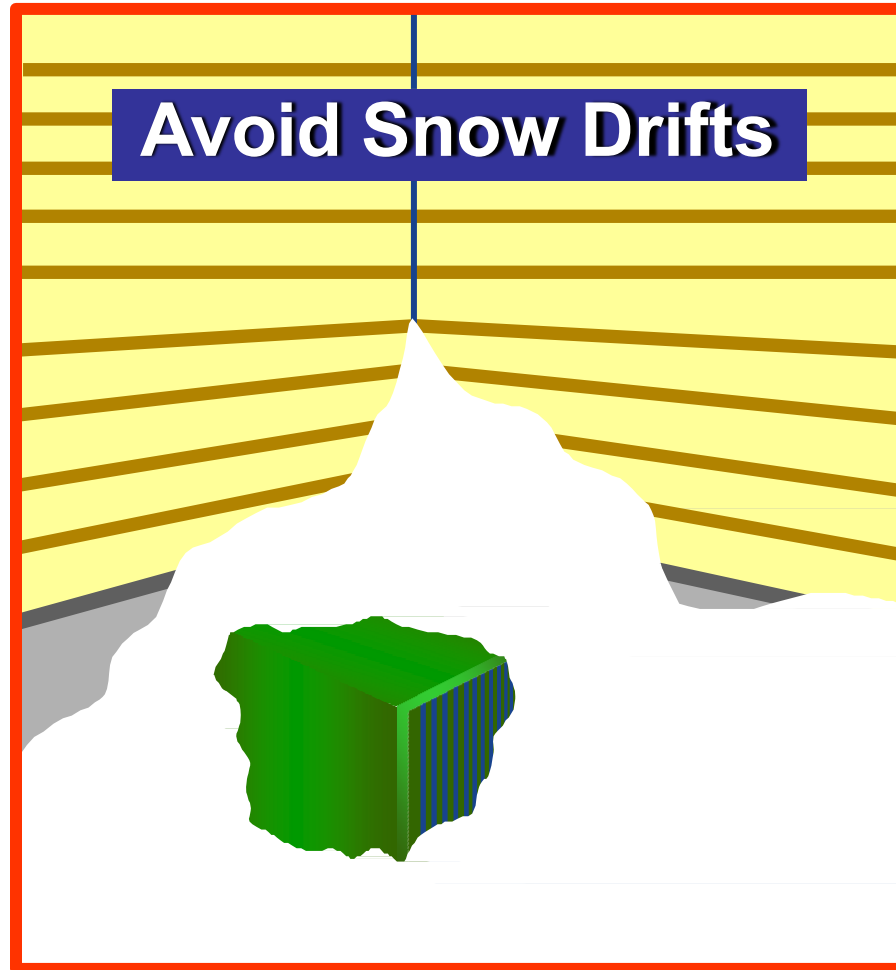
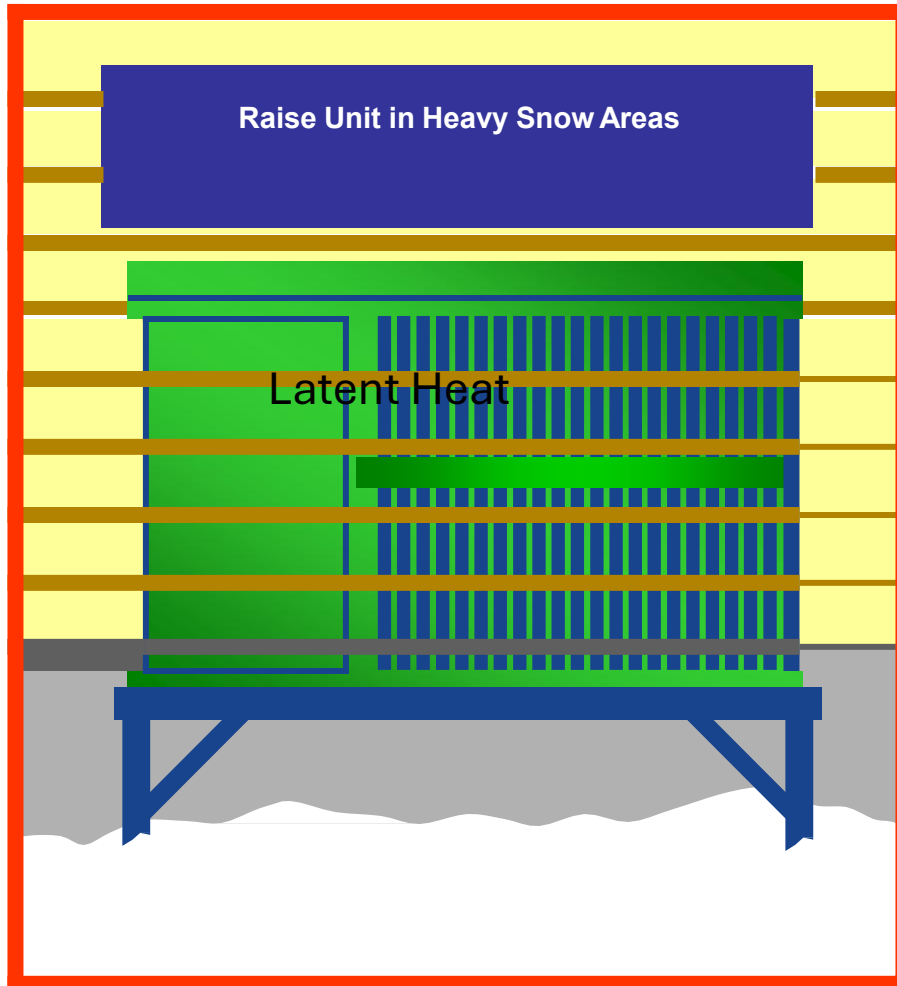
SPLIT SYSTEM INSTALLATION

- 1. Locate Unit**
- 2. Run Line Set**
- 3. Braze Connections**
- 4. Leak Check the Lines**
- 5. Evacuate the System**
- 6. Check System Airflow**
- 7. Check/Charge System**

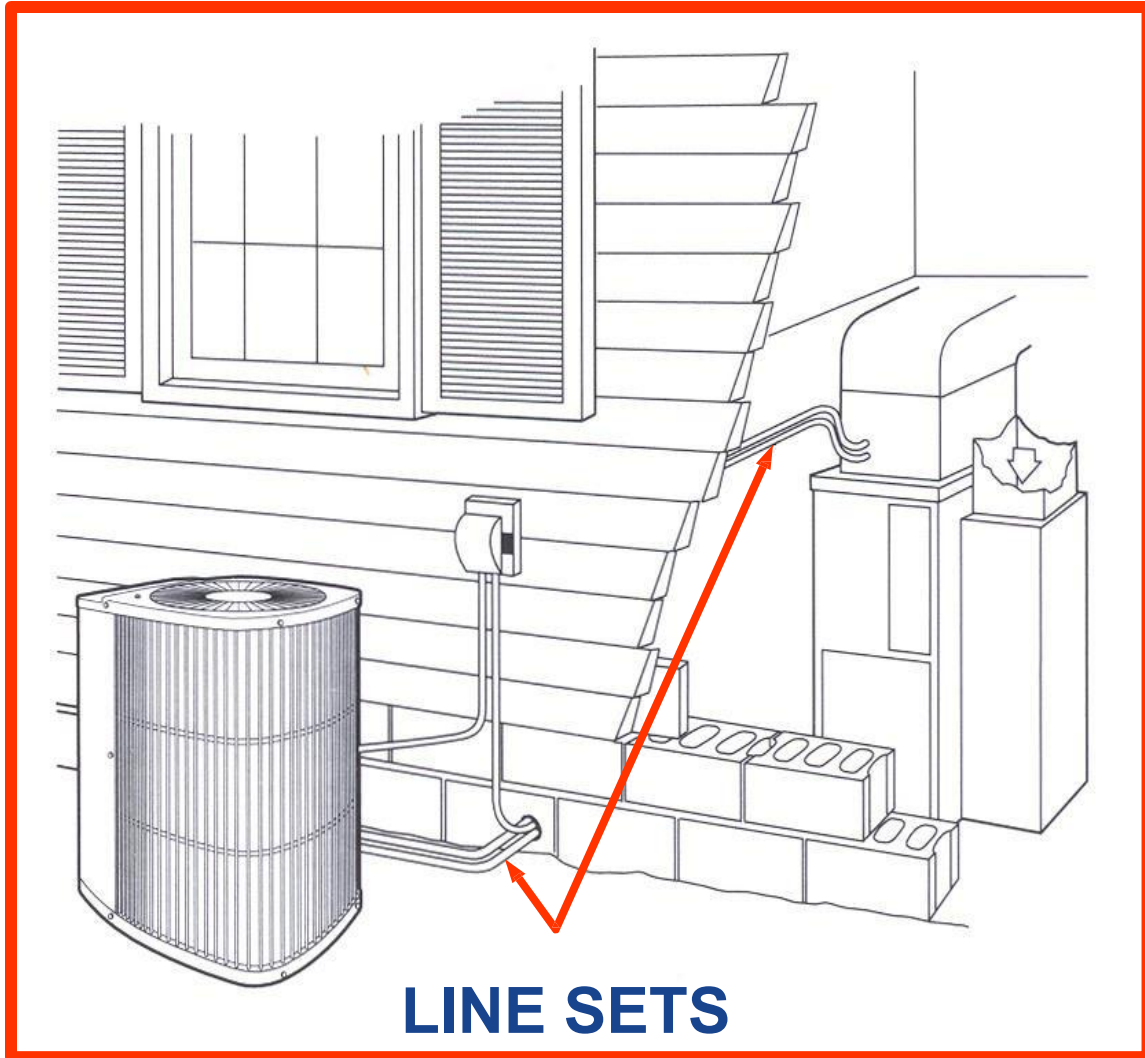


LOCATING THE UNIT

– Snow Considerations –

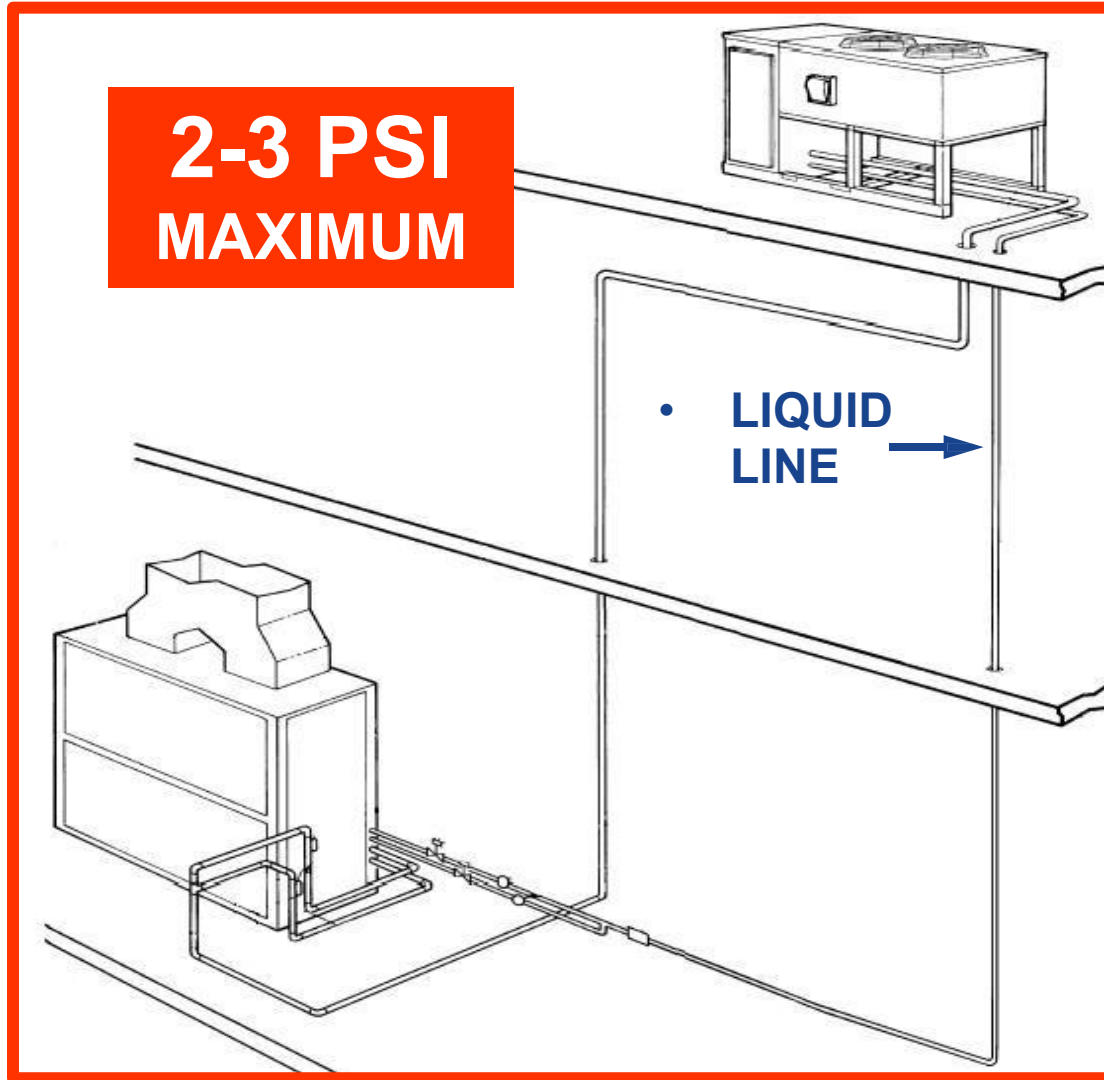


Wingledorff's REFRIGERANT LINES



- Line sets should be installed in such a way to also prevent a pressure drop.
- If a heat pump system is showing sweating on the liquid line that is mounted in a vertical application, it may indicate that there may be a restriction, or you may have exceeded the vertical lift limits.
- A maximum of 2-3 PSI should be maintained.

REFRIGERANT LINES



- IF A HEAT PUMP SYSTEM IS SHOWING SWEATING ON THE LIQUID LINE THAT IS MOUNTED IN A VERTICAL APPLICATION, IT MAY INDICATE THAT THERE IS A RESTRICTION OR THAT THE VERTICAL LIFT LIMITS HAVE BEEN EXCEEDED.



SUPERHEAT AND SUBCOOLING

Calculating Superheat

Formula:

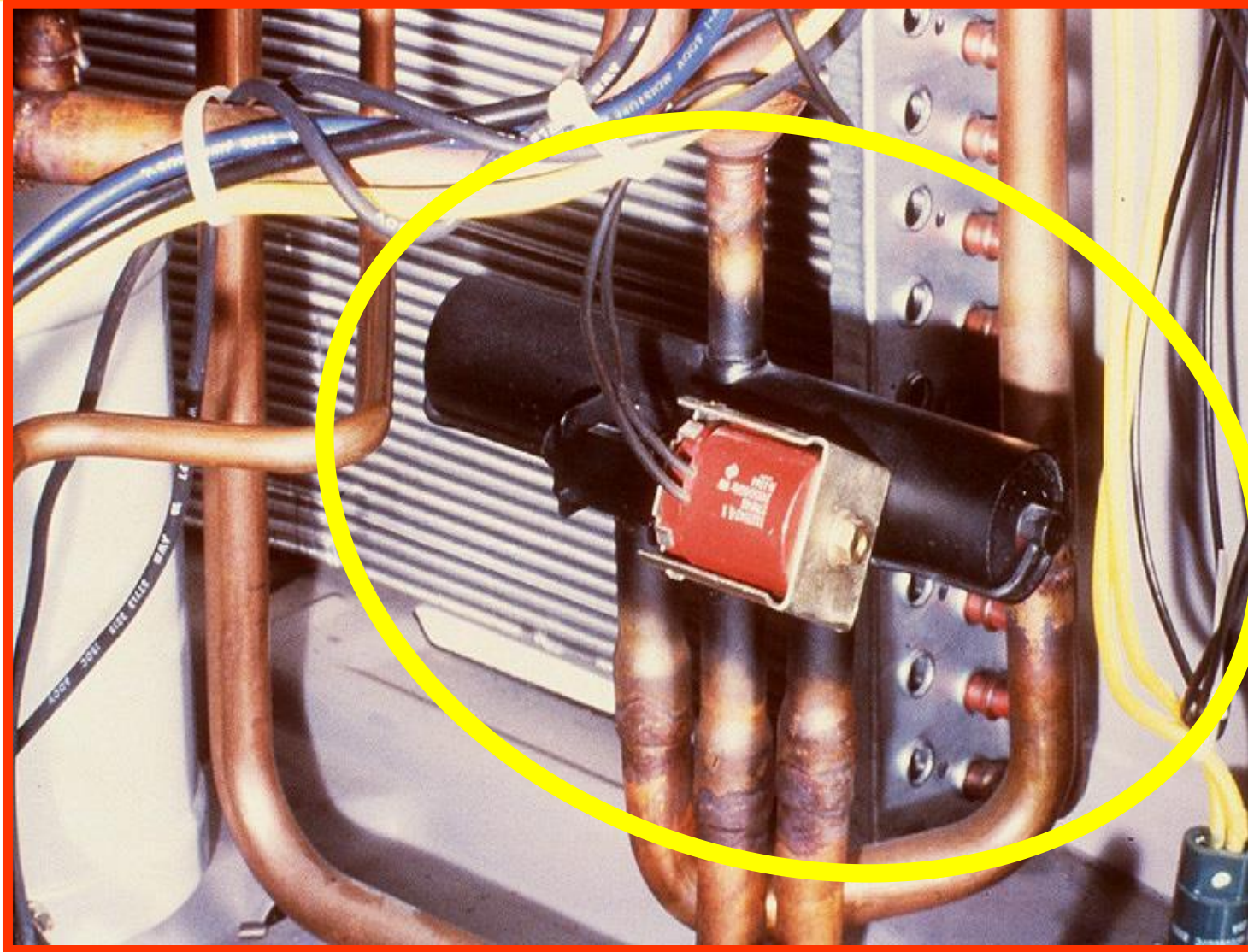
Superheat = Actual Suction Line Temperature - VSAT

Calculating Subcooling

Formula:

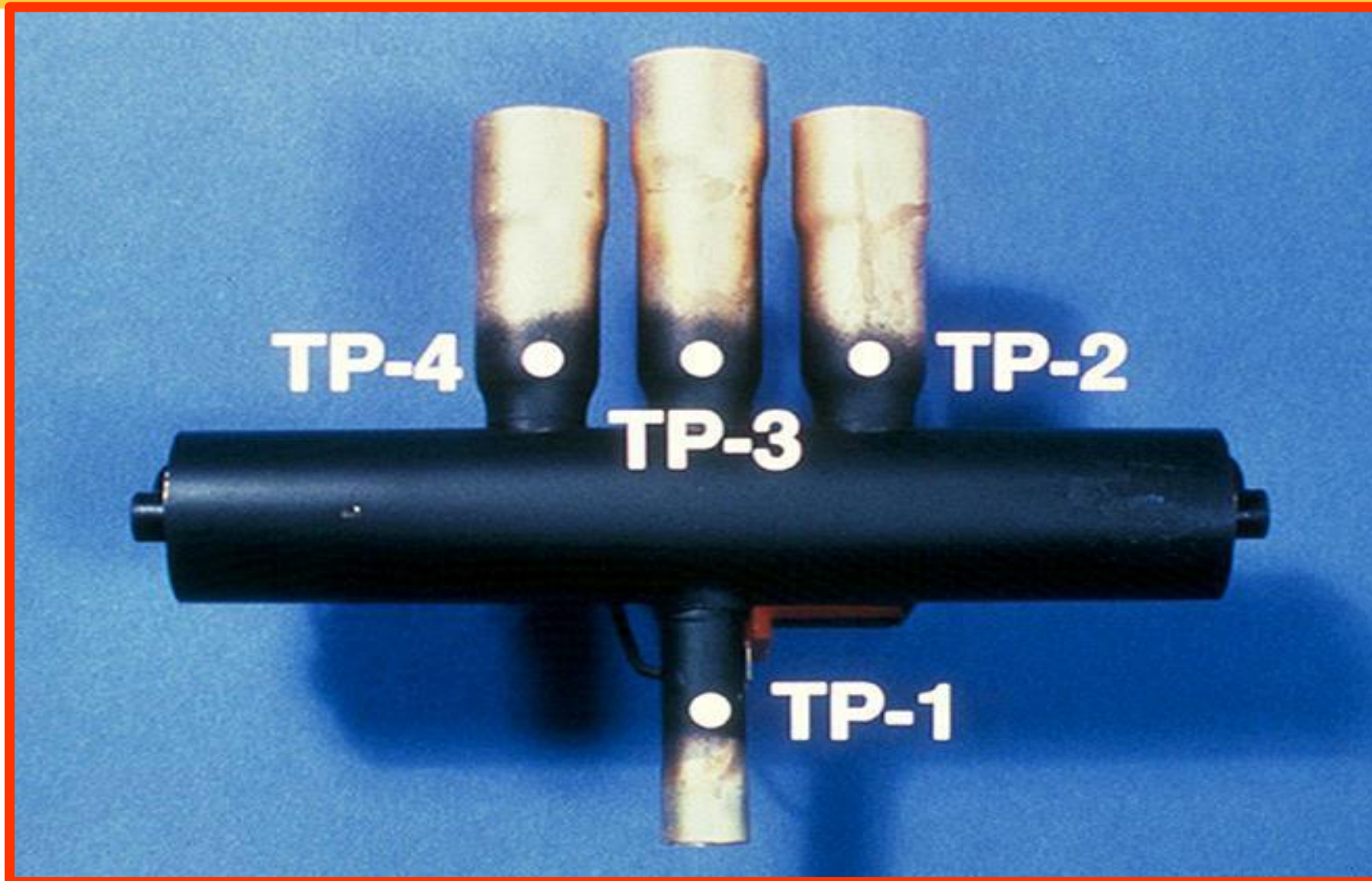
Subcooling = LSAT – Actual Liquid Line Temperature

Wingledorff's REVERSING VALVE



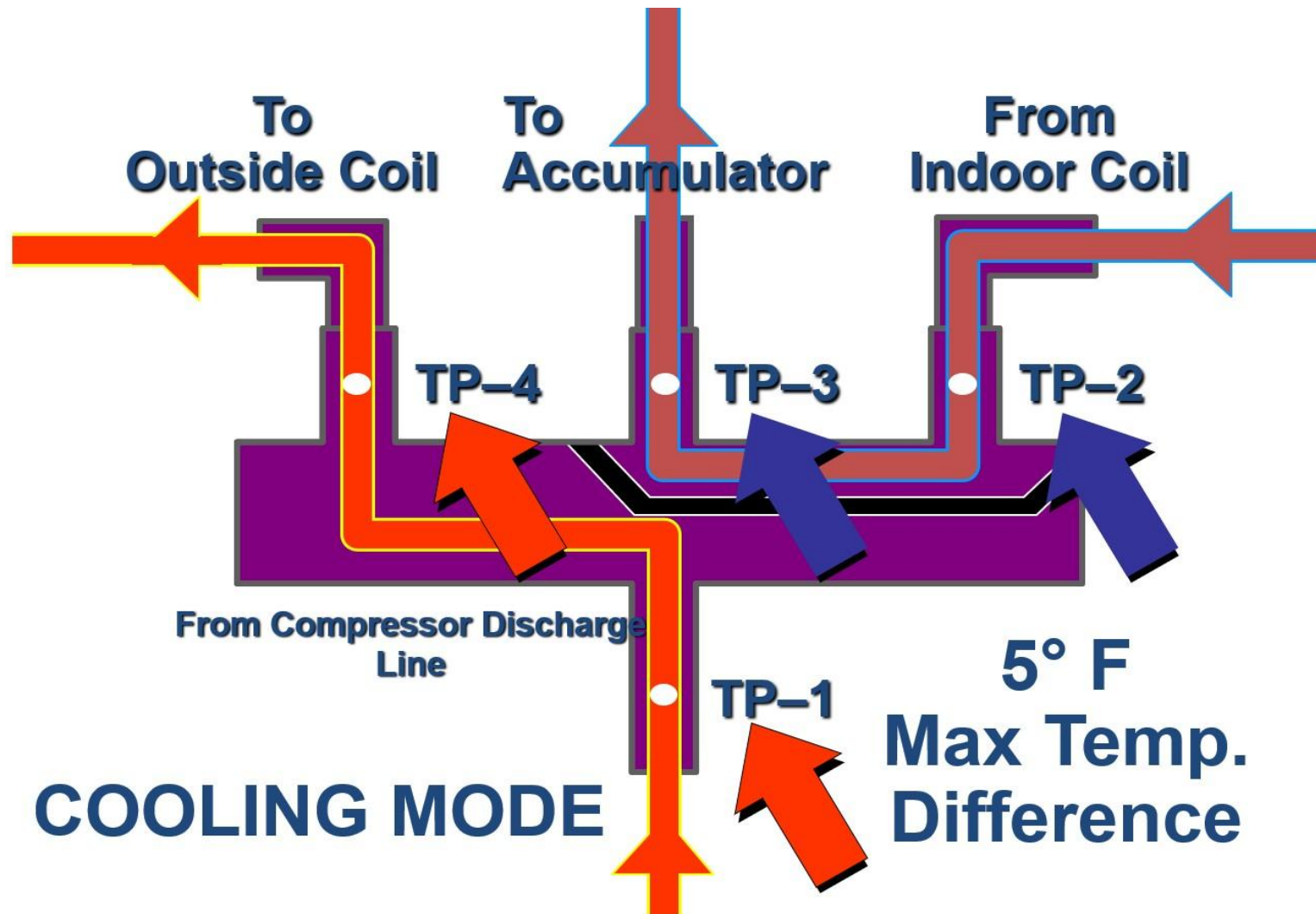


TROUBLESHOOTING REVERSING VALVES



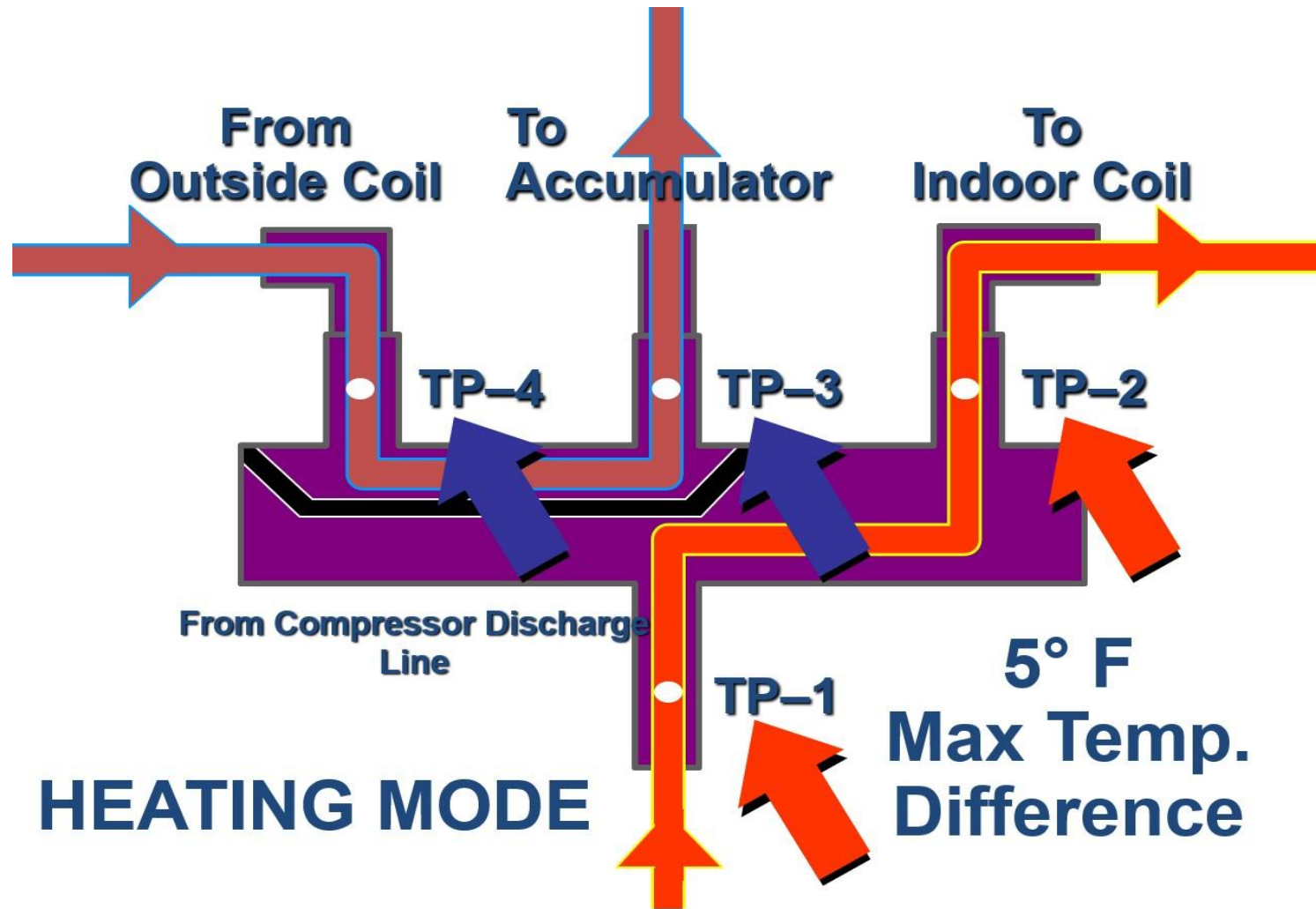


TROUBLESHOOTING REVERSING VALVES

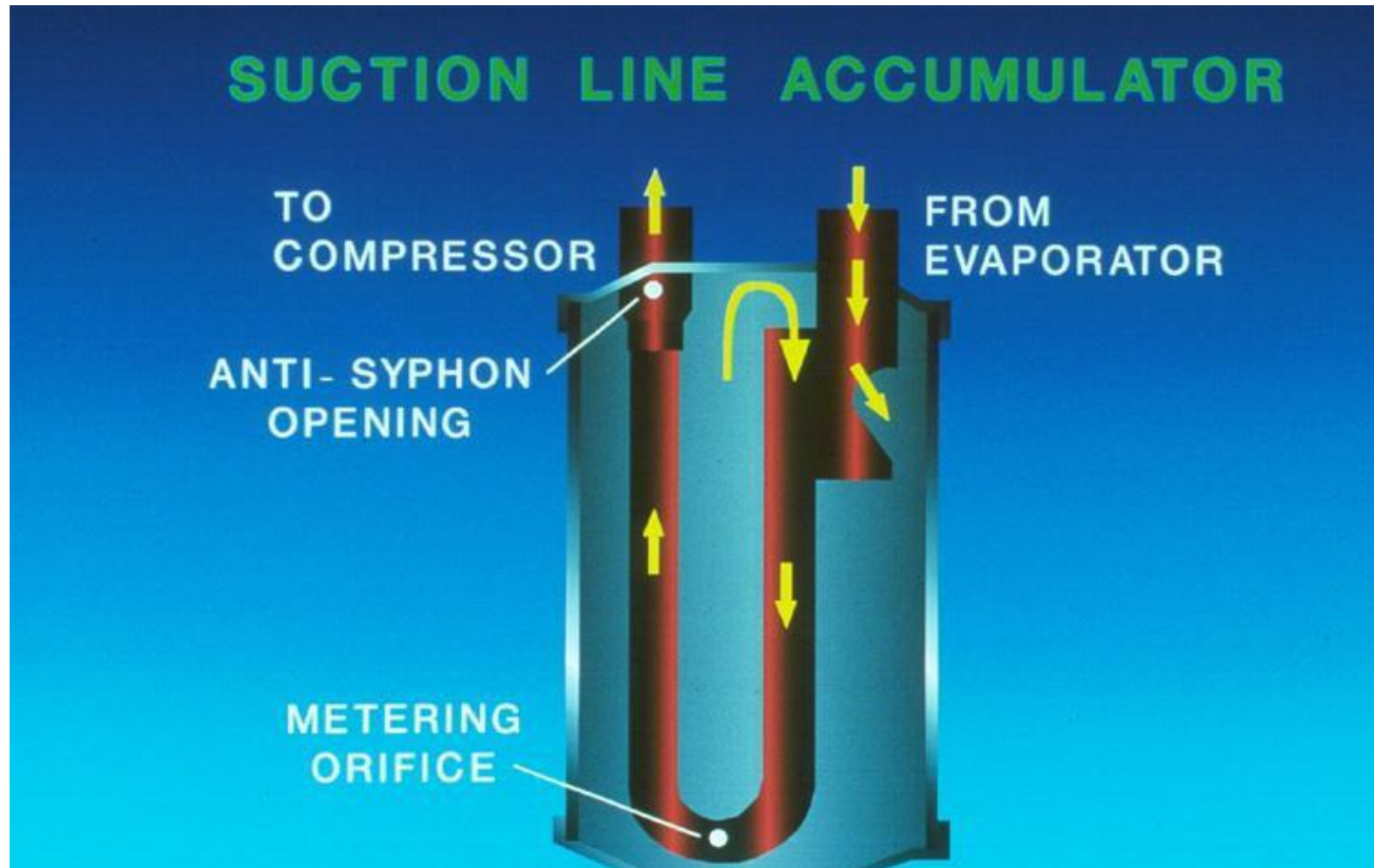




TROUBLESHOOTING REVERSING VALVES



SUCTION LINE ACCUMULATOR



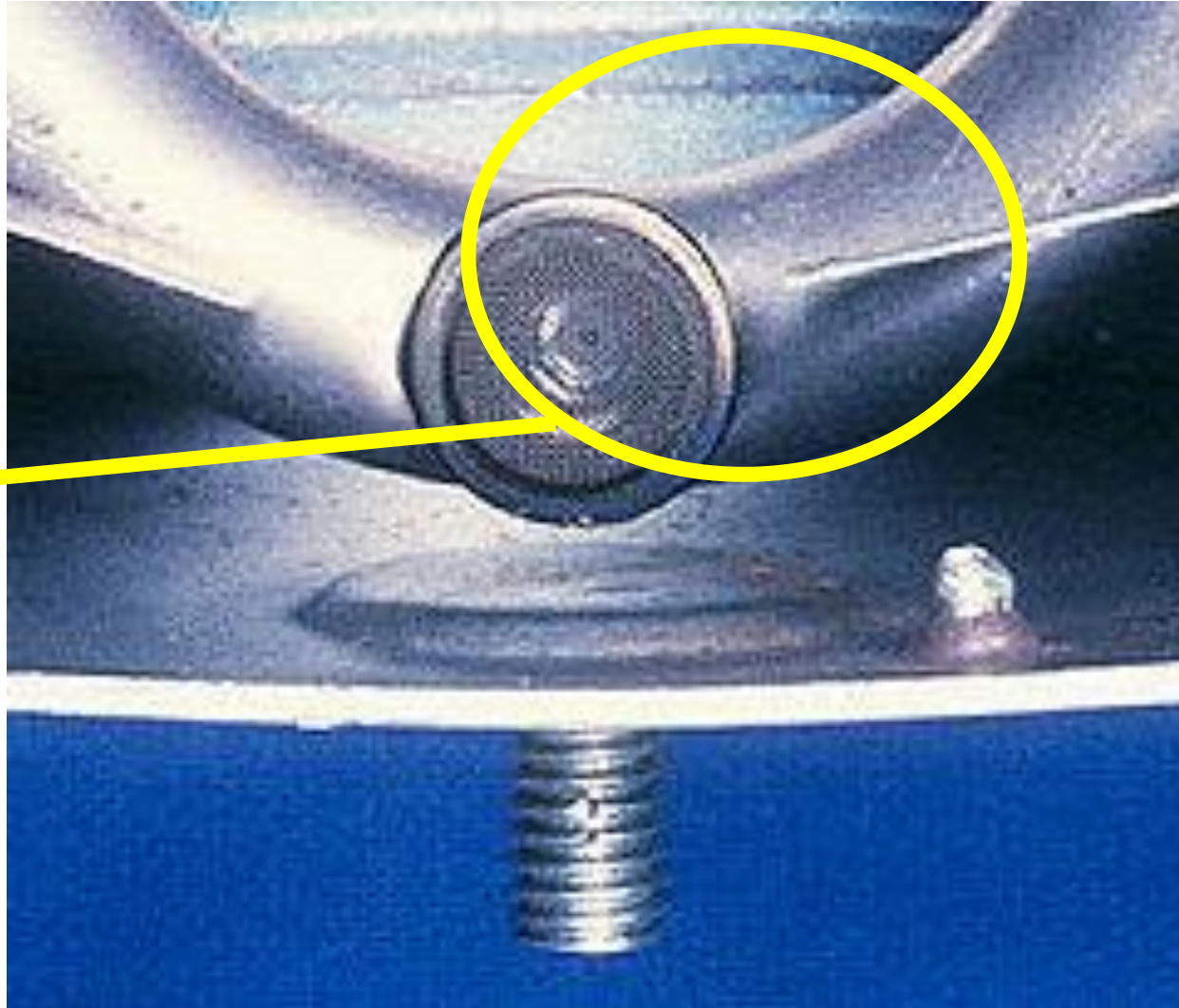
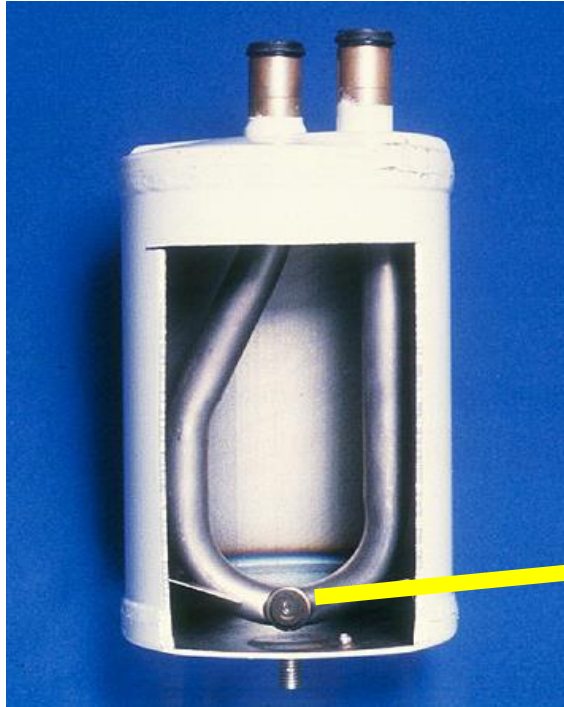


SUCTION LINE ACCUMULATOR



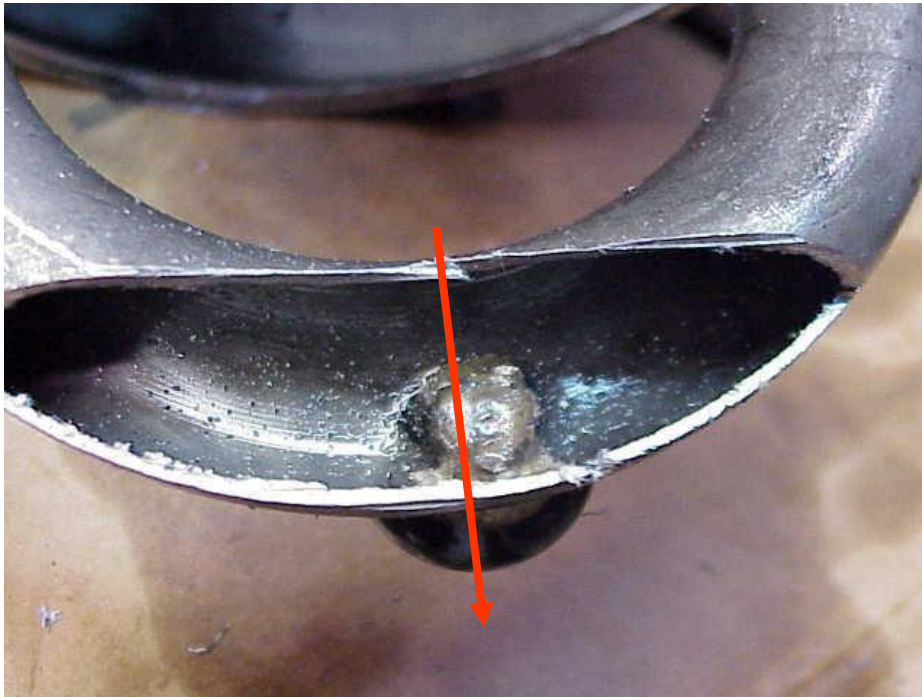


ACCUMULATOR BLEED HOLE



SUCTION LINE ACCUMULATOR

Oil return hole
plugged



Screen damage
and corrosion





NEW ACCUMULATOR



R-22



R-410A

**Mixing
tube mixes
the oil and
refrigerant
to
maximize
oil return**

PROTECT DEVICES WHILE BRAZING



**Use a heat sink
conductive paste
or wet rag**

NITROGEN PURGE WHILE BRAZING



Nitrogen Purge
Hookup

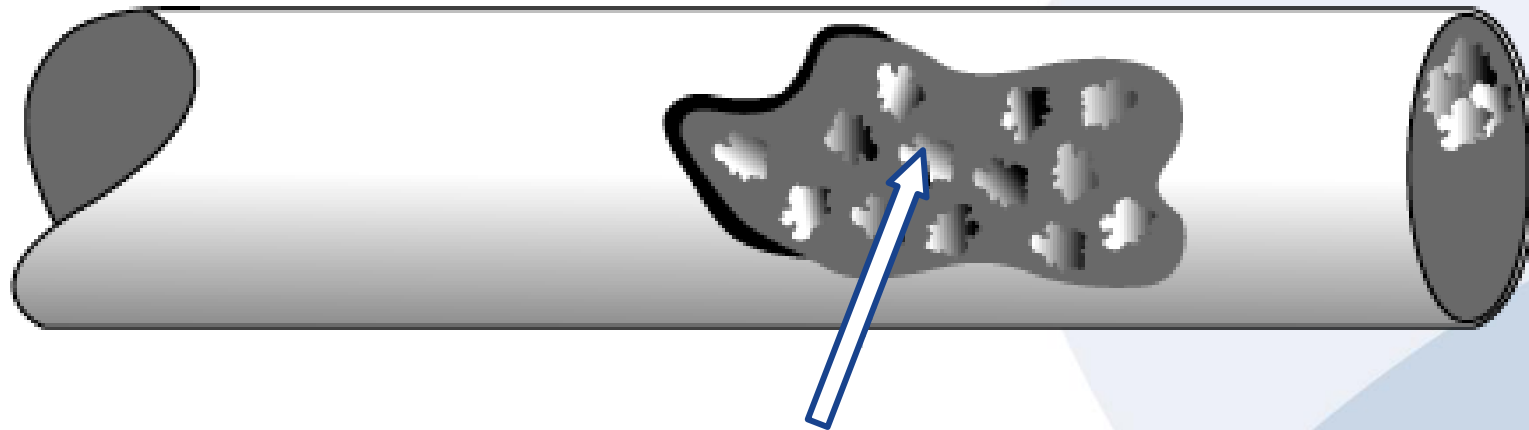


Braze Training Notes

- Importance of Nitrogen use and purging fully explained
 - A. Prevents oxides from forming during the braze operation.
 - B. All tubing assemblies shall be purged with nitrogen during brazing.



The debris, left of the tubes, are oxides from sample (left tube) resulting from no nitrogen purge. Right hand tube was properly purged with nitrogen.



COPPER OXIDE SCALE WITHOUT NITROGEN

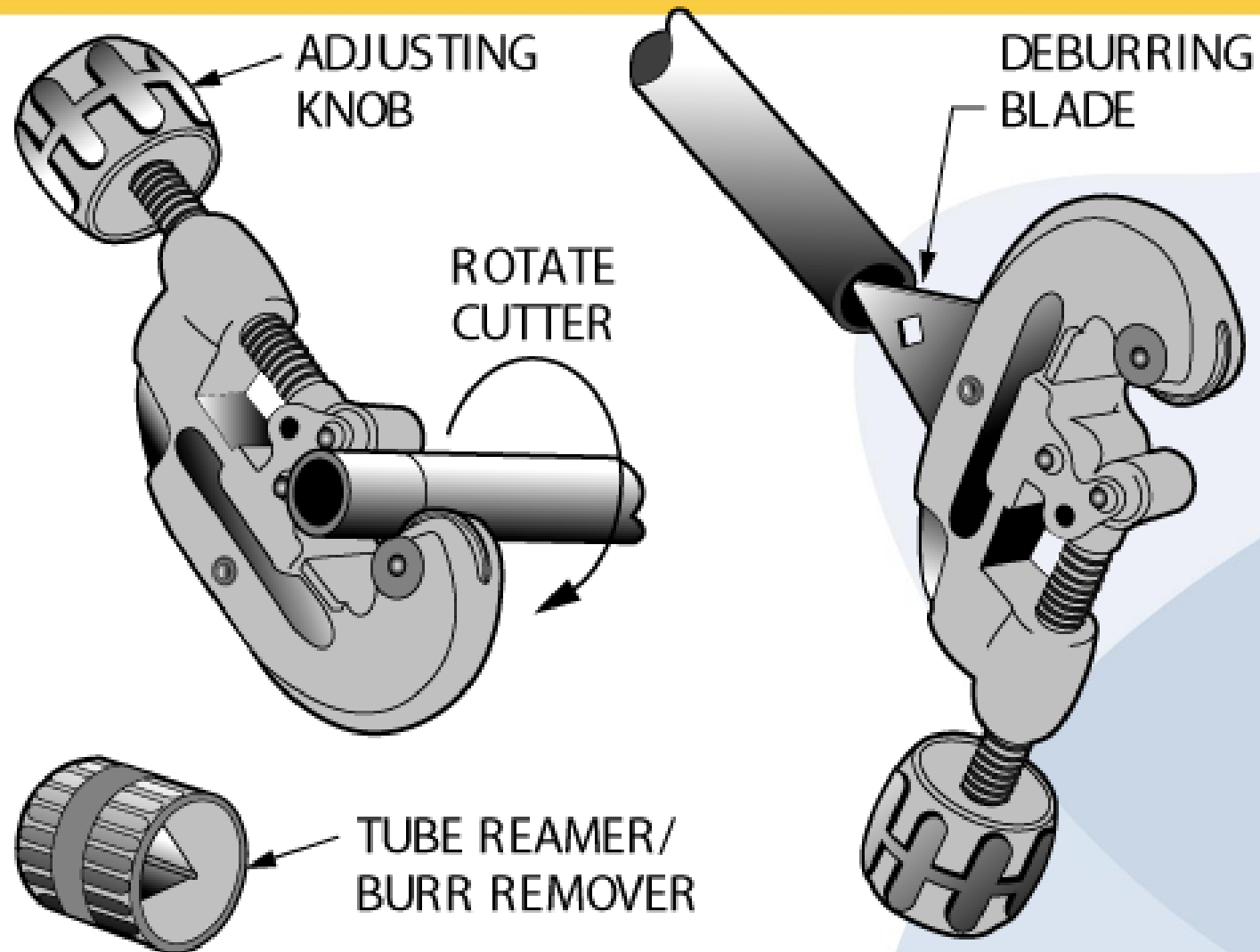
Purging refrigerant lines with nitrogen displaces any oxygen in the refrigerant lines and can prevent copper oxide formation

Braze Joint Examples - Acceptable





CUT TUBING PROPERLY





DEFROST METHODS

Method 1

Cyclic (30, 60, 90 Minutes)

Time & Temperature

Method 2

Demand Defrost

Outdoor Air Temperature / Outdoor Coil Temperature Difference

Air Pressure Drop

Refrigerant Pressure

COP

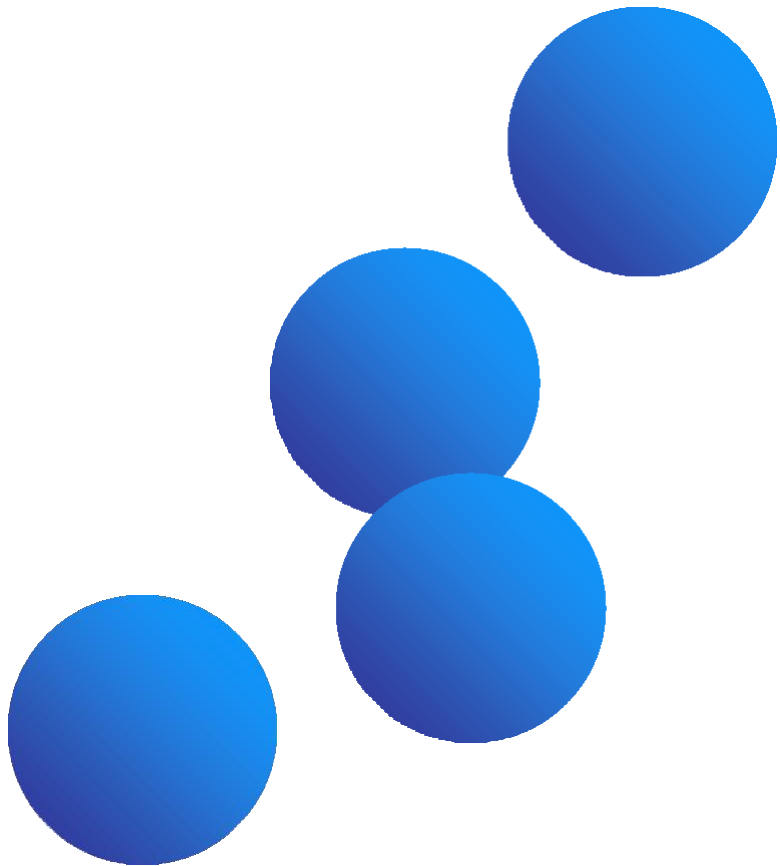
1. Generally =
$$\frac{\text{Useable Energy Output}}{\text{Total Energy Input}}$$

COEFFICIENT OF PERFORMANCE

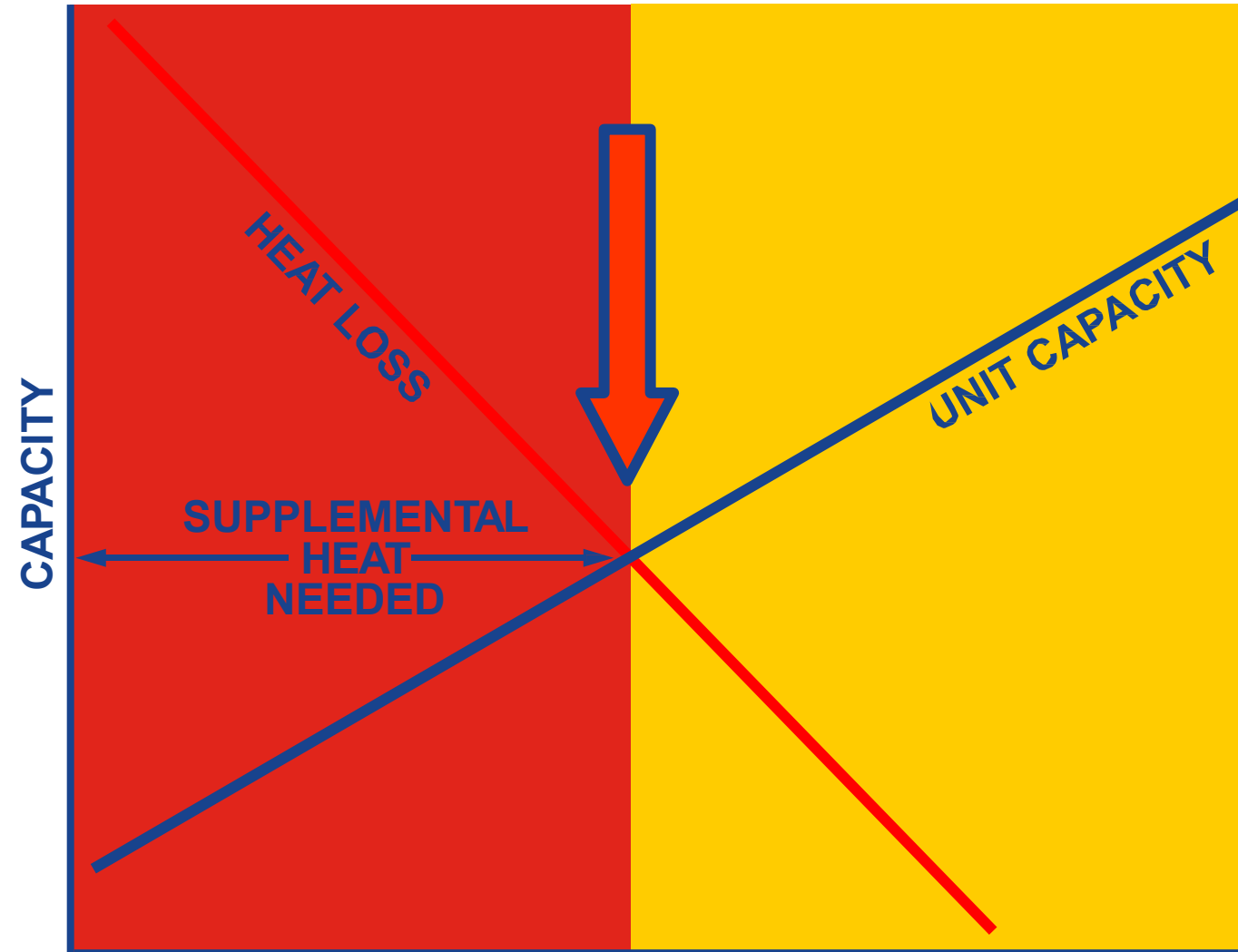


$$\begin{array}{c}
 \text{BTU's OUT} \\
 \hline
 \text{BTU'S WE PAY FOR}
 \end{array}
 = \frac{39,000^{\text{BTU/HR}}}{4380^{\text{WATTS/HR}} \times 3.413^{\text{BTU/HR}}} = 2.6$$

HEATING CAPACITY = HEAT LOSS



CAPACITY vs HEAT LOSS





CALCULATING CFM

Volts X Amps = Watts (Power)

1 Watt = **3.414** BTU'S

The SQRT of 3 is **1.73**

Constant 1.08

(1.08 = 0.24 X 0.075 X 60) FYI Not on TEST (Specific heat of air is 0.24, Specific density of air is 0.075 and 60 is number of minutes. 1.08 is not truly a constant but we use it below 2000')

Delta T is the Temperature Difference Between Supply and Return

Gas Heat

$$\text{CFM} = \frac{\text{Heating Capacity}}{1.08 \times \text{Delta T}}$$

Single Phase Electric Heat

$$\text{CFM} = \frac{\text{Volts X Amps X } \mathbf{3.414}}{1.08 \times \text{Delta T}}$$

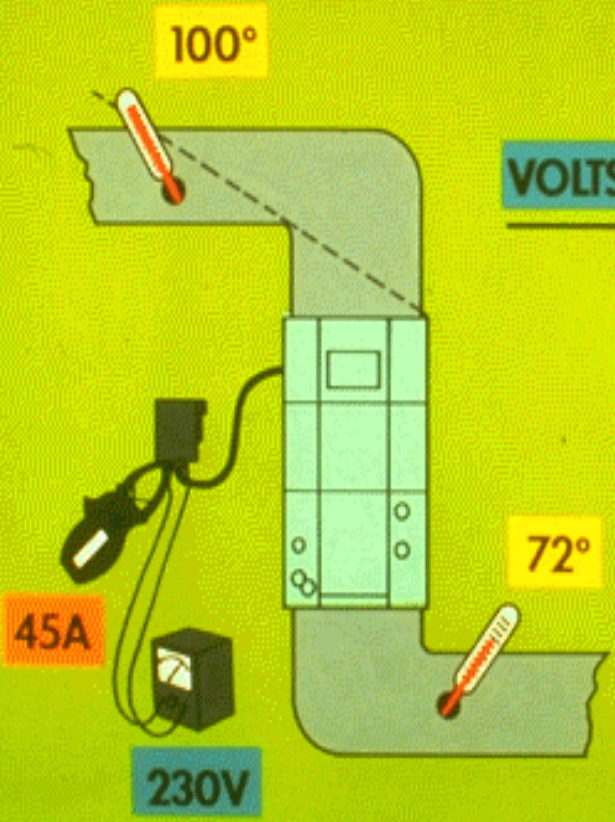
Three Phase Electric Heat

$$\text{CFM} = \frac{\text{Volts X Amps X } \mathbf{3.414} \times \mathbf{1.73}}{1.08 \times \text{Delta T}}$$



CALCULATING CFM

CFM =



100°

72°

45A

230V

$$\frac{\text{VOLTS} \times \text{AMPS} \times 3.414 \text{ BTU/WATT}}{1.08 \times \text{TEMP. DIFF.}} =$$
$$\frac{230 \times 45 \times 3.414}{1.08 \times 28} =$$

1170 C.F.M.

Questions/Discussions

Heat Pump “Things To Consider”

THINGS TO CONSIDER

Vapor line diameter & Length should be sized for a pressure drop not to exceed:

2-3 P.S.I. or 2 deg. F.

While bending soft copper tubing:

The cross-sectional area of the tubing must not be significantly reduced.

Improperly draining heat pump defrost runoff:

Will cause ice buildup and capacity loss.

Package unit curb gaskets: **Reduce sound transmission and prevent water leaks.**

A system evacuation is considered complete:

When the vacuum pressure reaches & holds 500 microns, or less.

A leaking system should be first inspected: **For visual traces of oil.**

To determine superheat:

You must measure suction line pressure and temperature.

Rectangular duct drive slips are: **Installed on the shorter side of duct.**

Heating control circuit amp draw must be measured:

In order to set thermostat heat anticipator.

Outdoor unit voltage drop is measured:

With the unit running, then when it is off.

Most electronic leak detectors: **Can detect down to .5 oz. per year.**

THINGS TO CONSIDER

If a loose vane causes a noisy supply diffuser:

Then replace the diffuser.

A 230-volt compressor running at 170 volts:

Will have the current increased and may trip on overload.

Liquid line condensation:

Is caused by a restriction, or excessive line length.

Dirty return air filters:

Cause cool air complaints, in the heat pump heating mode.

Undersized ductwork causes:

High sound levels, insufficient air volume, and high static pressures.

A system low on charge:

Will cause the reversing valve to not shift, or transfer.

To check a suspected shorted compressor motor winding:

Use an ohm-meter and check for continuity between the compressor terminals and between the compressor terminals to *ground (case)*.

A direct drive blower wheel, has bent vanes:

It causes loss in airflow, excessive motor wear, and increased noise.

In an electrical circuit:

A corroded wire to terminal connection acts like a resistor.

A flexible supply duct is leaking: **You should check all connections including inner and outer layers.**

The maximum external static pressure for blowers used for heating & cooling, 5-tons or less,
is 1 in. W.C. (Residential)

A wet bulb reading that is very close to the dry bulb reading:
Means the relative humidity is very high.

To properly evaluate a system in the heating mode, of a feeling “drafty” complaint:
You would measure supply temperature, register velocity, and C.F.M.

A line-set incased with-in an exterior wall:

Is subject to condensation on the suction line.

An extended plenum duct system is: **A single size trunk extending in one, or two directions, with many branch ducts.**

Supply airflow is increased when: **Static pressure on the return is reduced.**

Most residential t-stat wire is: **18 gauge.**

More tube circuits in the heat pump outdoor coil:

Minimizes the coil pressure losses.

THINGS TO CONSIDER

A restricted drier can cause: **Lower than normal suction pressure.**

Most electronic air-cleaners operate: **With 5000 volts or less.**

A line voltage fuse: **Is sized to protect the conductors.**

TXV's meter refrigerant flow, to the evap. Coil:

To maintain superheated refrigerant leaving the coil.

Some electro-mechanical thermostats require:

Both hot & common hookup, to transformer secondary.

The purpose of the auto change-over system switch on the heat pump thermostat is:

For auto switching between heat & cool, as the load changes.

An outdoor ambient thermostat sensor is installed:

In the entering air stream to the O.D. Heat-pump coil.

A high-pressure limit control is installed in the compressor discharge line:

To prevent excessive condensing pressure.

Heat pump suction line low pressure limit control, has dual purpose compressor protection: **To protect the compressor if suction pressure drops to low and detect loss of charge.**

The reversing valve function is to provide: **Heating & or cooling.**

A relay coils inrush current: **Is always greater than its holding current.**

The method to stage a two-stage heat pump compressor: **Is based on deviation from thermostat set point.**

Electronic controls are best used:

Because they make decisions based on many inputs.

Fire dampers must be used:

In any duct that passes thru a two hour fire rated wall or partition.

Heat pumps are typically sized for:

The cooling load of the space to be heated and cooled.

ACCA manual J is used for: **Accurate residential load calculations.**

The thermal balance point of a dual fuel heat pump is the outdoor conditions at which:

The capacity of the heat pump alone matches the heating load.

Taking average readings of air velocity in the cross-sectional area of a duct is called: **Traversing**

A motor can have two, four, or more poles. What happens when a motor has fewer number of poles: **The motor turns faster**

The combined output of a heat pump and its auxiliary heat should not exceed the calculated heat loss of a home by more than: **15%**

What effect does raising the pressure in a sealed system have on refrigerant? **The refrigerant's boiling point increases**

Zero pounds gauge corresponds on the absolute scale to: **14.7**

Hidden heat in refrigeration work is referred to as: **Latent heat**

The heat used to change a liquid to a gas is called the latent heat of **Vaporization**

Five pounds of water is heated by two degrees F. How many btu were added to the water: **10 btu**

The amount of heat required to melt one pound of ice at 32 degrees F is: **144 btu**

When performing preventive maintenance on a heat pump the technician should check the outdoor fan to be certain that the:

Fan runs freely with no binding

Why do you need to add a control for a heat pump indoor coil that is installed on a fossil fuel furnace:

So, the heat pump and furnace do not operate at the same time in normal heating

What happens when you energize a hermetic refrigeration compressor, and the system is in a deep vacuum:

Motor windings could become damaged

What needs to happen in order to consider an evacuation to be complete:

System should be evacuated to a vacuum of 500 Microns or below

Why must the runoff be drained off and away from the outdoor coil:

Excessive ice can build up on the bottom of the coil and can reduce capacity

THINGS TO CONSIDER

To properly set a heat anticipator it is necessary to check the:

Heating control circuit amperage draw

When suspended with metal strap and no saddle, flexible duct should be:

Supported with a minimum strap width of 1/2"

What does the outdoor fan do during the defrost cycle on a heat pump and why: **Shuts off to minimize defrost time**

Charging a heat pump with refrigerant is best accomplished in the:

Cooling mode

Heat pumps can provide both heating in the winter and cooling in the summer. In which mode is the heat pump more efficient: **Heating mode**

Which of the following components is exclusive to the heat pump:

Reversing valve

Which of the following airflow rates is the most reasonable for a heat pump system operating in the heating cycle: **450 CFM per ton**

Heat is present in winter outdoor air until the outside air ambient temperature reaches a low temperature of: **45 degrees F**

During the heat pump's cooling cycle, the outdoor coil is utilized as a _____ while the indoor coil is utilized as a _____.

Condenser, evaporator

The correct way to size a heat pump is to perform both heating and cooling load calculations and select the heat pump size by:

Using the cooling load to size the system

Reading a voltage across the contacts of the outdoor thermostat means:
The thermostat contacts are open

On an air-to-air heat pump system, the suction pressure and discharge pressure are low during the cooling months. What are two possible problems: **A restricted indoor metering device and a dirty air filter**

On an air-to-air heat pump system, the discharge pressure and suction pressure are high during the heating months. What are two possible problems: **A dirty indoor filter and non-condensables in the system**

How can a system be tested to determine if the reversing valve is leaking internally: **A temperature measurement can be taken at the inlet and the outlet of the valve in the heating and cooling mode**

When an air-to-air heat pump is in the cooling mode, what can cause a decrease in high-side and low-side pressure:

A restricted indoor metering device

A residential supply diffuser that is noisy because of a loose vane is best serviced by: **Replacing the diffuser**

A technician measures the return air temperature of a 100,000 Btu output furnace to be 65°F and the supply side air temperature is 135°F: **? CFM**

At sea level, a gauge pressure of 35 psig is equal to an:

Absolute pressure of 49.7 psia

When checking the pressures in an operating system with a manifold gauge set:

Refrigerant oil in a hose will have no effect on the gauge reading

The smallest refrigerant leak that an electronic leak detector should be capable of sensing is: **0.5 oz. per year**

A heat pump operating in normal ice-free conditions maintains a certain temperature difference between the outdoor coil temperature and the surrounding outdoor ambient:

This temperature difference is referred to as coil TD

When a capillary tube is overcharged you would get a:

Low superheat and high sub cooling

The effect of adding a charge to subcooling is it:

Increases its subcooling

A reason for cool air complaints when a heat pump is operating in the heating cycle: **Excessive supply air velocities**

On a service call for a cooling problem with a heat pump, your inspections find a liquid line that has condensation on it: **The most likely cause would be the liquid line is restricted**

What is the effect of 170 volts supplied to a 208/230-volt compressor:
Would cause a current increase and the motor may trip on overload

Conditions that can cause a reduction from design capacity in a heat pump are an: **Undersized vapor line**

Flash gas in the liquid line of any heat pump must be avoided. Liquid line flash gas can be caused by: **Excessive liquid line length or lift**



THINGS TO CONSIDER

A split system heat pump is using thermostatic expansion valves to regulate superheat:

The system performs properly in heating but in cooling the compressor pumps down:

Which could mean the power element of the indoor expansion valve has lost its charge

Bent vanes on a direct drive blower wheel in an air handler can cause:

Loss in airflow -Excessive motor wear -Increased noise

A capacitor start-capacitor run (CSCR) motor has an open run capacitor so it may start:

But it draws a higher-than-normal running current

A step-down transformer has a rating of 40 VA. Its primary voltage is 120V with a secondary voltage of 24V. This transformer must not be connected to a load above a maximum current draw of: **1.7 amps**

A bright red or orange glow from the resistance element in a duct heater:

Indicates that the flow of air is insufficient

A technician is working on a heat pump with a capacitor start-capacitor run compressor. On initial startup, the compressor hums momentarily and it shuts down on internal overload: **The issue is a faulty capacitor!**

The effect of a low charge on the switchover operations of a reversing valve is the: **Reversing valves are less likely to transfer if charge is low**

If the technician believes that a hermetic compressor has a permanently open internal overload protector:

The technician should test the compressor while it is cool

In a low voltage circuit, a corroded wire-to-terminal connection in the circuit is like: **An additional resistor**

The technician is using an analog multimeter to check a run capacitor. With the meter set to ohms the needle swings toward zero and then slowly rises toward infinity:

This tells the technician that the capacitor charges and discharges

A symptom that a technician would expect on a heat pump system in the cooling mode if the check valve is leaking internally is a:

Flooding of the indoor coil

The first two checks typically made on an electronic control are:

Presence of proper input signals & proper output voltages

The following conditions exist in a circuit that supplies power to three parallel loads:

One load is resistive / One load is capacitive / One load is inductive

THINGS TO CONSIDER

A wet bulb reading that is very close to the dry bulb reading from the same instrument indicates: **The relative humidity is very high**

Sensible heat ratio is: **Sensible removed ÷ total heat removed**

A technician has determined a supply in a flexible duct system is leaking: **All connections including inner and outer layers should be checked**

When a balancing check of a newly installed duct system the: **Dampers should be open completely in all rooms**

The recommended maximum external static pressure used for heating and cooling equipment with blowers for 5 ton of cooling or less is: **1 in W.C.**

When changing out an evaporator coil the installer must be certain to: **Plumb the cabinet so its sides are vertical**

The technician suspects that an outdoor thermostat used to bring on auxiliary heat may be out of calibration. The thermostat is a close-on-fall type that is adjustable. One method for checking the thermostat calibration is to:

Manually rotate the shaft until the thermostat closes and compare the dial setting to an accurate outdoor temperature reading plus 10°F

A control string is defined as two or more switch contacts connected in a circuit, or set of circuits, to control a load. In order to troubleshoot a load controlled by a control string:

The technician must first check for proper voltage applied across the load

The voltage most often used to power the outdoor unit in a residential system is: **240V single phase**

THINGS TO CONSIDER

The effect on supply airflow when static pressure on the return is reduced is:

Airflow will be increased

Residential control or low voltage wiring normally is: **Shielded wired**

An extended plenum duct system is a:

Single trunk extending in one or two directions with many branch ducts

The three things that happen when a heat pump is cycled into the defrost mode are:

The reversing valve switches to the cooling mode , the outdoor fan is shut off and the auxiliary heat is energized

There are two generally used methods for changing capacity on demand in a heat pump:
One is to use a two-speed compressor. The other method is using a two-stage thermostat

In a simple refrigerant system: **The refrigerant boils in the evaporator**

What type of energy is transferred when work is done in the condenser:

Both latent and sensible heat energy

When the heat load on an evaporator increases, what is the effect on the system: **Suction pressure and discharge pressure both increase**

Why is superheat necessary in a system that utilizes hermetic compressors:

It ensures that dry vapor reaches the compressor so that mechanical damage does not occur

Boiling of the refrigerant occurs in which system component: **Evaporator**

The following measurements would be needed to properly evaluate a complaint of “drafty” operation with a heating system are:

System TD drop / Static pressure

Disc type temperature limit controls, used to protect auxiliary heat elements from overheating are: **Always auto reset by temperature**

THINGS TO CONSIDER

Some electromechanical type thermostats require both the hot side and common connections to: **Display lights**

The terms grille and register are often used interchangeably. There is a difference between these two components. The primary difference between a grille and a register is that: **A register is equipped with an air volume control device and the grille is not**

A “cross break” made on all flat sides of any rectangular section of metal duct will: **Increase rigidity and reduce vibration**

If you increased suction pressure on a reciprocating compressor:
The capacity would decrease

An important reason for using electronic controls is:
They can make decisions based on many inputs

The sensor of an outdoor ambient thermostat for a heat pump system typically installed in the:

Entering airstream to the outdoor coil

A high-pressure limit control, used to shut down a compressor if condensing pressure becomes excessive is:

Typically installed to sense compressor discharge line pressure

A disc-type, close-on –rise pressure control is being used as a loss-of-charge limit control on the liquid line of a heat pump. The control must sense a specified pressure within 15 seconds of a compressor start for the compressor to continue operation. If the cut-in setting of the control drifts lower: **The system is less likely to shut down as a result of a small leak**

Low pressure limit controls are often placed in the suction line of a heat pump for two purposes. They are to: **Protect the compressor if suction pressure drops too low & to detect a loss of a charge**

The relationship between inrush current and holding current of a relay coil is: **Inrush current is always greater than holding current**

THINGS TO CONSIDER

The timing specification of sequencers is often marked on the device using a code similar to H1-24 C45-75. The specification for this particular sequencer marked with this code is: **Contacts close 1 to 24 seconds after coil is energized and contacts open 45 to 75 seconds after coil is de-energized**

A seven-day programmable thermostat can program a different daily schedule which is: **Used for the next seven days only**

The capability of electronic programmable room thermostat to reset the set point early so that the space temperature reaches a set temperature at a specific time is called: **Computed recovery**

One method used with electronic defrost controls to determine the need for defrost is: **To use two temperature sensors**

When using a double (dual) element time-delay fuse with a 20-amp motor: **The maximum fuse size should be 25 amps**

One of the sensors measures coil temperature. The other measures outdoor air temperature. The two temperatures used by the control to determine if a defrost is needed because:

The lower temperature, the faster the outdoor coil builds up frost

When the capacity of a heat pump in heating, measured in Btu's, is the same as the heat loss of a structure:

The system is said to have reached its balance point

Electronic air cleaners: **Do not remove odors**

A packaged heat pump must be: **Mounted on a slab if its location is at grade level**

Whenever possible, the slab should be:

Located away from the structure to minimize noise

A suction line accumulator should be used in a residential heat pump only when recommended by the manufacturer: **If long refrigerant lines increase system charge over recommended maximum charge**

The measurement of a heat pumps efficiency is often stated using its:

Coefficient of Performance or COP

The COP of a heat pump is the: **Heat pumps heat output in watts divided by the total electrical input in watts**

A benefit in using electronic air cleaner is: **Indoor air quality (IAQ) is improved**

The purpose of calculating the heat loss at an outside design temperature is to: **Select the appropriate equipment based on Btu output**

The minimum circuit amp listed on a units' data plate is used to:

Determine the max fuse or circuit breaker size

The effective method of reducing sound when AHU is located in a closet is to: **Use vibration isolators**

The purpose of a sequencer in a HP with an AUX 20 kW electric heater is to:

Energize one or two elements and the blower then energize the other elements in timed intervals

In a HP circuit, an open check valve is used to:

By-pass refrigerant flow around the metering device

The forward curve centrifugal fan is the:

Most commonly used type in residential systems

In a reversing valve: **The single pipe is connected to the compressor discharge**

THINGS TO CONSIDER

Economizer systems close the outdoor air vent to a:

Preset minimum when outdoor air enthalpy exceeds the set point

Condensation on vapor lines is a:

Concern when the lines are routed inside a wall

Refrigerant sub-cooling is measured:

Between the refrigerant condensing temperature & liquid line temperature

In a single zone system; if a customer complains of feeling damp or sticky the cause could be:

Unconditioned air being pulled into the duct work through holes in the duct

Checking voltage input to a compressor should take place at the:

Load side of the contactor

After compressor burn out: **Test the oil for acidity levels**

Manufacturers recommend that the most acceptable method of attaching line sets to the AHU is: **Utilizing brazing alloy**

THINGS TO CONSIDER

There are more circuits in a HP outdoor coil than in an A/C outdoor coil to:

Minimize refrigerant pressure drop

Inefficient voltage or current to a solenoid will result in:

Vibration or chatter of the solenoid

A compressor that is suspected to be grounded to its' housing should be checked

Continuity from the terminal windings to ground

The coil of a potential relay is connected to:

The common and start terminals of a compressor

When the load on a HP in cooling mode decreases:

Suction pressure increases & discharge pressure decreases

The measurements needed to find suction superheat are:

Suction pressure & suction line temperature

The purpose of an auto change over switch on a t-stat is to:

Allow automatic change over between heating and cooling

THINGS TO CONSIDER

Undersized duct work will often cause: **Increased static pressure.**

Determining voltage drop at the outdoor unit requires:

Checking voltage feed with the outdoor unit not running & then with the outdoor unit running

A manometer is used to: **Measure static duct pressure**

A system that has been evacuated to 500 microns & rises immediately and at a constant rate after the vacuum pump has been shut off:

Due to a leak in the system

To obtain an accurate refrigerant temperature on a horizontal suction line that is 1 1/8" or larger:

The TXV sensing bulb should be located at 4 or 8 o'clock on the pipe

The primary consideration when bending soft copper to any radius is the:

Cross sectional area must not be significantly reduced

A simple time-activated switch is an example of a control that does not use:
Feedback

Which of the following systems would typically require a blower with a 2000 cfm output: **5-ton ac system**

A typical induced-draft furnace uses a blower-off delay in the cooling mode to: **Increase the efficiency of the system**

Typical wood studs in residential homes are spaced how far apart: **16 inches**

The following component is energized first after an intermittent ignition gas furnace calls for heat? **Induced draft motor**

The number 3,412 btu is equal to: **1 kilowatt**

A cooling load calculation estimates the sensible heat gain of a structure. The maximum sensible capacity of a cooling-only system should be within _____% of this calculated value: **+15%**

THINGS TO CONSIDER

The maximum sensible cooling capacity of a heat pump should be within _____% of the calculated sensible heat gain of a structure with a large heating load: **+25%**

The combined output of a heat pump and its auxiliary heat should not exceed the calculated heat loss of a home by more than _____%: **15%**

What amount of auxiliary electric heat is needed when the output of a heat pump on a design day equals 18,800 Btuh and the heat loss of a home is 29,700 Btuh: 3.2 or 3.8? **kWh**

The three processes that transfer heat energy are conduction, convection, and _____: **Radiation**

Heat transfer that occurs when substances of different temperatures are in contact with each other is called _____: **Conduction**

What effect does raising the pressure in a sealed system have on refrigerant:
It raises the refrigerants boiling point.

What is the primary danger of an accidental refrigerant spill:

Suffocation caused by the heavier refrigerant displacing oxygen in the air

The maximum temperature at which refrigerant may be stored is _____°F
when the container is no more than _____% full of liquid by volume:

125°F, 80%

The effect of a low charge on the switchover operations of a reversing valve is the: **Reversing valves are less likely to transfer if charge is low**

On some installations, a heat pump indoor coil can be installed on an existing, operable, fossil fuel furnace. When this type of installation is done, you need to add a control so that:

The furnace and heat pump do not operate at the same time in heating



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THE END

Questions/Discussions