COMMERCIAL REFRIGERATION EUROPE

SOLSTICE® L40X (R-455A) IMPLEMENTATION GUIDELINES

HOW TO MANAGE AND TAKE ADVANTAGE OF GLIDE.

Honeywell

TARGET AUDIENCE | TABLE OF CONTENTS

Target Audience

- **Contractors:** Learn how to handle refrigerants with glide successfully, including R-455A.
- **System Engineers and Designers:** Get information on how to design, optimize and commission systems operating with refrigerants with glide, including R-455A.

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INTRODUCTION TO GLIDE

What Is Glide

Azeotropic or near-azeotropic refrigerants behave as a single component with a boiling temperature that doesn't change in the evaporator or the condenser. When using zeotropic refrigerant blends, the temperature in the evaporator will be colder at the start of the coil than at the end. At the same time, the temperature in the condenser will be warmer at the beginning than at the end of the coil. The difference between these temperatures is the Glide.

- Glide is often a compromise one needs to make with a refrigerant in exchange for lower GWP, performance match (COP, capacity) and higher safety (lowest possible safety risk).
- Glide is not a constant value throughout the range of operating pressures, though its value varies as pressure varies. When we talk about average glide, we mean a theoretical value calculated based on the properties of the respective refrigerant. In practice, the real glide values need to be checked at the evaporator and condenser level, where they are usually lower.
- Glide is not an issue as long as you manage it. Glide can be an opportunity to reach even better system performance.

Glide is easy to manage and can improve system performance.

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INTRODUCTION TO GLIDE

2000

R-407C
average glide 5K

Comfort cooling applications

Widely used for 20 years without any issue.

2014

R-448A
average glide 4,5K

Low- and medium-temperature refrigeration applications

Main A1 substitute for R-404A and used in >25,000 installations worldwide, in new equipment and as a retrofit product in existing installations.

2017

R-455A
average glide 10K

Low- and medium-temperature refrigeration applications

Long-term, GWP<150 alternative to R-404A and mid-GWP blends in new refrigeration systems. Already implemented successfully without any issue in commercial and industrial refrigeration installations.

Glide is not new and does not represent an issue in practice.

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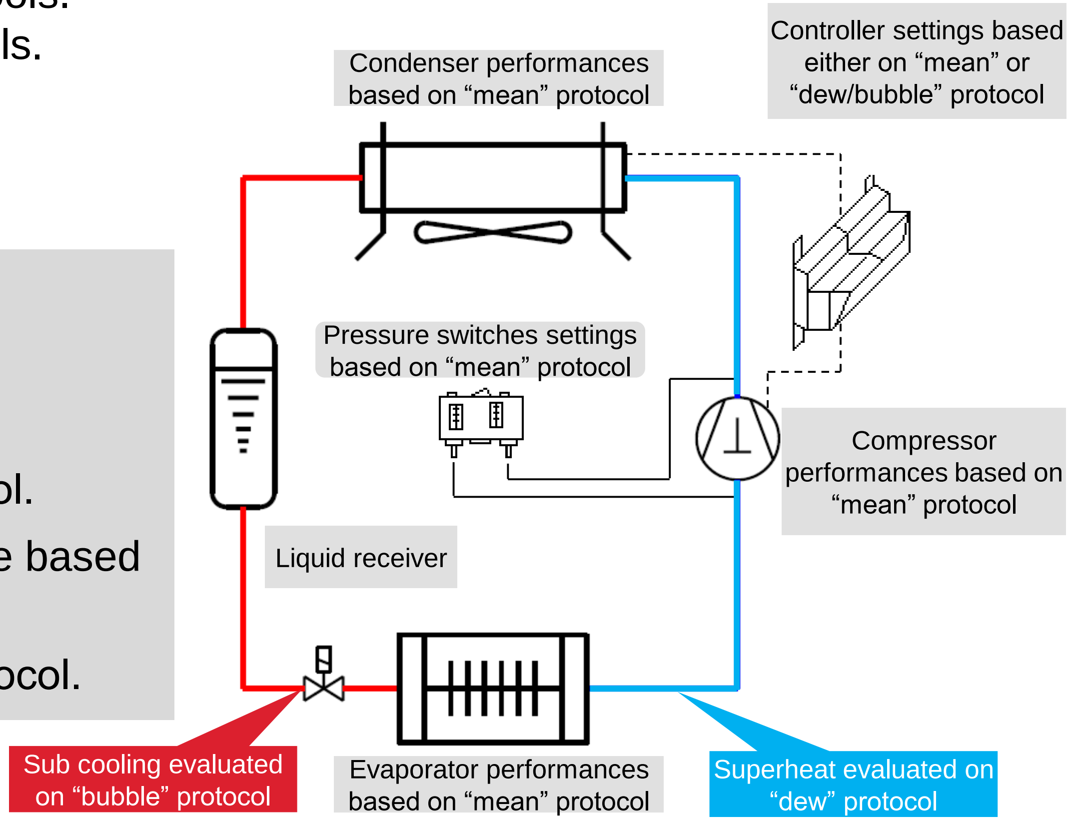
PART 1: HOW DO I SELECT THE RIGHT SYSTEM COMPONENTS?

- Glide is only relevant in the design of heat exchangers.
- Most major manufacturers of heat exchangers have integrated Honeywell's blend refrigerants, also R-455A, into their selection tools. Take the advantage of selecting your components using these tools.
- For a list of components approved for R-455A, please click **here**.

Important Recommendations

- During component selection, the performances of compressor, evaporator and condenser should be evaluated on "mean" protocol.
- The parameter calculation for other system components should be based on "dew" or "bubble" protocol.
- System controls can be set either on "mean" or "dew/bubble" protocol.



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HEAT EXCHANGERS | EVAPORATOR

Selection based on mean temperature reflects best the natural response of a blend with glide in an evaporator.

Using dew point for evaporating temperature can lead to erroneous design and undersized evaporators.

✓ Evaporator sized on mean temperature

Kelvion

DATASHEET
Kelvion Select RT

Air Cooler Direct Expansion | DFAE 052D HX32

Capacity [kW]	Air inlet temp. [°C]	Rel. humidity [%]	Air outlet temp. [°C]	Evaporation temp. [°C]	Refrigerant	Operation mode
4,28	0,0	85,0	-4,6	-10,0 (Mid point)	R455A (Solstice® L40X)	AC

Air data			Heat exchanger			Materials	
Air volume flow	1.900	m³/h	Surface	13,8	m²	Tubes	Copper
Ext. static pressure	0	Pa	Fin spacing	4,5	mm	Fins	Alu
Air throw	11	m	Internal volume	2,7	dm³	End plates	Alu
Altitude	0	m	Liquid temp.	15,7	°C	Casing	Alu, galvanised steel
Air outlet rel. humidity	100,0	%	Superheating temp.	-1,8	°C	Finish	
			Max. operating pressure	32,0	bar		

✗ Evaporator sized on dew temperature

Kelvion

DATASHEET
Kelvion Select RT

Air Cooler Direct Expansion | S-DFAE 052D HX32

Capacity [kW]	Air inlet temp. [°C]	Rel. humidity [%]	Air outlet temp. [°C]	Evaporation temp. [°C]	Refrigerant	Operation mode
6,88	0,0	85,0	-7,0	-10,0 (Dew point)	R455A (Solstice® L40X)	AC

Air data			Heat exchanger			Materials	
Air volume flow	1.900	m³/h	Surface	13,8	m²	Tubes	Copper
Ext. static pressure	0	Pa	Fin spacing	4,5	mm	Fins	Alu
Air throw	11	m	Internal volume	2,7	dm³	End plates	Alu
Altitude	0	m	Liquid temp.	15,7	°C	Casing	Alu, galvanised steel
Air outlet rel. humidity	99,9	%	Superheating temp.	-3,5	°C	Finish	
			Max. operating pressure	32,0	bar		

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HEAT EXCHANGERS | CONDENSER

Selection based on mean temperature reflects best the natural response of a blend with glide in a condenser.

Using dew point for condensing temperature can lead to erroneous design and oversized condensers.

✓ Condenser sized on mean temperature

Kelvion

DATASHEET
Kelvion Select RT

Condenser | RF-SJ101L4H-063S069

Capacity [kW]	Ambient [°C]	Rel. humidity [%]	Condensing temp. [°C]	Eff. condensing temp. at 26 [kW] [°C]	Hot gas tsup [°C]	Refrigerant	Sections x Circuits	Operation mode
29,38	32,0	41,0	49,5 (Mid point)	47,5	75,0	R455A (Solstice® L40X)	1 x 8	EC

Air data		Heat exchanger		Materials	
Air volume flow	5580 m³/h	Surface	62,3 m²	Tubes	Copper
Fans in stand-by	-			Fins	Alu
Ext. static pressure	0 Pa			Casing	
Altitude	50 m	Fin spacing	2,12 mm	Finish	
Air outlet temp.	48,8 °C	Internal volume	10,6 dm³	Corrosion class	-
Coil direction	Horizontal	Subcooling	4,5 K		
Air direction	Vertical	Max. operating pressure	32,0 bar		

✗ Condenser sized on dew temperature

Kelvion

DATASHEET
Kelvion Select RT

Condenser | RF-SJ101L4H-063S069

Capacity [kW]	Ambient [°C]	Rel. humidity [%]	Condensing temp. [°C]	Eff. condensing temp. at 20 [kW] [°C]	Hot gas tsup [°C]	Refrigerant	Sections x Circuits	Operation mode
18,10	32,0	41,	45,0 (Dew point)	46,4	75,0	R455A (Solstice® L40X)	1 x 8	EC

Air data		Heat exchanger		Materials	
Air volume flow	5580 m³/h	Surface	62,3 m²	Tubes	Copper
Fans in stand-by	-			Fins	Alu
Ext. static pressure	0 Pa			Casing	
Altitude	50 m	Fin spacing	2,12 mm	Finish	
Air outlet temp.	42,3 °C	Internal volume	10,6 dm³	Corrosion class	-
Coil direction	Horizontal	Subcooling	0,0 K		
Air direction	Vertical	Max. operating pressure	32,0 bar		

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COMPRESSOR

Selection based on mean temperature reflects best the natural response of a blend with glide in a compressor.

✓ Compressor sized on mean temperature

Tecumseh

Compressor
Voltage Code : FZ

AJ4480P-FZ

High Temp. Commercial (HP)

220 - 240V 1~ 50 Hz

R455A

AJ4480P-FZ3A

Operating conditions	Customized... / 50 Hz / Mid			Sound Power ISO3745 / ISO 3743-1
Evaporating Temp. :	-10.0 °C	Refrig. Capacity :	1078 Watt	61 dBA
Superheat :	5.00 K			
Return gas temp. :	-10.0 °C	Power Input :	573 Watt	
Condensing Temp. :	45.0 °C	Amps :	[illegible] A	
Subcooling :	2.00 K	C.O.P :	1.88 Watt/W	
Liquid :	33.4 °C			

✗ Compressor sized on dew temperature

Tecumseh

Compressor
Voltage Code : FZ

AJ4480P-FZ

High Temp. Commercial (HP)

220 - 240V 1~ 50 Hz

R455A

AJ4480P-FZ3A

Operating conditions :	Customized... / 50 Hz / Dew			Sound Power ISO3745 / ISO 3743-1
Evaporating Temp. :	-10.0 °C	Refrig. Capacity :	948 Watt	61 dBA
Superheat :	5.00 K			
Return gas temp. :	-10.0 °C	Power Input :	573 Watt	
Condensing Temp. :	45.0 °C	Amps :	[illegible] A	
Subcooling :	2.00 K	C.O.P :	1.65 Watt/W	
Liquid :	33.4 °C			

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PART 1: RESOURCES

- If you want to learn more about the concept of glide, please see **Appendix pages 21 - 22.**
- For a list of components approved for R-455A and an example of component selection, please see **Appendix pages 23 - 24.**
- For more information on how to take advantage of glide in system design, see **Appendix pages 25 - 27**.
- For more information on evaporator selection and settings, please see **Appendix pages 28 - 29.**
- For more information on condenser selection and settings, please see **Appendix pages 30 – 31.**
- For more information on compressor selection, please see **Appendix page 32.**
- If you are a designer of heat exchanger systems, and want to learn more about sub-component selection process for glide refrigerants, please see **Appendix pages 33 - 35.**

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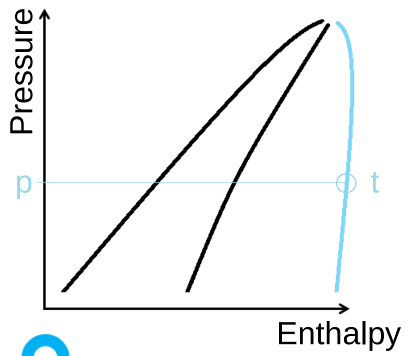
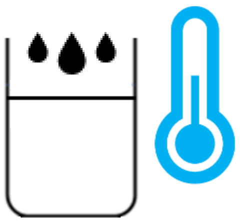
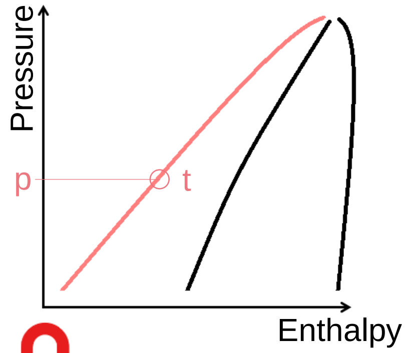
PART 2: HOW DO I TUNE THE SYSTEM RIGHT?

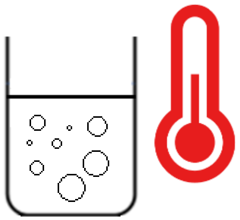
System controls can be set either on “mean” or “dew/bubble” protocol.



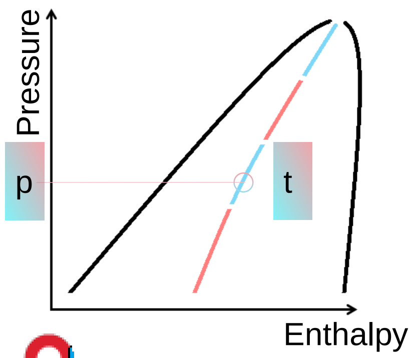


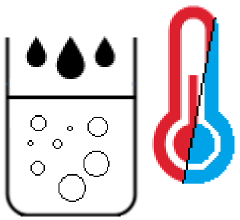
Controls convert temperature setpoint into pressure and vice versa based on **dew point curve**





Controls convert temperature setpoint into pressure and vice versa based on **bubble point curve**





Controls convert temperature setpoint into pressure and vice versa based on **mean point curve**

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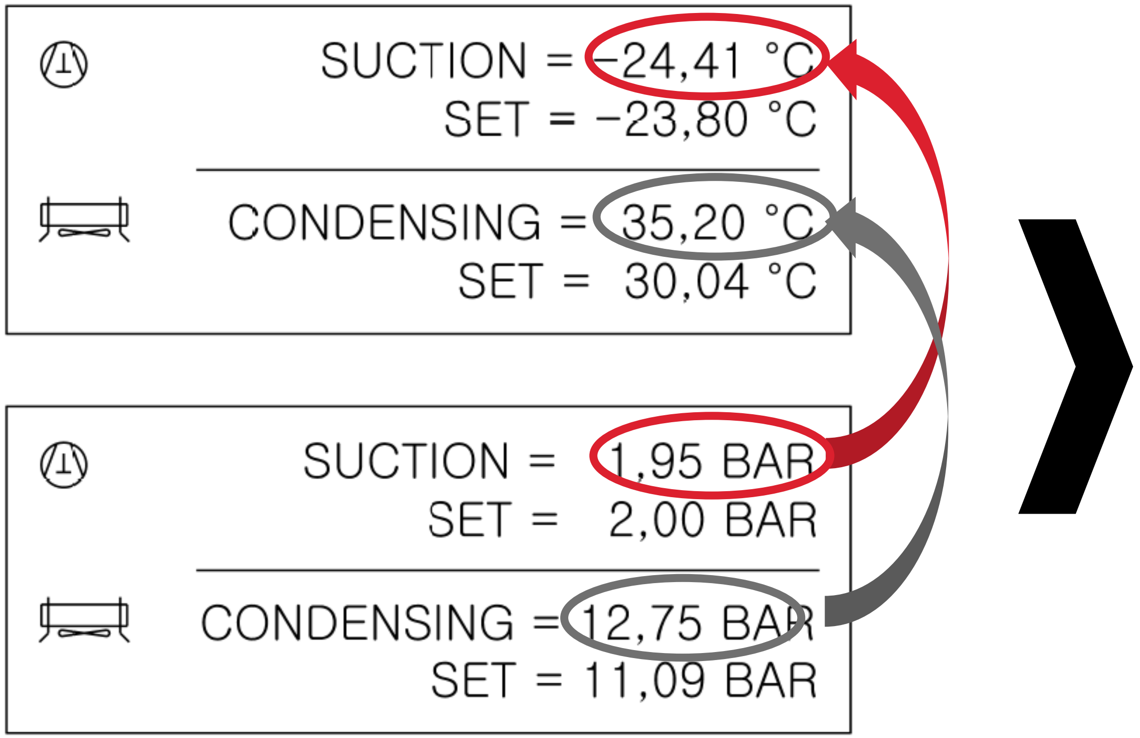
RACK AND CONDENSER CONTROLLERS

The identification of the operation mode of the controller (dew (ref. table a), bubble (ref. table b) or mean (ref. table c) point curve) is key to set controls parameters in order to reflect the "mean" protocol on the back end of the controller. Depending on controller's operation mode (curve type), you need to match the relevant P-T chart of the respective refrigerant to the controller display values.



a ✓

Liquid Pressure	R-455A Dew Temp
(bar)	(°C)
1.3	-33.8
1.35	-32.96
1.4	-32.14
1.45	-31.35
1.5	-30.58
1.55	-29.83
1.6	-29.09
1.65	-28.38
1.7	-27.68
1.75	-27
1.8	-26.33
1.85	-25.68
1.9	-25.04
1.95	-24.41
2	-23.8

b ✗

Liquid Pressure	R-455A Bubble Temp
(bar)	(°C)
1.3	-46.58
1.35	-45.73
1.4	-44.9
1.45	-44.1
1.5	-43.31
1.55	-42.55
1.6	-41.81
1.65	-41.08
1.7	-40.37
1.75	-39.68
1.8	-39
1.85	-38.34
1.9	-37.69
1.95	-37.05
2	-36.43

c ✗

Liquid Pressure	R-455A Mean Temp
(bar)	(°C)
1.3	-38.91
1.35	-38.07
1.4	-37.24
1.45	-36.45
1.5	-35.67
1.55	-34.92
1.6	-34.18
1.65	-33.46
1.7	-32.76
1.75	-32.07
1.8	-31.40
1.85	-30.74
1.9	-30.10
1.95	-29.47
2	-28.85

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SETUP EXAMPLE

- **Set-up parameter:** Evaporating temperature set-point
- **Inputs:**
  - Evaporating temperature (-10°C)
  - Refrigerant (R-455A)
  - Average glide (10 K)
- **Mode:** Curve type #a (dew-point)
- For more information and additional set-up examples, please see **Appendix pages 37 – 40.**

Sanity check:

at constant P, $T_{dew} > T_{mean} > T_{bubble}$

$$T_{des} = Tsp - \frac{1}{2}\ x\ glide$$

$$-10 = Tsp - \frac{1}{2}\ x\ 10$$

$$T_{sp} = -10 + 5 = -5$$

Back end of controller

Rack controller

Parameter = evaporating temperature set point

T_{evap_des} = -10°C

T_{evap_sp} = -5°C

Controller display

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SUPERHEAT SETTINGS

Superheat should be evaluated based on the dew temperature.

Proper superheat setting ensures efficient operation of the system and compressor safety.

Liquid pressure	R-455A bubble temperature	R-455A dew temperature
bar	°C	°C
1,5	-43,31	-30,58
1,55	-42,55	-29,83
1,6	-41,81	-29,09
1,65	-41,08	-28,38
1,7	-40,37	-27,68
1,75 ①	-39,68	-27 ②
1,8	-39	-26,33
1,85	-38,34	-25,68
1,9	-37,69	-25,04
1,95	-37,05	-24,41
2	-36,43	-23,8

Example:

- measured evaporator outlet temperature: minus 20˚C
- evaporating pressure: 1,75 bar ①
- dew temperature: minus 27˚C ②
- superheat amount: -20˚C - (-27˚C) = 7K

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PART 2: RESOURCES

- For more information on rack and condenser controller settings, and additional set-up examples, please see **Appendix pages 37 - 40**.
- For more information on superheat and sub-cooling settings, please see **Appendix pages 41 - 48**.
- You can find the commissioning data you need under the following **Appendix pages 49 - 50**.

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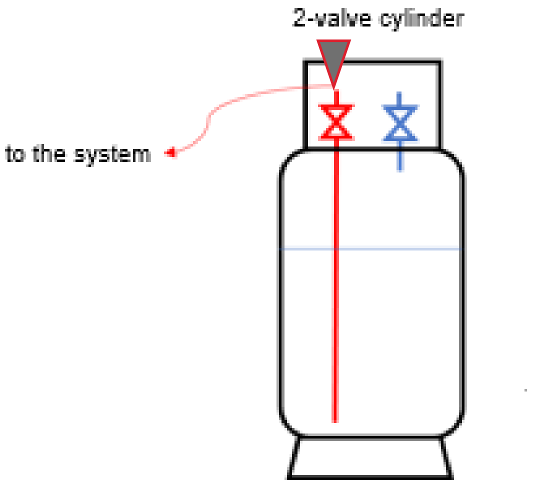
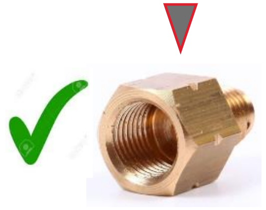
PART 3: HOW TO CHARGE REFRIGERANT WITH GLIDE INTO MY SYSTEM

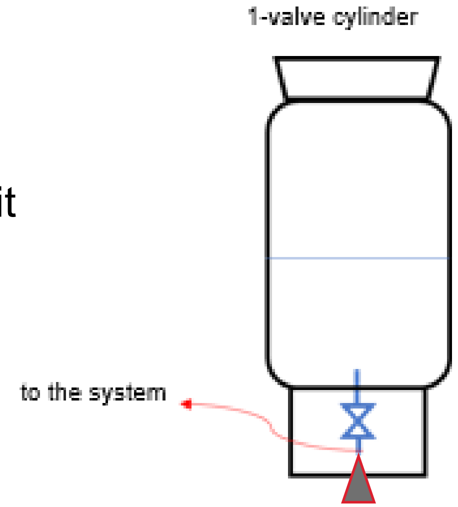
Please remember that A2L refrigerants are filled in cylinders with left-hand thread. In order to connect to a standard flexible hose, you need to use an inter-connector on cylinders.

- Charge the system with refrigerant in liquid phase only.
- In the final stage of the charging procedure, use throttling device connected to the low-pressure side of the system.
- In the case of a 2-valve cylinder (with dip tube): Charge from liquid (red) valve.
- In the case of a 1-valve cylinder (without dip tube): Put carefully and safely cylinder upside down.
- Following these guidelines will ensure proper system performance.



Use the left-hand-thread connector on the cylinder to connect 1/4 “ flexible hose after it





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PART 3: RESOURCES

- If you want to learn more about charging of systems with glide refrigerants, please see **Appendix pages 52 – 53.**

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PART 4: DO I NEED TO REFILL THE WHOLE SYSTEM AFTER LEAKAGE?

If a system filled with R-455A loses part of its charge, you do not need to refill it with the whole charge again.

The reason for that is: R-455A does not fractionate, not even in the case of system leakage.

The term “fractionation” means the change of the composition of a refrigerant blend, and belongs to the most frequent myths around refrigerants with glide.

Several studies have been conducted on the subject; the most recent one from the certified laboratory of the CETIM/CNAM institute (Paris). This study consisted in a simulation of repeated severe leakages (30% of the refrigerant charge) and top-off recharge of the missing charge in a condensing unit. It has been observed, how the composition of the refrigerant blend R-455A and the performances of the system evolved over repeated rounds of leakage and top-off recharge.

This fractionation study, simulating extreme conditions, shows in particular that:

- The composition of the refrigerant blend R-455A does not change and
- The actual system cooling capacity and energy consumption do not experience any noticeable variations over the repeated steps of leakage and top-off recharge operations.

As a conclusion, this study confirms that in case of charge loss in a system filled with R-455A, you can top-off the system just with the missing charge, without fearing any change in the composition of the blend and/or negative impact on the performances of the system. Hence it is not necessary to empty and refill the whole refrigerant charge into the system.

The following slides show you the results of the CETIM/CNAM study.

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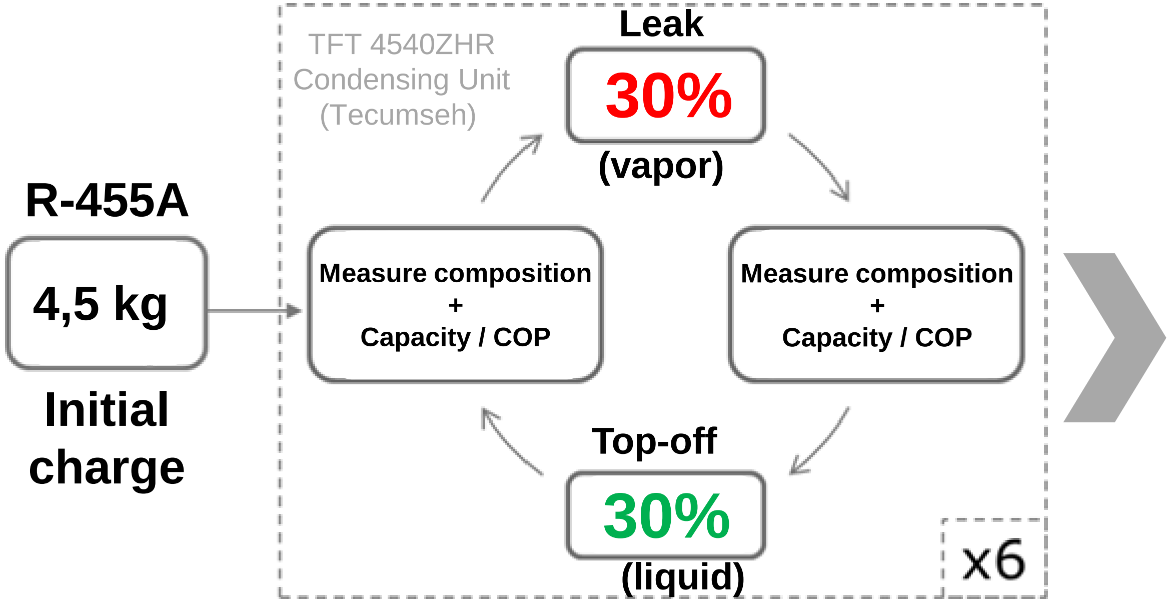
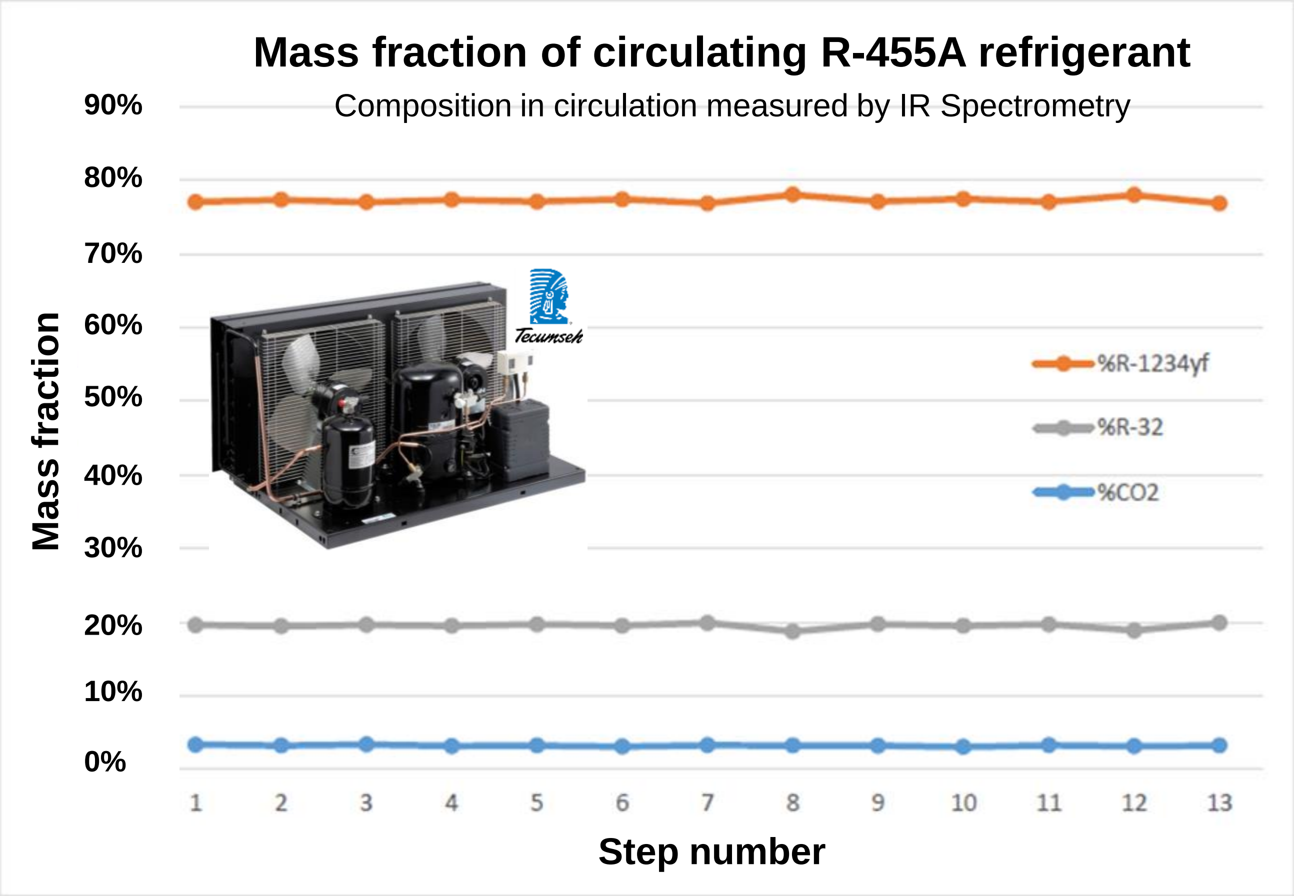
R-455A LEAKAGE ANALYSIS BY CETIM/CNAM





No fractionation observed after 6 leakages & top-off – the composition of the refrigerant blend does not change.

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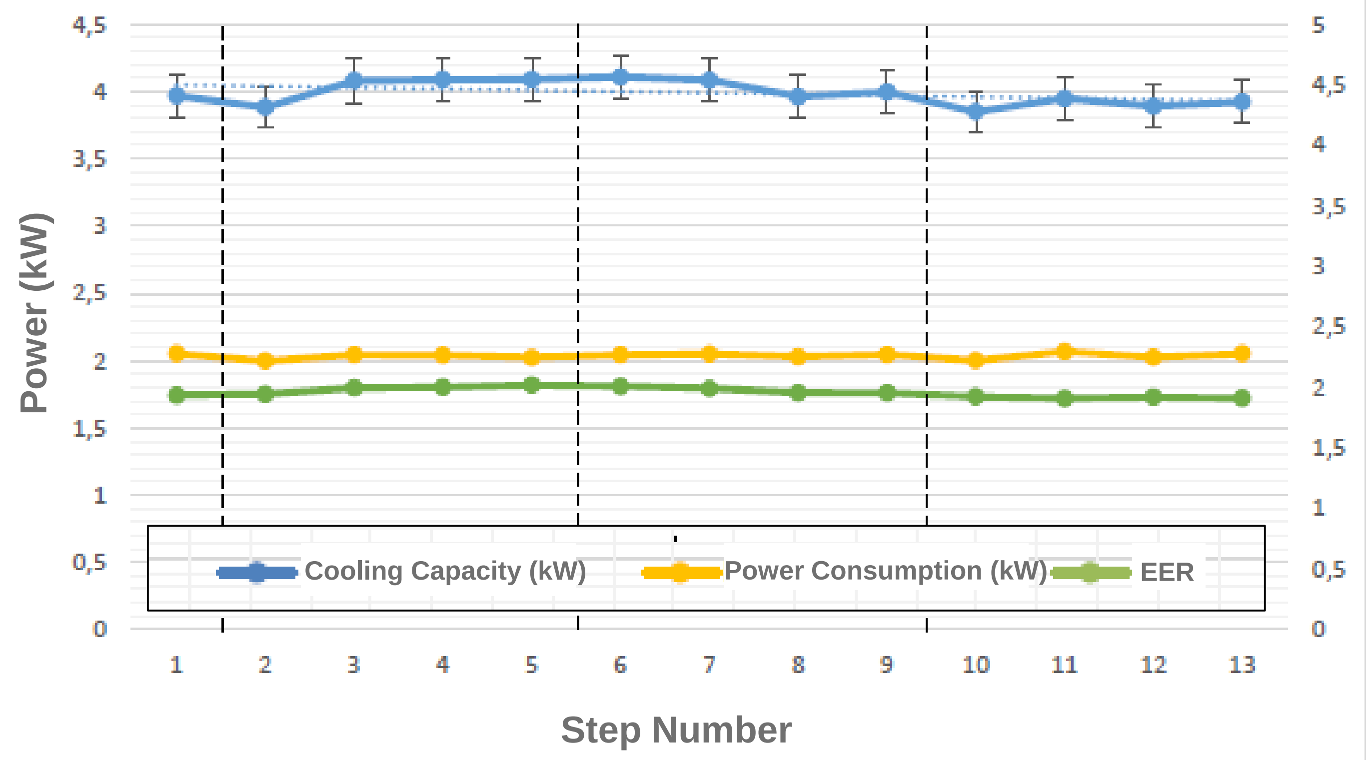
R-455A LEAKAGE ANALYSIS BY CETIM/CNAM

System performance and capacity are stable over the series of 6 leakages & top-off.

Evolution of cooling capacity, power consumption and EER



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APPENDIX

Honeywell

APPENDIX TO PART 1: HOW DO I SELECT THE RIGHT SYSTEM COMPONENTS?

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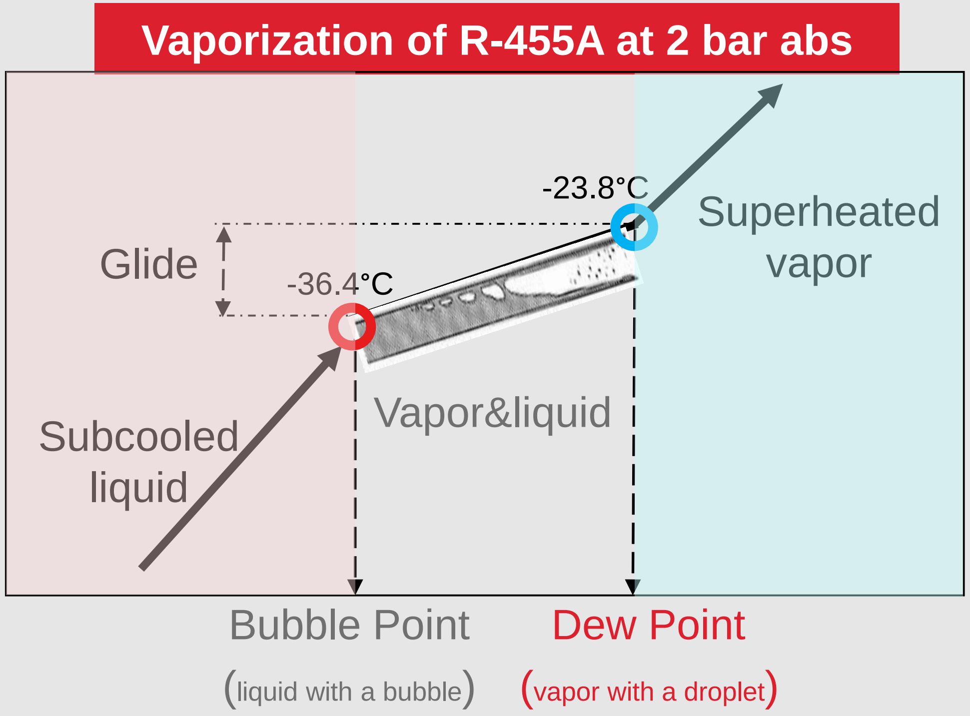
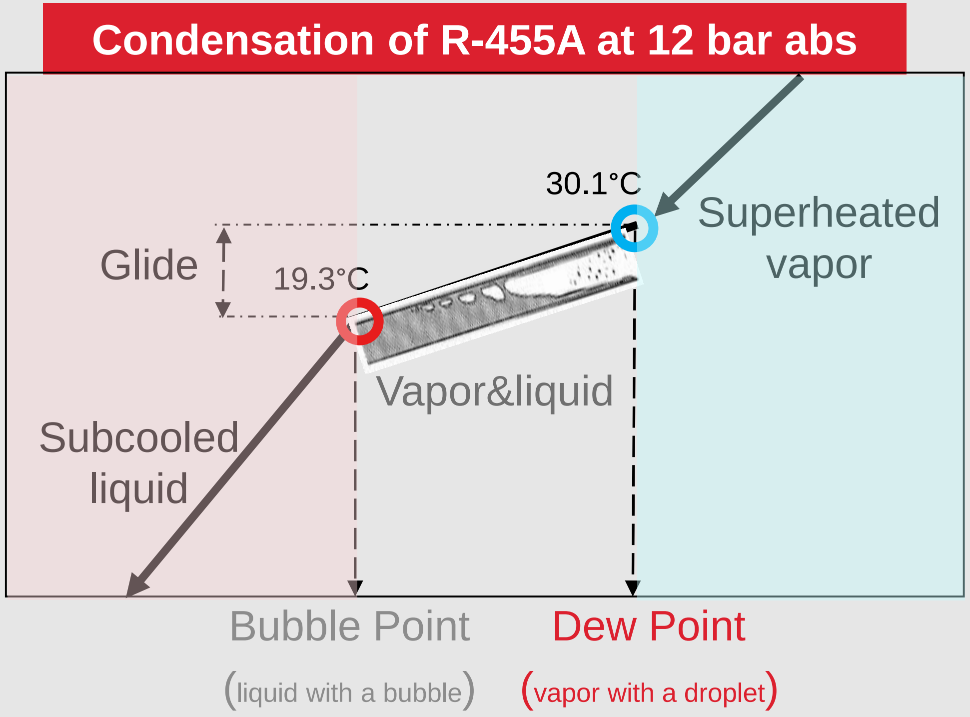
THE CONCEPT OF GLIDE (1/2)





- All refrigerant blends classified by ASHRAE as “R-4xx“ are zeotropic blends and have a glide.
- For zeotropic blends, the temperature varies between dew (saturated vapor) temperature and bubble (saturated liquid) points in a constant pressure process (vaporization, condensation).
- In the graphs above (refrigerant R-455A), the average temperature glide is 10K.

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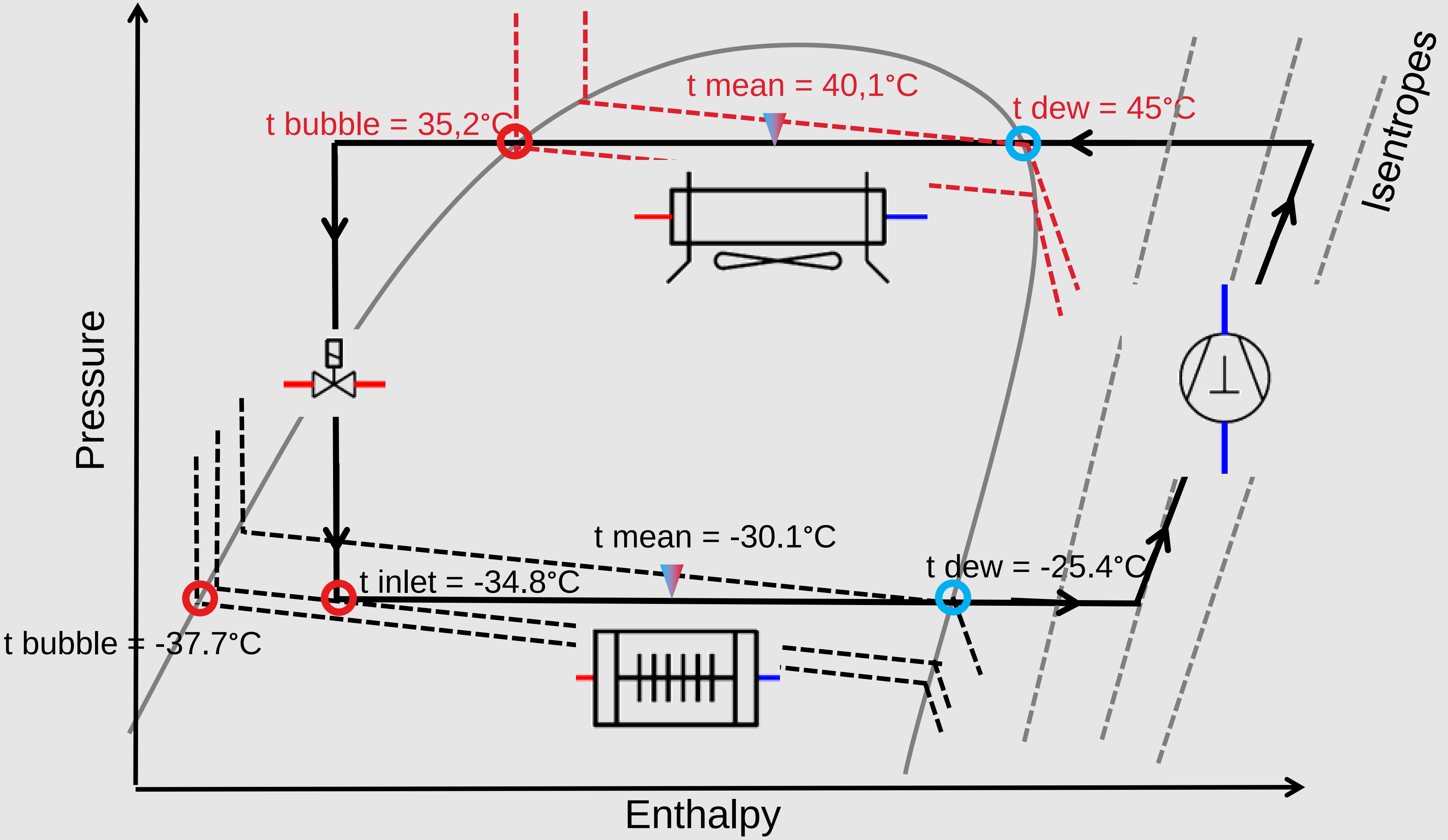
THE CONCEPT OF GLIDE (2/2)



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APPROVED COMPONENTS LIST

Whenever you design, assemble or repair a system with Honeywell low GWP refrigerants you need basic components. We provide the most relevant list of components suitable for our newest refrigerants Solstice® ze (R-1234ze), Solstice® yf (R-1234yf) and Solstice® L40X (R-455A).

FIND COMPONENTS AND MANUFACTURERS

Refrigerant: Solstice L40X (R-455A)

Component Group: Please select Component Group

Manufacturer:

☐ By completing this form, one of our technical experts will contact you to discuss your requirement.

Here you will find the updated list of components approved for R-455A: LINK

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EXAMPLE OF SYSTEM COMPONENTS SELECTION

Nr	Component	R-455A	
1	Compressor	type [-]	Bitzer 4NES-14Y
		capacity [kW]	9,1
		COP [-]	1,48
		displacement [m^3/h]	56,25
		to [^oC] / tc [^oC] mean	-32 / 40
		sup/sub [K]	10/2
2	Condenser	type [-]	Guentner GCHC RD 045.2/12-44-4234260M
		capacity [kW]	17,4
		heat exch. area [m^2]	54,2
		noise pressure level [dB(A)]	44@10m
		design temperature difference [K]	10
3	Air cooler	type [-]	Guentner S-GHF 045.2J/17-ENW50.E
		capacity [kW]	9,8
		heat exch. area [m^2]	38,4
		design temperature difference [K]	10
4	Expansion valve	type [-]	Danfoss TE5-2
5	Suction line	outer diameter [mm]	28
6	Liquid line	outer diameter [mm]	10
7	Discharge line	outer diameter [mm]	15
8	Liquid receiver	internal volume [ltr]	14
9	System charge size	charge size [kg]	12,8

Example:

Low temperature, direct expansion system supplying freezer room, system based on reciprocating compressor, air condenser, air cooler, distance air cooler-compressor 10 m, distance compressor-condenser 5 m.

- $T_{internal}$ = -20°/-22°C
- Freezer room dimensions: 3 x 4 x 3.5 m
- Cooling capacity Q = 9 kW

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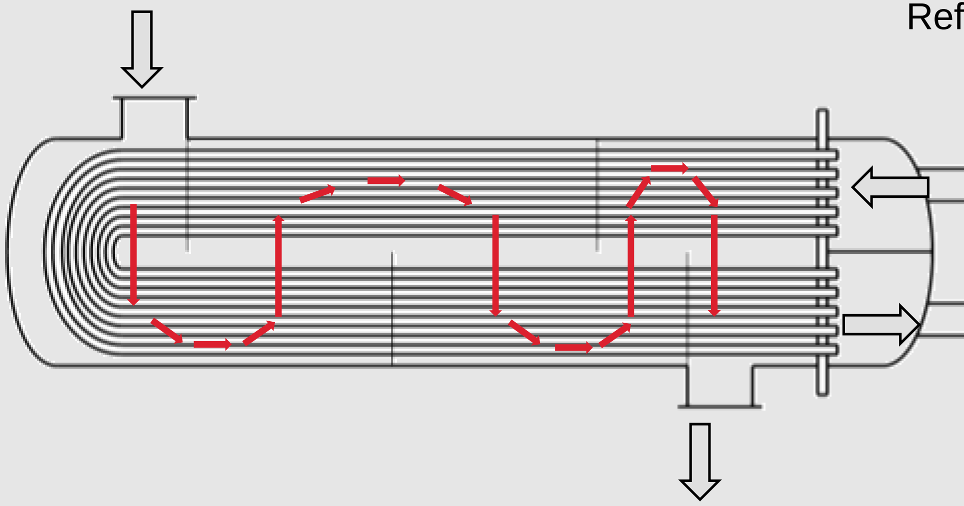
HEAT EXCHANGERS (1/2)

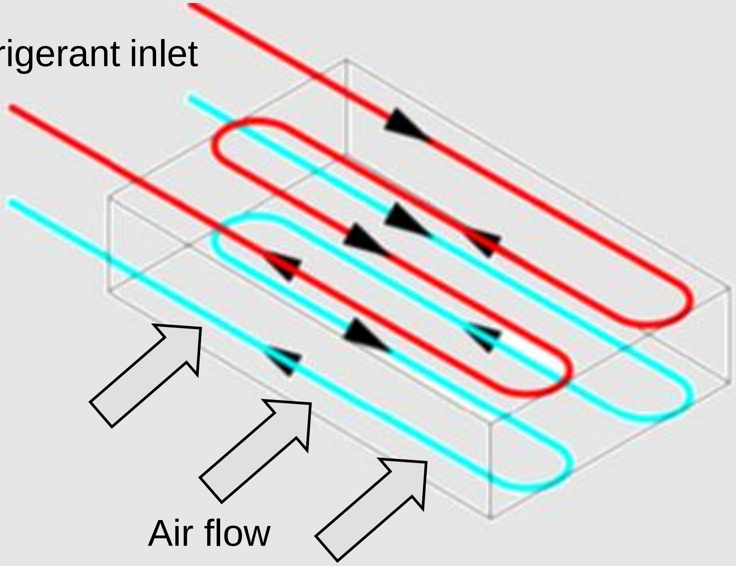
Orientation of evaporator and condenser in the system

- Only counter-flow or cross-counter-flow pattern in condenser and evaporator are suitable.

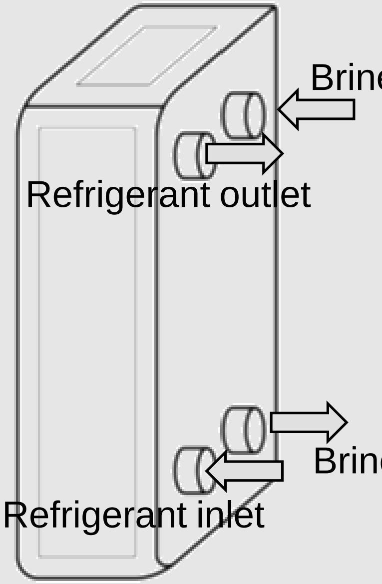
Cross-counter flow



Cross-counter flow



Counter flow



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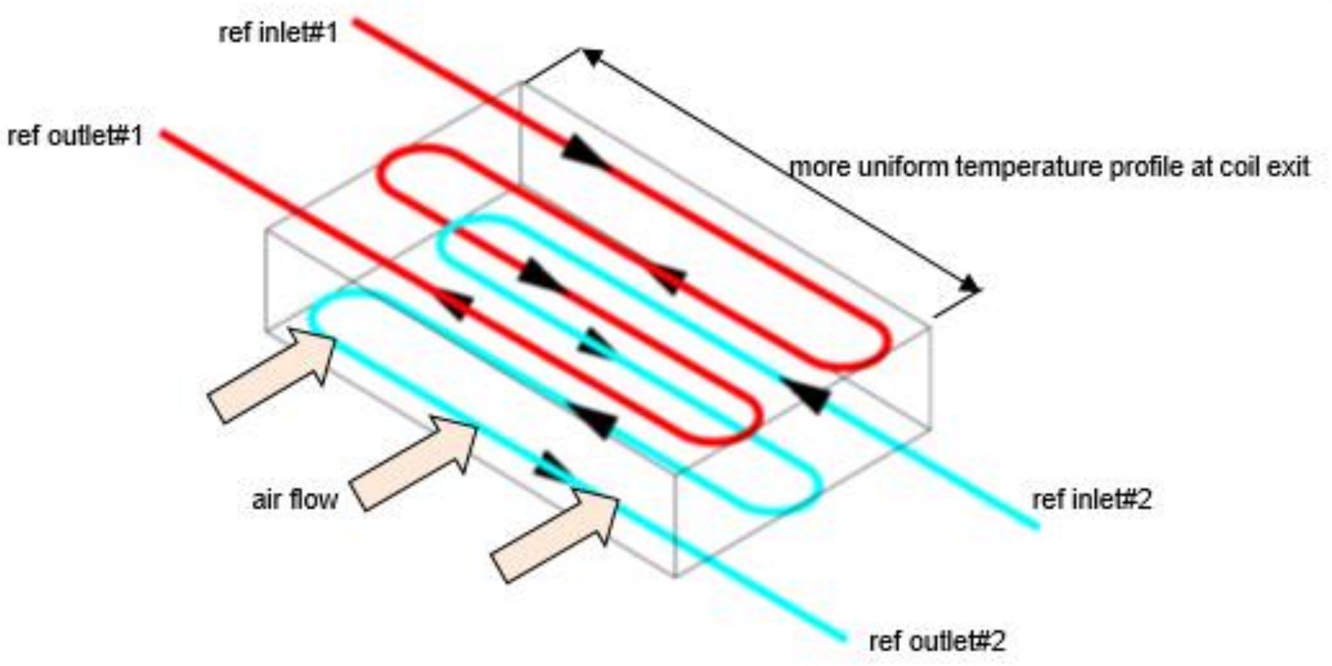
HEAT EXCHANGERS (2/2)

- For lengthy coils e.g. in display cabinets (i.e. where discharge air streams do not mix well with each other along the coil), apply coil with counter-flow refrigerant circuits.



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HOW TO TAKE ADVANTAGE OF GLIDE

The relative orientation of evaporator and condenser in the system can lead to higher COP

Configuration	Cooling		Heating	
	COP increase by CYCLE-11 (*)	COP increase by Cavallini (**)	COP increase by CYCLE-11(*)	COP increase by Cavallini (**)
Cross-Flow Evaporator Counter-Flow Condenser	3,9%	1,4%	2,3%	1,1%
Counter-Flow Evaporator Cross-Flow Condenser	2,9%	2,1%	1,2%	0,7%
Counter-Flow Evaporator Counter-Flow Condenser	7,1%	3,5%	3,6%	1,8%

(*) semi-theoretical, vapor compression cycle model

(**) method on thermodynamic fundamentals of the Carnot and the Lorenz cycles

Source: Potential Coefficient of Performance Improvements Due to Glide Matching with R-407C (1998), M. Marques, P. A. Domanski

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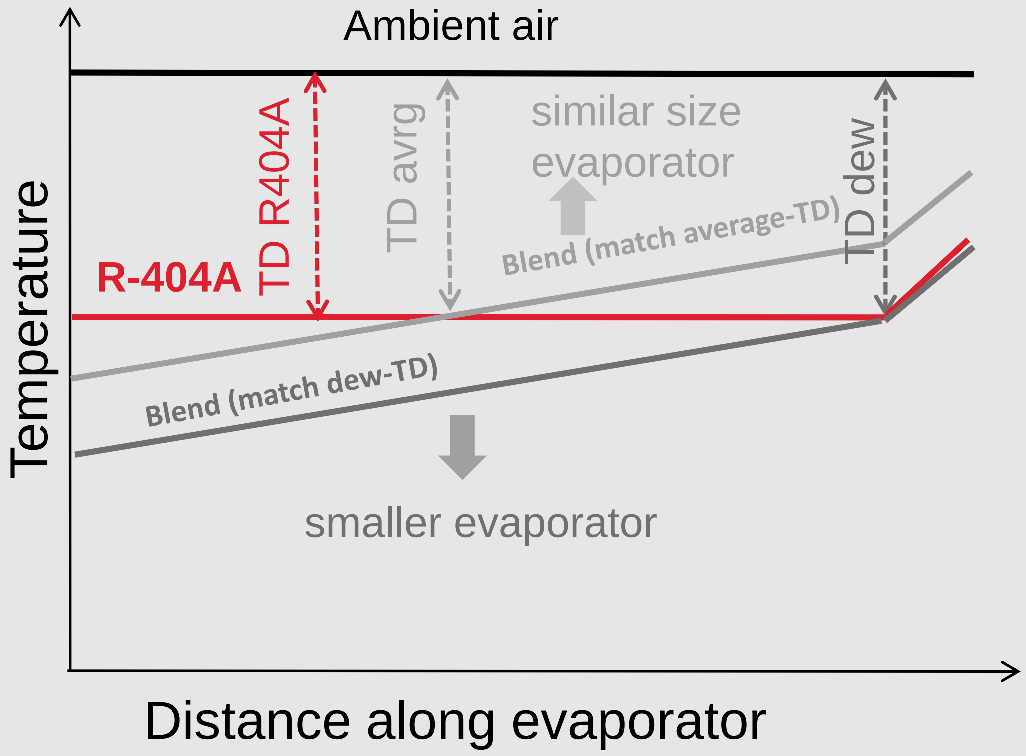
EVAPORATORS

Sizing of evaporators needs to be based on average temperature between inlet and dew points

- The evaporating temperature for system design should use the average of inlet and dew points.



Temperature Difference (TD) in evaporator = T(ambient) – T(evaporating)

- Catalogs may use dew point for evaporating temperature of blends
- With TD based on dew point, refrigerants with glide will show bigger capacity than refrigerants without glide
- This will lead to undersized evaporators for blends

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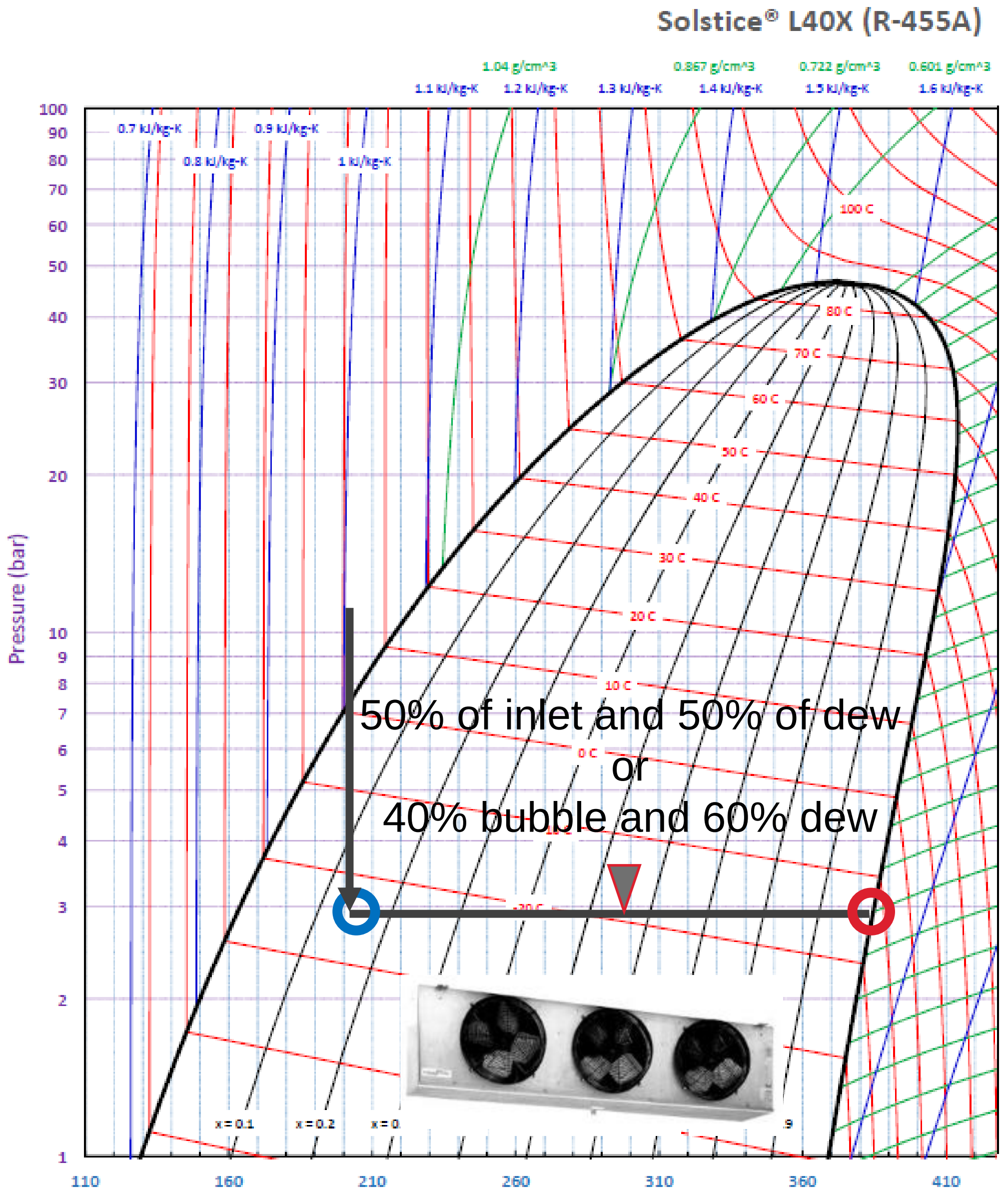
EVAPORATOR TEMPERATURE SETTINGS

Reference evaporating temperature should be:

- mean of inlet and dew temperature or
- 60% of dew and 40% of bubble.



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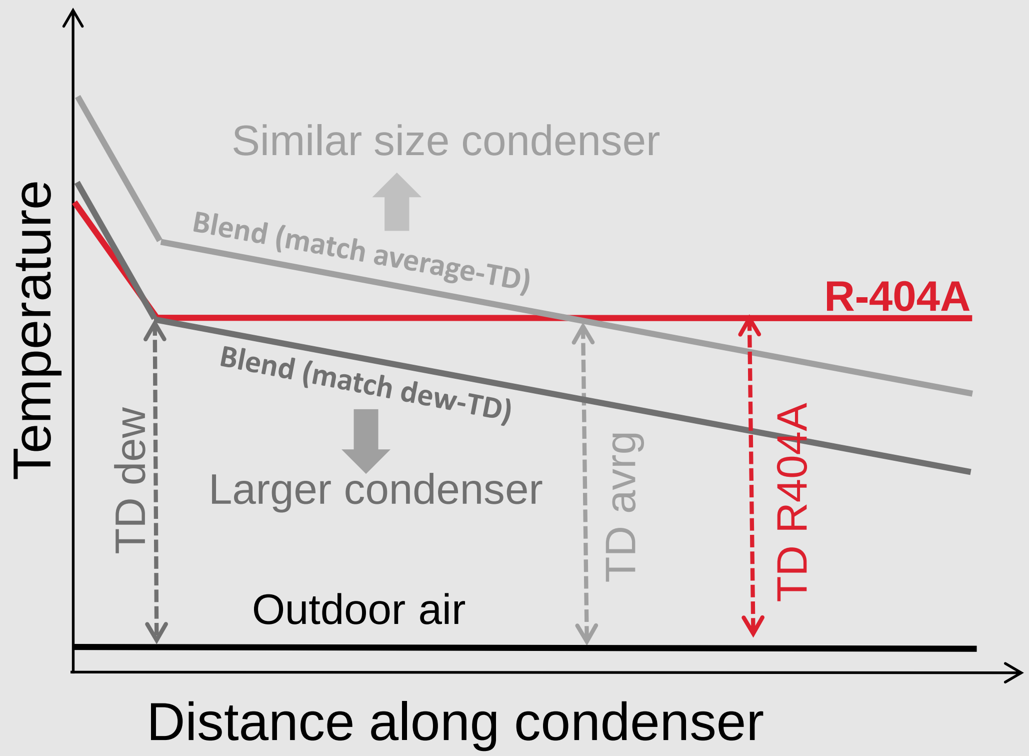
CONDENSERS

Sizing of condensers needs to be based on average temperature between bubble and dew points

- The condensing temperature for system design should use the average of bubble and dew points.

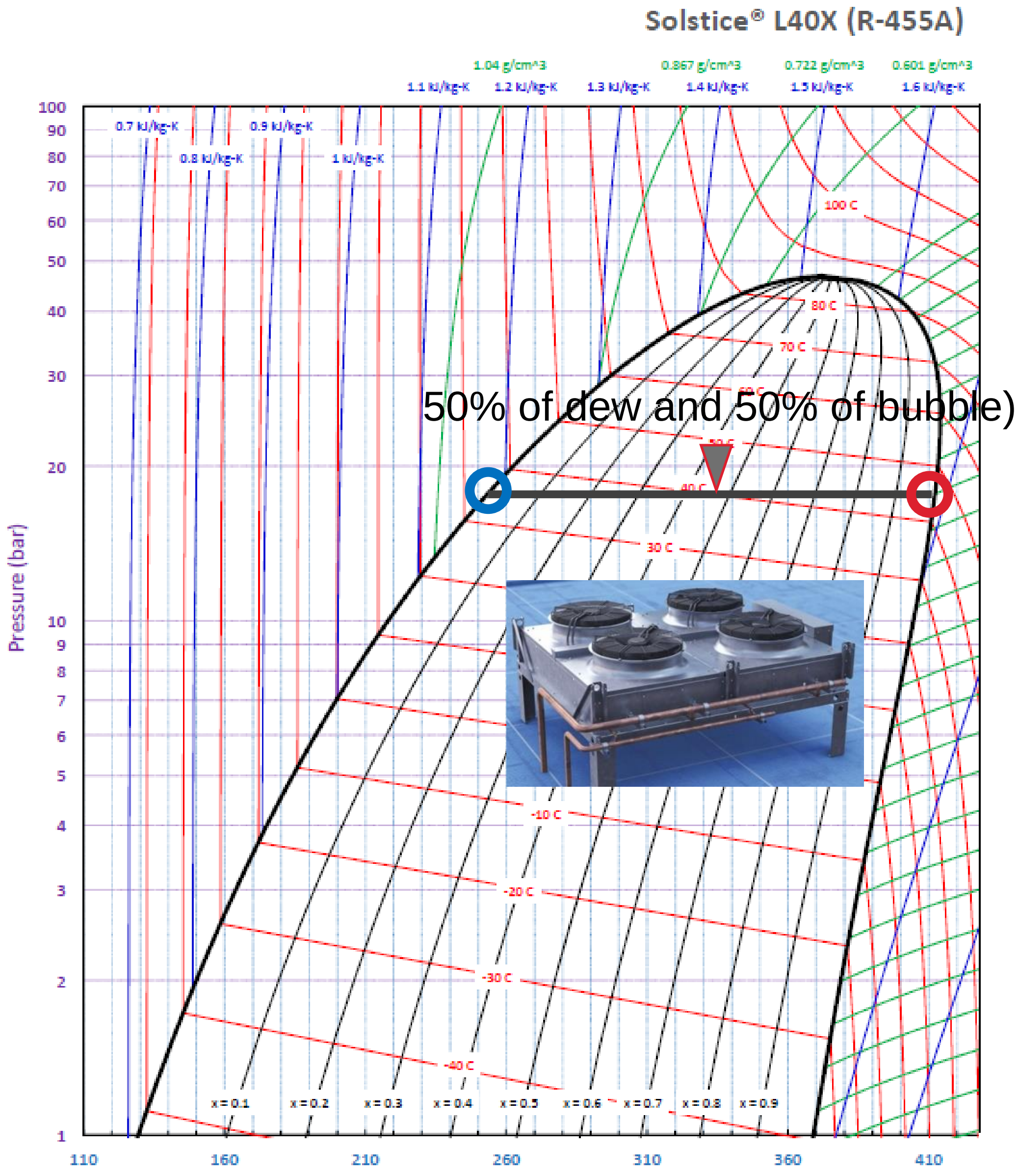


Temperature Difference (TD) in condenser = T(condensing) – T(ambient)

- Catalogs may use dew point for condensing temperature of blends
- With TD based on dew point, refrigerants with glide will show smaller capacity than refrigerants without glide
- This will lead to oversized condensers for blends with glide

CONDENSER TEMPERATURE SETTINGS

Reference condensing temperature should be the mean of bubble and dew temperature.



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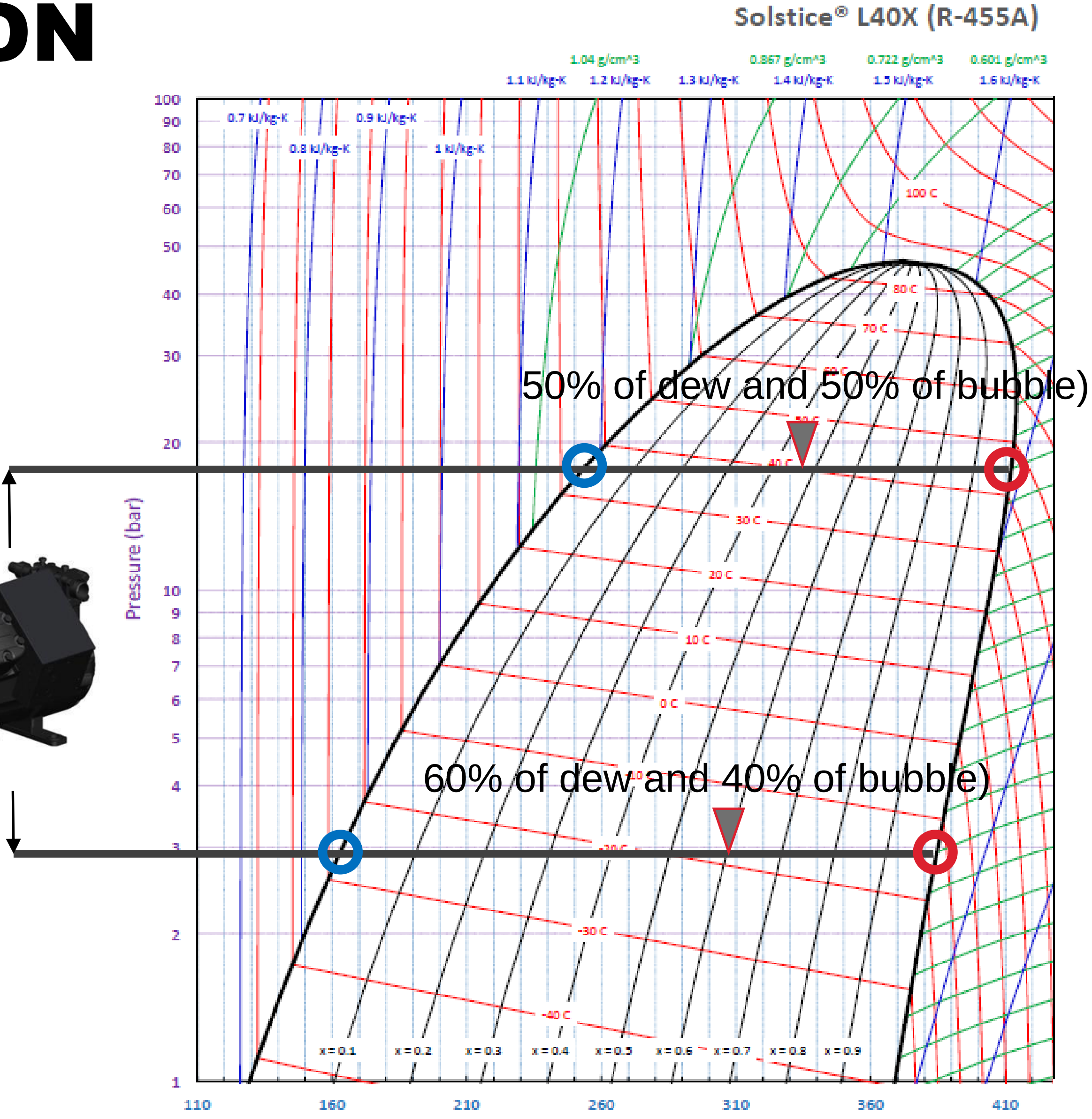
COMPRESSOR SELECTION

- For the evaporating side, use mean temperature defined as:
  60% of dew and 40% of bubble.
- For the condensing side, use mean temperature defined as:
  50% of dew and 50% of bubble.
- Dew point selection leads to oversized compressor.



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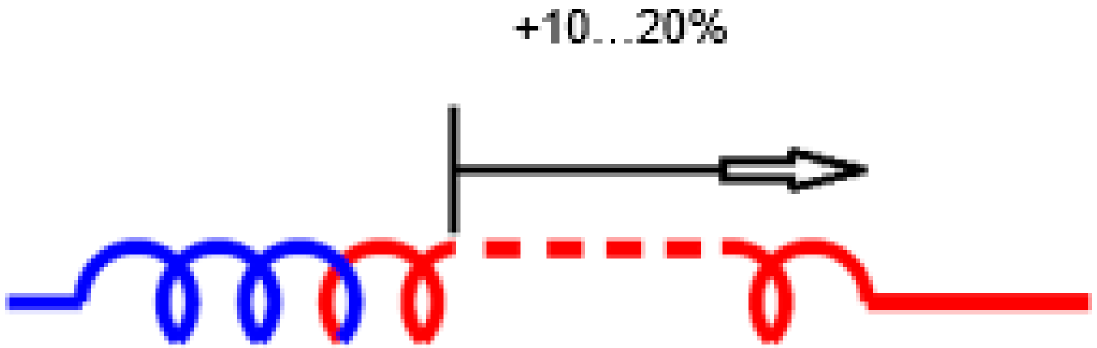
CAPILLARY TUBE SYSTEMS

- Use longer capillary tube (10-20%) compared to that for R-404A
- Determine the exact capillary tube length experimentally



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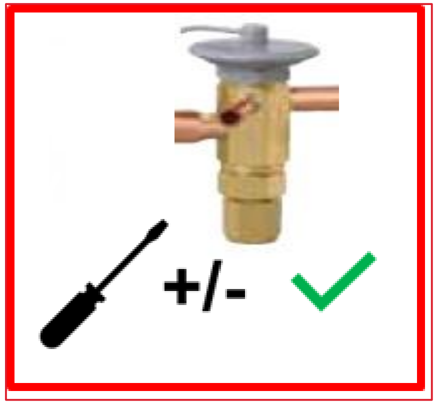
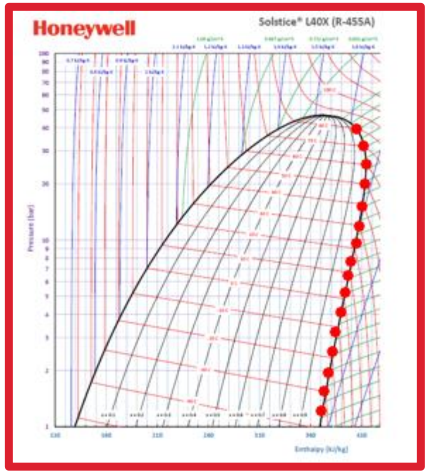
EXPANSION VALVES

Expansion Valves

- In case of thermostatic expansion valves, please use adjustable ones.



- In case of electronic expansion valves, a P-T chart should be uploaded to the valve controller.



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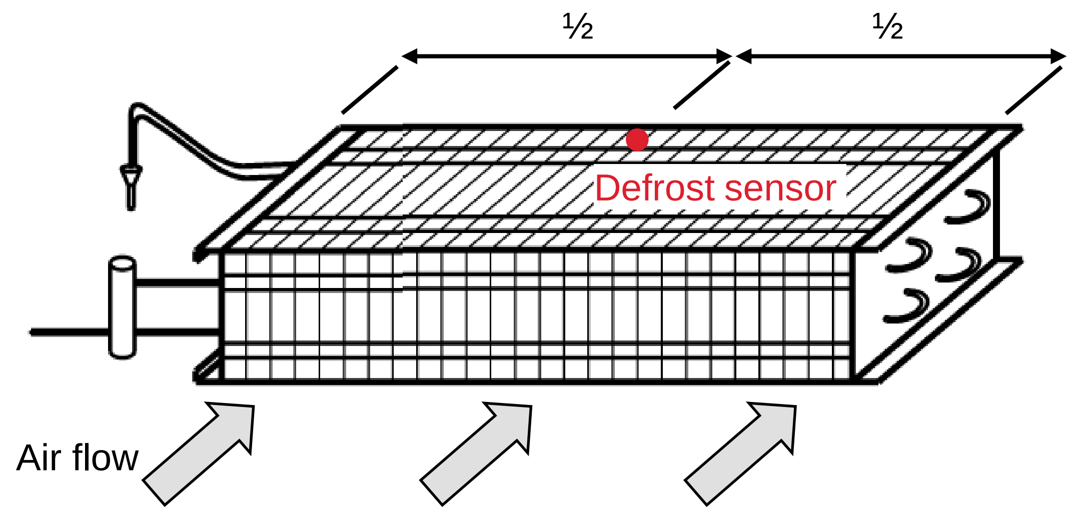
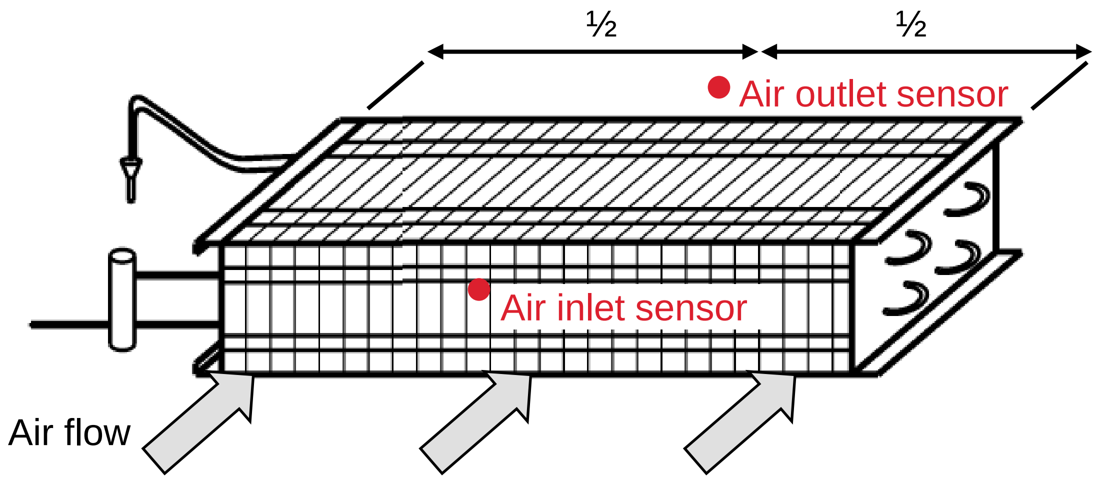
SENSOR LOCATIONS

- Defrost sensors should be placed in the middle of the coil.



- Air temperature control sensors for lengthy evaporators should be placed in the middle of the coil.



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APPENDIX TO PART 2: HOW DO I TUNE THE SYSTEM RIGHT?

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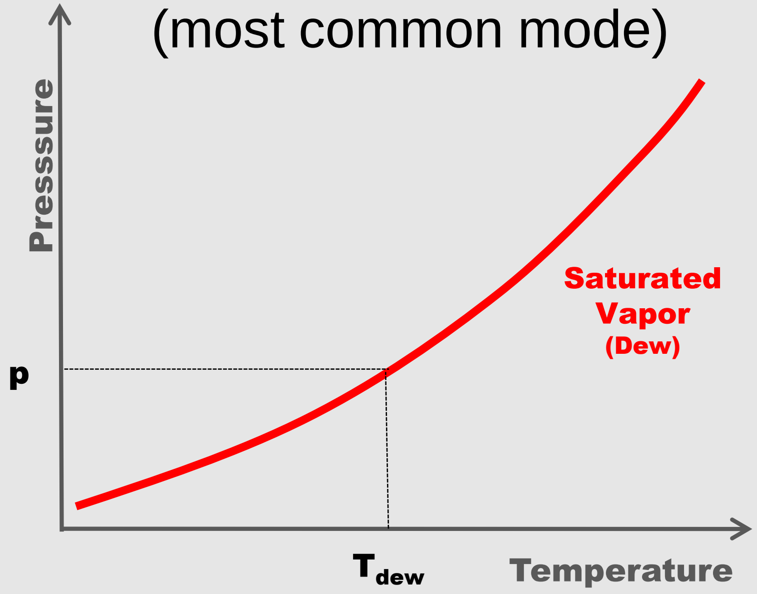
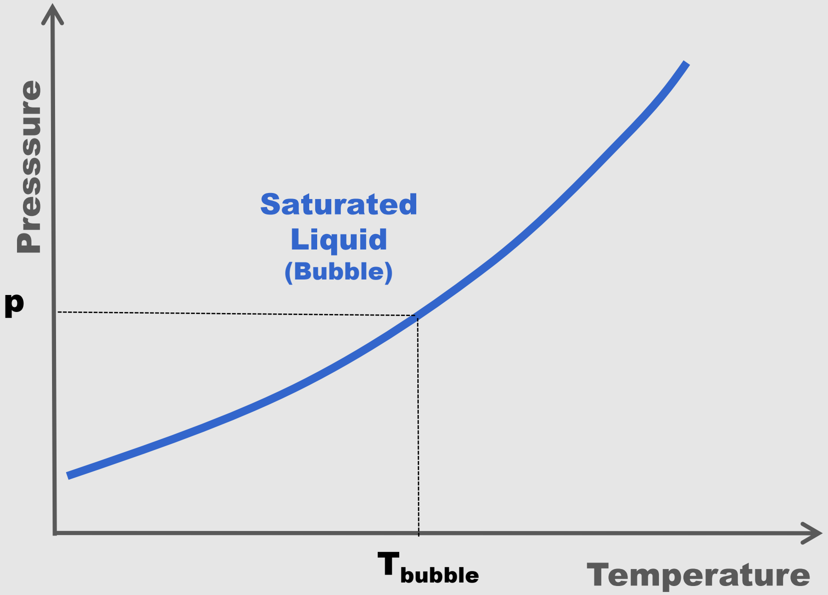
RACK AND CONDENSER CONTROLLERS (1/4)

Almost all controllers have one of the following factory-set modes built-in:

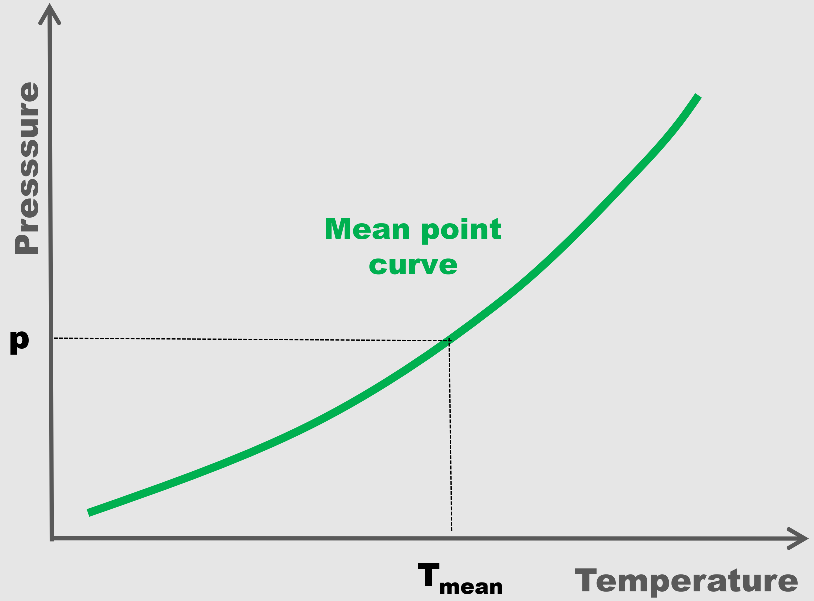
Curve type #a
(most common mode)



Curve type #b



Curve type #c



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RACK AND CONDENSER CONTROLLERS (2/4) | SET-UP EXAMPLE

- **Set-up parameter:** Minimum condensing temperature set-point
- **Inputs:**
  - Condensing temperature (24°C)
  - Refrigerant (R-455A)
  - Average glide (10 K)
- **Mode:** Curve type #a (dew-point)

Sanity check:

at constant P, $T_{dew} > T_{mean} > T_{bubble}$

$$T_{des} = Tsp - \frac{1}{2}\, x\ glide$$

$$24 = Tsp - \frac{1}{2}\, x\ 10$$

$$T_{sp} = 24 + 5 = 29$$

Back end of controller

Condenser controller

Parameter = Minimum condensing temperature set point

T_{cond_des} = <u>24°C</u>

T_{cond_sp} = <u>29°C</u>

Controller display

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RACK AND CONDENSER CONTROLLERS (3/4) | SET-UP EXAMPLE

- **Set-up parameter:** Condensing temperature difference set-point
- **Inputs:**
  - Design condensing temperature difference (10 K),
  - Refrigerant (R-455A)
  - Average glide (10 K)
- **Mode:** Curve type #a (dew-point)

Sanity check:

at constant P, $T_{dew} > T_{mean} > T_{bubble}$

$$TD_{des} = TDsp - \frac{1}{2}\ x\ glide$$

$$10 = TDsp - \frac{1}{2}\ x\ 10$$

$$TD_{sp} = 10 + 5 = 15$$

Back end of controller

Condenser controller

Parameter = Condensing TD Set-point

TD_{cond_des} = 10 K

TD_{cond_sp} = 15 K

Controller display

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RACK AND CONDENSER CONTROLLERS (4/4)

What if the curve for the refrigerant R-455A does not exist in the controller?

Make adjustment to the refrigerant curve of R-404A.

Liquid pressure	R-404A bubble temperature	R-404A dew temperature	R-404A mean temperature	R-455A bubble temperature	R-455A dew temperature	R-455A mean temperature
bar	°C	°C		°C	°C	°C
11,8	22,69	23,11	22,9	18,65	29,49	24,07
11,85 ①	22,85	23,27 ②	23,06	18,81	29,65	24,23 ①
11,9	23,01	23,42	23,215	18,98	29,8	24,39
11,95	23,17	23,58	23,375	19,14	29,96	24,55
12	23,32	23,73	23,525	19,3	30,11	24,705
12,05	23,48	23,89	23,685	19,46	30,26	24,86

R-455A: Condensing temperature set point around 24°C ① or 11.9 bar ①

R-404A: As per above PT chart match, the condensing temperature set point should be 23.5°C ②

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ELECTRONIC EXPANSION VALVE (EEV) CONTROLLERS (1/3)

Setting Superheat (SH) Using Pressure-Temperature (P-T) Readings

- If the curve for R-455A is available in the EEV controller, set the SH set-point according to the system design specification.
- If the curve for R-455A is not available in the EEV controller, set the SH set-point for the EEV using the methods described on the next slide.

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ELECTRONIC EXPANSION VALVE (EEV) CONTROLLERS (2/3)

First method: If curve for refrigerant R-448A is available

- Take advantage of the fact that the dew temperature of R-448A (e.g. ①) is very similar to the one of R-455A (②) for a given evaporating pressure.

Liquid pressure	R-455A dew temperature	R-448A dew temperature
bar	°C	°C
1,05	-38,42	-39,02
1,1	-37,43	-38,06
1,15	-36,48	-37,13
1,2	-35,55 ②	-36,23 ①
1,25	-34,66	-35,36
1,3	-33,8	-34,52
1,35	-32,96	-33,7
1,4	-32,14	-32,91
1,45	-31,35	-32,13

Second method: If curve for refrigerant R-448A is not available

- Use the curve for the refrigerant R-404A
- Because the difference in dew temperature between R-455A (③) and R-404A (④) is around 6K, adjust the SH set-point for R-455A by 6K
- Example on P-T chart below: Required SH is e.g. 10K, hence SH set-point for R-455A is 10+6=16K

Liquid pressure	R-455A dew temperature	R-404A dew temperature
bar	°C	°C
1,9	-25,04 ③	-31,5 ④

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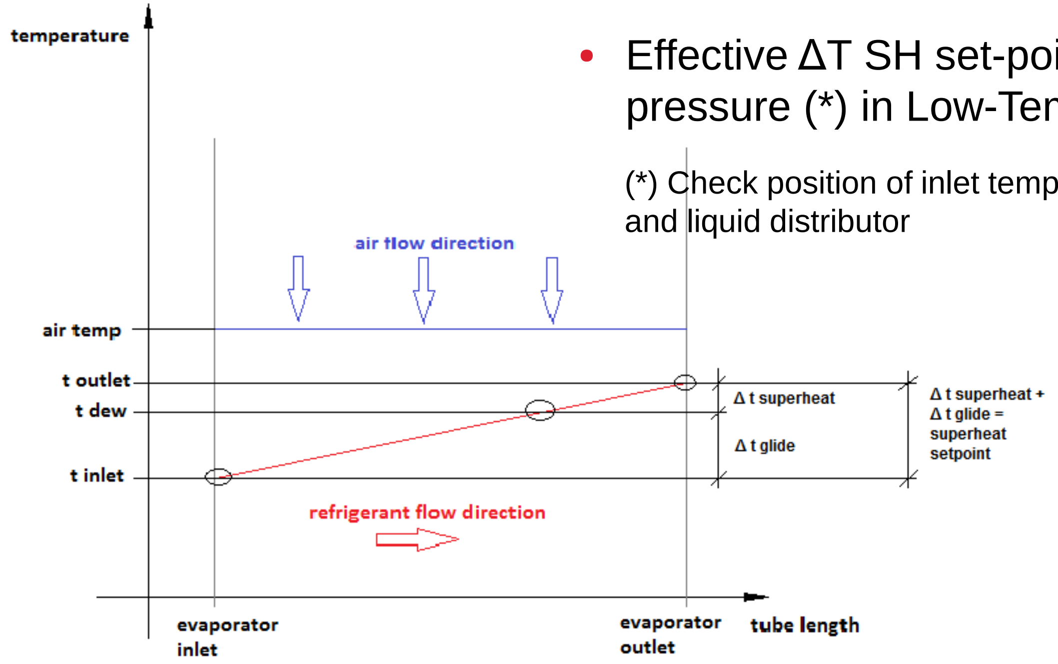
ELECTRONIC EXPANSION VALVE (EEV) CONTROLLERS (3/3)

Setting Superheat (SH) Using Temperature-Temperature (T-T) Readings

- Effective ΔT SH set-point in controller = ΔT SH set-point + 0.8 x glide for a given evaporating pressure (*) in Medium-Temperature (MT) application
- Effective ΔT SH set-point in controller = ΔT SH set-point + 0.7 x glide for a given evaporating pressure (*) in Low-Temperature (LT) application

(*) Check position of inlet temperature probe; the above formula is valid if the probe is placed just after the expansion valve and liquid distributor



Example: The MT system is supposed to run with 5K effective SH; refrigerant glide for the working evaporation pressure is 10K. What should be the SH set-point in the EEV controller using T-T readings?

- Effective ΔT SH set-point in controller = ΔT (SH set-point) + 0.8 x glide
- ΔT SH set-point in controller = 5K + 0.8 x 10K
- ΔT SH set-point in controller = 5K + 8K
- ΔT SH set-point in controller = 13K

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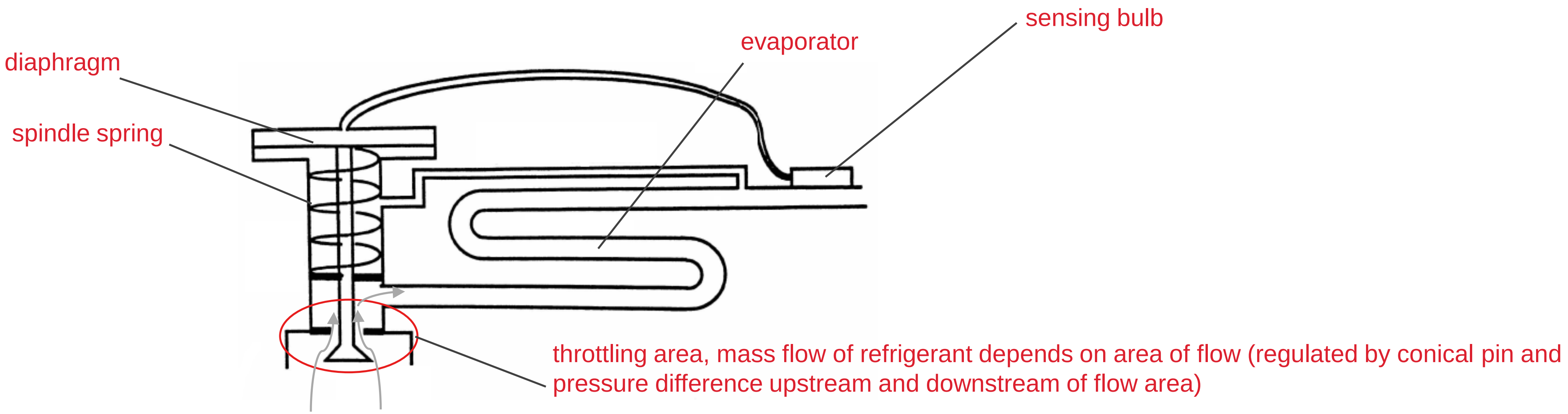
THERMOSTATIC EXPANSION VALVE (TEV) ADJUSTMENTS (1/3)

Setting Superheat (SH) with TEV

- **First method:** We check the recommendations of the TEV producer, and follow its guidelines.
- **Second method:** We need to check the mass flow of the new refrigerant vs. the mass flow of the refrigerant for which the valve is rated for:
  a) in case the flow of the new refrigerant is lower, the TEV spindle needs to be turned to achieve higher SH
  b) in case the flow of the new refrigerant is higher, the TEV spindle needs to be turned to achieve lower SH

For the second method, the detailed procedure is described on the next 2 pages.



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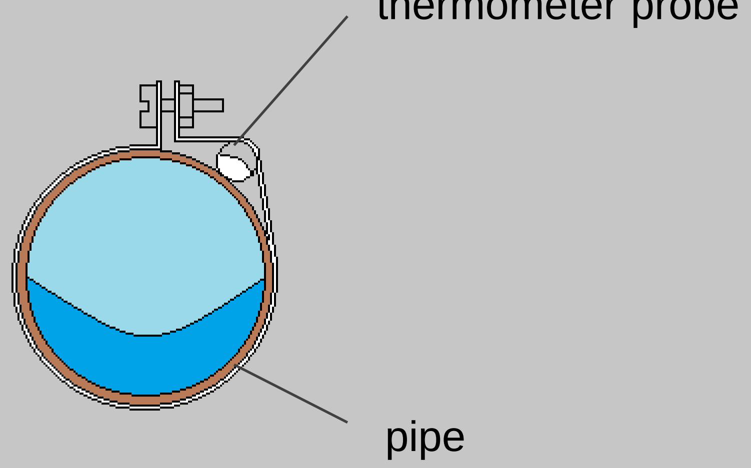
THERMOSTATIC EXPANSION VALVE (TEV) ADJUSTMENTS (2/3)

1) Starting point: The case is working around its set-point temperature
2) Connect the manifold gauge to the service port at the suction line of the case
3) Connect a thermometer to the suction collector just after the evaporator outlet / Thermometer probe needs to be placed on the upper side of the collector
4) Make sure that the cooling mode is on
5) Read the following indications:
   - Gauge pressure①
   - Corresponding dew temperature②
   - Thermometer probe temperature③
6) Within 1-6 minutes, the TEV starts to open to its full position, the gauge temperature③ is dropping down very quickly and then maintains its lowest value for a while, before starting to rise up again



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THERMOSTATIC EXPANSION VALVE (TEV) ADJUSTMENTS (3/3)

7) At lowest gauge temperature, evaluate the SH = Gauge temperature③ – corresponding dew temperature②.
   - NOTICE 1: for refrigerants with glide like R-455A, SH can reach negative values
   - NOTICE 2: modern digital manifolds enable to measure SH, provided that the refrigerant curve is included

8) If SH evaluated under 7) is lower than 4 K, adjust SH spindle in TEV by ½ or ¼ (*) clockwise turn (**)

9) If SH evaluated under 7) is higher than 12 K, adjust SH spindle in TEV by ½ or ¼ (*) counterclockwise turn (**)

10) Repeat procedure from point 6) again and measure SH according to point 7) until a value between 6 and 10K is reached

11) The closer the running SH comes to values between 6 and 10K, the smaller the additional turns of the spindle need to be.

(*) ½ turn is recommended for Medium-Temperature systems, ¼ turn is recommended for Low-Temperature systems
(**) We assume that clockwise turn leads to increase SH and counterclockwise turn leads to decrease SH - Check with TEV producer if unclear

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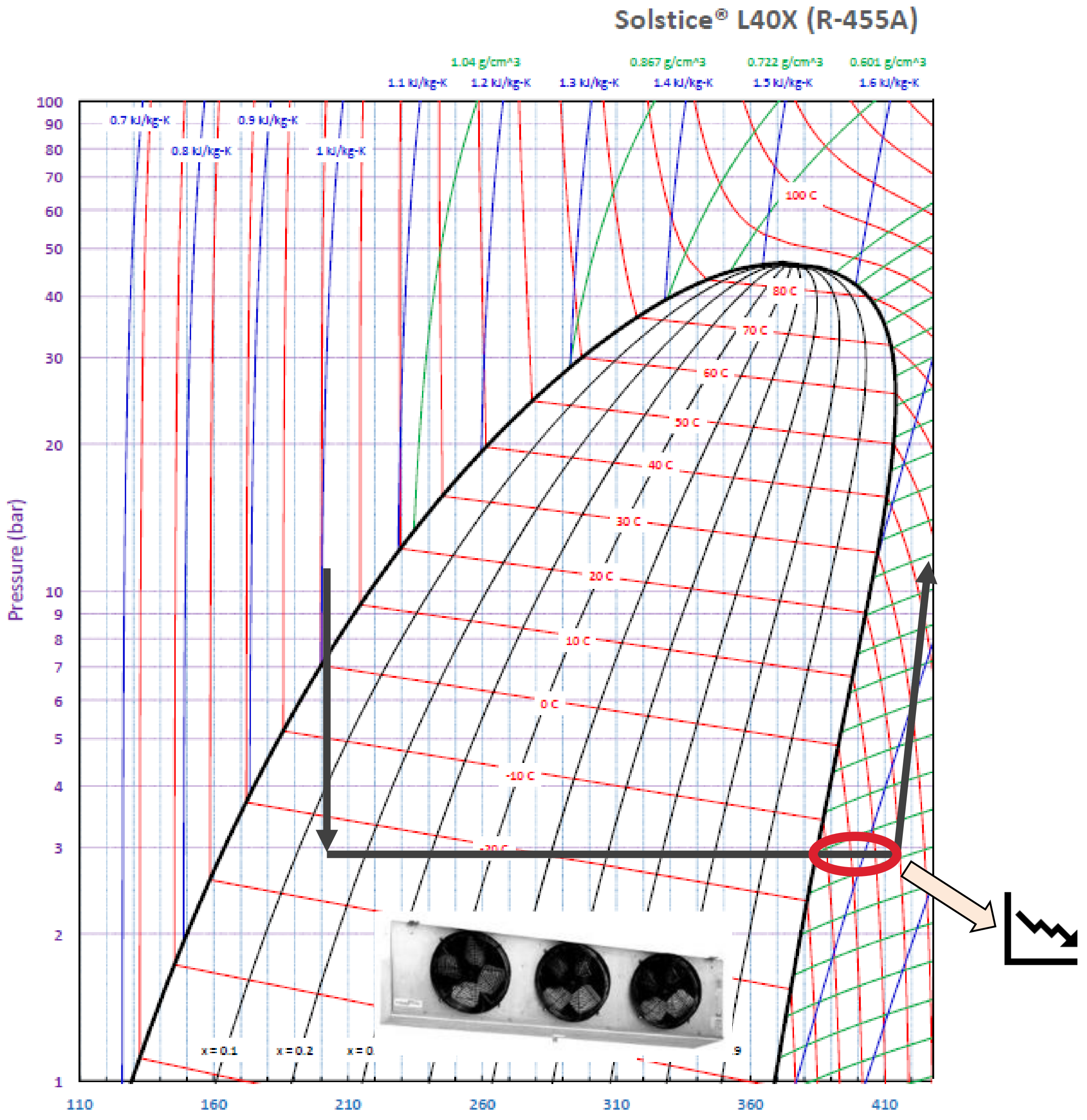
SUPERHEAT SETTINGS

- Keep running superheat at evaporator outlet as low as possible, but avoiding evaporator flooding.



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SUB COOLING SETTINGS

- Sub cooling should be evaluated based on the bubble temperature.

Liquid pressure	R-455A bubble temperature	R-455A dew temperature
bar	°C	°C
8,1	4,78	16,27
9,1	8,92	20,24
10,1	12,74	23,88
11,1 ①	16,3 ②	27,26
12,1	19,63	30,42
13,1	22,76	33,38
14,1	25,73	36,17
15,1	28,55	38,81
16,1	31,24	41,32
17,1	33,81	43,71

Example:

- Measured sub cooler outlet temperature: 10°C
- Condensing pressure: 11,1 bar ①
- Bubble temperature: 16,3°C ②
- Sub cooling amount: 16,3°C - 10°C = 6,3K

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COMMISSIONING DATA | LOW-PRESSURE SIDE

Gauge pressure	Bubble temp.	Mean evaporating temp.	Dew temp
[bar]	[ºC]	[ºC]	[ºC]
0,11	(-49,9)	-42	(-37,1)
0,17	(-48,6)	-41	(-35,8)
0,23	(-47,7)	-40	(-34,9)
0,28	(-46,8)	-39	(-34,0)
0,35	(-45,6)	-38	(-32,8)
0,4	(-44,8)	-37	(-32,0)
0,46	(-43,7)	-36	(-30,9)
0,53	(-42,6)	-35	(-29,9)
0,6	(-41,6)	-34	(-28,9)
0,67	(-40,6)	-33	(-27,9)
0,75	(-39,5)	-32	(-26,8)
0,82	(-38,5)	-31	(-25,9)
0,91	(-37,4)	-30	(-24,8)
0,97	(-36,6)	-29	(-23,9)
1,06	(-35,5)	-28	(-22,9)
1,14	(-34,5)	-27	(-21,9)
1,23	(-33,6)	-26	(-21,0)
1,33	(-32,4)	-25	(-19,9)
1,42	(-31,5)	-24	(-19,0)
1,52	(-30,4)	-23	(-17,9)
1,62	(-29,4)	-22	(-16,9)
1,72	(-28,4)	-21	(-15,9)
1,82	(-27,4)	-20	(-14,9)
1,93	(-26,4)	-19	(-14,0)
2,05	(-25,4)	-18	(-12,9)
2,15	(-24,5)	-17	(-12,1)

Gauge pressure	Bubble temp.	Mean evaporating temp.	Dew temp
[bar]	[ºC]	[ºC]	[ºC]
2,27	(-23,4)	-16	(-11,1)
2,4	(-22,3)	-15	(-10,0)
2,52	(-21,3)	-14	(-9,0)
2,64	(-20,4)	-13	(-8,1)
2,78	(-19,3)	-12	(-7,1)
2,91	(-18,3)	-11	(-6,1)
3,05	(-17,3)	-10	(-5,1)
3,2	(-16,2)	-9	(-4,0)
3,34	(-15,3)	-8	(-3,1)
3,49	(-14,3)	-7	(-2,1)
3,64	(-13,2)	-6	(-1,1)
3,81	(-12,2)	-5	(-0,1)
3,97	(-11,2)	-4	(0,8)
4,14	(-10,2)	-3	(1,8)
4,31	(-9,1)	-2	(2,8)
4,48	(-8,1)	-1	(3,7)
4,66	(-7,1)	0	(4,8)
4,85	(-6,0)	1	(5,8)
5,04	(-5,0)	2	(6,7)
5,22	(-4,0)	3	(7,7)
5,43	(-3,0)	4	(8,7)
5,61	(-2,0)	5	(9,6)
5,82	(-1,0)	6	(10,6)
6,04	(0)	7	(11,6)
6,26	(1,0)	8	(12,6)
6,48	(2,0)	9	(13,6)

- Table of pressures and corresponding temperatures for the **low-pressure side** of the system
- Use this table for:
  - evaluation of suction pressure settings and corresponding mean evaporating temperatures
  - evaluation of pressure switches settings
  - evaluation of superheat amount

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COMMISSIONING DATA | HIGH-PRESSURE SIDE

Gauge pressure	Bubble temp.	Mean condensing temp.	Dew temp
[bar]	[ºC]	[ºC]	[ºC]
6,97	(4,2)	10	(15,7)
7,2	(5,2)	11	(16,7)
7,45	(6,3)	12	(17,7)
7,69	(7,3)	13	(18,6)
7,94	(8,3)	14	(19,6)
8,2	(9,3)	15	(20,6)
8,45	(10,3)	16	(21,6)
8,73	(11,3)	17	(22,5)
9	(12,4)	18	(23,5)
9,29	(13,4)	19	(24,5)
9,58	(14,5)	20	(25,5)
9,87	(15,5)	21	(26,5)
10,15	(16,5)	22	(27,4)
10,46	(17,5)	23	(28,4)
10,77	(18,5)	24	(29,4)
11,09	(19,6)	25	(30,4)
11,41	(20,6)	26	(31,3)
11,73	(21,6)	27	(32,3)
12,07	(22,7)	28	(33,3)
12,41	(23,7)	29	(34,3)
12,75	(24,7)	30	(35,2)
13,11	(25,7)	31	(36,2)
13,47	(26,8)	32	(37,1)
13,84	(27,8)	33	(38,1)
14,22	(28,9)	34	(39,1)
14,59	(29,9)	35	(40,0)

Gauge pressure	Bubble temp.	Mean condensing temp.	Dew temp
[bar]	[ºC]	[ºC]	[ºC]
14,98	(30,9)	36	(41,0)
15,37	(31,9)	37	(42,0)
15,78	(33,0)	38	(42,9)
16,19	(34,0)	39	(43,9)
16,61	(35,1)	40	(44,9)
17,04	(36,1)	41	(45,8)
17,46	(37,1)	42	(46,8)
17,91	(38,2)	43	(47,7)
18,35	(39,2)	44	(48,7)
18,81	(40,3)	45	(49,6)
19,27	(41,3)	46	(50,6)
19,74	(42,3)	47	(51,6)
20,22	(43,4)	48	(52,5)
20,71	(44,4)	49	(53,5)
21,2	(45,5)	50	(54,4)
21,71	(46,5)	51	(55,4)
22,24	(47,6)	52	(56,3)
22,75	(48,6)	53	(57,3)
23,29	(49,7)	54	(58,2)
23,82	(50,7)	55	(59,1)
24,38	(51,8)	56	(60,1)
24,94	(52,9)	57	(61,1)
25,51	(53,9)	58	(62,0)
26,08	(55,0)	59	(62,9)
26,68	(56,0)	60	(63,9)
27,27	(57,1)	61	(64,8)

- Table of pressures and corresponding temperatures for the **high-pressure side** of the system
- Use this table for:
  - evaluation of discharge pressure settings and corresponding mean condensing temperatures
  - evaluation of pressure switches settings
  - evaluation of sub cooling amount

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APPENDIX TO PART 3: HOW TO CHARGE REFRIGERANT WITH GLIDE INTO MY SYSTEM

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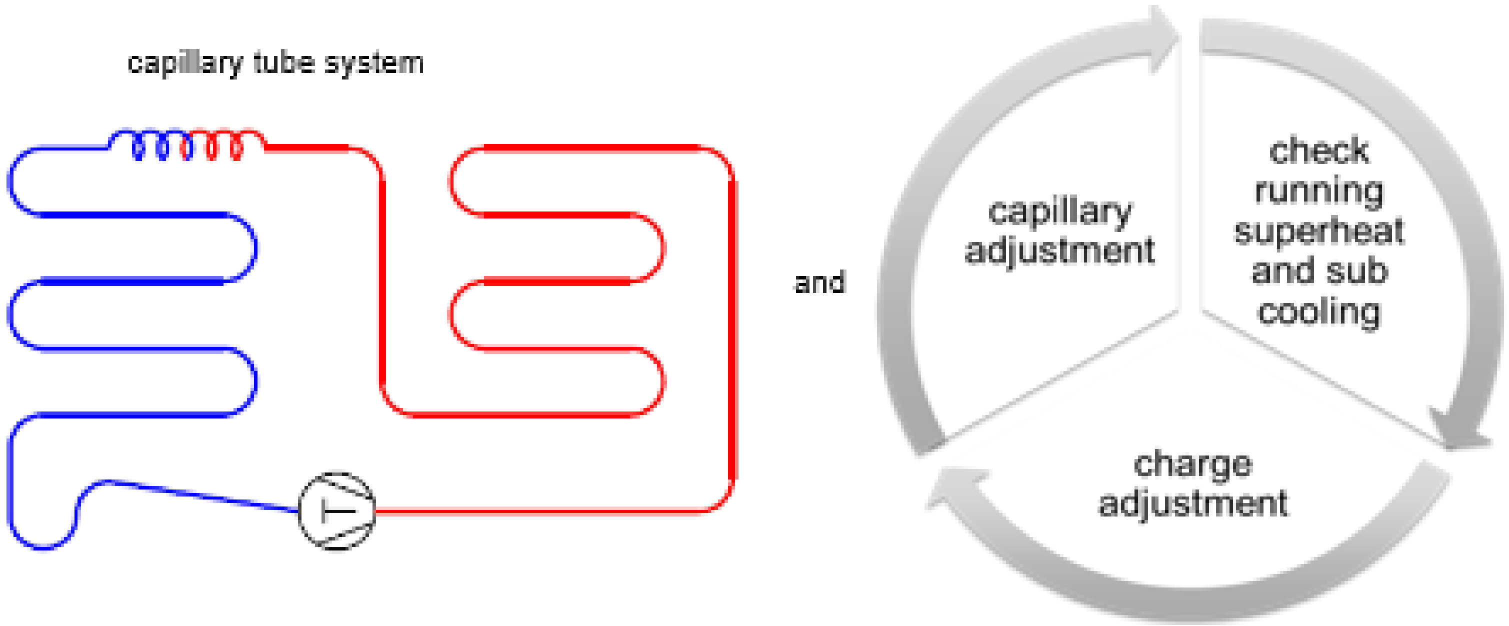
HOW TO CHARGE REFRIGERANT WITH GLIDE INTO MY SYSTEM (1/2)

When Charge Size is Critical for System Performance

- For systems in which charge size is critical for system performance (e.g. systems without liquid receiver), the optimization of the charge is required to maximize system capacity and efficiency.



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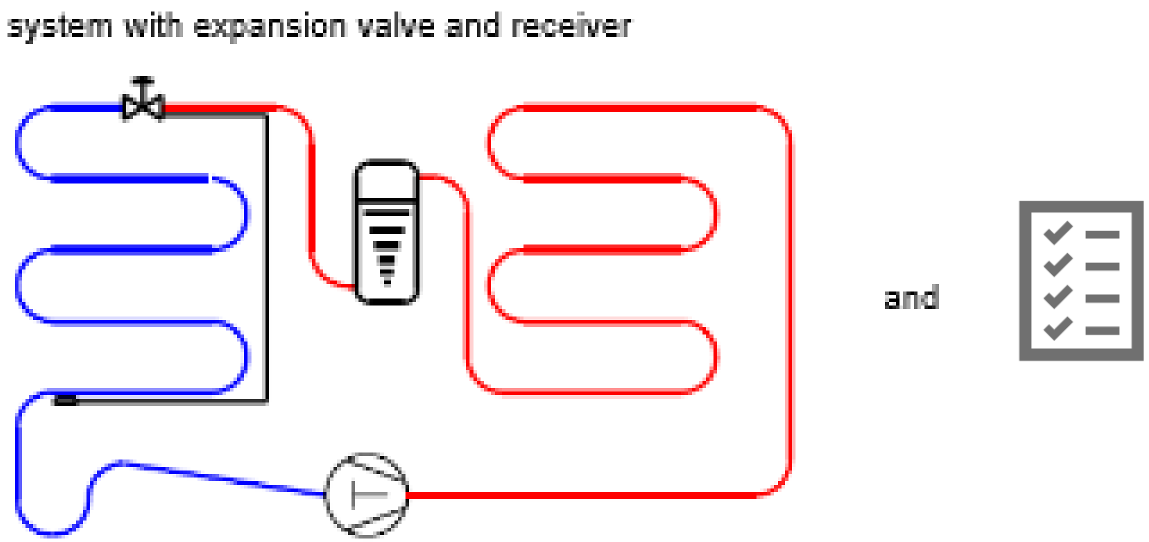
HOW TO CHARGE REFRIGERANT WITH GLIDE INTO MY SYSTEM (2/2)

Other Cases

- For systems in which charge size is less critical for system performance (like in most systems with liquid receiver), follow the respective system design guidelines.



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