ENERGY EFFICIENCY IN THE RAC SECTOR

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SUMMARY

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- INTRODUCTION
- ENERGETIC EFFICIENCY
- ENERGETIC PERFORMANCE
- CONCLUSION

CONTEXT

- Challenges

The reduction of fossil energy sources
Greenhouse gas emissions: global warming
Sustainable development

INTRODUCTION

- The total number of Refrigeration systems, air conditioning and heat pump systems in operation worldwide: **5 billion**, of which:

  2.6 billion air conditioning units (fixed and mobile),

  2.4 billion domestic refrigerators and freezers, refrigerated cabinets, display cases, cold rooms, heat pumps, etc.

- The refrigeration sector including air conditioning uses **20% of the total electricity** consumed worldwide;

- Global electricity demand for cooling - including air conditioning – **could be more than double by 2050.**

- **Emissions** from the refrigeration sector represent 4.14 GtCO2eq, or 7.8% of total greenhouse gas emission

ENERGETIC EFFICIENCY

The concepts of Energy Efficiency

- COP: coefficient of performance

COP = the amount of heat absorbed by the evaporator / the total amount of electrical energy absorbed by the installation

- EER: Energy Efficiency Ratio: cooling efficiency coefficient

EER = Annual air conditioning requirements (kWh) / Annual electricity consumption of the device in (kWh)

ENERGETIC EFFICIENCY

The concepts of Energy Efficiency

- SEER: Seasonal Energy Efficiency Ratio: seasonal energy efficiency ratio:

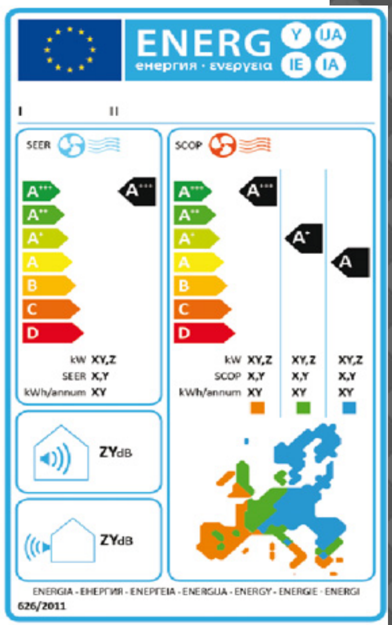
SEER = Annual air conditioning requirements (kWh / year) / Annual electricity consumption of the device in air conditioning mode (kWh / year)

- HSPF or SCOP: heating seasonal performance factor: seasonal heating performance coefficient:

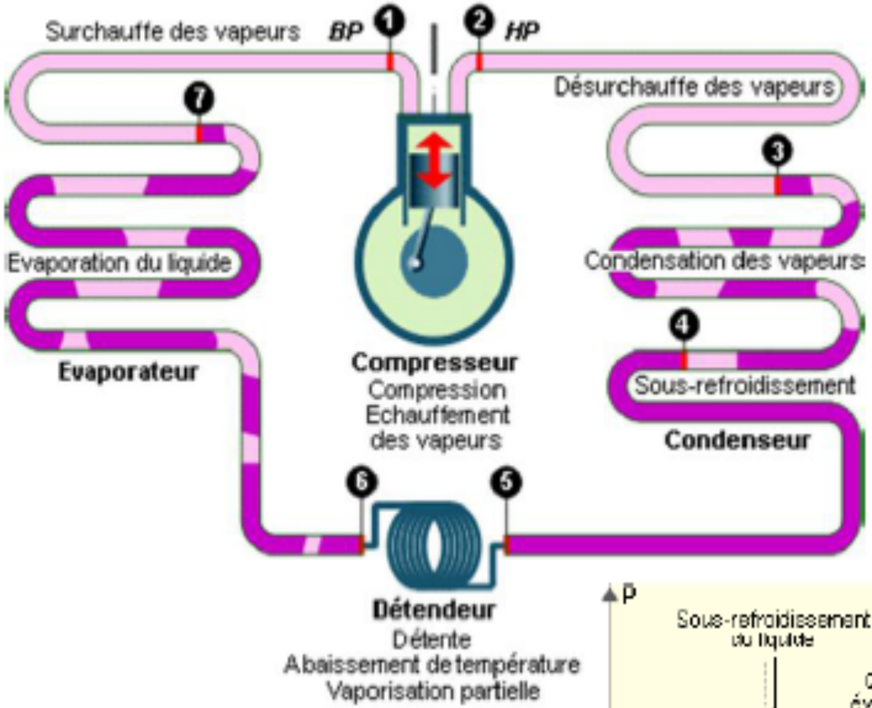
SCOP = Annual heating requirements (kWh / year) / Annual electricity consumption of the device in heating mode (kWh / year)

Letter	EER	Performance
A	Consumption greater than 3.2 kWh	Excellent cooling performance
B	Consumption between 3 kWh and 3.2 kWh	Very good cooling performance
C	Consumption between 2.8 kWh and 3 kWh	Good cooling performance
D	Consumption between 2.6 kWh and 2.8 kWh	Good cooling performance
E	Consumption between 2.4 kWh and 2.6 kWh	Average refrigeration performance
F	Consumption between 2.2 kWh and 2.4 kWh	Low refrigeration performance
G	Consumption less than or equal to 2.2 kWh	Poor refrigeration performance

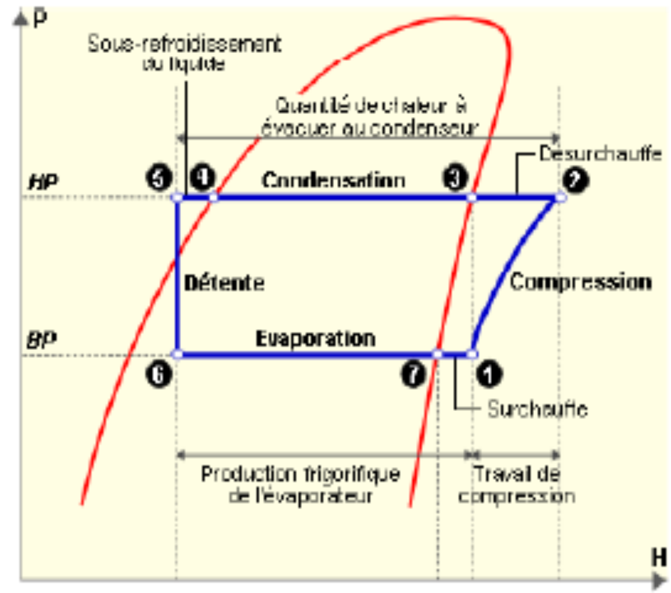
Letter	SEER	Performance
A+++	Consumption greater than or equal to 8.5 kWh	Excellent cooling performance
A++	Consumption between 6.1 kWh and 8.5 kWh	Good cooling performance
A+	Consumption between 5.6 kWh and 6.1 kWh	Average refrigeration performance
A	Consumption between 5.1 kWh and 5.6 kWh	Low refrigeration performance
B	Consumption less than or equal to 5.1 kWh	Poor refrigeration performance



REFRIGERATION MACHINE



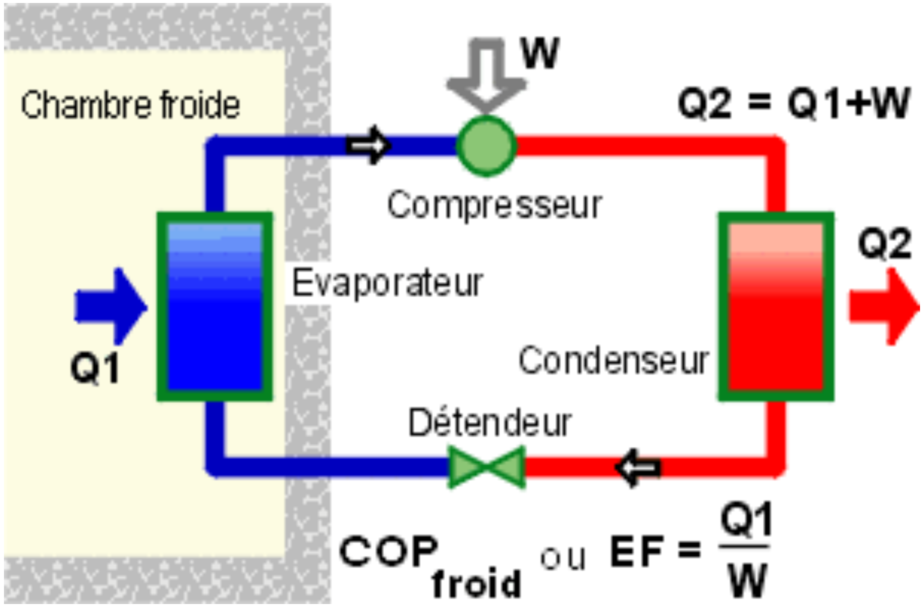
- 4 composants principaux
  - évaporateur
  - compresseur
  - condenseur
  - détendeur



Energy efficiency

A refrigeration machine is energy efficient if it requires little energy to provide a given cooling capacity.

- The efficiency measurement index: COP
  -



HOW TO ASSESS THE ENERGY EFFICIENCY OF A MACHINE IN OPERATION?

- The measurements will be carried out during a "stable" time, the outside temperature being 25 to 35°C because the installation must be fully charged, the compressor must operate at full speed, all the fans being in continuous operation.

MEASURING DEVICES

Electric energy meter

Refrigeration manifold

Thermometer

Anemometer

WE MEASURE

Settings	Unit of measure
the temperature of the air drawn in by the condenser	Tec (in°C)
the air temperature at the outlet of the condenser (as close to the outlet as possible)	Tsc (in°C)
the temperature of the air drawn in by the evaporator	Tee (in°C)
the temperature of the air delivered by the evaporator	Tse (in°C)
the speed of the air flowing through each of the batteries	Vair (in m/sec)
the energy absorbed by the compressor only	Qa (in kWh)
the energy absorbed by the entire installation	Qt (in kWh)
compressor running time	t (in hours)
the compressor suction pressure	P0 (bar)
the discharge pressure of the compressor	Pc (bar)
the evaporation temperature	T0 [in°C]
the condensing temperature	Tc [in°C]

WE CALCULATE

Setting	formula	
the front surface of the condenser drawing in air		S (in m^2)
Condenser power: PC	S x v x 1,2 x (Tsc – Tec)	[kW]
Absorbed power: Pabs	Qa / t	[kW]
Total power: Ptot	Qt / t	[kW]
Evaporator power: PF		[kW]
Coefficient of performance	COP = PF/Ptot	without unit
Seasonal heating coefficient of performance	SCOP= PC/Pabs (t of heating)	without unit

On the basis of these measurements, it is possible to deduce the operating point of the device and to verify its adequacy with the data of the manufacturer and the data of the designer of the installation.

HOW TO IMPROVE THE ENERGY PERFORMANCE OF REFRIGERATION INSTALLATIONS?

ENERGY PERFORMANCE

- **The cheapest energy is the energy that we do not consume**
- **PERFORMANCE = ENERGY EFFICIENCY + BEHAVIOR**
- **Reducing our energy consumption does not mean reducing our level of comfort but finding methods to reduce this consumption and optimize the installation**
- **Ways to improve the performance of a refrigeration installation:**
  - ✓ **Optimize the use of equipment**
  - ✓ **Adopt good practices**
  - ✓ **Choosing the right equipment**

OPTIMIZE THE USE OF EQUIPMENT

OPERATION OF A FACILITY

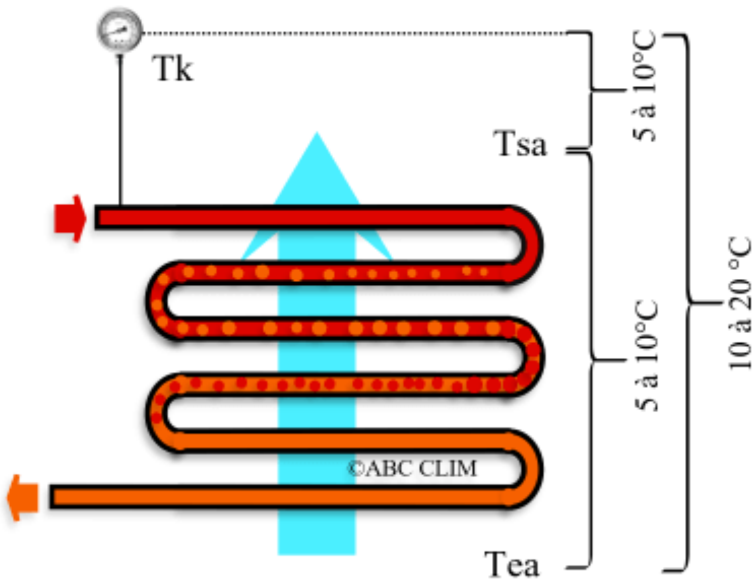
- There are two important aspects in the operation of a refrigeration plant; two points that the service can easily control:

- The temperature of the cold rooms
- Defrost cycles

These two points represent some of the keys to optimizing a refrigeration installation.

ENERGY OPTIMIZATION: CONDENSER

❑ Optimization of the temperature difference between the refrigerant (Tc) and the ambient air (max 15 ° C)

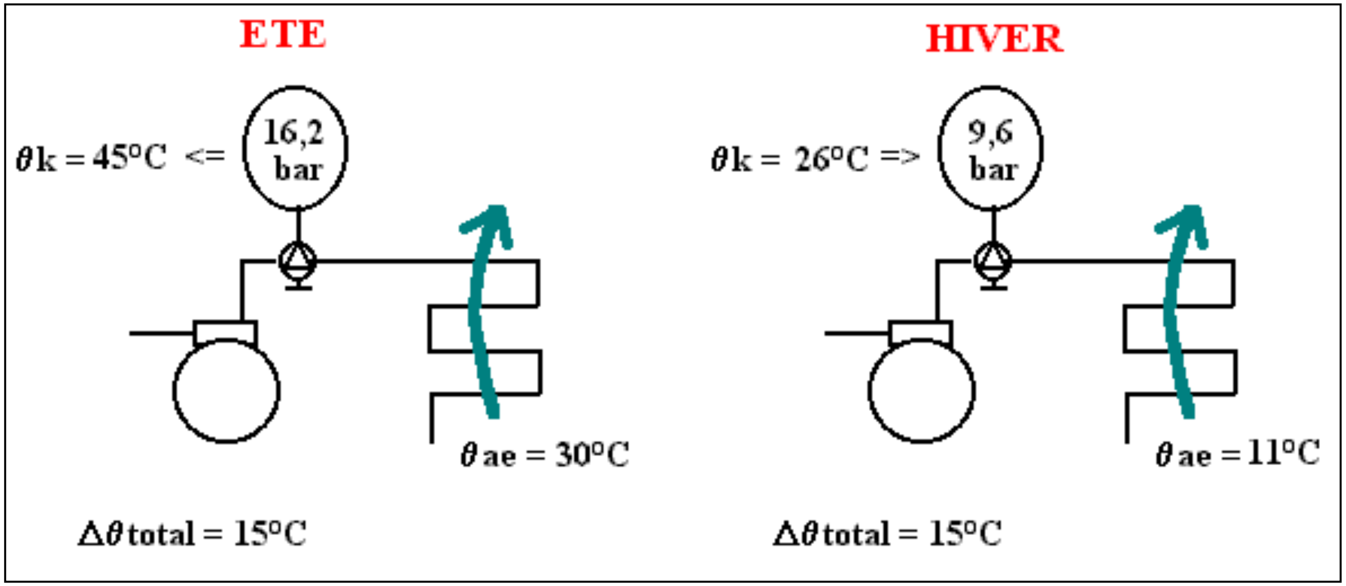


Optimize Δθ =15°C

- Place the condensers preferably in the shade
- Facilitate the entry and exit of pulsed air through the condensers
- Avoid trapping the condensers in order to prevent the return of hot air coming out.

ENERGY OPTIMIZATION: CONDENSER

- Optimization of the condensing temperature: floating HP

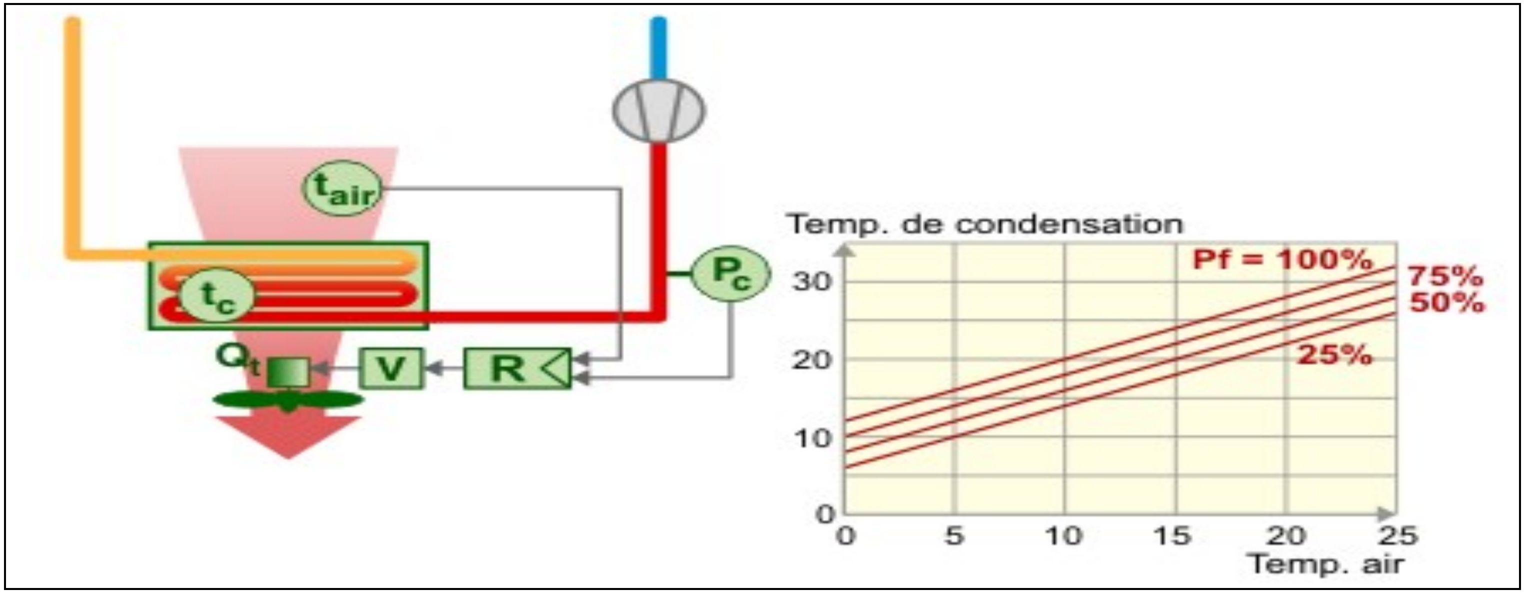


-When the θext is low, cooling the condenser requires less energy from the fans.

- The optimum condensing temperature therefore moves according to the Text

-- Pay attention to the lower limit to avoid the formation of vapor in the liquid phase

ENERGY OPTIMIZATION: CONDENSER



The floating HP regulation requires some modifications:

- Electronic expansion valve rather than thermostatic
- Frequency variation on the fans to increase the adjustment range

➢ This regulation is profitable for large installations.

ENERGY OPTIMIZATION - CONDENSER

- Clean the condenser: Dirty condenser: loss of 12.5 to 25%

COP increases when Tc decreases

- **1 ° K increase in condensing temperature corresponds to 2 to 3% increase in compressor power consumption.**

ENERGY OPTIMIZATION - EVAPORATOR

❑ Optimization of the temperature difference between the refrigerant T0 and the area to be refrigerated

- **In air conditioning:**

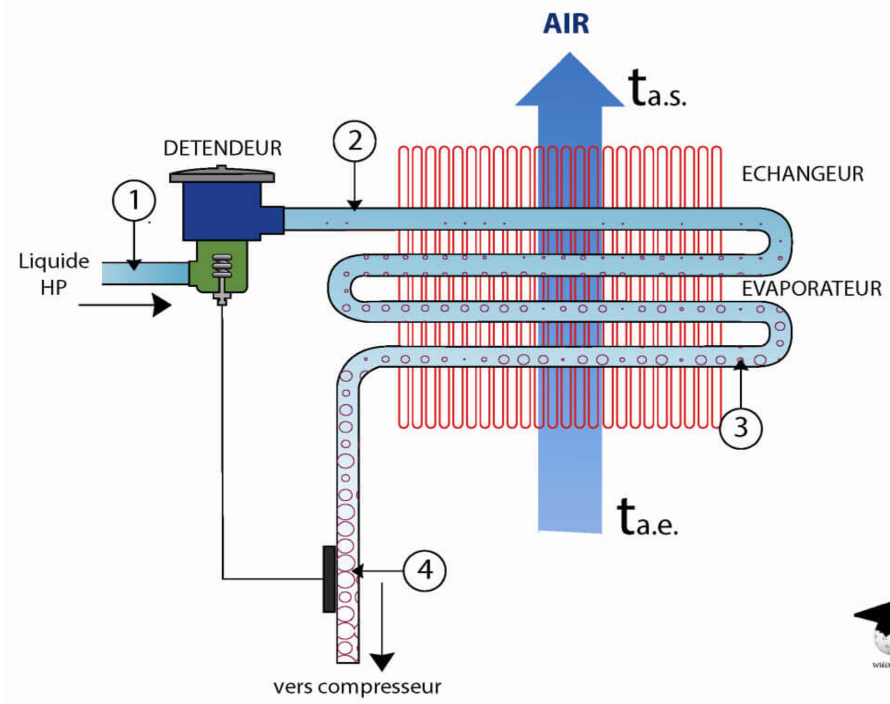
A Δθ on air (tae - tas) from 6 to 10°C

A total Δθ (tae - to) of 16 to 20°C

- **In commercial refrigeration:**

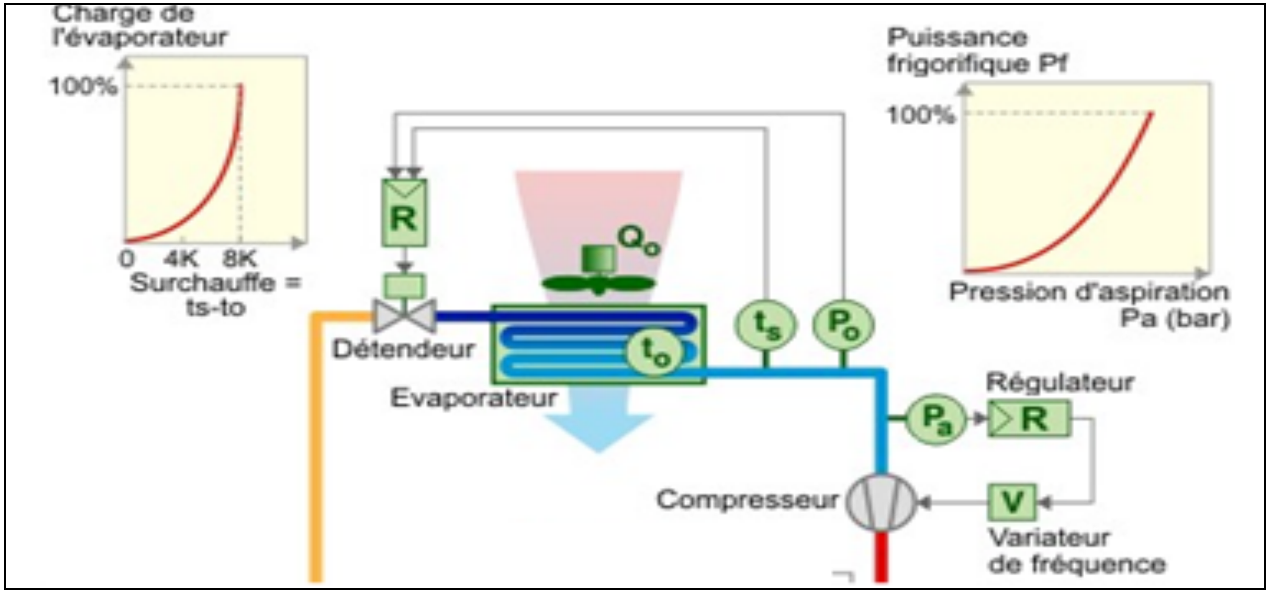
A Δθ on air of 3 to 5 ° C

A total Δθ (tae-to) of 6 to 10 ° C



ENERGY OPTIMIZATION - EVAPORATOR

❑ Optimization of the evaporation temperature: floating BP



* Constantly adapt the operating pressures according to real needs and this without affecting the conservation of the products.
* Choose T0 according to a differentiated day / night setpoint

➢ Requires the use of an electronic expansion valve
➢ this regulation is profitable for large installations

ENERGY OPTIMIZATION - EVAPORATOR

- Clean the evaporator: Dirty evaporator: loss of 5% to 12.5%

- The higher suction pressures limit the formation of frost on the evaporators, the defrost time is therefore reduced.

The COP increases when the T0 increases

By reducing the evaporation T by 1 ° K: 2.5% additional consumption

ENERGY OPTIMIZATION - DEFROST CYCLE

Basics

- Origin of frost

ambient air contains water; this water freezes on contact with cold surfaces (T <0 ° C)

- The consequences of frost

It decreases the heat transfer between the evaporator and the ambient environment (creation of an insulating layer on the evaporator)

It decreases the efficiency of the compressor (poorer evaporation of the refrigerant, lower compressor inlet pressure, risk of "liquid blows")

- The problem of defrosting

Too many defrosts leads to overconsumption of the defrost system

Too little defrost reduces the energy efficiency of the installation

We must therefore find an optimum between these two constraints

ENERGY OPTIMIZATION - DEFROST CYCLE

- To optimize defrost, you must:
- Choose the right type of defrost and regulation
- Minimize the opening of doors
- Check the door closing contact
- Optimize the evaporating temperature
- Check the location of the defrost probe

From the basic setting, the refrigeration engineer can reduce the number of defrost cycles and set the duration of each cycle.

ADOPTING GOOD PRACTICES

MAINTENANCE OPERATIONS

- **Compressors and other electric motors:**
- ✓ Checking the oil level and pressure,
- ✓ Regular oil change and lubrication of the engines,
- ✓ Belt tension control,
- ✓ Checking the load on the motors by measuring the electrical power consumed,
- ✓ Control of alignment and vibration level.

- **Evaporators, condensers, cooling towers and other exchangers:**
- ✓ Regular control of the level of contamination,
- ✓ Cleaning of the exchange surfaces if necessary,
- ✓ Checking the operation of the fans,
- ✓ Purge unwanted bodies (air, oil and water),
- ✓ defrost system check

MAINTENANCE OPERATIONS

- **The control and regulation system:**
  - Control of thermostats setpoint values,
  - Regular verification of the calibration of the probes,
  - Checking the capacity control of the compressors.
  - Correctly adjust the superheat on the expansion valve

- **The distribution network:**
  - Overhaul of the network to reduce load losses,
  - Checking the filters and the opening of the valves,
  - Checking the condition of the insulation

Commercial / domestic refrigeration control

Indispensable measures and actions	Potential
Checking the doors - Replace the rubber seals - Replace the magnetic tapes - Check the door closing contacts	**
Lighting verification - Install a motion detector - Use LEDs	**
Checking the outlet openings of the ventilation system (refrigerated furniture) - Reorient the outlet openings - Have the air flow analyzed using a smoke test	****
Control of mobile refrigeration equipment - Turn the device or change its place	***
Device charging control - Respect stacking limits - Check the air circulation - Switch off refrigeration devices not in use	***

Air conditioning control

Indispensable measures and actions	Potentiel
Checking the chilled water temperature set values Adjust the regulator's cooling curve so that it adapts to different outside temperatures in winter and summer (sliding according to the outside temperature).	****
Control of operating times Check whether the operating times of the refrigeration system and the building occupancy times are coordinated (day & night operation, weekends, public holidays or during holidays).	****
Control of the climatic cold release value (Freecoling) Set it to as high a value as possible.	****
Avoid simultaneous heating and cooling Make sure the heating and cooling are not running simultaneously.	***
Checking that the doors and windows of an air-conditioned room are closed	***
Checking filter clogging Clean or replace filters	***
Air quality control Optimize the flow of recycled air	

CHOICE OF EQUIPMENT

At the time of conception, you have to think about:

- Choose suitable equipment so that the installation operates under nominal conditions
- Optimize compressor power (calculation and choice of the appropriate technology)
- Use electric motors fitted with speed regulation systems (inverter / frequency converter)
- Heavily oversized motors have low efficiency.

- Choosing electronic expansion valves for large installations
- Regulate Tc and T0 to avoid waste
- Size the pipe diameters and the exchange surfaces of the exchangers
- Favor centralized installations
- Programming of cold production

- Reduce the amount of cold produced: reduce heat leaks

* Reinforce the insulation of cold surfaces

* Reduce heat input from the sun

* Reduce heat input by air renewal

- Choose a refrigerant with high thermodynamic and ecological properties

CONCLUSION