REFRIGERANT GASES MANIPULATION CERTIFICATION & REEFERMAN TRAINING

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2. Vapor compression refrigerators

- 2.1. Application on board ships
- 2.2. Compressor types
- 2.3. Other elements
- 2.4. Main manufacturers and characteristics
- 2.5. Container refrigerating systems
- 2.6. Cooling effect regulation
- 2.7. Operation management and basic diagnostics
- 2.8. Filling and evacuation of the equipment

2.1. Application on board ships

Applications

- Food preservation
- Cooling of air in the acclimatization units
- Cargo
  - Liquefaction of gaseous cargos
  - Cooling of cargo holds
  - **Containerized cargo**
- Smaller units

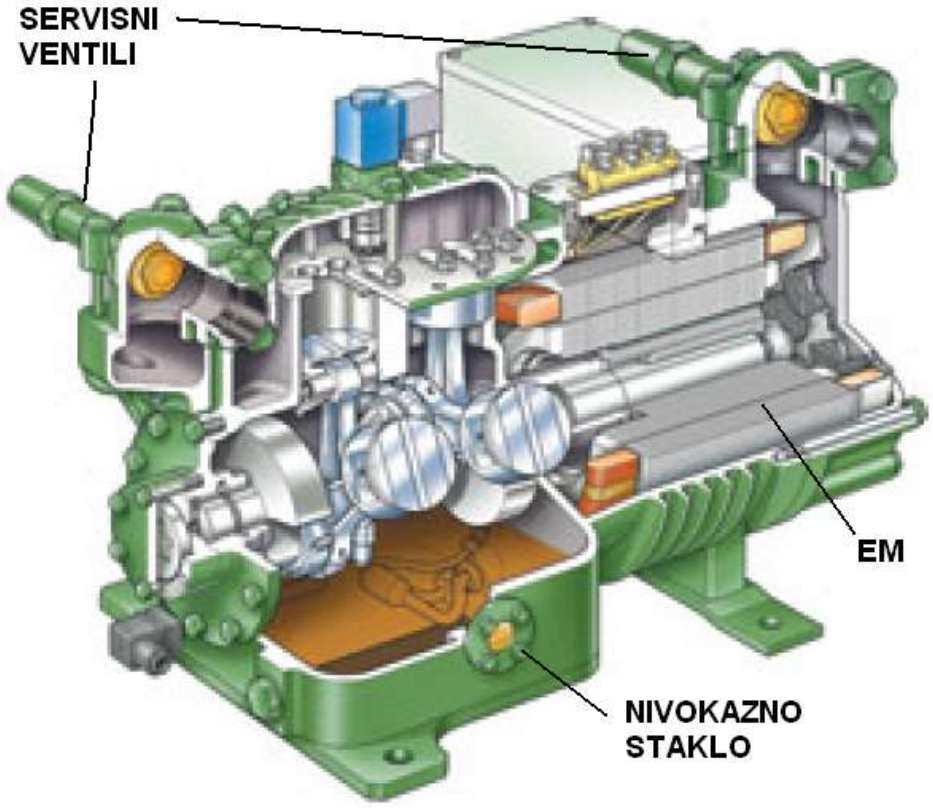
2.2. Compressor types

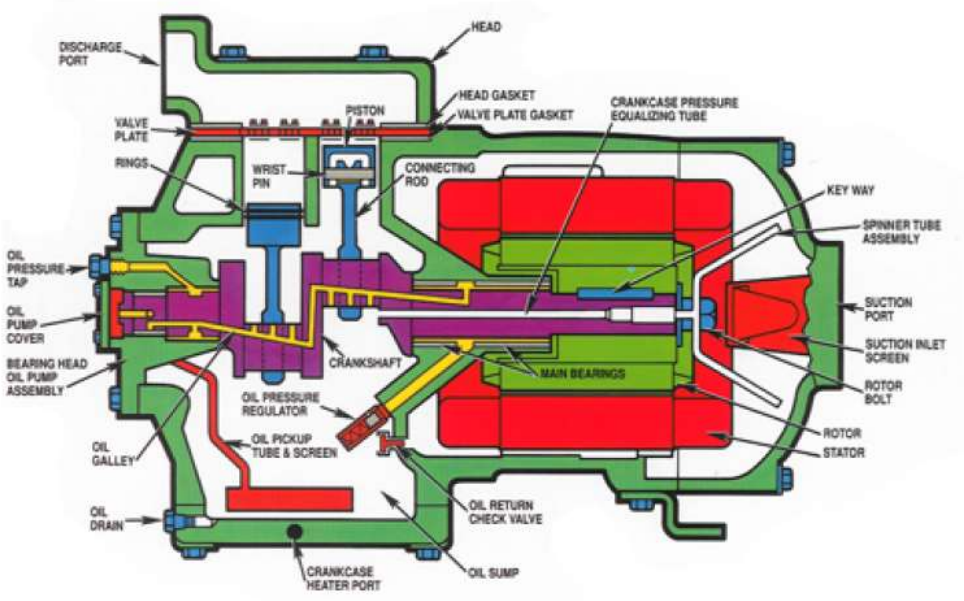
Characteristics

- Casings: open, semi hermetic, hermetic
- Transformation of energy: piston – plunger, screw, rotary vane, scroll etc.
- Most common types in container refrigerating systems: multi cylinder piston single acting, open or semi hermetic, and hermetic one or two piston or hermetic scroll

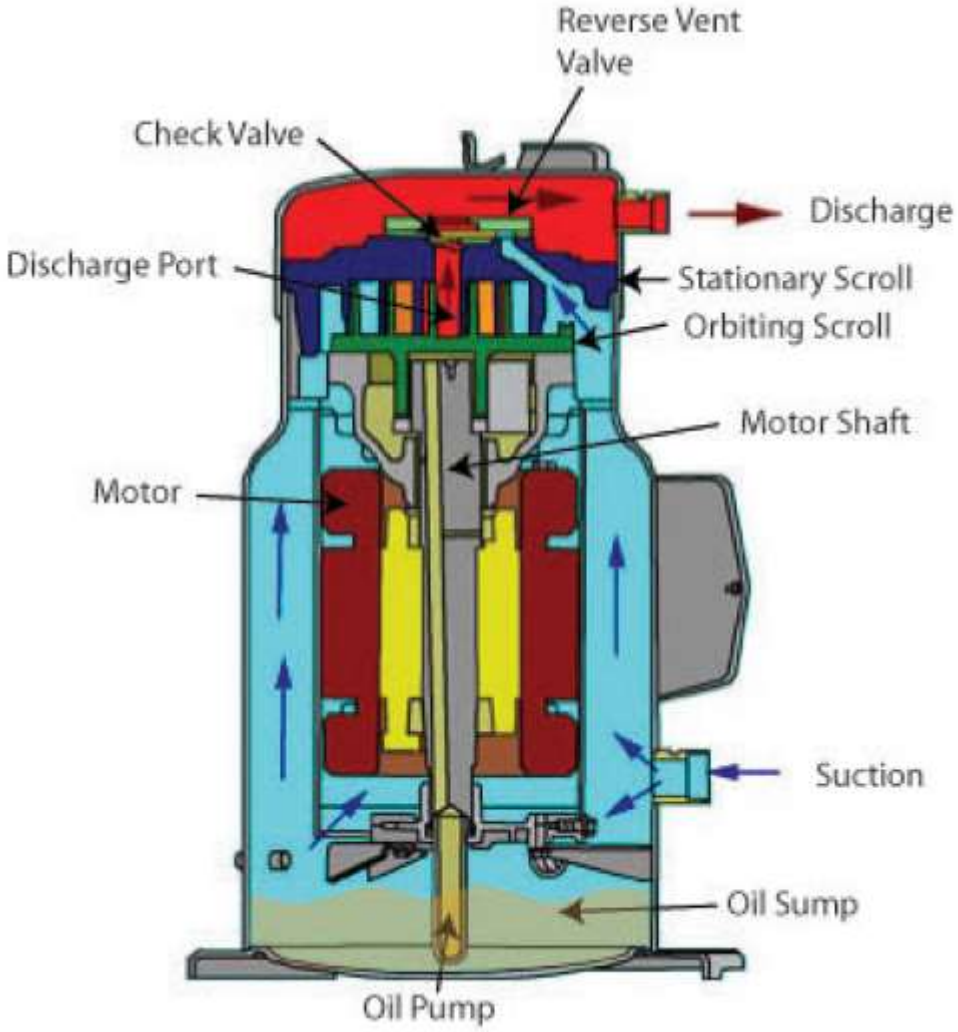
Open, semi hermetic, hermetic type

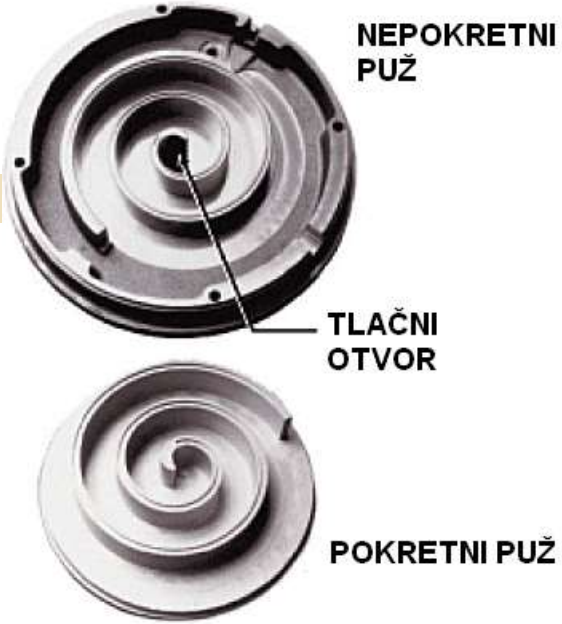
Semi hermetic multi cylinder type

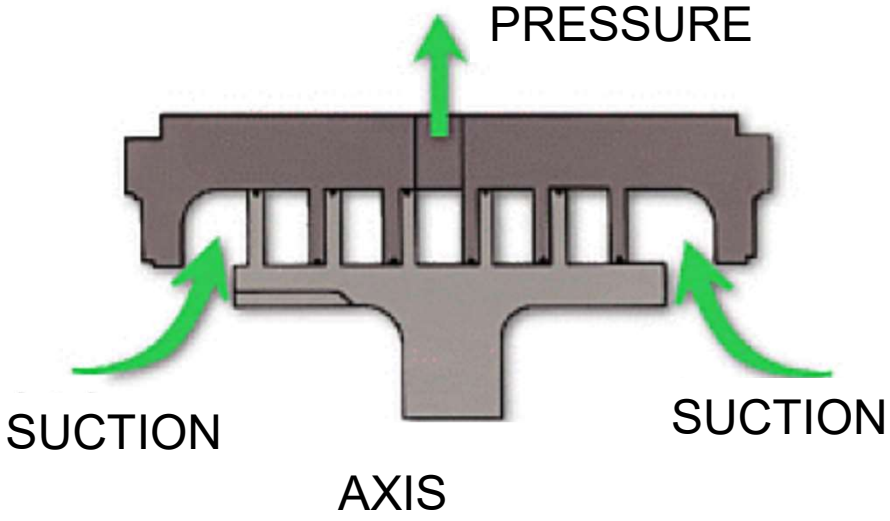




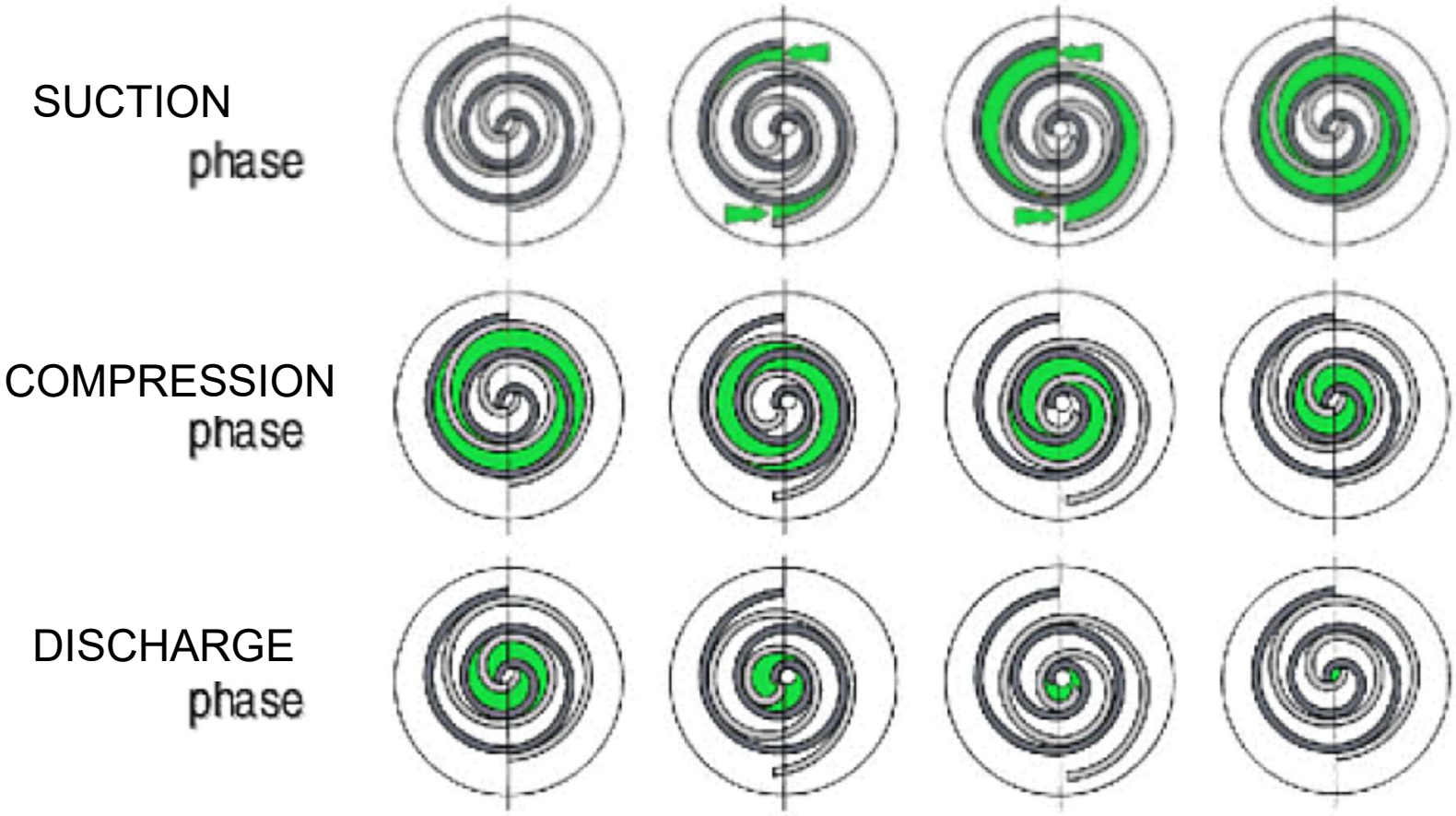
Scroll type


Reverse Vent Valve
Check Valve
Discharge
Discharge Port
Stationary Scroll
Orbiting Scroll
Motor Shaft
Motor
Suction
Oil Sump
Oil Pump


NEPOKRETNI PUŽ
TLAČNI OTVOR
POKRETNI PUŽ


PRESSURE
SUCTION
SUCTION
AXIS

Scroll



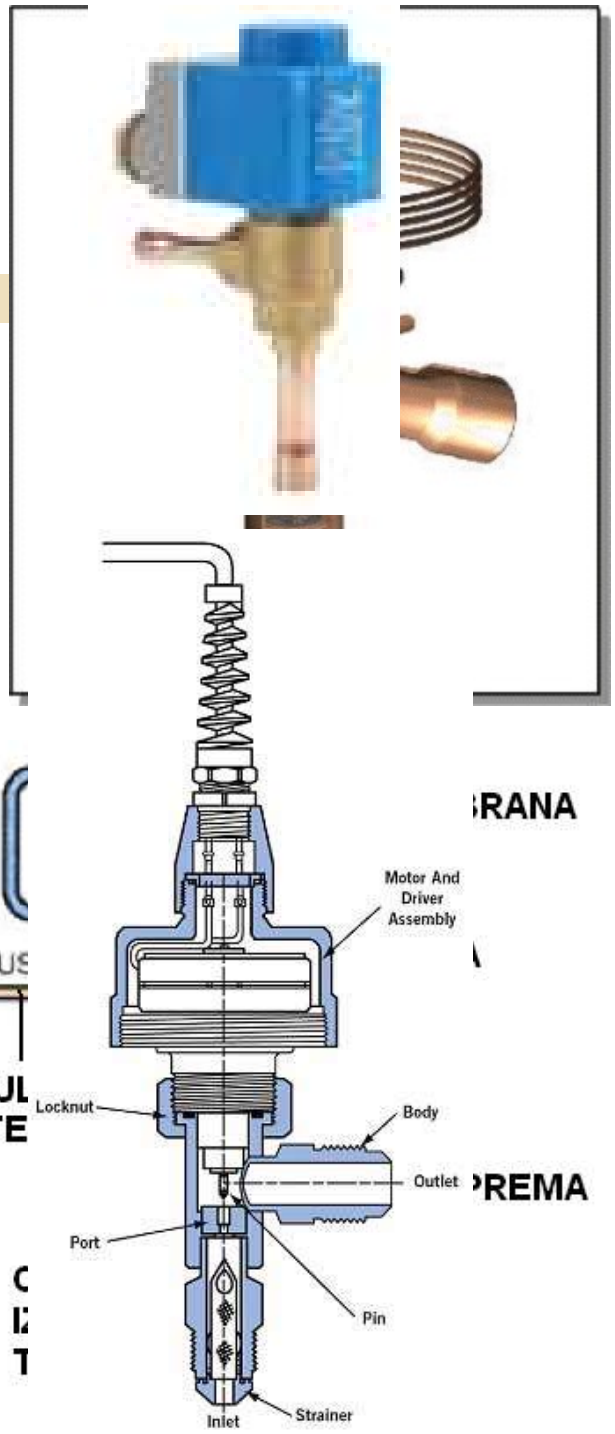
2.3. Other elements

Condenser

- Water cooled (sea), cylindrical casing, water passing through pipes – refrigerant around pipes, pressure vessel – safety armature)
- **Air cooled (refrigerant passing through pipes, cooling air around pipes –** natural or **forced circulation)**

Metering devices

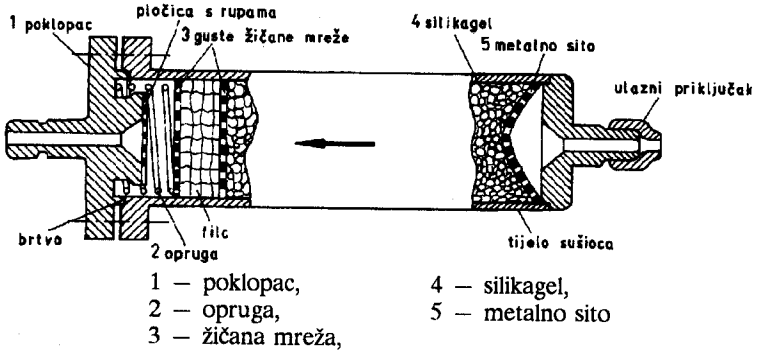
- Capillary tube or **regulating valve (TEV or EEV)**
- Significant pressure drop causes liquid transformation to low pressure vapor
- TEV or EEV releases amount of refrigerant to the evaporator which exit as slightly superheated vapor
- Superheating set from 3 to 10˚C



Evaporator

- Natural or **forced** air flow
- Forced air flow: flow regulation by switching the ventilators on and off and by driving electric motors regulation
- defrosting
  - Why? Ice is a heat isolator, creates the heat flow resistance.
  - Electrical heaters or with warm vapor from the compressor
- Air dehumidification (additional warm vapor pipe)

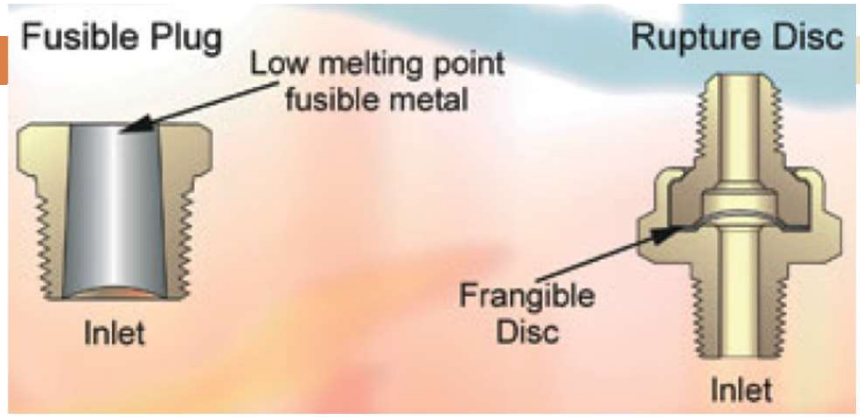
Other elements



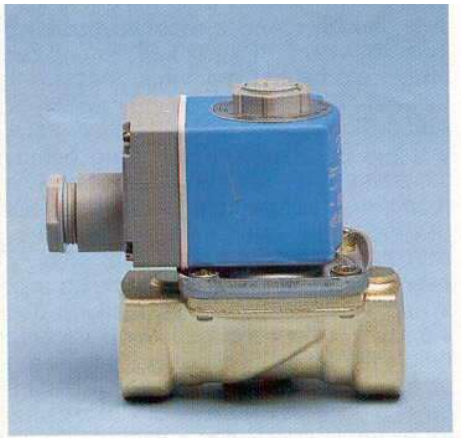
- filter-dryer
  - Open type or **hermetic**
  - Arrow showing direction of flow
- Moisture and flow indicators (glass)
  - Shortage of refrigerant
  - Saturation of drying agent
- Sub cooler
- Receiver with fusible plug
- Solenoid valves
- Non return valves and double sided valves
- Measuring and regulating armature

Sub cooler

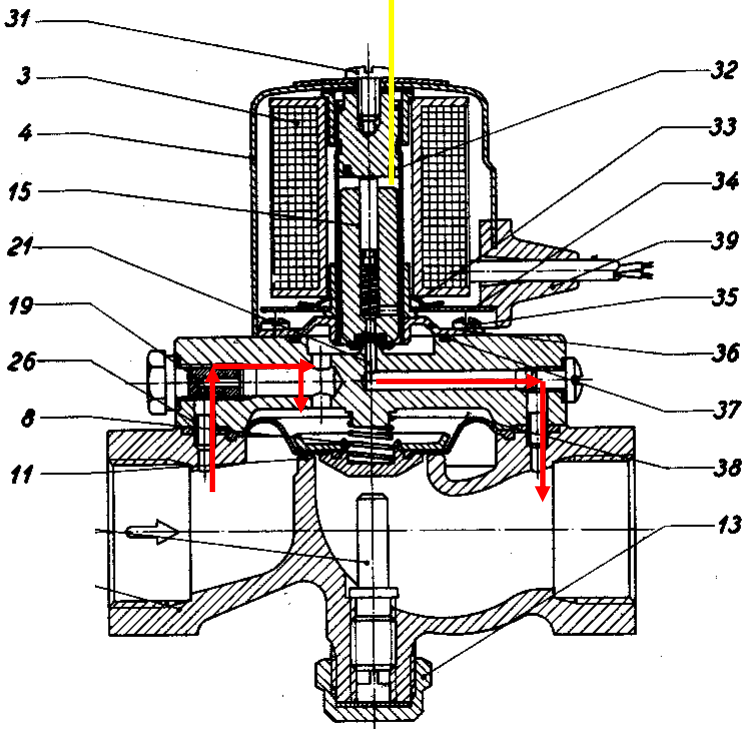
Receiver


Fusible Plug
Low melting point
fusible metal
Rupture Disc
Inlet
Frangible
Disc
Inlet

Solenoid valves



Membrane: rubber or teflon
Emergency hand operated
Pilot valve
Membrane upper side area is bigger, in case of equal pressure valve is closed
Electric coil attracts element 15 and pressure on the upper side is decreased – valve opens



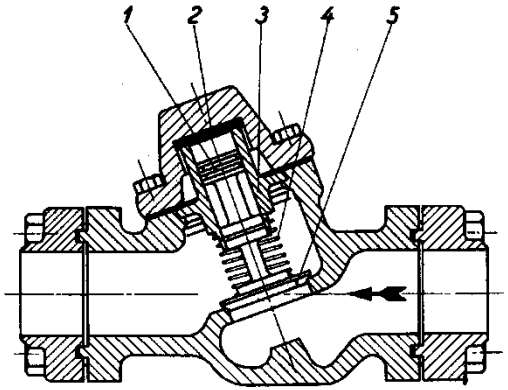
$$p_{ulaz} A_{memb,dolje} = F_{otv}$$

$$p_{ulaz} A_{memb,gore} = F_{zatv}$$

$$A_{mem} p_{ulaz} A_{memb,dolje} = F_{otv} > F_{zatv} = p_{izlaz} A_{memb,gore}$$

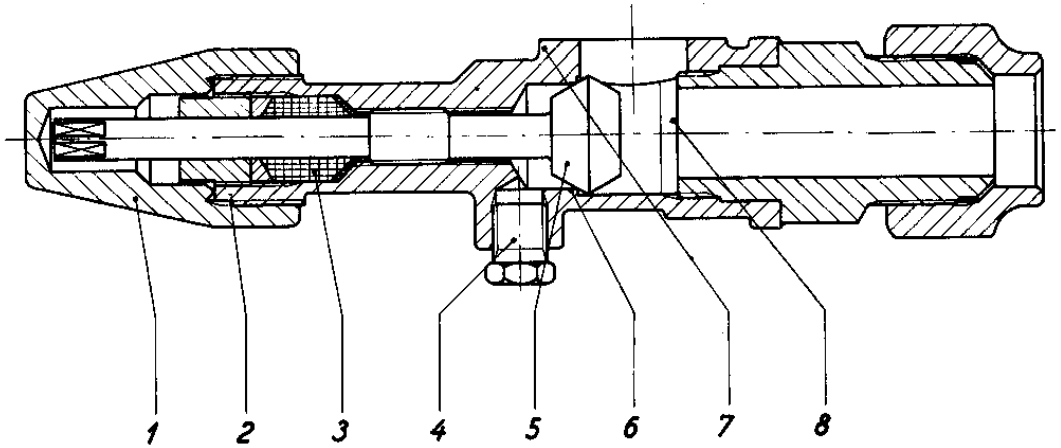
Valves

NON RETURN VALVE



Type KVDA 35 - 40

DOUBLE SIDED VALVE (SERVICE)



2.4. Main manufacturers and characteristics

Manufacturers

- Carrier
- Thermoking
- Daikin
- Star Cool
- Denso

Carrier

Carrier is the leader. They are the pioneers of refrigeration.

Several types of containers. Most common today: *Primeline* and *Thinline*.

Primeline uses R-134a. It has a hermetic scroll compressor and an EEV. Cooling capacity regulation: by two opposite acting valves (DUV and DUV), one open to increase, and the other to decrease capacity, or with one by-pass valve connecting suction and discharge sides of the compressor.

Thinline also uses R-134a. It has multi cylinder (6) piston semi hermetic compressor and a TEV. Cooling capacity regulation is done with the suction (choke) valve on the suction pipe of the compressor (SMV).

Thermoking

Second great manufacturer on the market.

Mostly used is a *Magnum* container (*Magnum*, *Magnum SL*, *Magnum* 20).

Magnum works with R-404A. It's a mixture. Slightly difficult management.

It has a hermetic scroll compressor.

Cooling capacity regulation by EMV acting on the compressor – unloads the compressor by lifting one of the scrolls.

Thermoking Superfreezer (CRR DF model)

It’s used for especially low cargo temperatures, around -60°C.

Cascade refrigeration system: primary, using R-134a with Copeland Discus multi cylinder semi hermetic piston compressor cools secondary system with R-23 having hermetic scroll compressor.

Daikin

Fights with thermoking for the second place on the market.

Type LXE. Several types of control units (DECOS).

Also uses R-134a.

It also has a hermetic scroll compressor. Cooling capacity regulation by suction (choke) valve on the suction pipe of the compressor (SMV.

Air cooled condenser or water cooled additional condenser (receiver).

Metering device is EEV.

Denso

Two compressors with three phase electric motors and inverters – number of revolutions regulation.

It uses R-404A (6,3 kg).

It has a rotary hermetic compressor.

Metering devices are EEV – separately for economizer and for evaporator.

Economizer is used in the economizer mode as sub cooler to increase the cooling capacity and COP.

Defrosting by electrical heaters.

Star cool

Koristi R-134a.

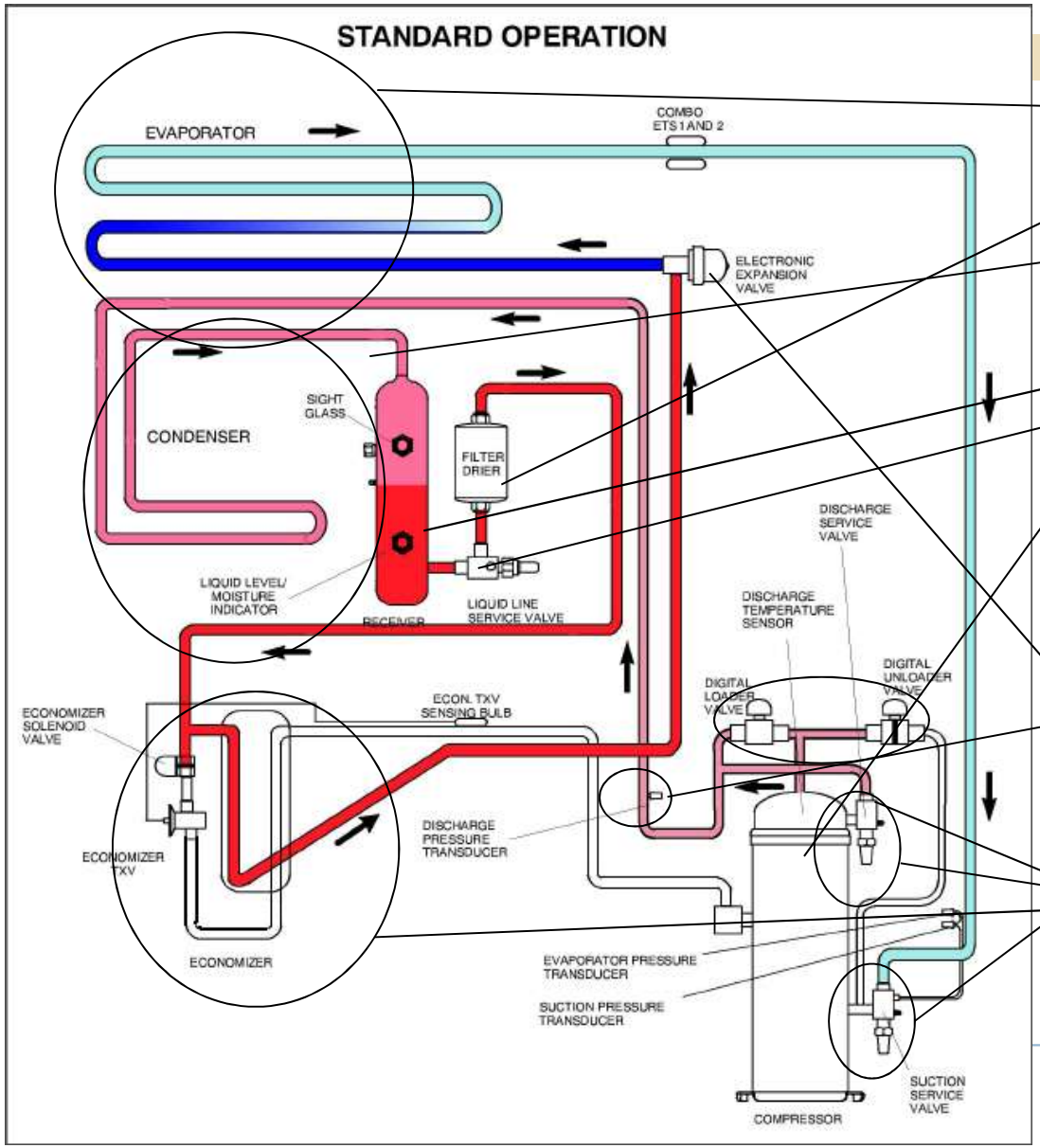
Dvostepeni stapni kompresor s regulacijom broja okretaja (inverter).

Koristi EEV.

Ima ekonomajzer za pothlađivanje kondenzata.

2.5. Container refrigerating systems

Shema Carrier Primeline



Refrigerating system characteristics:

- 4,54 kg R-134a
- Safety – receiver fusible plug melts at 99˚C or rupture disc bursting at 35 barg
- HPS 17,5 / 24,5 barg

RECEIVER

LIQUID PHASE SERVICE VALVE

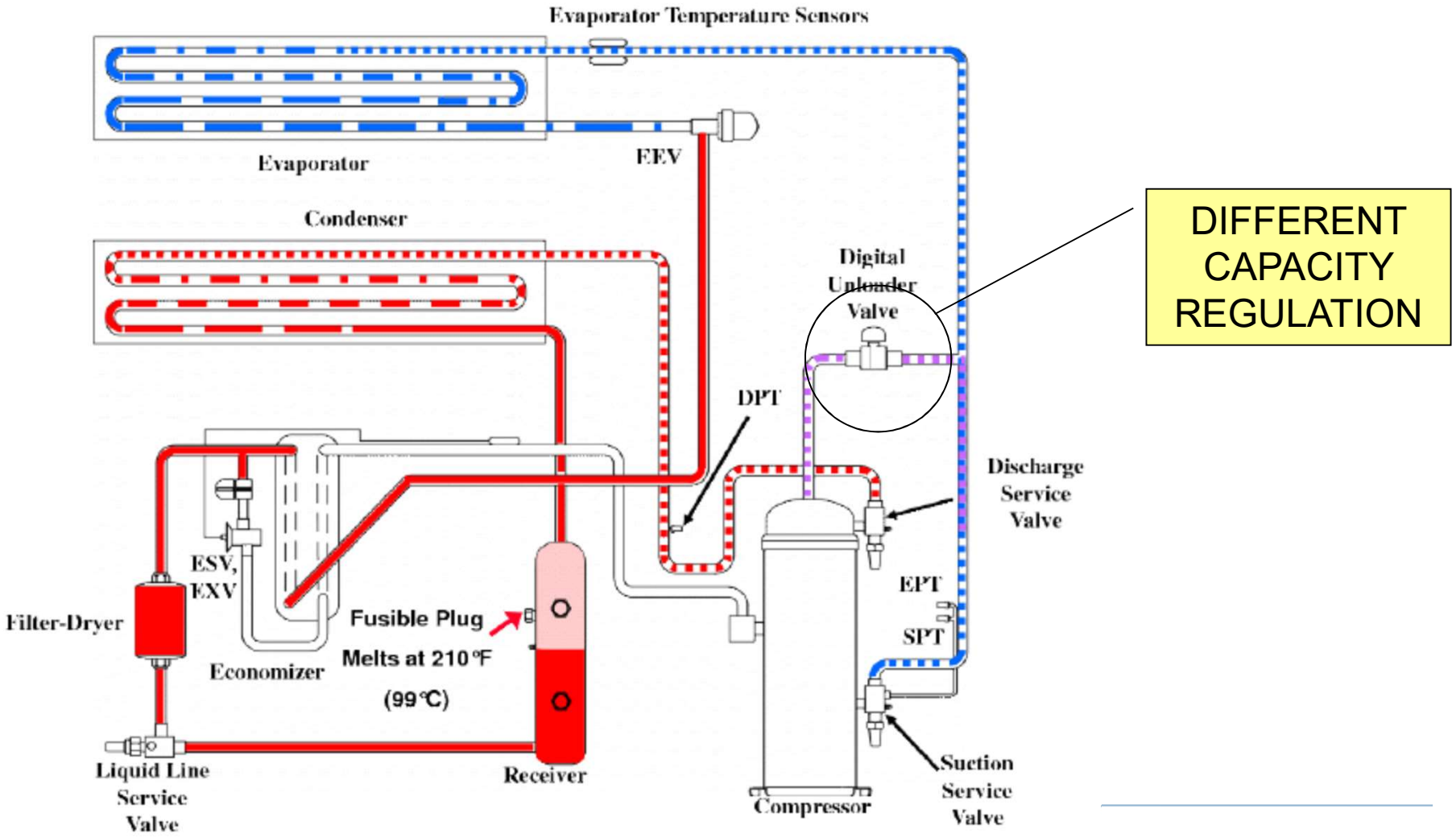
COMPRESSOR

DOUBLE SIDED

PRESSURE TRANSDUCER ON DISCHARGE SIDE OF THE COMPRESSOR

LOADER AND UNLOADER DIGITAL VALVES

Shema Carrier Primeline



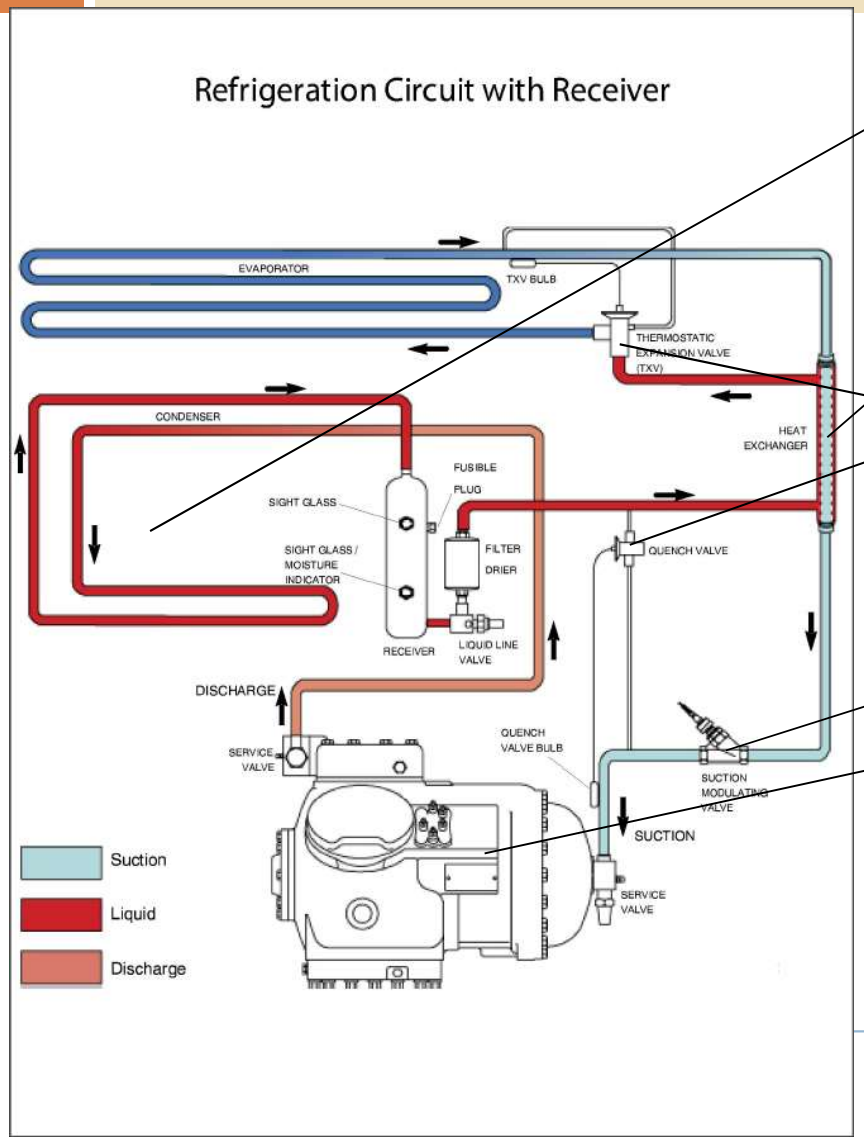
Shema Carrier Thinline 368

Characteristics:

-3,3 kg R-134a

-HPS same values

- Fusible plug or rupture disc

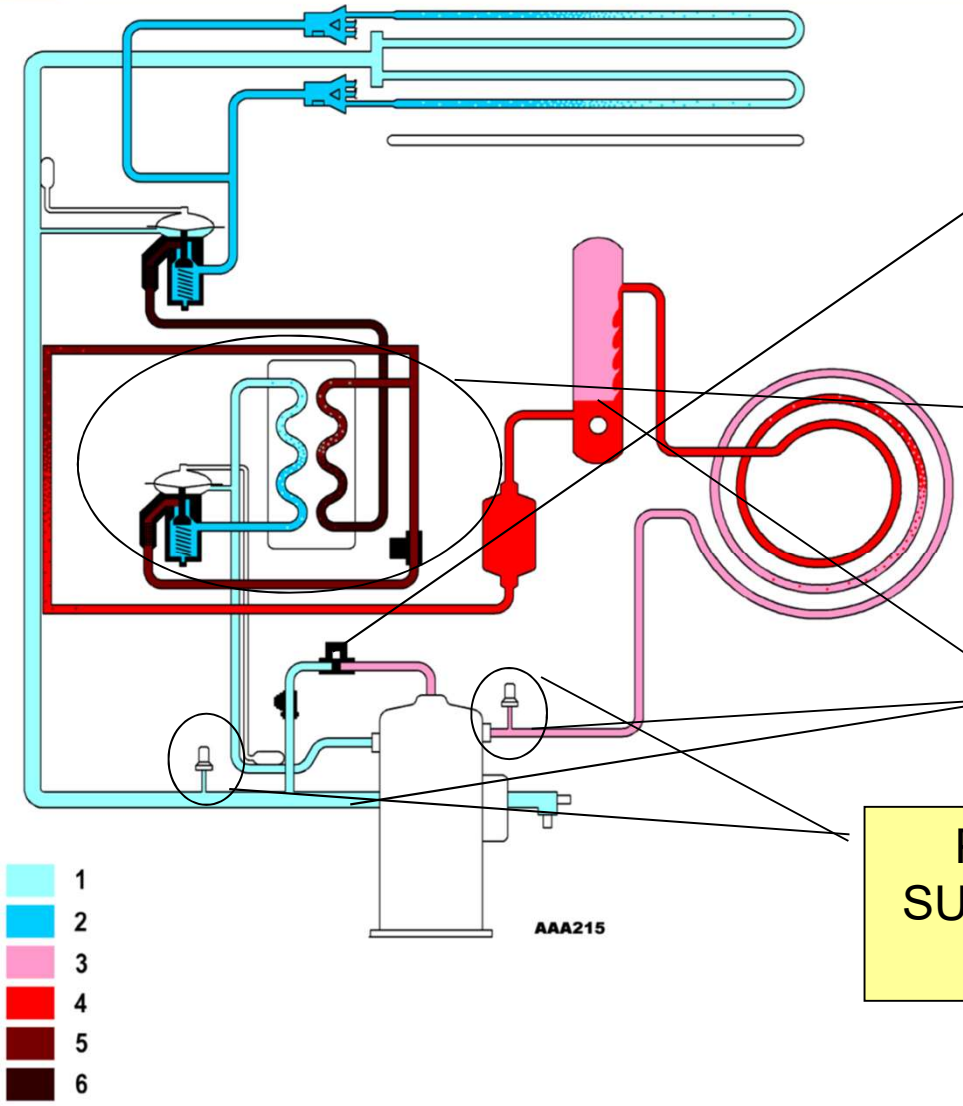


SYSTEM HAS PRESSURE TRANSDUCER: IF OUTSIDE TEMPERATURE IS BELOW 27˚C VENTILATOR CUTS ON WHEN PRESSURE IS ABOVE 200psig (14barg) OR HAS BEEN STOPPED FOR 60s, AND CUTS OFF WHEN PRESSURE IS BELOW 130psig (9,1barg) OR HAS BEEN WORKING MORE THAN 30s

REGULATION (SMV)

CYLINDER COMPRESSOR

Shema Thermoking Magnum



COM

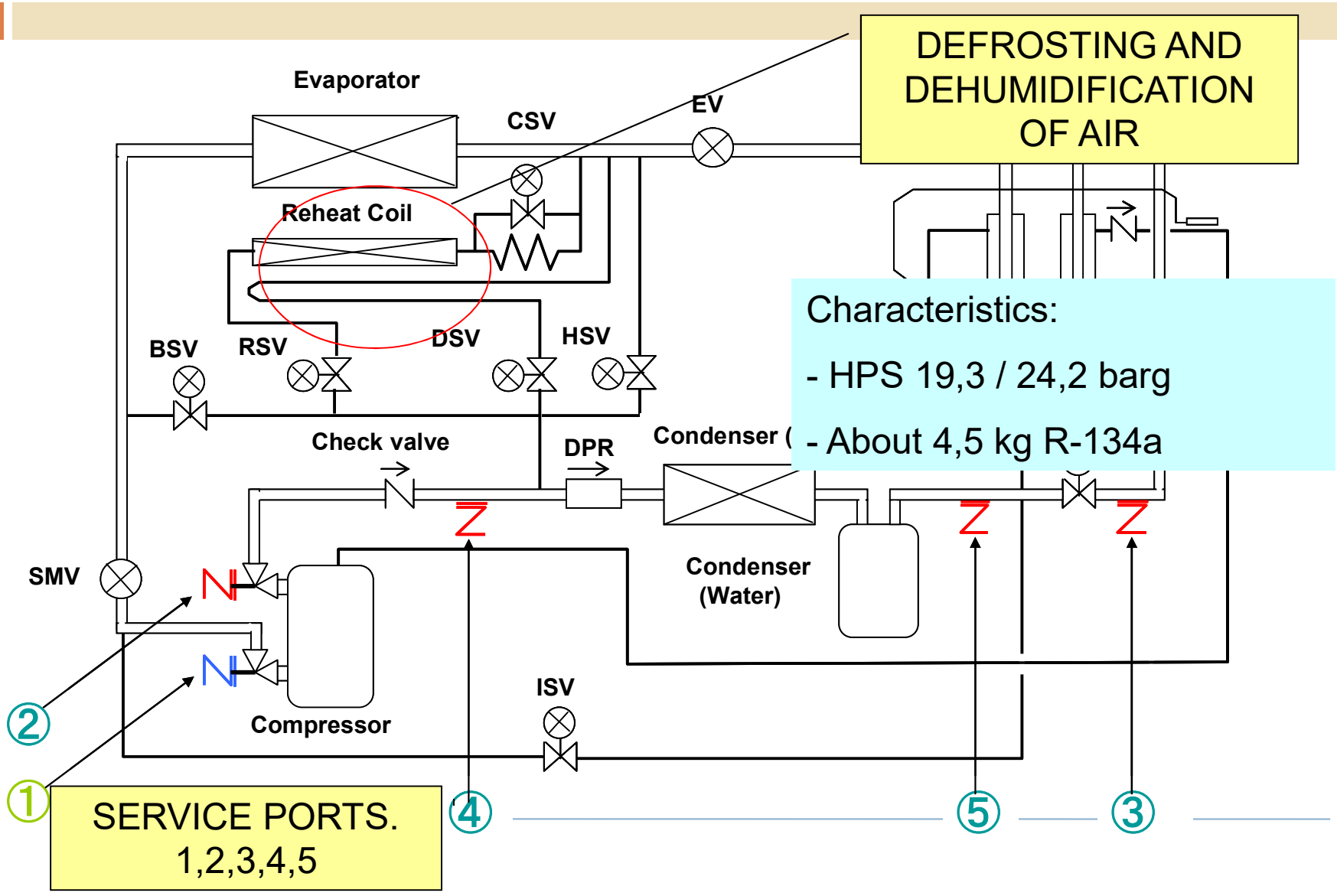
SE
SUCT
SIDE OF THE COMPRESSOR
AND AFTER THE RECEIVER

PRI
SUCT
THE COMPRESSOR

Characteristics:

- 4,0 kg (4,8 if equiped with water cooled condenser - receiver)
- fusible plug
- HPS 26 / 32,4 barg
- LPS from -0,17 to -0,37 / 0,28 – 0,48 bar
-Suction pressure from 1,3 to 6,7 barg
- Discharge side from 10,35 to 26,5 barg

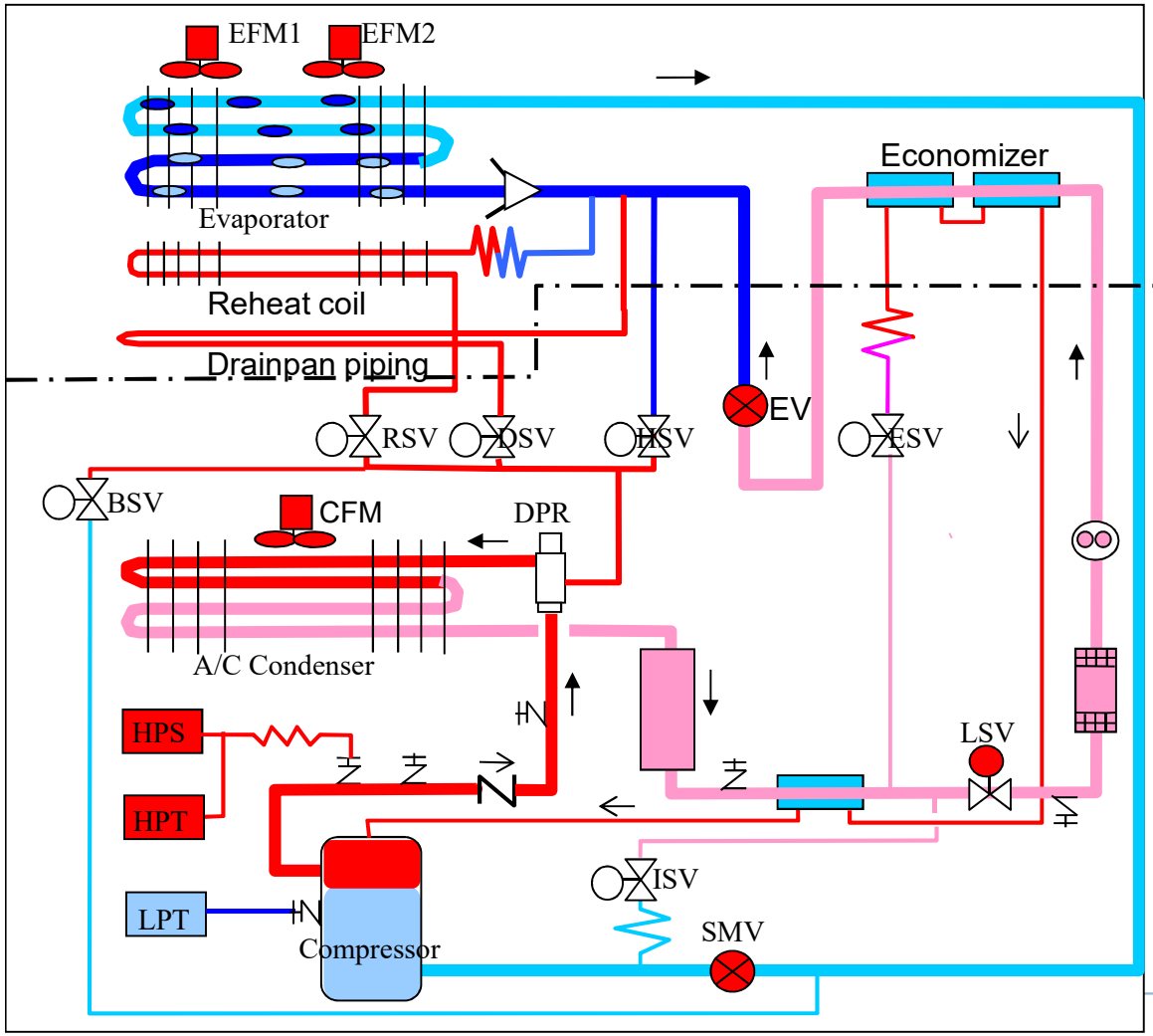
Daikin: service non return valves (ports)



When and how to use ports 1 to 5?

1. Compressor pressures checking (ports 1 i 2)
2. Evacuation of the system after automatic ‘pump down’ procedure (first with port 5 for liquid phase, and then 4 and 5)
3. Pressure checking with nitrogen
4. Vacuuming and drying of the system
5. Filling of the system with refrigerant

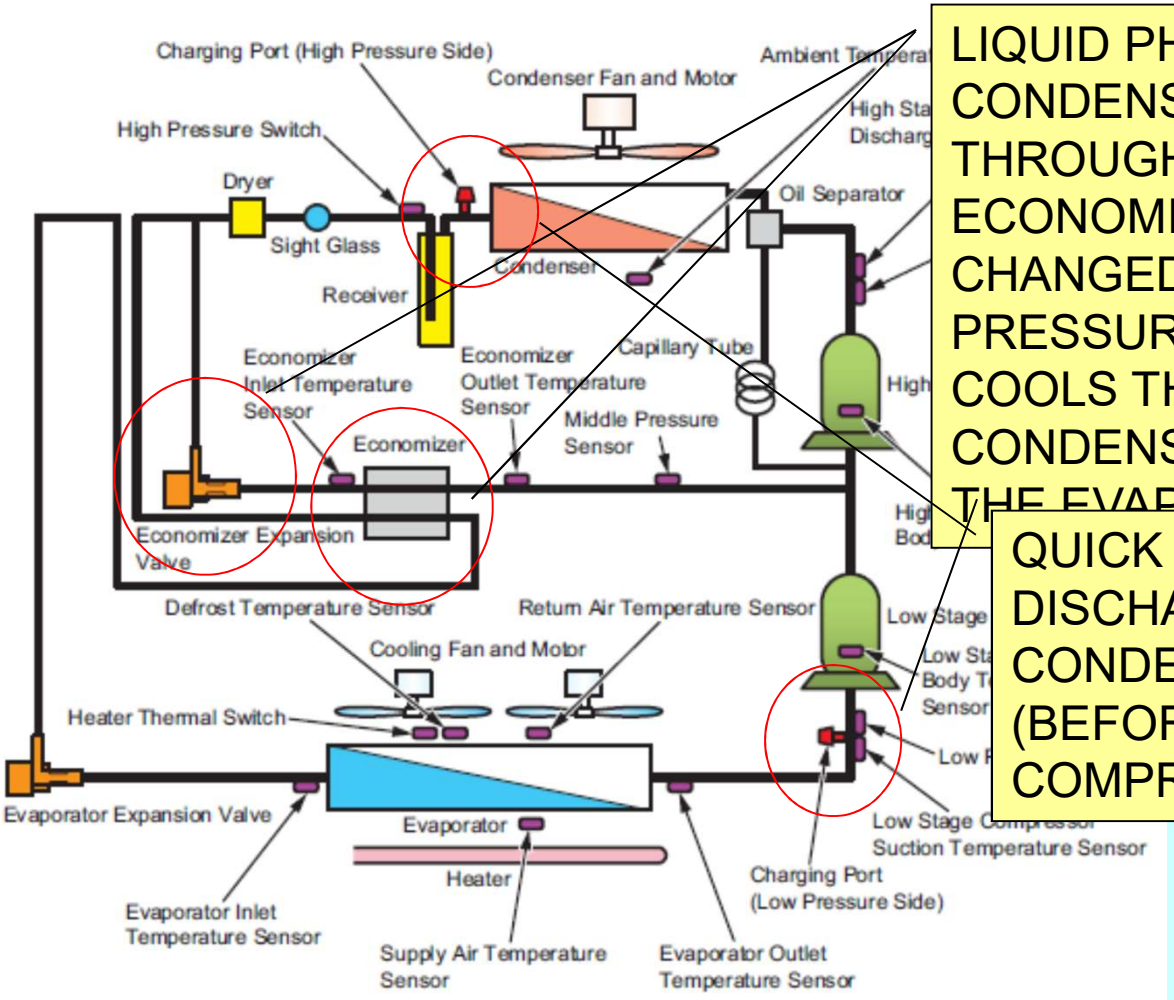
Daikin –solenoid valves functions



- **By-pass Solenoid Valve** (BSV) > main function is oil return.
- **Reheat Solenoid Valve** (RSV) (option) > used for De-Humidification.
- **Defrost Solenoid Valve** (DSV) > used for defrost and heating.
- **Hot-gas Solenoid Valve** (HSV) > also used for defrost and heating.
- **Injection Solenoid Valve** (ISV) > to protect compressor for high temperature.
- **Economizer Solenoid Valve** (ESV) > used for extra cooling capacity.
- **Liquid Solenoid Valve** (LSV) > **ON** during cooling operation.

Note: All solenoid valves are normally closed valves.

Denso



LIQUID PHASE FROM THE CONDENSER PARTIALY PASSES THROUGH EEV OF THE ECONOMIZER WHERE IT IS CHANGED IN THE COOL LOW PRESSURE VAPOR WHICH SUB COOLS THE REST OF THE CONDENSATE ON ITS PASS TO THE EVAPORATOR

QUICK CONNECTING PORTS: DISCHARGE (AFTER CONDENSER) ANDSUCTION (BEFORE LOW PRESSURE COMPRESSOR)

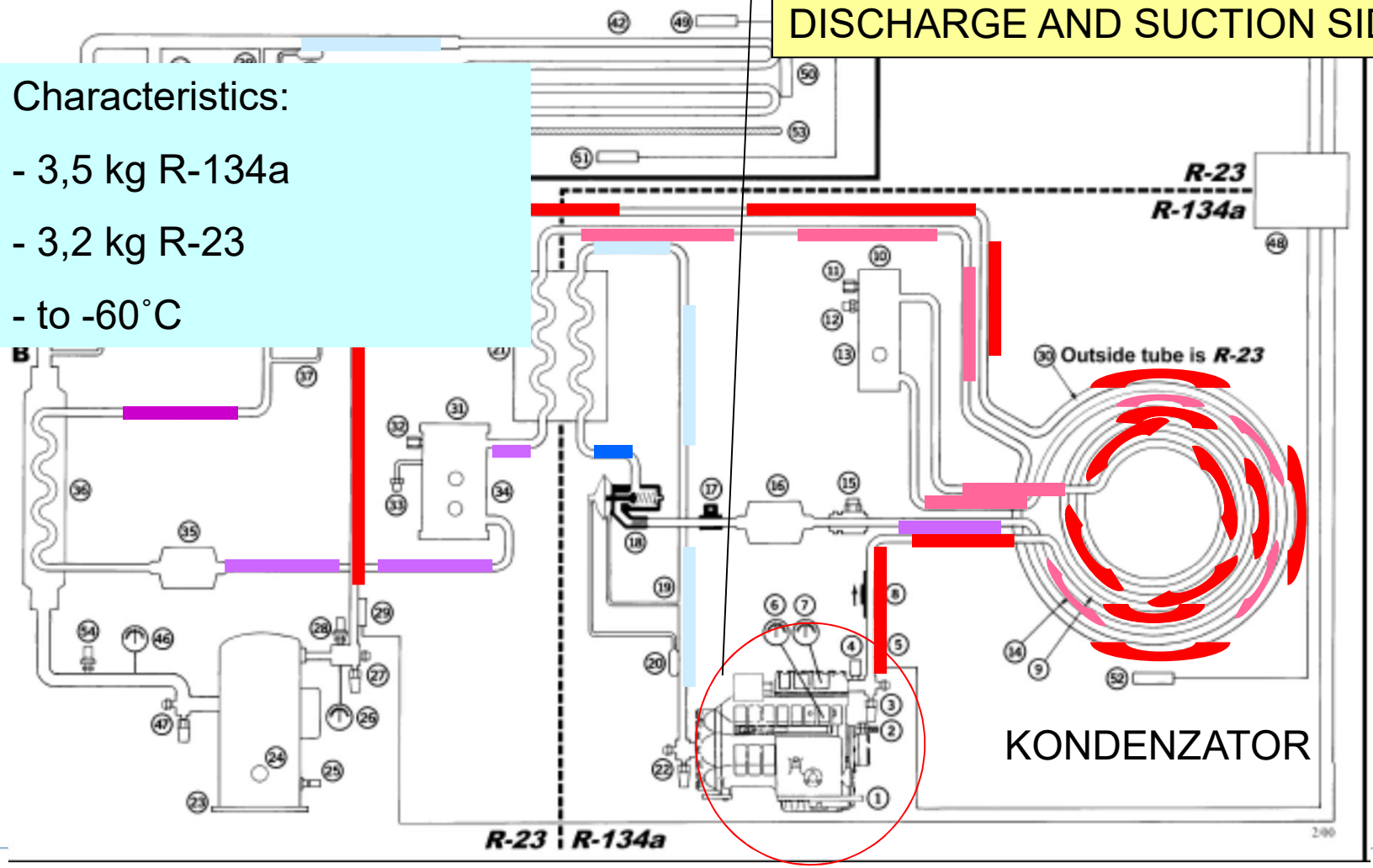
- 6,3 kg R-404A
- two stage compression
- inverters

Thermoking Superfreezer

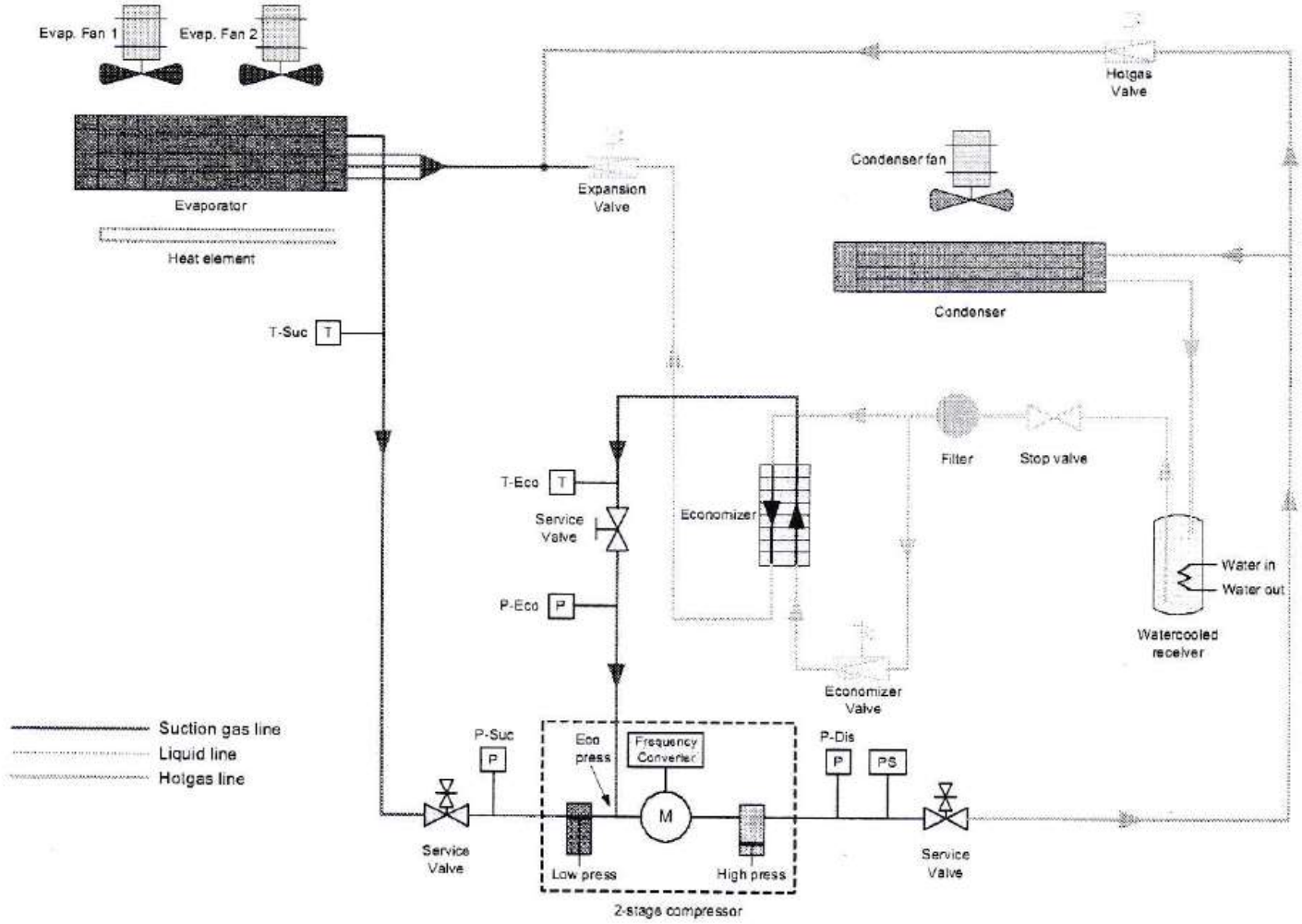
SEMI HERMETIC MULTI CYLINDER COMPRESSOR UNLOADED START WITH BY-PASS VALVE CONNECTING THE DISCHARGE AND SUCTION SIDE

Characteristics:

- 3,5 kg R-134a
- 3,2 kg R-23
- to -60˚C



Star Cool


Evap. Fan 1
Evap. Fan 2
Evaporator
Heat element
T-Suc
T
Expansion Valve
Hotgas Valve
Condenser fan
Condenser
Filter
Stop valve
T-Eco
Service Valve
P-Eco
P
Economizer
Economizer Valve
Water in
Water out
Watercooled receiver
Suction gas line
Liquid line
Hotgas line
P-Suc
Eco press
Frequency Converter
M
P-Dis
PS
Service Valve
Low press
High press
2-stage compressor

Transducers

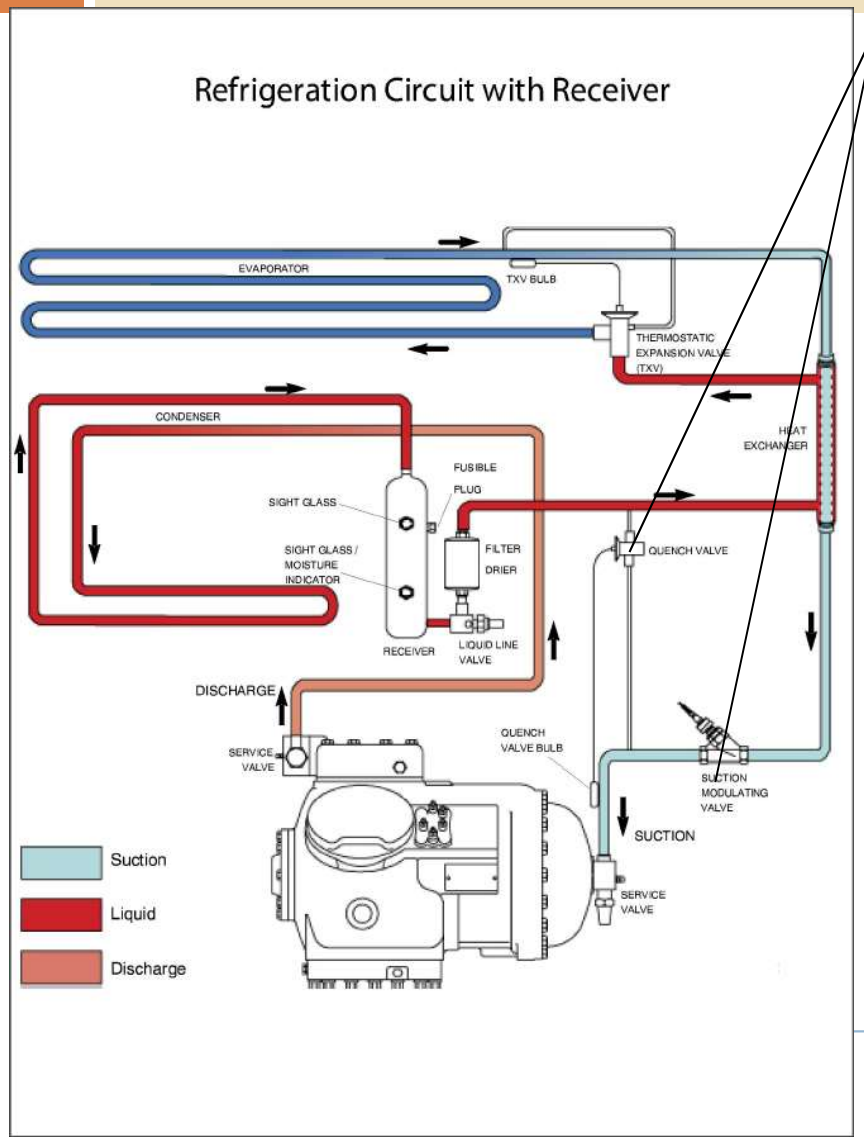
- Pressure
  - Suction and discharge side of the compressor
  - Condenser
  - Evaporator
- Temperature
  - Compressor
  - Evaporator
  - Condenser
  - Air before and after evaporator
  - Air and (or) water of the condenser
- Humi9dity
  - If system is in chill mode

2.6. Cooling effect regulation

Capacity regulation

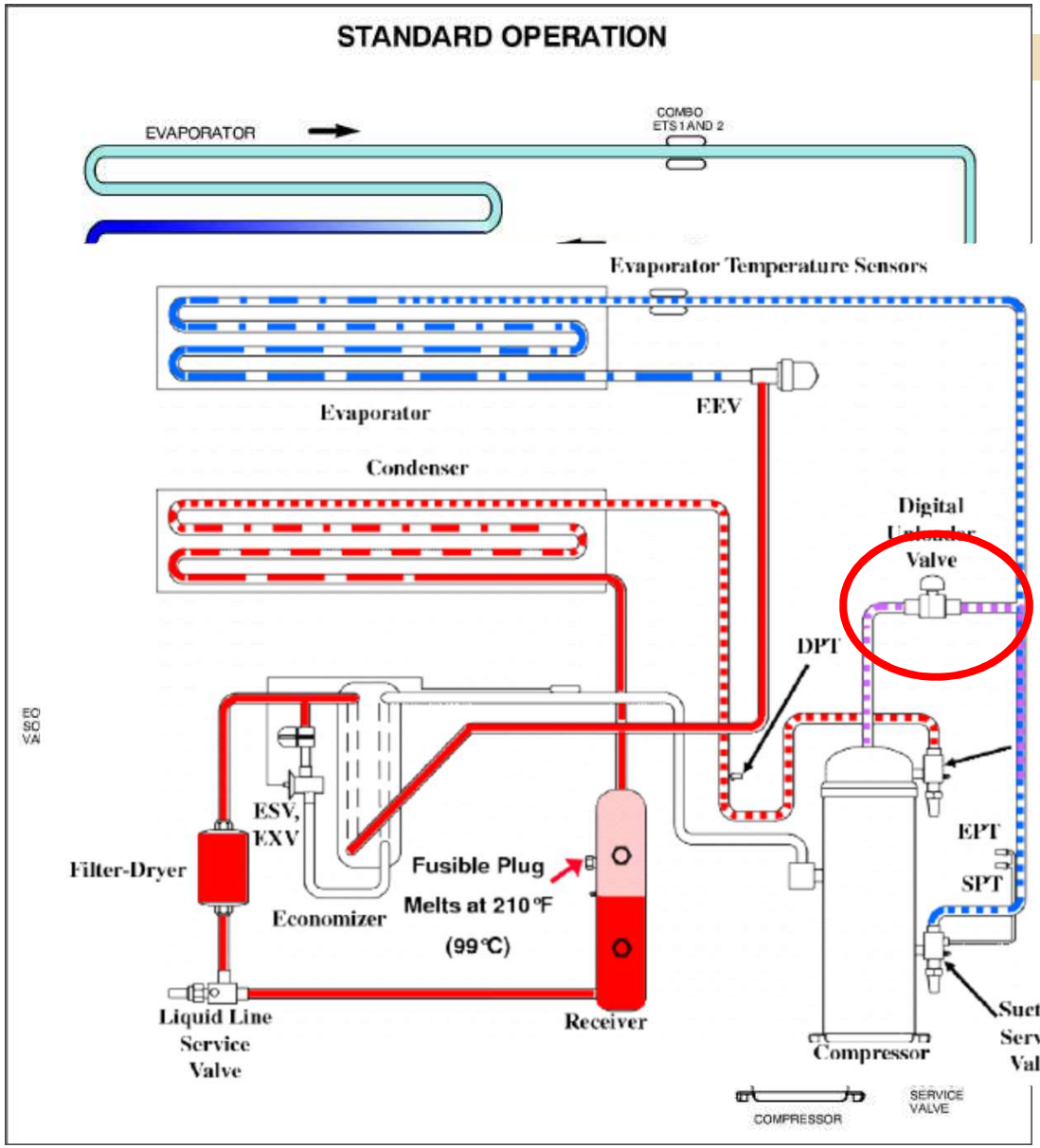
- Acting on the compressor or its driving electric motor
  - scroll compressor – Thermoking Magnum
  - Number of revolutions of the electric motor (inverter) – Denso, Star Cool
- Acting on the system
  - by-pass of the system – essentially it's a constant pressure valve (suction) – Carrier Primeline
  - Two opposite acting valves (DLV&DUV) – Carrier Primeline
  - Suction choking (SMV) – Carrier Thinline, Daikin

Carrier Thinline



DURING LOW LOAD PERIODS SMV (SUCTION MODULATING VALVE) CHOKES THE SUCTION REDUCING THE REFRIGERANTS FLOW TO THE COMPRESSOR IN ACCORDANCE TO THE DEMANDED COOLING EFFECT, BUT THERE IS A DANGER OF ELECTRIC MOTOR AND COMPRESSOR OVERHEATING DURING THAT KIND OF OPERATION. WORKING FLUID IN CASE OF HERMETIC AND SEMI HERMETIC COMPRESSORS ALSO COOLS THE ELECTRIC MOTOR AND THE COMPRESSOR. SYSTEMS ARE EQUIPED WITH QUENCH VALVES (ALSO TEV), WHICH ACCORDING TO THE SUCTION PIPE TEMPERATURE RELEASES COOL VAPOR IN THE COMPRESSOR'S SUCTION PIPE.

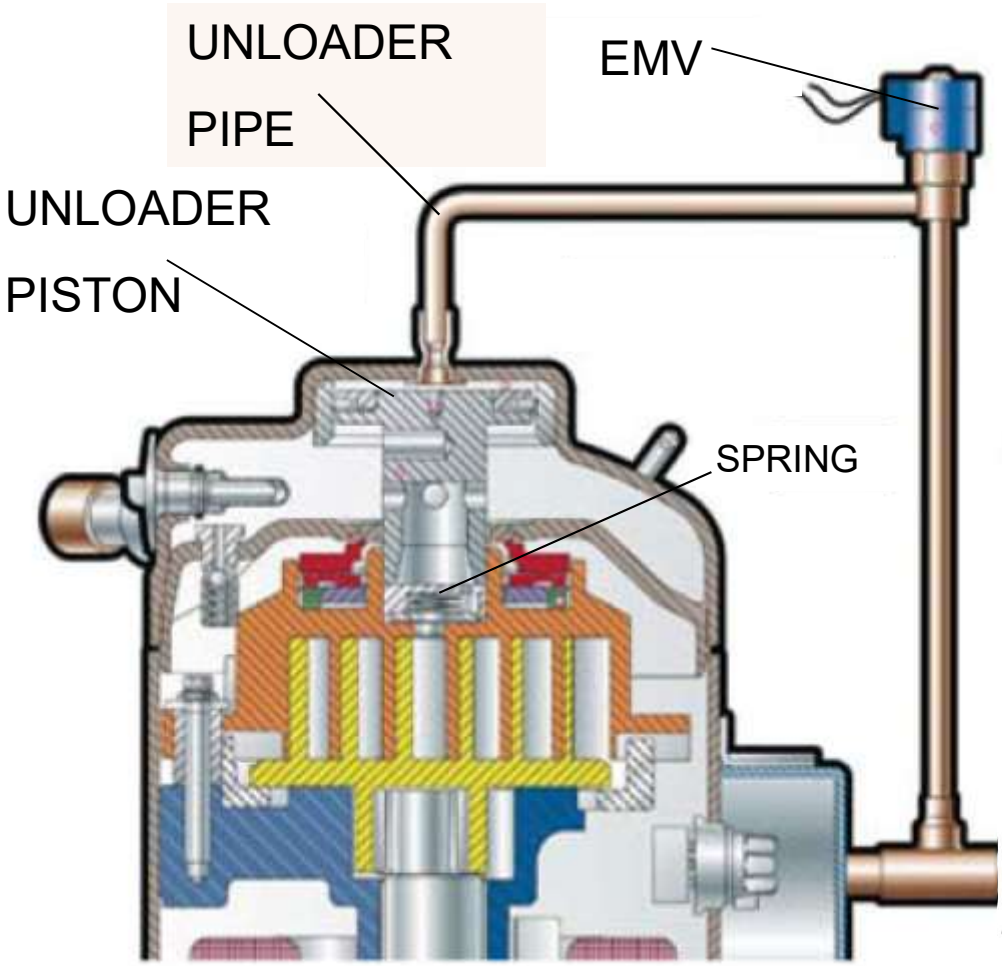
Carrier Primeline

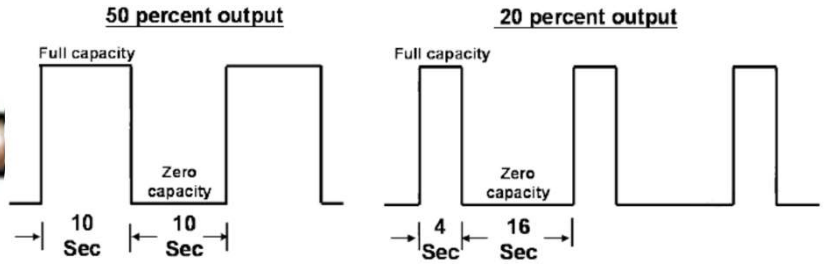


IN SUCH TYPES REGULATING VALVE RELEASES THE REFRIGERANT FROM DISCHARGE TO THE SUCTION SIDE OF THE COMPRESSOR, SO THERE IS ALSO A DANGER OF OVERHEATING. CASING (ELECTRIC MOTOR AND COMPRESSOR) IS COOLED WITH SEPARATE TEV.

Thermoking Magnum

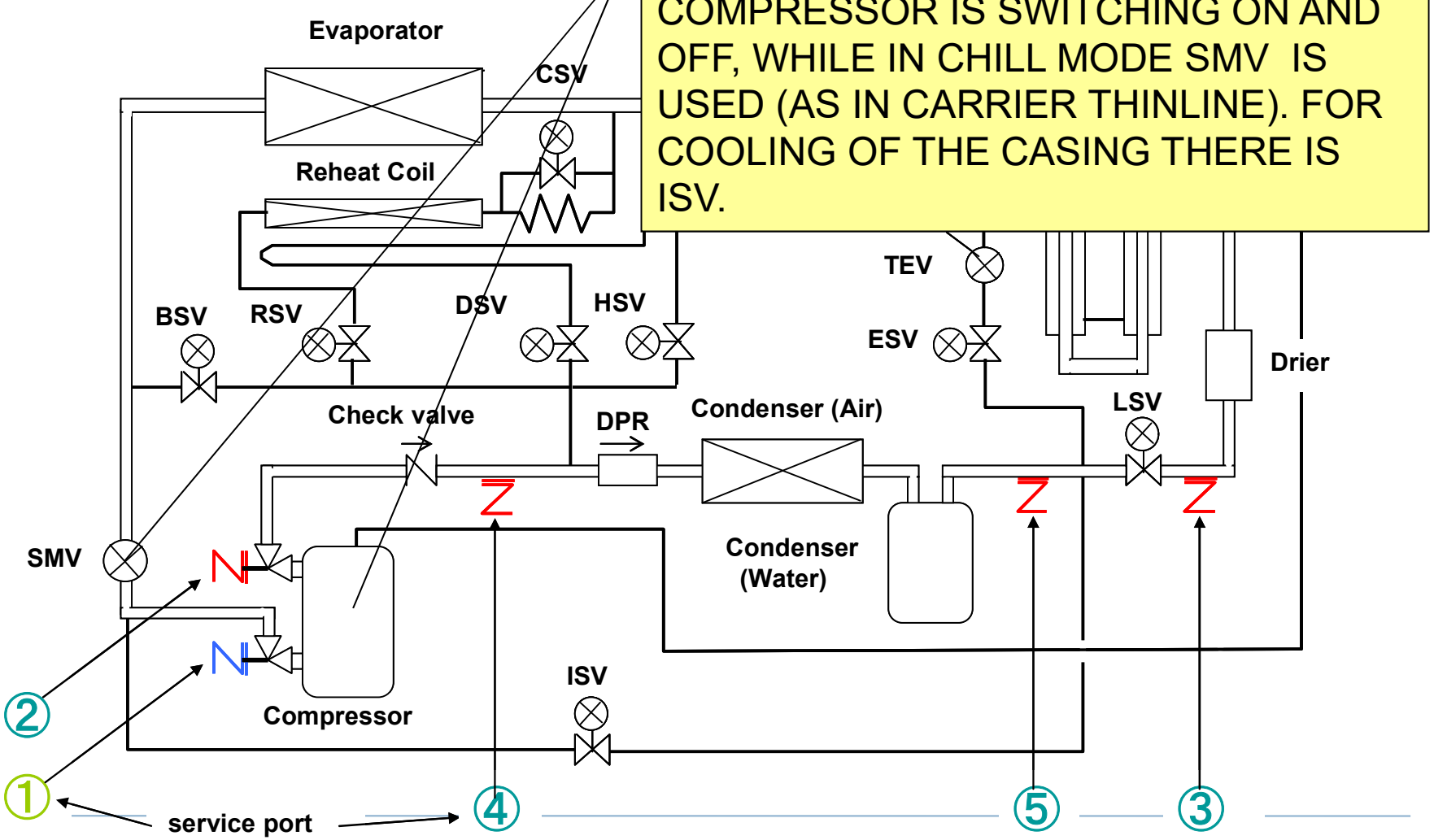
SOLENOID VALVE HAS A DIFFERENT ROLE: WHEN CLOSED CHAMBER ABOVE UNLOADER PISTON HAS THE SAME PRESSURE AS IN THE DISCHARGE CHAMBER, BUT WHEN OPENED PRESSURE ABOVE UNLOADER PISTON IS REDUCED AND SPRING LIFTS UNLOADER PISTON REDUCING THE COMPRESSOR'S DISCHARGE TO ZERO.





Daikin

IN THE FROZEN MODE THE COMPRESSOR IS SWITCHING ON AND OFF, WHILE IN CHILL MODE SMV IS USED (AS IN CARRIER THINLINE). FOR COOLING OF THE CASING THERE IS ISV.

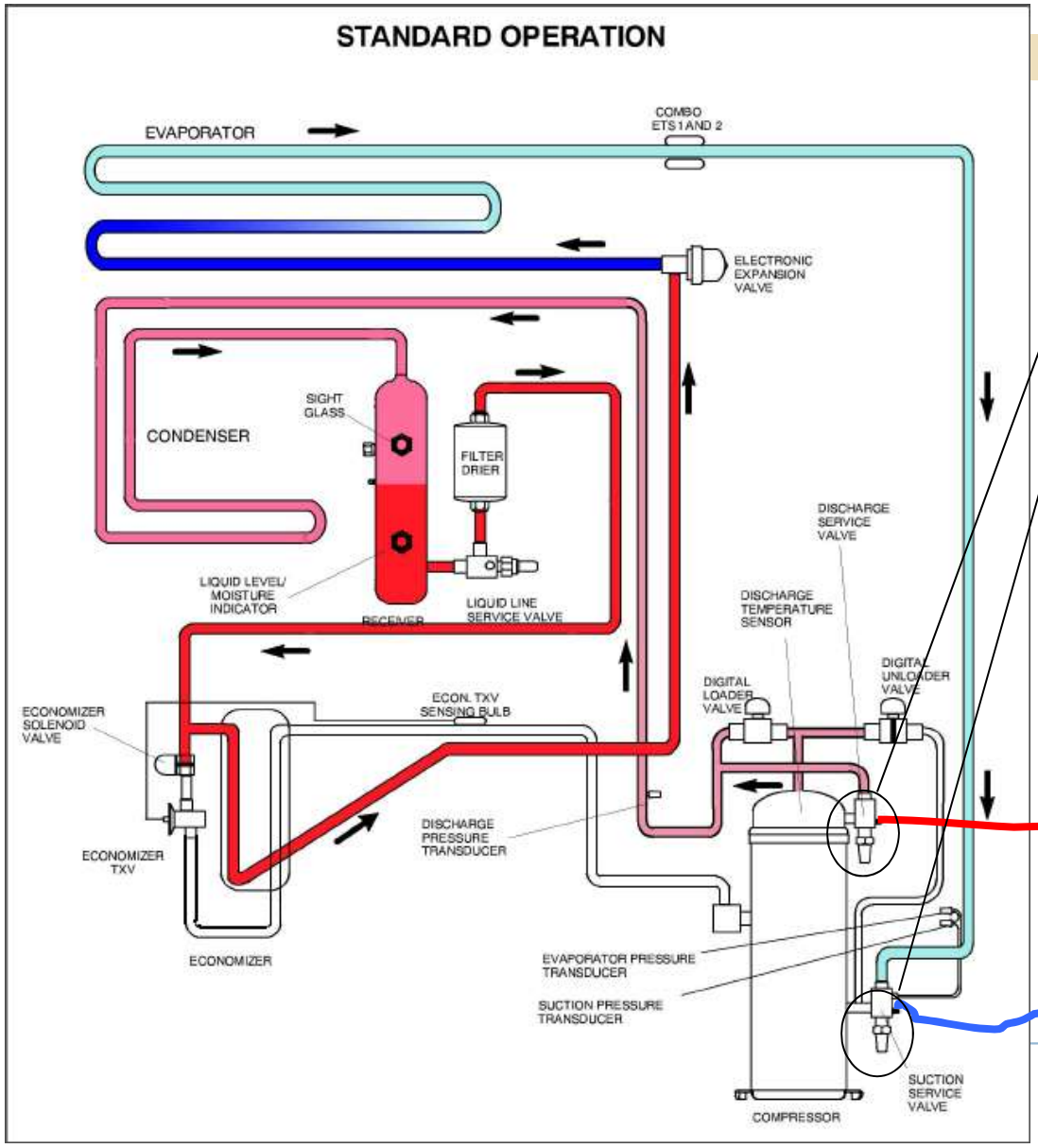


2.7. Operation management and basic diagnostics

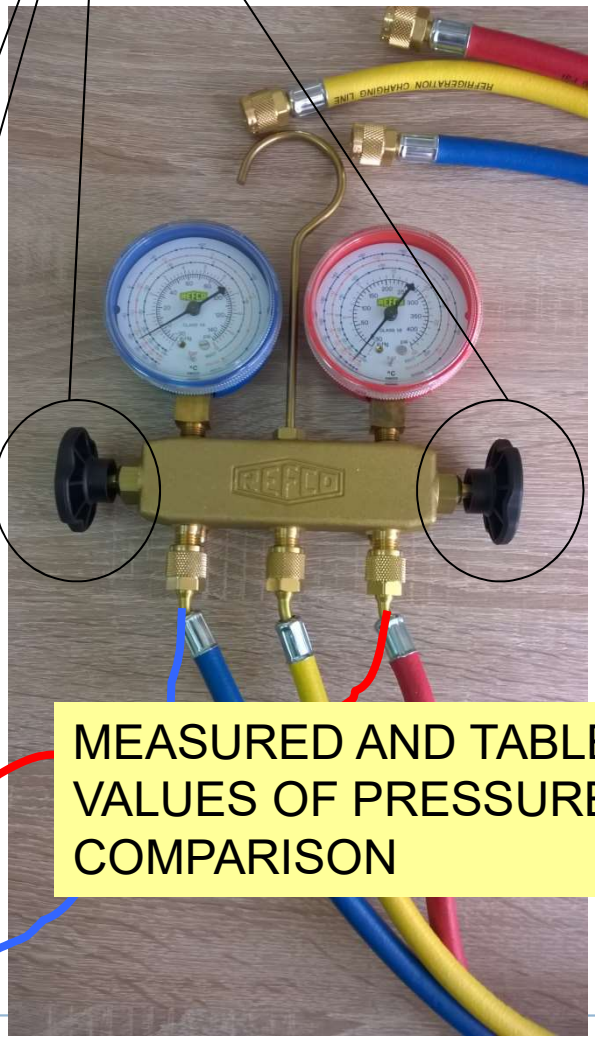
Built in armature or service equipment

- Compressor suction and discharge pressures measuring
- Measuring of temperatures of the container etc.
- Level indicators (on the condenser and compressor casing, **on the receiver**), flow and moisture indicator on the pipe after the filter-dryer
- Electrical (compressor power)

Manometers attachment

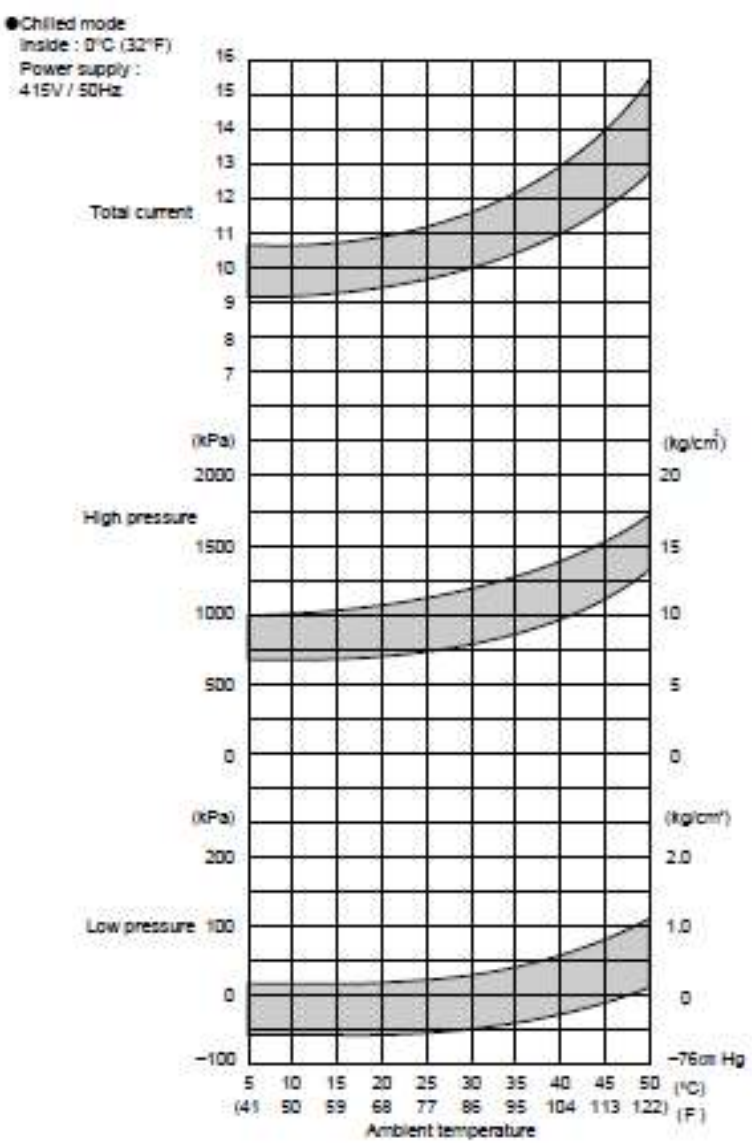


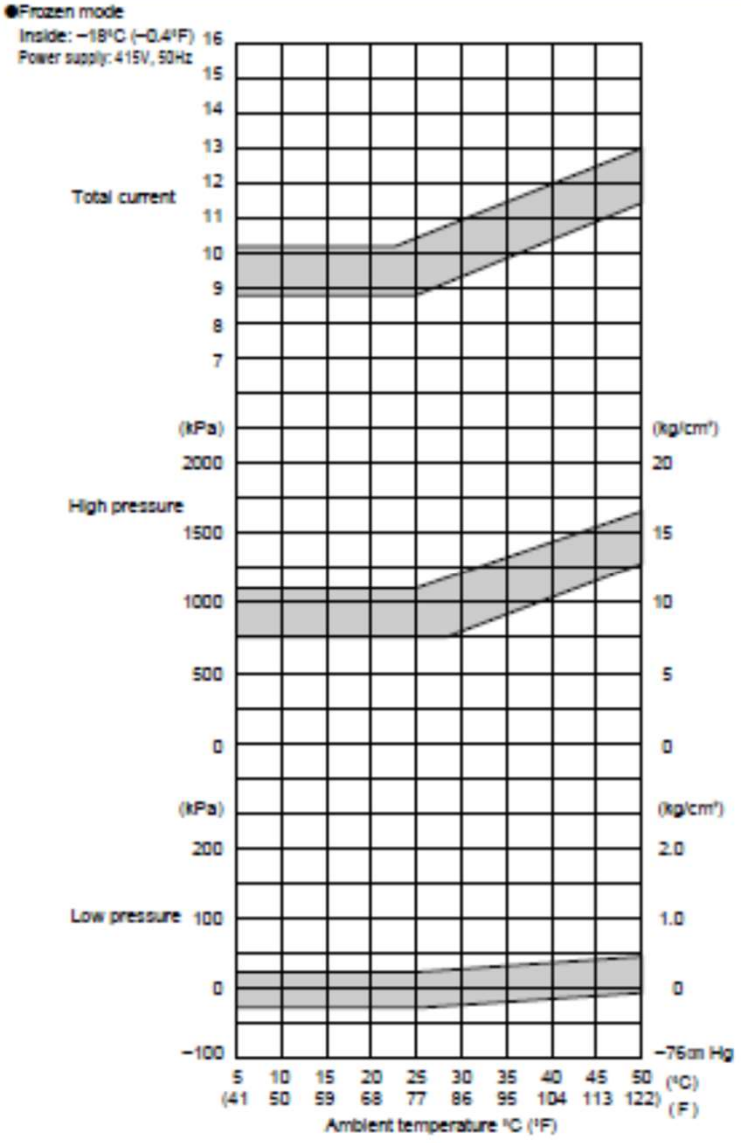
OP./CLO. VALVES



MEASURED AND TABLE VALUES OF PRESSURE COMPARISON

Normal pressure values dependence on outside temperature





Pressure dependence with faults

- Both have higher values
  - Overfilling of the system, high thermal load, filthy condenser, condenser's ventilator fault
- Both have lower values
  - Under filling of the system, small thermal load, ice on the evaporator
- Suction is higher, and discharge is lower
  - Compressor fault, TEV fault or system reads out higher temperature on the evaporator exit
- Suction is lower, and discharge is higher
  - Choking (?) in the system

Other

- Sight glass (in the piping or on the receiver)
- It could show under filling of the system
  - Necessary to find points of leakage
  - Refilling of the system
- It could show filter-dryer saturation with moisture
  - Filter-dryer replacement (or it's agent)
  - Probable icing on the TEV

What is the reason of system having low cooling capacity?

- Temperature switch – cargo temperatures set to high
- Compressor failure
- Evaporator
  - Frosted
  - Ventilator failure
- Shortage of refrigerant
- TEV or EEV
  - Opened to much or closed
  - Sensing bulb detached or system reads out higher temperature on the evaporator exit
  - blocked, frosted inside
  - Capillary fault – or the sensing bulb
  - Under sized or oversized EV

2.8. Filling and evacuation of the equipment

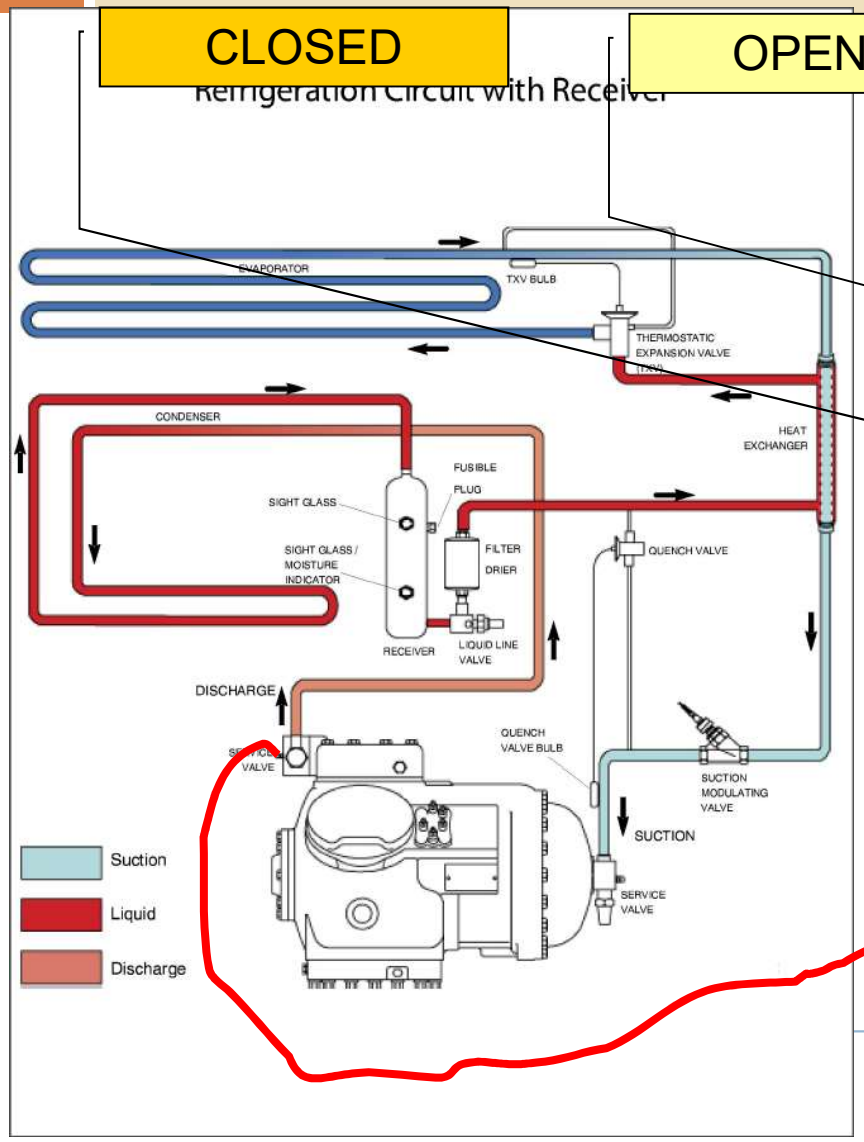
Evacuation

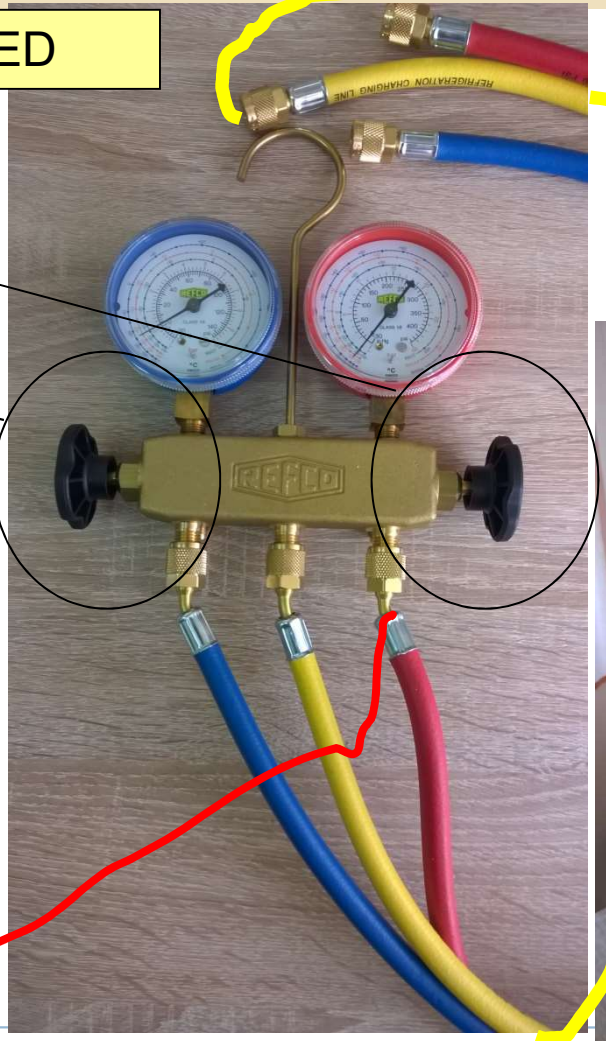
- Separate receivers
- Using vacuum pump, recovery units or compressor itself, using the pressure in the system partially
- desirable: put the receiver in a bucket of cold water (0˚C)
- To speed up the procedure and to measure the quantity of the refrigerant in the system some manufacturers use procedure of ‘complete evacuation and refilling of the system (pump down)

Evacuation of Carrier Thinline – with the compressor

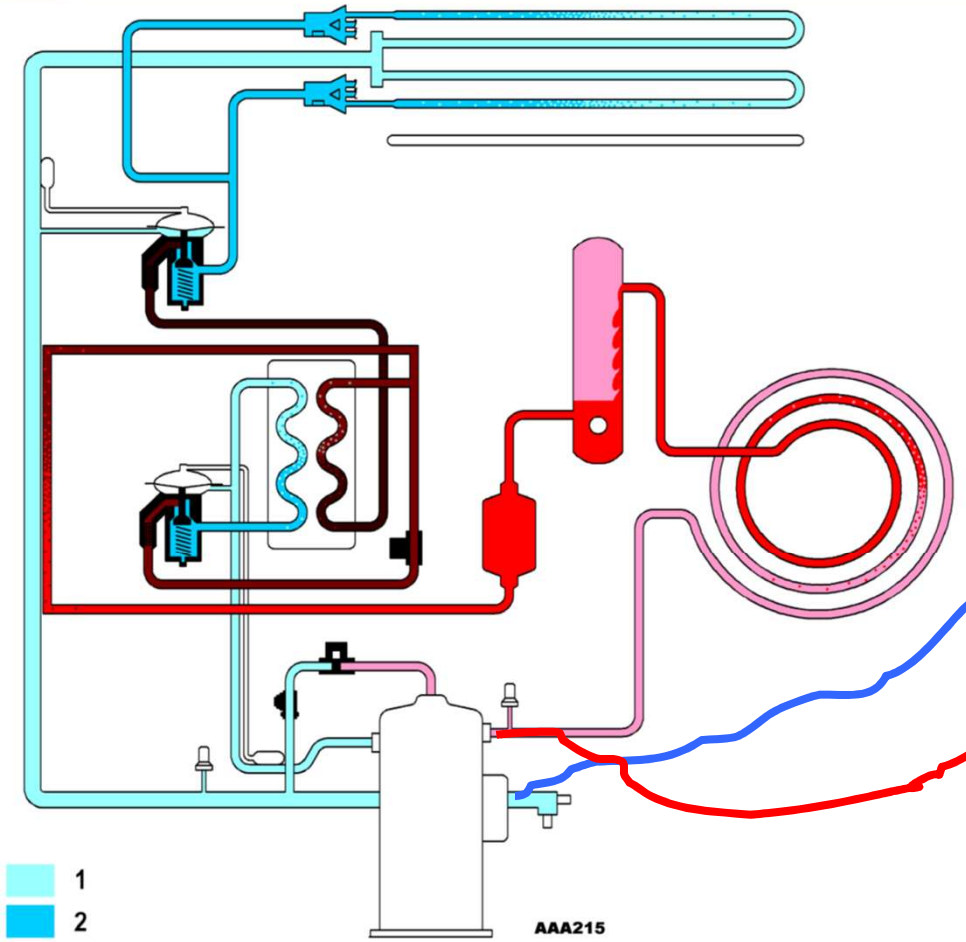
CLOSED

OPENED

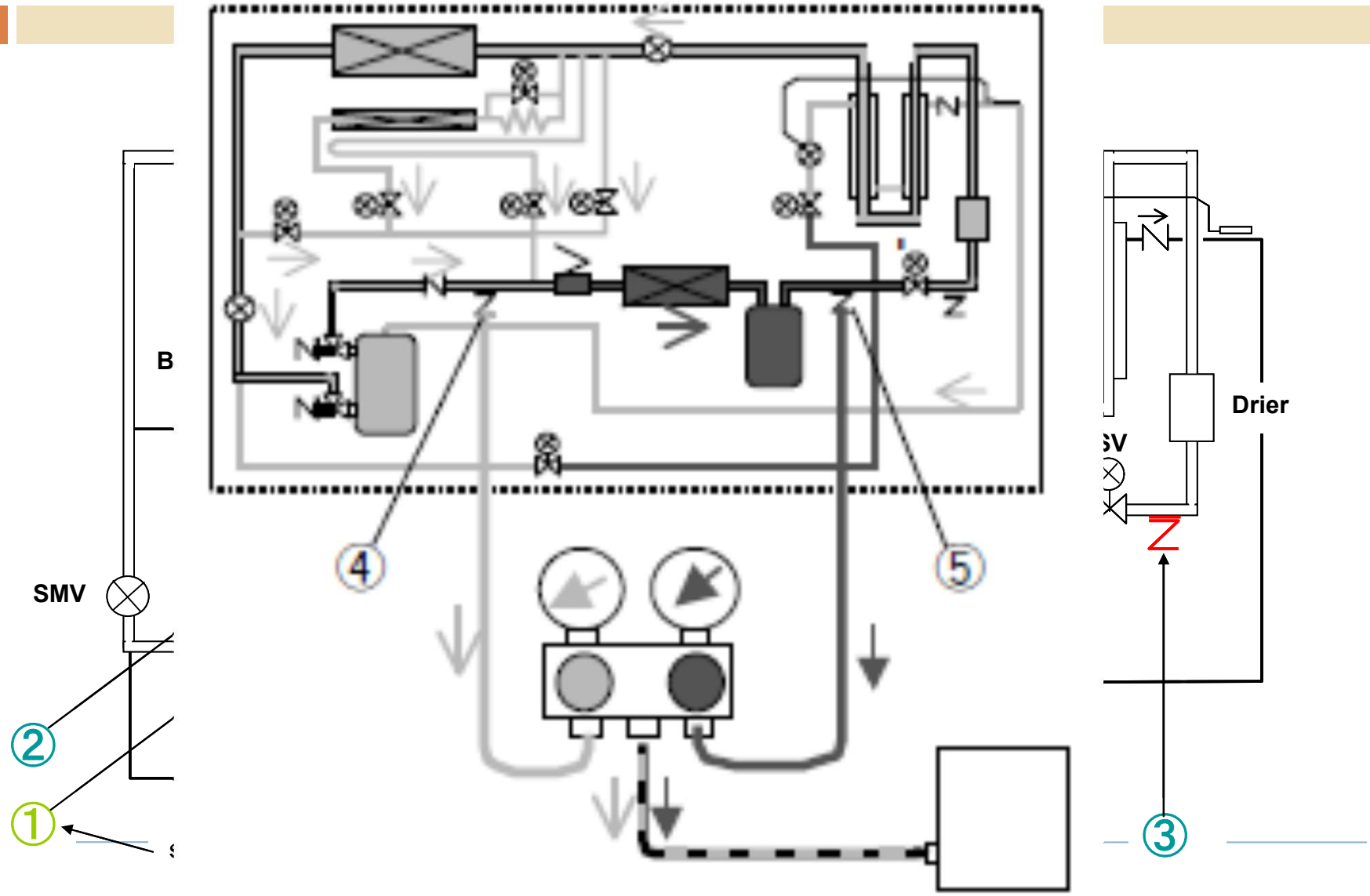




Evacuation with vacuum pump



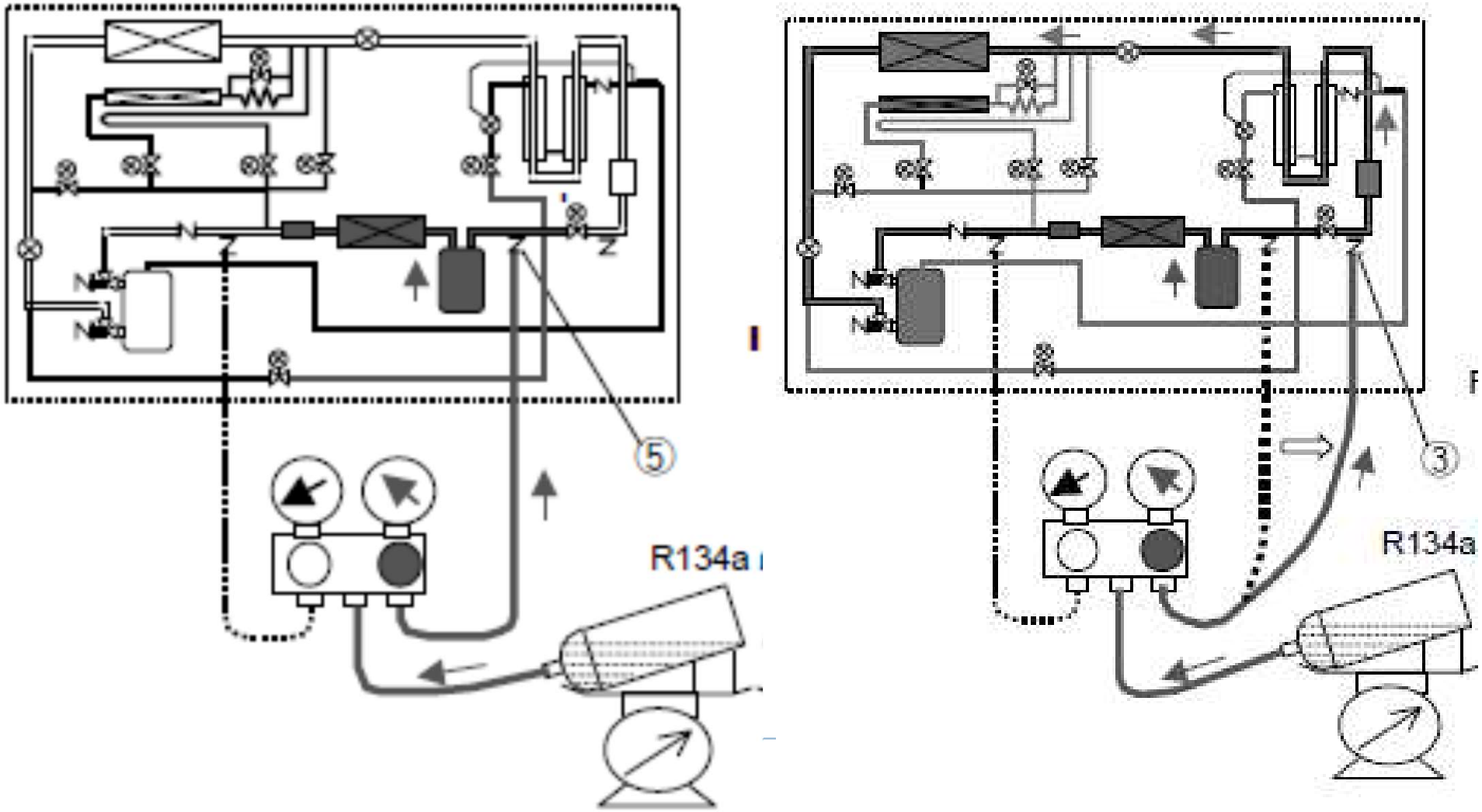
Evacuation - Daikin



Filling and refilling

- filling: liquid and gaseous phase
- Filling with the liquid phase is faster because of its higher density
- Open and semi hermetic compressors have service valves on both sides – **filling with gaseous phase only!**
- Ports for filling (and evacuation)
- Separate receivers (bigger ones have two service valves: for gas and for liquid)

Filling of Daikin system in two steps



Receivers

- Carry the mark of the refrigerant (Rxx)
- Have colors according with the refrigerant
- Measuring scale should be used durin operations of filling

- IMPORTANT: filling of the system through the compressor's suction service valve could result in serious damage of the compressor
- You could speed up the procedure by **short time** turning the receiver upside down and filling with liquid phase (but not more than few seconds)

Lubricating oil

- Caps for drainage and refilling
- Old oil replacement, refilling
- Some compressors could have oil service valves, if not you could use suction service valve of the compressor
- If compressor is equipped with the oil cap, before its removal there should be an atmospheric pressure in the compressor*

* Actually the pressure should be slightly above atmospheric

Other

- Pressurization (with nitrogen)
- Vacuuming and drying
- Some system elements replacement

THANK YOU!