Total height of tank:

\[ H_t = 2h + H \]

In which:

- \( H_t \): Total height of Tank (m).
- \( h \): Total height from body to top of cap (m).
- \( L \): The height of body Tank (m).

\[ H_t = 2h + H = 2 \times 0.28 + 7 = 7.56 \, [m] \]

2. Calculation coolant system have temperature -5\(^\circ\)C

2.1 Calculation Temperature

We design cooling system at Ho Chi Minh City, so we choose temperature, humidity at location to calculation.

<table>
<thead>
<tr>
<th>Location</th>
<th>Temperature</th>
<th>Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average year</td>
<td>Wet bulb</td>
</tr>
<tr>
<td>TP.HCM</td>
<td>27(^\circ)C</td>
<td>28(^\circ)C</td>
</tr>
</tbody>
</table>

- Wet bulb temperature:

\[ t_{wb} = 28\(^\circ\)C \]

2.1.1 Condensing temperature

In the condenser, Heat dissipation is mainly due to water evaporation, so the water temperature in the condenser is always constant \( t_w = const \).

The water temperature in condenser is equal to wet bulb temperature plus \((3 \div 5)\(^\circ\)C\):

\[ t_w = t_{wb} + (3 \div 5)\(^\circ\)C \]

In which:

- \( t_{wb} \): Wet bulb temperature \((28\(^\circ\)C)\)
- \( t_w \): Water temperature out of the condenser \((\circ)^\)C

\[ t_w = t_{wb} + (3 \div 5)\(^\circ\)C = 28 + 4 = 32\(^\circ\)C \]

- We take condensing temperature is greater than water temperature out of the condenser\((3 \div 5)\(^\circ\)C\)
\[ t_k = t_w + (3 \div 5)^\circ C \]

In which:
\( t_w \): Water temperature out of the condenser \((32^\circ C)\)
\( t_k \): Condensing Temperature is \((^\circ C)\)

\[ t_k = t_w + (3 \div 5)^\circ C = 32 + 3 = 35^\circ C \]
\[ p_k = 13.504 \ [bar] \]

2.1.2 Evaporative temperature for cooling system
- We choose direct cooling evaporator .
- We choose design temperature \(-5^\circ C\) , with evaporator we choose range temperature \((3 \div 15) \ ^\circ C\) :

We choose \( \Delta t = 3^\circ C \).

\[ t_e = t_r - (3 \div 15)^\circ C \]

In which:
\( t_r \): Design temperature \((-5^\circ C)\)
\( t_e \): evaporative temperature \((^\circ C)\)

\[ t_e = t_r - (3 \div 15)^\circ C = -5 - 3 = -8^\circ C \]
\[ \rightarrow p_e = 3.152 \ [bar] \]

We choose \( \Delta t = 5^\circ C \).

\[ t_e = t_r - (3 \div 15)^\circ C \]

In which:
\( t_r \): Design temperature \((-5^\circ C)\)
\( t_e \): Evaporative temperature \((^\circ C)\)

\[ t_e = t_r - (3 \div 15)^\circ C = -5 - 5 = -10^\circ C \]
\[ \rightarrow p_e = 2.9075 \ [bar] \]

2.1.3 Subcooling :
- The temperature of the refrigerant after TBNT, to condense completely we range of subcooling is : \( \Delta t = 2^\circ C \)

\[ t_{ql} = 33^\circ C \]
2.1.4 Superheat

- Superheat is the temperature of refrigerants at suction head of compressor, range of superheat help vapor go into compressor is full vapor, avoid liquid go into the compressor cause broken

- we choose \( \Delta t_{qn} = 5^\circ C \).

- Superheat when we choose evaporative temperature is\(-8^\circ C:\)

\[
t_{qn} = t_e + \Delta t_{qn}
\]

\( t_{qn} \): Superheat\( (^\circ C)\)

\( t_e \): Evaporative temperature\((-8^\circ C)\)

\( \Delta t_{qn} \): Range of superheat\( (5^\circ C)\)

\[
t_{qn} = t_e + \Delta t_{qn} = -8 + 5 = -3^\circ C
\]

- Superheat when we choose evaporative temperature is \(-10^\circ C:\)

\[
t_{qn} = t_e + \Delta t_{qn}
\]

\( t_{qn} \): Superheat\( (^\circ C)\)

\( t_e \): Evaporative temperature\((-10^\circ C)\)

\( \Delta t_{qn} \): Range superheat\( (5^\circ C)\)

\[
t_{qn} = t_e + \Delta t_{qn} = -10 + 5 = -5^\circ C
\]

\( \Rightarrow \) Parameters for cooling system:

+ Evaporative temperature: \( t_e = -8^\circ C \rightarrow p_e = 3.152 \) [bar]

+ Evaporative temperature: \( t_e = -10^\circ C \rightarrow p_e = 2.9075 \) [bar]

+ Condensing Temperature: \( t_k = 35^\circ C \rightarrow p_k = 13.504 \) [bar]

+ Superheat : \( t_{qn} = -3^\circ C \)

+ Subcooling : \( t_{ql} = 33^\circ C \)

2.2 Pressure Ratio

Pressure ratio at \(-8^\circ C\) is:

\[
\Pi = \frac{p_k}{p_e} = \frac{13.504}{3.152} = 4.284 < 9
\]

Pressure ratio at \(-10^\circ C\) is:

\[
\Pi = \frac{p_k}{p_e} = \frac{13.504}{2.9075} = 4.64454 < 9
\]
Concluding: We choose one stage refrigeration cycle for cooling system

2.3 Calculation choose Evaporator

2.3.1 Introduce about Evaporator

The evaponsible for liquefying the moisture gas after the throttle and simultaneously cooling the refrigerated medium. As such with condensers, compressors and throttling devices, evaporators are one of the most important equipment indispensable in refrigeration systems especially cold storage. The working process of the evaporator affects the time and the cooling effect. So, no matter how good the whole system is, the evaporator works poorly, so it’s all worthless.

Evaporators used in refrigeration systems are very diverse. Depending on the purpose of different uses should choose the appropriate type of staging. There are many ways to classify evaporators.

– The environment needs to be cooled:

Evaporation vessels are used to cool liquids such as water, salt water, glycol...
+ Indoor air coolers, used for air cooling.
+ Indoor coolers can be used to cool air, liquids or solid products. For example, the shakes in the freezer are exposed, the drum is made of ice in the freezer...
+ Fluid cooler: Fishbone fish cooler, panen in cold stone block plants.
– According to the level of fluid contained in the indoor unit.
Indoor unit is liquid or not liquid. In addition, they are classified according to the open-air nature of the refrigeration medium.

2.3.2. Evaporator cooling liquid

2.3.2.1 Evaporator vessel

a. Structure and operating principle

The liquid cooling evaporation flask has a structure similar to a horizontal condenser condenser. Can liquid evaporate the liquid into 02 types:

- NH3 evaporator system: The basic characteristic of this evaporator is the evaporative coolant outside the heat exchanger, ie the space between the tubes, the liquid to be cooled inside the tubes heat exchangers.

- Freon evaporator: Frêôn evaporator in contrast to refrigerant can boil inside or outside. Heat exchanger, liquid to be cooled, movement inside or outside the heat exchanger.
b. Evaporator vessel NH₃

Figure 7-1. Shows the NH₃ evaporation tank. The use of heat exchangers is smooth steel pressure C₂₀ of Ø38x3, Ø51x3.5 or Ø57x3.5. The beams were spaced steadily and spaced at the right triangular tip, with relatively long densities to reduce the size of the tank, while reducing the volume of NH₃.

Body and lid made of steel CT3. In order to have a nice shape, the ratio between the length and the diameter should be maintained in L/D=5÷8. The floor is usually made of carbon steel or alloy steel and has a fairly large length of 20÷30mm. The tube is firmly attached to the floor or soldered. The minimum clearance between the outer and inner tubes of the body is 15÷20mm. The bottom of the bottle may have a navel to recover the oil, from which the oil is returned to the oil recovery tank. The substance is released from the bottom after the heat exchanger is vaporized from the separator mounted above the evaporator. For large, liquid tanks are inserted into the manifold and inserted into a number of branch pipes into the tank, evenly distributed in length. The vapors are also output from multiple tubes distributed evenly in space. The evaporator is equipped with a float valve to control the level of liquid to avoid moisture absorption on the compressor. The service valve closes when the fluid level exceeds the permissible level. In case of want to control the lower level can use the second float valve to open the valve from the fluid level when the fluid level is too low.

The flasks also have flow dividers to allow the refrigerant to move several times in the tank, increase its cooling time and speed of movement to improve heat exchange efficiency.

1- nắp bình; 2- Thân bình; 3- Tách lòng; 4- ống NH₃ ra; 5- Tâm chăn lòng; 6- ống TĐN; 7- ống lòng ra; 8- ống lòng vào; 9- Chân bình; 10- Rốn bình; 11- ống nối van phao

Hình 7-1: Bình bay hơi NH₃
The heat transfer coefficient in the device depends on many factors such as the heat regime, the speed of movement, the temperature and the physical nature of the liquid in the tube. For salt water coolers at velocity $v=1 \div 1.5 \text{ m/s}$, salt water cooling capacity is about $2 \div 3^\circ C$, heat transfer coefficient $k = 400 \div 520 \text{ W/m}^2\text{.K}$; heat flux density $q_{cl} = 2000 \div 4500 \text{ W/m}^2$.

The commonly used liquid is water, glycol, NaCl and CaCl$_2$. When cooling NaCl and CaCl$_2$ salts, the equipment is particularly corrosion-resistant when it leaks into the interior, so it is practically less used. In this case, it is advisable to use open-type refrigerators when they are easily damaged and replaced. For cooling water and glicol people usually use freon vapors.

The advantage of a volatile vaporizer is that the refrigerant circulates in a closed system that does not leak air into the interior, reducing corrosion.

- **Freon evaporator Vessel**

Figure 7-2 shows 2 types of evaporator type boiling liquid outside the tube. Freon volatile liquids in pipes are commonly used to heal high temperature freezing agents such as water in chilled water system.

![Diagram of Freon evaporator vessel]

- a) Mới chất sôi ngoài ống: 1) ống phân phối lỏng, 2,3- Chất tải lạnh vào, ra; 4- Van an toàn; 5- Hơi ra; 6- áp kế; 7- ống thuỷ
- b) Mới chất sôi trong ống (dảng chứa U)
- c) Tiết diện ống có cảnh trong gồm 02 lớp: lớp ngoài là đồng niken, trong là nhôm

_Hình 7-2: Bình hối freon_
When freezing occurs, it is less dangerous than water to move inside. For the boiling vial in the tube the volume of the media drops 2-3 times than the boiling tube. This is very significant for freon systems because the cost of freon is much higher than NH₃. In order to improve the efficiency of the heat exchanger for the freon flasks, especially R₁₂, the wings are made towards the medium. When the interior movement is made, the wings are made of two different layers of material, the outside is animated, the inside is aluminum.

The condenser heat transfer coefficient using R₁₂ is about 230÷350 W/m².K, the temperature difference is about 5÷8K. For R₁₂ medium the heat exchanger tube may be copper tube because its heat transfer coefficient is higher than R₁₂ from 20÷30%.
2.3.2.2 Panel Evaporator:
To make cooling coolant in open cycle. We use panel evaporator.

Hình 7-3: Panel Evaporator

1- Liquid- liquid separator; 2- Vapor Suction compressor; 3- Main vapor pipe;
4- Liquid pipe; 5- Liquid pipe; 6- Drain pipe of salt; 7- discharge of salt ; 8-
    Discharge ; 9- insulation floor; 10- discharge of oil; 11- Safe valve

The structure of the stagibf consists of two manifold located above and below,
connected between the two manifold is the pipe, heat exchanger pipe, smooth,
vertical.Fluid motion and boiling in the tubes, the liquid need refrigerated
horizontal movement through the tube. The indoor unit panel is provided
according to the type flooded, liquid thanks to binh holding the cup of liquid.
Refrigerant goes into the manifold and out the manifold on.

Rotation speed of the brine in the tank about 0,5÷0,8 m/s, heat transfer
coefficient, k=460÷580 w/m². When the temperature between the lip and the
salt water of about 5÷6K, the density of heat flow of the fly over penen quite
high about 2900÷3500 W/m².
Indoor unit panel type straight pipe has the disadvantage that ads the path of the fluid in the tube heat exchanger is quite short and thus noticeably bulky. To fix that people make seamless cold styled herringbone.

2.3.2.3 Fish bone Evaporator

Seamless cold fish bone is used very popular in the cooling system water or salt water, example ice machine system tree. About the texture, similar to the indoor unit panel, but here the heat exchanger tubers are bent, so that length of each tube increased significantly. The heat exchanger tubes attached to the donate tubes look like a giant fish bone. It is a smooth, non-impeller-shaped steel tube. The ankle is also composed of several clusters (modun), each with a one on one tube, and an under the top system and 2÷4 heat exchanger tubes connecting the pipe.

The density of electric lines of the evaporator herringbone equivalent of indoor units panel news about 2900÷3500 W/m².
2.3.2.4 Plate heat exchanger

In addition to the indoor unit is often used in on, in industry we also use the evaporator type plate to rapid cooling of liquid. For example down fast free the and glycol in industrial beer production, cold water processing in factory processing of food...

Texture seamless cold plate type completely like the condenser plates, including the plate heat exchanger flat shape has embossed wave are coupled together by sealing. The two ends of the sheet frame thickness, be sure to be kept thanks to the bracing and bolts. The motion of the fluid and coolant in the opposite direction and alternating each other. Total area of heat exchange is very large. The process of heat exchange between two fluid carried through the wall relatively thin, so the heat exchange efficiency high. The layer of download cold quite thin, so the process of heat exchange takes place quickly. Seamless cold plate NH₃ can reach $k = 2500-4500$ W/m².K when cold water. For R22 refrigerant water heat transfer coefficient reaches $k = 1500-3000$ W/m².K. Characteristics of the cold plate type is duration do cold very quickly, the volume of refrigerant necessary small.

The downside is fabricated complex should only have the famous new have the ability to make. So that when damaged, there is no material replacement or repair difficult.
2.3.3 Evaporative air coolers.

2.3.3.1 Natural convection coolers.

Seamless cold natural convection without using a fan is used to cool the air in the cold chamber. Staging can be installed in ceiling or wall pressure tube heat exchangers are tube steel smooth or the tube has outer wings. The radiator used is either straight or twisted wing.

For seamless pipe, plain used is steel pipe $\varnothing 57 \times 3.5$, step pipe from 180÷300mm. Seamless tubes have a heat transfer coefficient of about $k=7 \div 10$ W/m$^2$.K.

With respect to the form of a tube with wings of Russia is made from the heat exchanger tubes by $\varnothing 38 \times 3$, the heat dissipation wing shape stainless steel thickness 0.8÷1.0mm, the width of steel leaf is 45mm, step wings about 20÷30mm. The heat transfer coefficient by area outside with wings for wall pressure $k=3 \div 4.5$ W/m$^2$.K and seamless ceiling $k = 4 \div 5.5$ W/m$^2$.K. Disadvantages of indoor natural convection is the heat exchange efficiency is low, so practically of little use.

![Diagram](image)

1- Heat exchange pipe; 2- Cooling wings; 3- Main pipe; 4- Support

Hình 7-6: Concealed natural convектор

For Russia, they usually make many types: Pipes (7-6a), Coil oil (7-6b), Coil oil finally (7-6c) and coil type have two pipe (7-6d)
2.3.3.2. Conductive coil cooler
Conductive coil cooler are widely used in refrigeration systems To cool the air like in the cold storage, freezing equipment, in air conditioning gas etc ...

Seamless cold forced convection there are two types: copper pipe into iron pipe. Often cold rooms are made of aluminum wings or iron wings. Seamless cold shell wrapped, cage fan, pipe, diffuser, tray, water condenser. Why soy can use a variety of methods, but the most common is to use a resistor to discharge the ice.

Tube cooler NH₃ have $k = 35-43 \text{ W/m}^2\text{.K}$. For freon cooler $k = 12 \text{ W/m}^2\text{.K}$.

Evaporator used in the cold storage structure with width quite large, spanning the width of the cold storage.

Each staging has from 1-6 fan, the cooler placed in front of each staging, suction, air movement through the staging. Dàn lạnh có buóc cánh từ 3 đến 8 mm, depending the level of exit moisture of the product in stock. Shell cover of evaporator is galvanized, the bottom has trough water condenser. .The gutters tilted back to the water stop running roles, avoiding the water in the trough, standing water can freeze clogging the drainage. Staging consists of several pipe assemblies independently in parallel along the height of the staging, so often have the doll distributing station to distribute the fluid evenly to the cluster.
Hình 7-8: Evaporator in cold storage

1- Evaporator; 2- Refrigerant pipe; 3- Wire box; 4- Condensate pipe; 5- Trough condensate; 6- V steel

2.3.4 Calculation for evaporator

*Calculation cooling capacity for PHE.*

*We have coolant flow rate need to supply to cooling process is 340 m³/h,* but coolant flow rate supply to buffer tank have greater than 10% to ensure supply coolant not suspended.

Coolant flow rate supply to buffer tank:

\[ G_{Tank} = G \times 10\% = 340 \times 10\% = 374 \text{ (m}^3\text{/h)} \]

The density of Ethylene glycol solution supply for buffer tank at temperature -10 °C is: *(see index 2.1)*

<table>
<thead>
<tr>
<th>Freezing Temperature (°C)</th>
<th>-4.2</th>
<th>-10</th>
<th>-32</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \rho ) (kg/m³)</td>
<td>999</td>
<td>X</td>
<td>1016.3</td>
</tr>
</tbody>
</table>

\[ x-999 \]
\[ \frac{1016.3-999}{1016.3-999} = \frac{-10+4.2}{-32+4.2} \]

\[ X = 1002.6094 \text{ (kg/m}^3\text{)} \]

<table>
<thead>
<tr>
<th>Freezing Temperature (°C)</th>
<th>-4.2</th>
<th>-8</th>
<th>-32</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \rho ) (kg/m³)</td>
<td>999</td>
<td>X</td>
<td>1016.3</td>
</tr>
</tbody>
</table>

\[ x-999 \]
\[ \frac{1016.3-999}{1016.3-999} = \frac{-8+4.2}{-32+4.2} \]

\[ X = 1001.36475 \text{ (kg/m}^3\text{)} \]
The mass of Ethylene glycol solution supply for buffer tank at temperature -10 °C is:

\[ M = D \times G \]

In which:
- \( M \): Mass supply (kg/h)
- \( D \): Density of ethylene glycol solution at concentration 30% (1002.6094 kg/m\(^3\))
- \( G \): Water flow rate supply for buffer tank (m\(^3\)/h)

We have:

\[ M = D \times G = 1002.6094 \times 374 = 374975.9156 \text{ (kg/h)} = 104.16 \text{ (kg/s)} \]

The mass of Ethylene glycol solution supply for buffer tank at temperature -8°C is:

\[ M = D \times G \]

In which:
- \( M \): Mass supply (kg/h)
- \( D \): Density of ethylene glycol solution at concentration 30% (1001.36475 kg/m\(^3\))
- \( G \): Water flow rate supply for buffer tank (m\(^3\)/h)

We have:

\[ M = D \times G = 1001.36475 \times 374 = 374510.4165 \text{ (kg/h)} = 104.0307 \text{ (kg/s)} \]

The specific heat of Ethylene glycol solution supply to tank concentration 30% : (see index 2.2)

<table>
<thead>
<tr>
<th>Freezing Temperature (°C)</th>
<th>-4.4</th>
<th>-10</th>
<th>-17.8</th>
</tr>
</thead>
<tbody>
<tr>
<td>( C_p) (Btu/lb.°F)</td>
<td>0.89</td>
<td>X</td>
<td>1</td>
</tr>
</tbody>
</table>

\[ x \cdot \frac{0.89 - 0.89}{1 - 0.89} = \frac{-10 + 4.4}{-17.8 + 4.4} \]

\[ x = 0.93597(\text{Btu/lb.°F}) = 3.91872(\text{KJ/kg.K}) \]
Freezing Temperature (°C) | -4.4 | -8 | -17.8 |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>$C_p$ (Btu/lb.°F)</td>
<td>0.89</td>
<td>x</td>
<td>1</td>
</tr>
</tbody>
</table>

\[
x = 0.91955 \times \frac{0.89}{1 - 0.89} = \frac{-8 + 4.4}{-17.8 + 4.4}.
\]

\[
x = 0.91955 = 3.849972 \text{ (KJ/kg.K)}
\]

**Cooling Capacity of PHE at -8°C is:**

\[
Q_0 = G x C_p x \Delta t
\]

In which:

$Q_0$ : Cooling capacity (kw)

$G$ : The mass supply to buffer tank (104.0307 kg/s)

$C_p$ : The specific heat of ethylene glycol solution (4.0457 KJ/kg.K)

$\Delta t$ : The temperature goes out and goes in PHE (°K)

We have:

\[
Q_0 = 104.0307 \times 3.849972 \times (3 + 273) - (-5 + 273) = 3204.122 \text{ (kW)}.
\]

**Cooling Capacity of PHE at -10°C is:**

\[
Q_0 = G x C_p x \Delta t
\]

In which:

$Q_0$ : Cooling capacity (kw)

$G$ : The mass supply to buffer tank (104.16 kg/s)

$C_p$ : The specific heat of ethylene glycol solution (4.0457 KJ/kg.K)

$\Delta t$ : The temperature goes out and goes in PHE (°K)

We have:

\[
Q_0 = 104.16 \times 3.91872 \times (3 + 273) - (-5 + 273) = 3265.391 \text{ (kW)}.
\]
We have comparison table for Compressors to choose evaporating temperature \(10 \degree C\) và \(-8\degree C\) follow cooling capacity.

The Percentage take COP of number 1 make original to calculator others compressor.

<table>
<thead>
<tr>
<th>STT</th>
<th>Evaporating Temperature (( ^\circ C) )</th>
<th>Model</th>
<th>Cooling capacity (kw)</th>
<th>Absorbed power (kw)</th>
<th>Drive shaft speed (min-1)</th>
<th>COP</th>
<th>Percentage (% )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-8</td>
<td>N250M**-L</td>
<td>1602.9</td>
<td>381.8</td>
<td>3320</td>
<td>4.2</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>-8</td>
<td>N250M**-M</td>
<td>1607.5</td>
<td>382.4</td>
<td>3350</td>
<td>4.2</td>
<td>100</td>
</tr>
<tr>
<td>3</td>
<td>-8</td>
<td>N250M**-H</td>
<td>1604.3</td>
<td>422.3</td>
<td>3370</td>
<td>3.8</td>
<td>90.48</td>
</tr>
<tr>
<td>4</td>
<td>-10</td>
<td>N250L**-L</td>
<td>1637.7</td>
<td>421</td>
<td>3100</td>
<td>3.89</td>
<td>92.62</td>
</tr>
<tr>
<td>5</td>
<td>-10</td>
<td>N250L**-M</td>
<td>1636.7</td>
<td>413.1</td>
<td>3110</td>
<td>3.96</td>
<td>94.29</td>
</tr>
<tr>
<td>6</td>
<td>-10</td>
<td>N250L**-H</td>
<td>1634</td>
<td>447.9</td>
<td>3125</td>
<td>3.65</td>
<td>86.9</td>
</tr>
</tbody>
</table>

After we comparison, we choose evaporative temperature \(8\degree C\) because Maximum COP and lowest absorbed power.

From above conditions we choose PHE:

Cooling Capacity of PHE : \(Q_0 = 3204.122\text{ kW}\).

Type : Gravity

Temperature Parameters of ethylene glycol solution go into PHE : \(3\degree C\).

Temperature Parameters of ethylene glycol solution out of PHE : \(-5\degree C\).

Temperature Parameters \(NH_3\) go into PHE : \(-8\degree C\).

Temperature Parameters \(NH_3\) out of PHE : \(-8\degree C\).

Ethylene Glycol solution concentration 30%

**Conclusion: From** above conditions we choose PHE evaporator:

Model: TL 1100 (see index 2.3)
Flow rate : 381.238 m³/h
Pipe Connect : D250
Heat exchange volume: 318.028 (dm³)
Size PHE (HxWxL) : 2500mm x 940mm x 2600mm

2.4 Calculation about Compressor
2.4.1 Introduce about Compressor
In refrigeration equipment, the compressor is used to draw steam out of the evaporator to maintain the constant boiling pressure in the evaporator and compress the vapor to the condensing pressure in the condenser. There are main types of compressors as follows:

1- Pittong compressor
2- Roto compressor
3- Tuabin compressor
4- Screw compressor

2.4.2 Compressors
2.4.2.1 Pittong compressor
a. Compressor has horizontal slider
Compressors with horizontal slides operate on both sides Q₀ > 465 KW = 400,000 Kcal/h.

The principle of the horizontal compressor is illustrated in Figure 5.1. When the piston moves from the leftmost position to the right, the left cylinder of the cylinder slightly in the dead space extends to pressure lower than the pressure. Prepare the suction head 1 'open and slightly away into the left compartment of the cylinder. When the piston moves in reverse, the 1' closes and the vapor in the cylinder is compressed to a slightly greater pressure than the propeller pressure. The steam is pushed into the condenser through the propeller cylinder 2'. At that time in the left cylinder of the cylinder is slightly compressed, while in the right chamber the vacuum is drawn and through the suction 1. Then the compressed air and discharge out 2. This type of compressor is no longer manufactured, so in this book no longer mentioned (in the book "Air conditioner" by PGS-T If you are interested in reading this section, please contact us.

b. Compressor without slider
Non-slip piston compressors can be either direct or non-flowing. The principle of operation of the linear compressor without slider is shown in Figure 5.2. As the piston moves below the cylinder volume and the pressure decreases When the pressure in the cylinder is less than the pressure in the evaporator a little, the suction head 1 opens and the steam from the suction tube goes into the cylinder. When the piston 2 moves upward, the suction cup is closed, the steam
in the cylinder 3 is compressed and when it reaches a pressure greater than the thrust pressure, the propeller 4 opens and the vapor is pushed out.

All compressors have the following components: bloc-cacti, cylinder head, suction head and piston head, piston rods, couplings.

Cast iron, closed, top with a cooling jacket. The front and rear holes for crankshaft and oil pump are covered. The side door has a lid to assemble the head under the bar and counterbalance. Bloc-cacte cast iron GX18-36, GX21-40 and GX22-44. Cast iron cylinder. In the top and bottom of the shirt there are two grooves on the outer surface to place the rubber inserts. Insertion on the compartment of the suction and discharge chambers, insertion rings under the suction chamber and cacti. Leave the ventilated compartment with four compartments

Pittong

In non-slip reciprocating compressors, guided piston type 1 has a highly developed lateral surface. Xupap 2 is located at the top of the piston. The intake manifold is separated from the cactus by three spherical membranes in the pittoong. In order to reduce the weight of the piston, the piston is made hollow with the lateral surface hollow, which also reduces the friction. In addition to the insertion rings 4 on the guide piston, there is an oil drainage ring 5 to remove excess oil from the cacti and into the cylinder, which lies on the bottom of the piston so that when it reaches the point of death below the fifth ring enters the cactus cavity, the ring 5 is still about the height of the ring at the bottom of the door. Without an oil drainage ring or incorrectly fitted ring, the oil will leave the cylinder to increase oil consumption, seal the oil on the pumps and pipes, and may contaminate the heat transfer surfaces.

Oil ring (H5.6) has 12 grooves on the outside. Oil concentrates between the walls and the cylinder surface compresses the oil drain and groove and flows into the piston. On the groove of the piston there are holes for the oil to flow. In the groove of the oil ring there are also such holes for evacuation. Pittong made of cast iron or aluminum alloy

Transmission rods

In the compressor there is no sliding rod used to convert the circular motion of the shaft into the piston's moving motion. Pittong connects directly to the piston rod 6 (H5.5)

The piston rod is hollow and can be swayed, not stationary at all, so it can rotate freely in the piston and at the top of the bar. The shaft held in the top of the piston is not moved in the axial direction by spring 7
Steel bars are I-shaped. The top of the coupler is made of staggered brass (where copper bushings are fitted). The lower end of the detachable bar has two silver bundles and adjustable cushions. The connecting rod is tightly secured to the connecting rod by means of two screws with snail nuts

**Crankshaft**

Made of steel pedal with two elbows at an angle of 180 ° and a cast iron counterbalance. The crankshaft is located on two spindle bearings. Drive shaft located in the bloc-cactus groove. Drive shaft of two ball bearing type

**Insert**

In the no-slip compressor, the shaft is inserted in the position out of the cactus. In modern compressors, spring inserts with friction inserts (H5.7) are used. It consists of moving parts and standing still. The moving parts are steel inserts 1 with elastic rings made of gasoline-resistant rubber 2, springs 3 in the fourth round. The stationary part consists of intermediate cap 5, outer cap 6. In cap 6 The cast iron rings 7 are still standing with graphite pads. 8. Graphite pad made of special graphite. The C20 series is made of 20Cr alloy steel. Between the lids and the shaft there is a gap. Springs on ring 1 on buffer 8, forming tightness. Lubricate the lead through the top hole of the cap and return to the cactus in the groove in the shaft. Insert 9 prevents oil flowing out. Lid 10 lid 9. Oil leakage is controlled by tube 11

In the compressors on the streamers, we use the type of lid and towel bar. Push the handle of the spring towel (H5.8a). Sprinkler with spring (H5.8c) or no springs. No spring inertia force

Bar type (H.5.8c) is used a lot. The lids are replaced with a lid and closed by the elastic force of the lid and pressure of the steam. C40 and C45 carbon steel or cast iron GX24-44. Bracket made of cold drawn spring steel or tool steel

In NH3 compressors and occasionally in freon compressors, the propulsion head is not attached to the cylinder but only to the cylinder wall due to the damping spring forming the dummy cap which prevents the hydraulic impact on the compressor when the fluid is dropped into the cylinder. The cross section of the propeller heads is calculated at the high speed of the steam. They do not allow the liquid to pass through, so when the liquid falls into the cylinder, the pressure increases, causing the damping spring to be compressed, the loupe elevated and the coolant not passing through the propeller that will pass through. Between the lid and the cylinder wall to go into the push
Safety valve

In non-slip compressors, self-acting spring-loaded safety valves are used. The ball safety valve (H5.9a) consists of: base 1, body 2, spring 3 and ball 4. These valves do not usually guarantee full sealing between the exposed metal surfaces of the ball and soles. Recently used shielding valves (H5.9b) that can be sealed with rubber rings. Valve shield consists of: base 1, body 2, spring 3, shield 4 with oil-filled rubber ring 5. Springs are calculated with the maximum pressure difference. Safety valve open to release from the head pushed on the suction head in case of trouble. The rubber seal ensures the valve is safe when the compressor is working normally.

Lubricating oil system

In the lubricant system, the compressor is equipped with a gear pump 1 soaked in oil. The oil pump is located in the cactus of the compressor and is driven by a closed end of the crankshaft with transmission 2 and a vertical shaft or cylindrical gear. On the suction nozzle of the coarse filter 3 set the bottom of the cactus about 10 ÷ 15mm. At the refill, there is a clear filter of slot 4. The oil filters have spring valves off, which will open in the case of dirty filter increases the oil pressure suddenly. The design of the slot filter allows the cleaner to be cleaned while the compressor is still in use. From the oil pipe in the spindle bearings, the oil is first inserted, followed by the straight grooves to the drive shafts, and then along the conveyor rods by means of holes or ducts in the connecting rod, the oil reaches the piston rod. The oil pressure is measured by an oil pressure gauge after the oil pump and the oil filter. The pressure gauge is only 0.59 ÷ 1.18 bar (0.6 ÷ 1.2 Kg / cm2) between the oil and the vapor. When the pressure difference decreases, the compressor will stop working due to the pressure relays 5.

On the pump head, the exhaust valve 6 can automatically discharge a portion of the oil in the cactus. in the back wall of the bloc-cactus valve 7 to adjust the oil pressure. The temperature of the oil in the cactus may be about 30 to 40oC above the ambient temperature. In large compressors, the oil is cooled by running water in coil sprinklers in cactus oil or outside cooling cylinders. Lubricating oil is used in air conditioners.

c. Non-slip compressor without slider

The operating principle of the compressor without the slider is shown in Figure 5.11. In the airless compressors the suction head 1 and the propeller 2 are individually mounted on the surface 3. The third side is also the top cover of the cylinder. As the piston moves downward in the four-pressure cylinder, it releases the suction head open and starts the aspiration process into the cylinder. When the piston 5 moves upward the compressed air is pushed out through the propeller.
In Figure 5.12, the longitudinal section and the horizontal section of the eight-cylinder W-block air compressor are a uniform cast iron block inside which the cylinders are placed. 2. In the suction chamber of the block -caps with 3 suction cups and steam filters. In the pushing cavity with the locking push button. 4. Crankshaft 5 has two elbows and counterbalance, by punching method. The 6-piece steel ingot is of the I-section type, the head is not removable, and the lower end has silver-plated steel, bobby white. The seven suction cups of a towel cover are located at the top of the cylinder door. The eight pushers are mounted in a separate position and form the top cover of the cylinder (H5.13). Cast iron 9 has two compression rings and an oil ring. Cup 10 can be self-stabilizing with eight springs in the distance. Inserts oil by means of graphite rings. In the compressor using a mixed lubrication system: use a gear oil pump 11 to lubricate the shaft of the shaft and use sprinkler to lubricate the cylinder, piston rod and spindle.

Oil passes through the insert to the crankshaft. On the suction head of the pump there is a screen 12 and on the nozzle a slot filter 13. The compressor has a capacity regulator 14 by loosening the suction cups of each individual cylinder. This regulator is also used to unload the compressor on startup. In addition, the cooling capacity can be adjusted by the use of multiple-speed electric motors to change the number of revolutions of the shaft.

The self-stabilizing inserts are shown in Figure 5.14. Loop graphite 3 spring 2 pressed firmly into the ring 1 stand. Round 3 firmly attached to the shirt. 4 When votive shirt with 3 turns rotation will create friction between the shaft and ring 5 of oil and freon rubber. For the fifth ring tight on the jacket. 4. The rubber ring also inserts the shaft from the oil chamber 6 out. Oil enters from the bottom hole of the cap and exits through the upper hole so the always flooded oil seal is completely sealed.

The low-freon type compressor with the fully enclosed electric motor is the most modern type. Compressed air compressors with open type have the following advantages:

1. Work reliably because there is no insertion, completely sealed, no leaking refrigerant
2. Size and weight are smaller because there is no insert and flywheel
3. Noise at work

There are two types of closed compressors
1. Compressor in steel casing is not removable
2. The compressor contained in a cast iron can be removed
The type of book that is not removable is reliable. Smooth, sure and cheap. Today, this type of compressor is not only used in home refrigerators, but also widely used in the refrigeration industry with \( Q_o < 3260 \) W refrigerators, in refrigerated air conditioners up to 19,800 W. Compressors with removable cast iron casings (H5.15) have a higher refrigerating capacity. They have started replacing open compressors.

Compressed air compressors typically work in three temperature modes:

1. \( T_o = 15^\circ C \) used in family refrigerators and in the commercial sector
2. \( T_o = +50^\circ C \) used in air conditioners
3. \( T_o = -35^\circ C \) for use in the small business and refrigeration industry

These refrigerators work with refrigerants R12 and R22

In Figure 5.16a, b is the horizontal and vertical cross section of the compressor with \( Q_o = 815 \) W and \( n = 1450 \) V / min. Axis 1 of the compressor stands upright on the slider. The top of the shaft connects to the rotor 2 of the electric motor. Thanks to the eccentric transmission or through the transmission system, the circular motion of the shaft is converted into the motion of the piston 3, the two cylinders 4 spaced at a 90° angle. Pittong 3 does not have a ring because the gap between the cylinder and the piston is very small (10 ÷ 20 micron). The Xupap 5 does not stream save type. The compressor is lubricated by spraying. Unplanned compressors, electric motors are cooled by suction into the compressor. Inserts are either xiphong type or insert type with friction rings

Figure 5.17a is the insertion of the compressor. Round steel ring 1 insert axle by rubber ring 2. Xiphong 3 one solder into the copper ring of 4, while the other is soldered into the lead pipe. 5. Piping direction 5 re-solder into the cap. pad 7 and the cap 6 to tighten on the cactus. Round copper 4 and steel ring 1 are closed by spring 8

Figure 5.17b is inserted with steel-steel friction rings. Stand 1 is mounted with rubber pad 2 in the lid 3. The round friction wheel 4 is sealed with rubber ring 5 and spring 6. This insert is more reliable and easier to fabricate. compared to xiphong inserts

### 2.4.2.2 Multi-level piston compressors

Multi-stage compressed air conditioning can be achieved by multiple-stage compressors or single-stage compressors (usually used in two stages). The pressure-lowering stage can be either a normal compressor or a special booster. Lower pressure cylinders are larger in diameter. Double-stage compressors may have slides with horizontal cylinders or angular displacement and may be without sliding.
Compressors without bloc-cacti, two-stage direct current compressors are included in the bloc-cacti. There are four V-shaped cylinders that are 90° apart. There are eight W-shaped cylinders that are 45 degrees apart. There are four V-shaped cylinders with a 75° angle. There are standardized compressors that can be lwsp for each other.

In Figure 5.18a, b is the longitudinal section and cross section of the NH3 two-level V-shaped compressor with a refrigeration capacity of 93KW, to = -40°C and to = 35°C, n = 720v / min.

Three-level compressors can be piston type or low pressure medium-pressure rotor medium and high pressure pumps are piston. At low temperatures, turbine compressors or step-ladder refrigerators are often used. Three-level CO₂ compressors are only used for the production of CO₂ and dry ice (solid CO₂)

2.4.2.3 Rotor Compressor
The rotary rotor relative to the cylinder is called the rotor compressor. According to rotary characteristics of roto, the division of the rotor compressor into two groups: rolling rotor compressor and rotary rotor

Figure 5.19 shows the roller rotor compressor. Roto 2 rolls on the stationary surface of cylinder 1 by an eccentric shaft. Since the rotor shaft does not coincide with the cylinder, so between the cylinder and the rotor form a crescent-shaped cavity that always changes position depending on the rotational angle of the rotor. The crescent space is secured to the rotating angle of the rotor by the spring 4, divided into two separate parts: the suction and the thrust. When the rotor is in the upper position (I) and pressing the shield upwards, the cylinder will create the vapor space of the refrigerant. As the rotor continues to rotate under the effect of gravity, the shield spring will fall off (II) and divide the cylinder into two separate sections. The volume of space behind the rotor increases and absorbs slightly from the suction head. The aspiration process ends when the cavity can be positive (III). As the rotor movement decreases the volume of the rotor front, the pressure is slightly compressed to a greater pressure than the minimum pressure, then the valve 5 starts to open and the compressed air is pushed into the piston (IV).

Figure 5.20 shows a rolling hollow compactor with a capacity of 815W. Compressors and electric motors contained in steel presses. Inside the yxlanh 2 there is a rotor 3 mounted on the eccentric vertical axis. 4. The shaft is on the two copper bushes 5 and 6. The left cylinder has a shield 7 with spring 8. Push the nth flap type cap in the lower cap. . The compressor is balanced by two counterbalances 11 placed on the rotor head 10. The liner 12 has a central hole and four radial holes acting as a centrifugal pump, which is fitted to the lower part of the eccentric shaft. This shaft has a central hole. The oil along the center hole of the shaft goes up to the center of the upper bearing, from which the
center hole enters the torsion groove and rinses into the cup 13 to compress the stator. Cup 13 is an oil reservoir. From the thirteenth, the oil goes into the groove of the lower towel and rinses into the cactus of the compressor. Cup 14 to block the oil is inserted into the upper part of the eccentric shaft by means of the rotor of the electromechanical rotor. It would therefore be good to cool the coils of the electric motor and prevent the oil from slipping into the gap between the stator and the rotor.

In Figure 5.21, the rotor rotates 2 in a stationary cylinder or body. 1. The rotary axis of the rotor does not coincide with the cylinder axis. In the roto there are slices to let the swing 3 slip. When the rotor rotates, under the effect of centrifugal force, the swivel will slide out of the groove and lean against the face of the cylinder, then they return to the position of the steering. The gap between the cylinder and the rotor was split into separate chambers. The upper part of the cylinder has the largest volume, while the lower part has the smallest volume. Vapor from the suction hose is absorbed by the inlet and compressed in the cavity between the wings. When approaching the compressed air door, it will exit into the propeller.

Today's NH3 wing compressors are used as low-pressure compressors to receive low temperatures in compressed-air refrigeration units. In Figure 5.22, the above mentioned vane compressor. Cylinder 1 and 2 of the cast iron compressor with the water jacket 3. Roto 4 is a cast iron drum fitted to the steel shaft 5. Along the length of the roto has a groove for the swing 6 Asphalt-tectolite. Axis on the center bearings. The output of the shaft is friction-free 7 graphite - steel. The compressor does not have vacuum, steam is drawn in and ejected through the cylinder door. Lubricate the compressor with an oil pump mounted on the machine platform and be automatically electromechanically driven through the belt. On the oil pump there is oil tank 8 with water tube. On the compressor there is a cover box with the glass to observe the lubrication and the pressure gauge and the vacuum to control the pressure of the suction head and thrust.

Compared with the piston compressor, the rotor compressor has many advantages as follows: the size and weight is very small, no balancers, so well balanced can not need solid foundation or can be easily arranged on the car, etc. Due to the small amount of moving parts that are prone to wear, rotor compressors are reliable in operation. The main disadvantage of rotor compressors is that the accuracy of the fabrication is very high, otherwise the efficiency of the compressor is very low, especially the gap between the rotor and end of the cylinder must be smallest and the lever is very susceptible. Abrasion
2.4.2.4 Tuabin Compressor

a. The principle of working turbine compressor in two types: centrifugal and axial. Axial compressors are only applicable in cases where the steam flow through the machine is very large (24 ÷ 30) x10^6 m^3 / h. Centrifugal compressors typically range from +5 to -100°C and have a cool capacity of 100 to several thousand kilowatts.

b. The working principle of centrifugal compressors

The main components of the centrifugal compressor (H5.23) are: body 1, working wheel with wing 2 mounted on axle, booster tube 3, guide 4. Parts 2, 3, 4 Composition of a compressor. Depending on the required temperature, the compressor may have one or several frequencies (usually two or three stages). The working principle of the turbine compressor is as follows: Cooling agent from vacuum chamber 5 goes into the rotor of the rotating wheel at high speed. Thanks to the centrifugal force slightly washed out of the wheel of the wheel, accelerating motion and kinetic energy. Out of the working wheel, the steam goes into the booster tube with increasing cross section, the speed of the steam decreases, the kinetic energy changes into the booster and the pressure of the steam increases. In multi-stage compressors, the steam coming out of the booster will return to the center and follow the guide to the next switch wheel. In order to reduce the air leakage inside the compressor, the rotary inserts between the rotating and non-rotating parts.

c. Select refrigerant for turbo compressor

The refrigerant used in the turbine compressors, in addition to the general requirements, has some additional characteristics, such as a high molecular weight to reduce the number of compressor layers or reduce the speed of the working wheel. In non-large compressors, a small q-cryogenic refrigerant is used to increase compressor efficiency due to small leakage losses. In large compressors, the refrigerant has a large volume of refrigeration. NH3 compressors with a velocity of less than 200m / s apply only to cold output Qo ≥ 70KW.

Today in turbine compressors often use refrigerants such as R11, R12, R113, R114, R21 and R22.

In air-conditioning compressors and heat pumps with t0 = (-10 ++ 5) °C, use R11, R113, R114.

In the other air conditioning when

\[ t0 = (-20 + -30) °C \text{ use R12, R21} \]
\[ t0 = (-30 + -60) °C \text{ use R12} \]
The C4F10 and R115 refrigerants have high molecular weights so there is a great deal of potential for use. NH3 is only used in piston compressors because of its small molecular weight (17,03) and high refrigeration capacity, which makes it difficult to use in turbine compressors.

d. Compressor centrifugal construction

Centrifugal compressors may vary depending on operating conditions, refrigerant or propulsion methods. Figure 5.24 shows the vertical section of the two-stage freon compressor. It can work with R12, R142 and R11. If working with R12 and having $t_0 = -15^\circ C$, $t_K = 35^\circ C$ then $Q_0 = 2680KW$, $N = 1000KW$, $n = 7550v / min$

The main parts of the compressor are: body 1, shaft 2, guide 3, wheel 4, insert 5. Body made of cast iron GX24-44 with 2% nickel. The compressor can remove the two upper and lower lwp. The cockpit 6 is located at the lower part of the body to guide the steam into the propeller. Exit 7 is located at the top. In a single-stage compressor, the shape of the hollow cone, while in the multi-stage compressor, is the shape of the two halves of the symmetry coil. The door is located behind the last floor. It reduces the speed of steam flow and steam conduction into the propeller

The wheel works with the curved rear wing and is covered. Wheel and shaft made of carbon steel or alloy steel. The wheels need to be heated before fitting them to the axles. For ease of mounting the wheel to the shaft, the shaft usually makes many steps. The position of the wheels on the shaft is fixed by the axes. Axis on two axles 8 (usually a sliding bearing with cast iron or babit steel). The axial force generated by the working wheels partially absorbed by the block 9, partly offset by the load-bearing piston 10

Booster to reduce the speed of the steam coming out of the work car and increase the pressure of the steam by reducing kinetic energy. There are two types of booster tubes: wingless and winged. The wingless type is structured as a circular space with increasing radius, thereby reducing the speed of the line. The winged type is a rounded rod made of straight or curved bows. Often the winged turbo charger is placed behind the turbocharged turbocharger to improve turbocharger performance and reduce turbulence. In the teeth of the forced supercharger the direction of rotation must be changed in the direction of the center and slowed down due to the increase in cross sectional area.

The conductor leads to the next floor. In order to adjust the compressor’s cooling capacity, the first front wheel of the adjustable butterfly wheel 11 is actuated by a unit mounted near the compressor. In front of the second wheel there is an
intake of steam from the intermediate tank which allows two-stage fluid circulation

The insertion points are inserted to reduce leakage inside the machine, while at the output of the shaft is inserted graphite ring (H5.25). The lubrication system of the bearings and inserts is mounted in a closed system and outside the compressor. The system has two oil pumps: oil pump work and oil pump trouble. Emergency oil pump only works when oil pressure in the oil pipe is reduced. The oil pump is located on the oil tank. Lubricating oil comes from the pumped pump and goes in the shaft and inserts. The oil from the bearings return to the oil tank, but from the insert back to the smaller oil on the horizontal inserts, then discharged into the oil tank. In the oil tank there is a water-cooled oil cooler and a resistor arranged to separate the freon from the oil before opening the machine. Today, centrifugal compressors, condensers and evaporators are often linked together into a single unit, ie, the production head of a small-capacity turbine compressor.

Compressor Comparisons with Piston Compressors have the following advantages:

1- Smaller size and weight, especially for very cold capacity, its weight may be less than 5 ÷ 8 times.

2- Simple, reliable operation and long service life (turbine compressors without crankshafts, crankshafts, transmission rods ... are the most likely cause of trouble for piston compressors)

3- Can be driven directly from the rotary engine, so very compact and high performance

4- Balance well, so the foundation can be placed gently on other devices

The refrigerant flow from the compressor is uniformly steady, with no lubricant in the refrigerant, so the coefficient of heat transfer in the refrigerant is increased.

It is possible to compress and throttle multiple levels with steam to the compressor intermediate wheels so that different values of t0 can be obtained in each individual evaporator.

The disadvantage of turbine rotary encumbrances is that the efficiency is lower for small and medium machines, requiring accelerators in the case of electric motors.
2.4.2.5 Screw compressor

Like the piston compressor, the vist shifter also belongs to the volume compressor. Vapors (or gases) are shaken to a high pressure. The volume decreases with less grooves and the compressor body.

Screw compressors are quick-rotating and do not have suction and discharge heads. The working parts are rotary screws but do not come in contact with each other and do not come into contact with the body. Screws only allow contact with each other in the case of lubricant supply to the compressor. Screw compressors may be of the following types:

1. Lubricating oil lubrication compressor
2. Dry compressor compressor. Whereas the main parts of the machine are cooled by the liquid or liquid working in the compressor
3. The wet screw compressor wet by spraying a small amount of liquid to reduce the temperature of the vapor or air after compression.

Today in refrigeration technology the screw type with lubricating oil is widely used. Lubricating oil with large amounts of oil is injected into the working compartments to seal the gaps between the compressor's working parts, to cool the compressed air and to heat the parts for lubrication and noise reduction. of the compressor.

Screw compressors of one, two or more rotor type. In that type of rotor type two is the most used. Figure 5.38 shows a rotor type double screw compressor with lubricating oil. The compressor has the following structure: the stem 2 can be removed in two vertical sections, the front cover 1 has no suction chamber and the back cover 3. In the cylindrical body, there is a rotor 5 and a rotary rotor 4 in the drive. Slide roller (or roller) 6. In the middle of the rotor, the teeth of the driving screw and the screw joints fit together as a pair of gears. Axial force acting on the rotor is absorbed by the thrust bearing 7. Partial axial force is suppressed by the load-bearing piston 8. In the lower part of the body in the compressed air region there is a drawer 9 to adjust compressor capacity. The drawer has a locating pin to keep it from rotating around its axis, but can move freely along the drawer shaft. This is the best method of power adjustment.

In dry and wet compression screw compressors do not allow the screws to contact, so the synchronization during rotation between the two screws is made by the alignment of the gear pair mounted on two screws.

In the late 1950s and early 1960s, lubricant screw compressors were introduced. Compared to dry compressors and wet compressors, they have a simpler structure. Thanks to the lubricant, the screws can come into contact with each other, so no gearing is needed. The insertion parts and bearings are also simpler.
In refrigeration technology screw compressors with lubricating oil are used with a cooling capacity of 50 to 3500 kW and working with refrigerants NH3, R12 and R22. The rotational speed of the compressor depends on the diameter of the screw that can range from 1500 to 12000 v / min.

The energy parameters of the best screw compressors in the optimum working conditions are the same as the piston compressors, but with a low refrigerant capacity it is less efficient. In contrast, the size of the screw compressor is much smaller than that of a piston compressor. The pressure difference between the suction and thrust of the screw compressor can reach 17-21 bar.

Compared with the piston compressor, the screw compressor has the following advantages: high reliability and durability, very fast rotation, so compact size, no moving parts and forces. In addition, the rotating parts are very balanced in terms of dynamics so there is no need for solid foundation, no cushions, xecmang and heavy damaged parts are easily damaged, energy and volume indicators. Stable in the long run, the pressure losses in the intake and the door are small because there is no cushion, almost no hydraulic impact, able to work with biphasic , can operate the machine without a regular attendant.

All of these advantages allow the screw compressor to have capital and operating costs per unit of productivity are smaller than the piston compressor.

Compared with centrifugal compressors, the screw compressor has the following advantages: no hydraulic failure, it can work with all refrigerants without much change. The rotational speed of the compressor does not affect the compression ratio of the machine, adjusting the economic power by changing the rotation speed of the machine and adjust the drawer.

One outstanding advantage of the screw compressor is that in the same compressor it is possible to perform two or more compression stages by mixing the required amount of coolant from the intermediate heat exchanger. This principle is implemented in a two-stage refrigerated chiller with incomplete intermediate cooling.

**Insert image**

On the picture is a two-stage air conditioner with the use of screw compressors. A cold state agent with state 1 is sucked into the working chamber of the screw compressor. Then this chamber was cut off the intake. By reducing the volume of the working chamber, the pressure of the refrigerant increases. At the pressure in the working chamber increased to Ptg value (compression process 1 to 2), the working chamber will be connected to the boiler 9 state away from the intermediate heat exchanger. By means of a mixture of two vapor streams, there is a state of 9 and a state of 2 in which the compressor receives the vapor stream having a state of 3 and is subsequently compressed to the state 4.
The liquid G flows out of the condenser having state 5 divided into two streams: the large stream G1 passes through the coil of the heat exchanger which is cooled from state 5 to state 7 by evaporation in Ptg and ttg of Liquid G2 throttling in TL1. This vapor then enters the compressor. The main fluid stream is secreted in TL2 to enter the evaporator.

The application of the above scheme has significantly increased the energy efficiency of the screw compressor cycle.

Screw compressors from the machine working points must have the following special requirements: Lubricating oil must be less soluble with cold agent, oil viscosity does not change too much. By temperature, if the refrigerant is soluble in oil, the viscosity of the oil should not be changed too large.

The oil is sprayed onto the screw compressor to reduce the gap between the screws simultaneously to cool the cylinders and the body, thereby reducing the volume losses of the volume losses and reducing the compressive strength of the machine. However, in order to spray oil into the machine also consumes a certain capacity, so the determination of the optimal oil consumption for screw lubrication oil lubrication is a very necessary and very beneficial.

### 2.4.2.6. Spiral compressors

In recent years, a wide variety of spiral compressors have been used in small air conditioners, especially in window type, wall and ceiling air conditioners with a capacity of <10HP. The main part of the compressor is composed of two discs, each with a spiral ring. The two plates are interlocked and thus the two spiral rings are interlocked. The disc is fixed, while the disc is eccentric with the disc. In the first round will be slightly sucked in. In the second rotation the vapor will be compressed to the required pressure. At the third rotation, the steam will be ejected through a small hole in the center of the disk.

Spiral compressors are an important scientific and technological achievement in the field of air conditioning, as it has many advantages compared to piston compressors as it is very simple and reliable (because they do not have a headlamp the speed of the motor is reduced by 64%, less friction, so the compressor performance is higher, the compressor is running smoothly, without vibration (vibration and noise only 30% of the piston compressor), which is essential for air conditioning systems. A significant advantage of the spiral compressor compared to the piston compressor is that it allows for work with moisture mixed with liquid or with unclean air because of many impurities and not afraid of trouble and hydraulic. Finally, the cost of a spiral compressor is cheaper than a piston.
2.4.3 Calculation select compressor.

2.4.3.1 Calculation graph and parameters points

- Graph LogP – h:

- Graph T – s:
• Points parameters :

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<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Status</td>
<td>Wet saturation steam</td>
<td>Saturated steam</td>
<td>Saturated steam</td>
</tr>
<tr>
<td>$t \ (^\circ C)$</td>
<td>33</td>
<td>−8</td>
<td>−8</td>
</tr>
<tr>
<td>$p (\text{bar})$</td>
<td>13.504</td>
<td>3.152</td>
<td>3.152</td>
</tr>
<tr>
<td>$h(\text{kJ}/\text{kg})$</td>
<td>353.22</td>
<td>353.22</td>
<td>163.55</td>
</tr>
<tr>
<td>$s(\text{kJ}/\text{kg} \cdot K)$</td>
<td>1.5246</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$v(\text{m}^3/\text{kg})$</td>
<td>0.0016933</td>
<td>0.0015399</td>
<td></td>
</tr>
</tbody>
</table>

### 2.4.2.2 Calculation choose cooling compressor

- **Specific refrigerating effect** $q_0$ là:
  \[ q_0 = i_{1'} - i_5 \]

  In which :

  - $q_0$ : Specific refrigerating effect (kJ/kg)
  - $i_{1'}, i_5$ : Entalpy (kJ/kg)

  \[ q_0 = i_{1'} - i_5 = 1451.8 - 353.22 = 1098.578 \ [\text{kJ/kg}] \]

- **Cooling capacity of one compressor**:

  We choose two compressor work and one backup compressor
\[ Q_{01} = \frac{Q_0}{2} = \frac{320.4122}{2} = 1602.061 \, \text{kw} \]

\( Q_0 \) : Cooling capacity (1602.061 kw)

\( Q_{01} \) : Cooling capacity of one compressor (kw)

- **Refrigerants flow rate through to compressor:**

Refrigerants flow rate through to compressor:

\[ m = \frac{Q_0}{i_{1'} - i_5} \]

In which:

- \( m \) : Refrigerants flow rate through to compressor (kg/s)

- \( Q_{01} \) : Cooling capacity (1602.061 kW)

- \( i_{1'} \) : Entalpy (1451.8 kJ/kg)

- \( i_{1'}, i_5 \) : Entalpy (353.22 kJ/kg)

\[ \Rightarrow m = \frac{1602.061}{1451.8 - 353.22} = 1.4583 \, [kg/s] \]

2.4.2.4 Calculation compressor

- Specific compression of compressor (l):

\[ l = i_2 - i_1 \]

In which:

- \( l \) : Specific compression of compressor (kJ/kg)

- \( i_1 \) : Entalpy at point 1 (1464.360 kJ/kg)

- \( i_2 \) : Entalpy at point 2 (1679.520 kJ/kg)

\[ l = i_2 - i_1 = 1679.520 - 1464.360 = 215.16 \, [kJ/kg] \]

- Refrigerants flow rate through to compressor (m):

\[ m = 1.4583[kg/s] \]
• Performance indicators ($\eta_i$):

$$\eta_i = \frac{T_0}{T_k} + b \times t_0$$

In which:

$\eta_i$ : Performance indicators  
$T_0$ : Evaporative temperature ($-8 \, ^\circ K$)  
$T_k$ : Condensing temperature ($35 \, ^\circ K$)  
$t_0$ : Evaporative temperature ($-8 \, ^\circ C$)  
$b$ : actual factor for amoniac compressor ($b = 0.0001$)

$$\eta_i = \frac{T_0}{T_k} + b \times t_0 = \frac{-8 + 273}{35 + 273} + 0.0001 \times (-8) = 0.8596$$

• Actual suction volume of compressor ($V_{tt}$):

$$V_{tt} = m \times v_1$$

In which:

$V_{tt}$ : Actual suction volume of compressor [$m^3/s$]  
m : Refrigerants flow rate through to compressor [$1.4583 \, kg/s$]  
$v_1$ : Specific volume at point 1 ($0.396408 \, m^3/kg$)

$$V_{tt} = m \times v_1 = 1.4583 \times 0.396408 = 0.5781 \, [m^3/s]$$

• Adiabatic compression ($N_s$):

$$N_s = m \times l$$

In which:

$N_s$ : Adiabatic compression capacity [$kW$]  
m : Refrigerants flow rate through to compressor [$1.4583 \, kg/s$]  
l : Specific compression of compressor ($kJ/kg$)

$$N_s = m \times l = 1.4583 \times 215.16 = 313.77 \, [kW]$$
• Performance indicators compression \((N_i)\):

\[
N_i = \frac{N_s}{\eta_i}
\]

In which:

\(N_s\): Adiabatic compression capacity\([kW]\)

\(N_i\): Performance indicators compression\([kW]\)

\(\eta_i\) : Performance indicators

\[
N_i = \frac{N_s}{\eta_i} = \frac{313.77}{0.8596} = 365.02 \text{ [kW]}
\]

• Specific friction pressure \((p_{ms} = 60 \text{ kPa})\):

\[
N_{ms} = V_{tt} \times p_{ms}
\]

In which:

\(N_{ms}\) : Friction compression Capacity \((kW)\)

\(p_{ms}\) : Specific friction pressure \((60 \text{ kPa})\)

\(V_{tt}\) : Actual suction volumn of compressor \([m^3/s]\)

\[
N_{ms} = V_{tt} \times p_{ms} = 0.5781 \times 60 = 34.686 \text{ [kW]}
\]

• Effective capacity \((N_e)\):

\[
N_e = N_i + N_{ms}
\]

In which:

\(N_e\) : Effective capacity \((kW)\)

\(N_{ms}\) : Friction compression Capacity \((34.686 kW)\)

\(N_i\) : Performance indicators compression \((365.02 kW)\)

\[
N_e = N_i + N_{ms} = 365.02 + 34.686 = 399.706 \text{ [kW]}
\]

2.4.2.4 Choose compressor

- Compressor capacity use to process make cooling:

\[
Q_{mn} = Q_{01} + Q_{qn} = Q_{01} + m \times (i_1 - i_1')
\]

In which:
$Q_{mn}$: Cooling capacity of compressor [$kW$]

$Q_{01}$: Cooling capacity of one compressor [$kW$]

$Q_{qn}$: Superheat capacity [$kW$].

$m$: Refrigerants flow rate through to compressor [$1.46084 \, \text{kg} / s$]

$i_1, i_{1'}$: Specific volum cooling capacity ($kJ / kg$)

\[
Q_{mn} = Q_{01} + Q_{qn} = Q_{01} + m \times (i_1 - i_{1'})
\]

\[
Q_{mn} = 1602.061 + 1.4583 \times (1464.360 - 1451.8).
\]

$Q_{mn} = 1620.38$

- We choose level one refrigeration cycle with two compressor work and one compress to Standby

We have:

- Operating in under conditions:

  ✓ Evaporative temperature: $t_e = -8^\circ C$
  ✓ Condensing tem : $t_k = 35^\circ C$
  ✓ Cooling capacity of compressor for cooling capacity
    \[
    Q_{mn} = 1620.38 \, [kW]
    \]
  ✓ Effective capacity : $N_e = 399.706 \, [kW]$
  ✓ Superheat : $t_{qn} = 5^\circ C$
  ✓ Subcooling : $t_{ql} = 2$

The Percentage take COP of number 1 make original to calculator others compressor.

<table>
<thead>
<tr>
<th>STT</th>
<th>Evaporative temperature (°C)</th>
<th>Model</th>
<th>Cooling capacity (kw)</th>
<th>Absorbed Power (kw)</th>
<th>Drive shaft speed (min-1)</th>
<th>COP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-8</td>
<td>N250M**-L</td>
<td>1625.7</td>
<td>386.6</td>
<td>3360</td>
<td>4.21</td>
</tr>
<tr>
<td>2</td>
<td>-8</td>
<td>N250M**-M</td>
<td>1622.8</td>
<td>386</td>
<td>3380</td>
<td>4.2</td>
</tr>
<tr>
<td>3</td>
<td>-8</td>
<td>N250M**-H</td>
<td>1626.7</td>
<td>426.6</td>
<td>3403</td>
<td>3.81</td>
</tr>
</tbody>
</table>

✓ After comparison compressor we choose N250M**-M because COP maximum and lowest absorbed power.
Conclusion: Base on operating conditions, we choose three compressor have model is: N250M**-M (see index 2.4)

- Parameters of compressor N250M**-M:
  ✓ Cooling compressor capacity: \(N = 1622.8[\text{kw}]\)
  ✓ Absorbed power: \(N_u = 386[\text{kw}]\)
  ✓ COP: \(COP = 4.2\)
  ✓ Drive shaft speed: \(n = 3380 \text{ [min } - 1]\)

2.5 Calculation select evaporative condenser (TBNT)

2.5.1 Application of Condenser

The condenser is responsible for condensing the superheated steam after the compressor into a liquid refrigerant. The working process of the condenser has a decisive influence on the pressure and condensing temperature and thus affects the efficiency and safety of the entire refrigeration system. When the same equipment works ineffectively, the system parameters will change in the wrong direction, namely:

+ The cooling capacity of the system decreases, and throttle losses increase.
+ The final temperature of the compression process increases.
+ Increased compression, engine overload.
+ Full feed off the high pressure side pressure increase, the HP role can stop the compressor, the safety valve can operate.
+ High temperatures affect oil as oil burns

2.5.2 Classification of condenser

Condensers come in a variety of types and working principles are very different. Classification of condensing equipment based on many different characteristics.

According to the cooling environment:

+ Condenser cooled by water. For cooling, the water of the device is usually in the form of a jar or jar in the tank.
+ Condenser cooled by water and air. Some condensers incorporate both water and air for cooling, in such devices the role of water and air is different: Water is used to cool the refrigerant and air to cool the water. Examples are evaporator condensers, irrigation condensers...
+ Condenser cooled by air. Conventional of forced convection air through the equipment and heat exchangers with the media.
+ Other condenser coolers. This type of equipment can be seen in multilayer air conditioning systems, where the lower cycle condenser is cooled by the evaporative cooling of the upper cycle.
According to structural characteristics:
+ Condenser cooled by water
+ Evaporation condenser
+ Irrigation type condenser
+ Air Condenser
+ Tube-type condenser
+ Plate-type condenser

According to the convective characteristics of air:
+ Condensers cooled by natural convection.
+ Condenser coolers due to forced convection

There are also a number of different ways to divide the features: According to the direction of the refrigerant and the cooling medium. There are many different types of structures such as condensation outside the tube surface in the heat exchanger, inside the heat exchanger or on flat surfaces.

Below we present some of the most commonly used condensers in refrigeration system in our country.

2.5.2.1 The condenser is cooled by water
2.5.2.1.1 Horizontal hose condenser.
Horizontal condenser hose condensers are widely used in refrigeration and air conditioning systems. Môi chất sử dụng có thể là amôniac hoặc frêôn. Condensation NH$_3$ of the heat exchanger tubes are C20 pressure pipes, and for condensers on freon often use winged copper pipes toward the refrigerant.

a. Horizontal hose condenser hose NH$_3$

Figure 6-1 shown the condenser structure used in NH$_3$ refrigeration systems. Condenser with horizontal cylindrical body made of CT3 steel material, the inside is the heat exchanger C20 pressure steel. The heat exchanger tubing is sealed or raised on both sides of the two ends. To be able to weld or heat exchanger tubes into the sieve surface, it must have a fairly large thickness of 20 to 30mm. The top of the body is the lid. The flask lid forms the water divider so that the water circulates. The lid made up Divide the flow of water to circulate water several times in the condenser. Purpose week multiple times is to increase the exposure time of water and the environment; Increase transfer speed the water in the heat exchanger tubes to improve the alpha emitting heat. Every new water moves from one end of the vase to the other end of the vase. Example vase stop 4 passes, the water is moving back and forth 4 times (Figure 6-2. One of the problem with the condenser is to arrange the
number of tubes in the pass. If not, then the speed of water in the pass will vary, resulting in pressure loss unnecessary.

![Diagram of horizontal hose condenser hose](image)

**Figure 6-1**: Horizontal hose condenser hose

1- Cap; 2- Dain pipe; 3- Belance pipe; 4- Heat exchange pipe; 5- Gas pipe in; 6- Safe valve; 7- Pressure gauge; 8- Air valve; 9- Water pipe out; 10- Water pipe in; 11- Dain pipe duty; 12- Liquid pipe to receiver

Equipments included in the condenser include: safety valve, pressure gauge with approx. work from 30 kG / cm² is the most reasonable, the gas pipe into, the equilibrium line discharge of condensed air, liquid lines of high pressure vessels, in and out water pipes, the exhaust valve and water drainage. In order for the gas to be distributed in the tank during operation, the gas pipeline is divided into two branches arranged in two cylinders and a liquid piping to the container in the center.

The working principle of the tank is as follows: Gas from the compressor is put into the tank from two branches at both ends and covering the space between the heat exchanger and the body. Inside the gas tank is a heat exchanger with cold water moving inside the exchange tubes. Heat and condensate into liquid. Liquid condensate immediately flows immediately to the tank. The container is placed below the condenser. Some systems do not have high-pressure containers that are used a condenser as a. In this case people do not arrange the tube bottom heat exchanger. For smooth flowing condensation, there must be a weighing tube by connecting the condenser to the high pressure container.

![Diagram of tank operation](image)

**Figure 6.2**: Arrange pipe in condenser.
Depending on the size and capacity of the tank, the heat exchanger can be either large or small. The commonly used tubes are: Ø27x3, Ø38x3, Ø9x3.5, Ø57x3.5.

From condenser people often extract air discharge does not stop leading to the gas tank, stay the non-condensable gas is separated from the medium and discharged to the outside. In case in the condenser condenser there is no condensation, the condensing pressure will be higher than normal, the clock is often vibrated.

When installing, note the two ends of the condenser there is a gap required to clean the inner surface of the heat exchanger. Seal the side water in rubber tube, pipe connected to the cap by flange to be able to remove when the need birth and repair.

**During use of condenser should be noted:**

- Regular cleaning of pots to improve working efficiency. Due to the evaporation of water in the tower the heat is very strong so impurities accumulate more and more, when the system is operating spurious the water comes into the tank and attaches to the heat exchanger surfaces, reducing the efficiency of the delivery heat exchangers. Cleaning can be done in many ways: soak Na2CO3 or NaOH to clean, then circulate several times for cleaning. However this method works not very high, especially for scales on the surface of the tube. Hygienic by mechanical means tie the wipes to the wires and two people standing on either side of the jug pulled back many times. When wiping carefully, avoid scratching the inside of the container, as such the next time easier to cling.

- Discharge when not stopped. Air enters the system to increase the condensing pressure, so it is necessary to regularly check and conduct non-condensable exhaust.

**b freon Condenser**

Condenser with steel heat exchanger for use in fridges it should be noted that fritants have a strong cleansing properties, so they must be cleaned inside the pipe very clean and the system must be equipped with a mechanical filter.

For the safe and most effective use of copper pipe problem of stains and better heat transfer, compact size.

Figure 6-3 shows the types of winged condenser cylinders used for the media freon. The wings are made towards the frit.
1- Cap, 2,6- Flange; 3- Pipe; 4- Lông ra; 5- Space pipe
c. Advantages and disadvantages of using horizontal hose condenser.

- Advantages

- Horizontal hose condenser, cooled by water, so high thermal efficiency, the heat density is quite large \( q = 3000 \div 6000 \, \text{W} / \text{m}^2 \), \( k = 800 \div 1000 \, \text{W} / \text{m}^2.K \), the difference average temperature \( \Delta t = 5 \div 6 \, \text{K} \). Easily change the speed of water in the tank to speed appropriate to improve heat exchange efficiency, by increasing the number of pass cycles country.

- The efficiency of the heat exchanger is quite stable, less dependent on the ambient temperature.

- Rugged, compact and very convenient to install in the home, with a needle capacity small type, about \( 40 \div 45 \, \text{kg} / \text{m}^2 \) surface heat exchanger, beautiful shape suitable with the requirement of industrial aesthetics.

- Easy to manufacture, install, sanitize, maintain and operate.
- Can use part of the tank to make the container, especially convenient in the system small refrigeration systems, such as cold storage systems.

- Low damage and long life: For other types of condensers, conventional iron pipes exposure to water and air environment should speed the heat exchanger tube pretty fast. For condensers, because of the frequent storage of water, the surface of the heat exchanger almost always submerged in water without contact with air. So the speed of eating worn out much slower.

  - **Defect**

- For large systems using condensers is not suitable because of the diameter of the tank too big, not secure. If the body thickness increase, it will be difficult to fabricate. Therefore, large capacity plants rarely use condensers.

- When using a condenser, it is mandatory to equip additional cooling water system including: Tower heat pump, cooling water pump, plumbing system, water line auxiliary equipment, etc. should increase the cost of investment and operation. Outside of the machine room, space is required open the outside to set the cooling tower. The work of the tower always drags on evaporation is significant, so the cost of cooling water is quite large, water often moistens the area neighborhood, so should be located far from the works.

- The size of the pot is neat, but when installed it is necessary to save space two pots are needed for cleaning and repair as needed.

- The process of stain on the surface of the pipe is relatively fast, especially when the quality poor water.

When using hose condenser horizontally, care should be taken to keep the surface clean the inside of the heat exchanger, in this case chemical hygiene or mechanical. Regularly dump the residue in the cooling tower and add fresh water. Discharge of gas and sediment.

### 2.5.2.1.2 Vertical tube Condenser

#### a. Structure and working principle

In order to save space, a condenser is used. Structure similar horizontal hollow condensers, including: cylindrical cylinders usually made up made of steel CT3, the inside is the heat exchanger C20 pressure, size Ø57x3,5, aligned, welded or molded into the screen. Water is pumped into the trough splash water at the top and flow into the heat exchangers. Let the water flow into the heat exchanger tube, above the heat exchanger tubes. The side under the water catcher. Water after cooling is usually. Steam overheating after the compressor enters the jar from above. Liquid condensation flows downward of the vessel between the heat exchanger tubes and the high pressure vessel. The
condenser has a page safety valve, pressure gauge, gas discharge valve, liquid level watch glass.

During use of the vertical condenser tube, note the possible damage occurs like staining inside the heat exchanger tubes, water gates into the delivery tubes heat is quite narrow so it is easy to clog, need periodic inspection repair. Cleaning of the condenser relatively complex. Also, when the air does not stop on the bottle, the efficiency of work decreased, the condensation pressure increased so must conduct regular non-condensate gas. Condenser tube is not used in our country because there are some disadvantages weight.

b. **Advantages and scope of use**

- **Advantages**
  - The heat output is quite large, the heat load of the tank reaches 4500 W / m² at the heat difference degree 4 ÷ 5K, corresponding coefficient of heat transfer $k = 800 \div 1000$ W / m².K
  - Suitable for medium and large power systems, narrow installation space, right condenser outside.
  - Because the heat exchangers are placed vertically, they are less likely to get stuck than they are discontinue horizontally, so do not require high quality water source.
  - Due to the vertical structure, the liquid and the oil flow outward rather conveniently, the collection oil is also easy. So the surface of the heat exchanger is quickly released to give coolant.
1- Balance tube, 2- Gas not stop, 3- Water distribution kit, 4- Safe valve 5- Refrigerant pipe, 6- pressure gauge, 7- Glasses, 8- Water pool, 9- High pressure tank

- **Defect**

- Transportation, installation, manufacturing, operation is relatively complex.
- Consumption of water is quite large, so it is only suitable for places where water is abundant and cheap money.
- For very large systems using this condenser type is not suitable, due to size bulky, too large diameter is not safe.
2.5.2.1.3 Vertical tube condenser
Tube-type condenser condensers

a. Structure and working principle

Pipe-type condenser condensers are also water-cooled condensers, they are widely used in small refrigerators, especially in regulators medium air power.

The device consists of two interlocking tubes and is usually rolled up for compactness. Water moves in the inner tube, the refrigerant moves back in space between the tubes.

The pipe used is copper pipe (frunnual system) and can use steel pipe.

Figure 6.5. Tube-type condenser condensers
b. Advantages and disadvantages

Effectively large heat exchangers, compact. But fabrication is relatively difficult, the tube interlocking is then rolled up for neat, if no condensation measures. In addition, the tube is prone to diarrhea, especially large pipes in the outside, leading to the area of the spasm, the effect to the flow of the interior. Because the media only moves in and out of a tube only small flow, tube-type condenser tube fitting is only suitable for small and medium systems.

2.5.2.1.4 Plate-type condenser

a. Structure and operating principle

Plate-type condensers are assembled from various metal plates pressed together by two high-grade metal caps. Refrigerant and liquid heat is arranged alternately. Wave formations have the effect of confusing the flow and increase the coefficient of heat transfer and increase its durability. Plates thickness is relatively thin, so the heat conduction heat, while the area of heat exchange is very great. Usually two sheets are welded together into a panel. Fluorine inside, the water moves in the gap between panels during installation.

In the process of use should note the phenomenon of stain on the surface outside the panel (side water) should be periodically opened to hygienic or use water quality high. It is possible to clean the inside with chemicals, after washing the chemical needs to neutralize and cleaned so that it does not corrode the panels.
b. Advantages and disadvantages.

- **Advantages**
  - Due to being made from thin sheets, the area of the heat exchanger is quite large and compact.
  - Easily removable for cleaning and replacement. Can add some panels to change the cooling capacity easily.
  - High heat transfer efficiency, equivalent to ammonia shell tube condenser.

- **Disadvantages**
  - Difficult fabrication. So far only foreign firms are capable of fabricating these condenser plate type. Hence the lack of spare parts available to replace the repairs.
  - The water leakage capacity is quite large due to the number of sealed buffer.

2.5.2.2 Condensers cooled by water and air

Condenser coolers combine water and air to maximize air quality condensate evaporator and irrigation condenser.

Unlike water-cooled condensers, additional cooling towers, water pump and cooling water system, water cooling condenser and the air does not need to be equipped with such equipment, the water here is airborne direct cooling in the heat exchanger with refrigerant.

2.5.2.2.1 Evaporative condenser

a. Structure and working principle

Figure 6-7 shows the structure of the evaporator condenser. The condenser consists of a cluster C20 steel pressure tube heat exchanger. Kích cỡ ống thường được sử dụng là Ø38x3.5, Ø49x3.5 và Ø57x3.5. The pipe size commonly used is Ø38x3.5. The whole set of pipes is placed on solid U-frame, below it is a recirculating tank for cooling, the top is a water sprinkler, the water bar and the exhaust fan wind. For anti-corrosion, the heat exchanger tube is dipped with hot zinc outer surface.

The liquid vapor enters the intake manifold at the top into the heat exchanger tubing and then condenses flowing to the high pressure tank at the bottom. Equipment is cooled by spray water from the nozzles distributed evenly above the heat exchanger assembly. Water after when the heat is exchanged with the refrigerant, it warms up and is cooled by the transfer air inverted from the bottom up, so the water temperature is almost unchanged. Whole heat \( Q_k \) of the air is removed by the air. Forced air movement thanks to fans placed above or below. Set the fan in the bottom (fan blow), then in the work process is not afraid of fan.
wet, while the upper (suction fan) is easy water gets wet and reduces life expectancy. However, the top is neat and easy to build more often used. During the heat exchanger a large amount of water evaporates and is swept away by the air, so it is necessary to supply additional water to the tank. The water supply method is fully automatic thanks to the float valve. Water barrier works keep water droplets out of the air, thus saving water and avoiding them wet the fan. Water barrier is made of thin sheet metal and is folded in a longitudinal direction, the air passing through the barrier bumps into the shield and at the same time continuous line turn the water droplets are over charged and fall down to the bottom.

After circulating about two thirds of the heat exchanger tubing, a large portion of the gas has been turned on liquid, to improve the heat exchange efficiency needs to separate this liquid first, liberate the surface rear heat exchanger for leftover steam. So in this position people the intermediate liquid manifolds are arranged to collect fluid for flowing straight to the lateral manifold downstream and directly to the container, the remaining part of the fluid continues to rotate by 1/3 of the tube rest.

All the outside of the pipe and spray drum cluster are covered with zinc coated sheet

Intermediate liquid coolant is also used as a place for balancing pipes.

Previously in many factories freezing our country often use the condenser array evaporation using a centrifugal fan located below. However we noticed these fans motor capacity is quite large, very expensive.

Figure 6-7: Evaporation Condenser

1- Exchange pipe; 2- Sprinkler system; 3- Fan; 4- Fan motor; 5- Stop water kit; 6-Gas pipe in; 7-Main pipe; 8-Balanced pipe; 9-Pressure gauge; 10- liquid pipe out; 11- Pump; 12-water catcher; 13- Drain pipe; 14- Overflow pipe
The specific heat capacity of the irrigation condenser is not very high, about 1900 ÷ 2300 W / m², the heat transfer coefficient \( k = 450 ÷ 600 \) W / m².K.

In the process of use should be noted, the spray is small size so easily clogged. When some of the noses are blocked, some areas of the heat exchanger tube are not cooled well, the heat dissipation efficiency drastically, the condensing pressure will be unusually large. So yes always check, clean or replace broken nozzles. As well as the condenser, exterior of the heat exchanger tubing after a period of work is also phenomenal dirty, corrosive, should be periodically cleaned and repaired.

b. Advantages and disadvantages.

- **Advantages**

- Because of the tubular structure, its power can be designed to be very large without being damaged limited for any reason. At present, many aquatic products processing enterprises in our country use evaporative condensing unit with capacity from 600 ÷ 1000 kW.

- Compared to other condensers, evaporative condensers are less water-intensive, because water used in a periodic manner.

- Small size pipes should work safely.

- Easy to manufacture, operate and repair.

- **Disadvantages.**

- Due to its own cooling capacity, the material consumption is rather large.

- The heat exchanger clusters are frequently exposed to water and air, which is the lip the strong corrosion field should be broken. It is therefore imperative to embed hot zinc to prevent it corrosive.

- The temperature of the condenser depends on the state of the meteorology and varies with the season.

- Only suitable for outdoor installation, during work, ground and space the surrounding area is often wet, so it needs to be installed in a separate location submit.

2.5.2.2 Irrigation type condenser

a. Structure and operating principle

Figure 6-8 shows the irrigation condenser structure. A set of exchange tubes heat-treated hot dip galvanized steel tube, without cover, has a lot of pipe in two head. Phía trên dàn là một mạng phân phối nước hoặc dàn ống phun, phun nước xuống. Above the frame is a water dispenser or spray pipe, spraying water down.
Pipes are usually placed just above a water tank. Water is pumped from the pump tank up the top distribution trough. Water distribution tray is made of steel and it has a lot of holes or jagged teeth. Water will flow freely in the holes and flush heat exchangers. The water after the heat exchanger is convective air convection natural heat directly on the staging. To increase the heat dissipation of the water at the tank lid people put nets or bamboo weaves.

Overheated gas enters the tube from above, condenses gradually and flows to the liquid side under, then to the high pressure container. At the top of the condenser is installed the safety valve full, pressure gauge and airless exhaust valve.

Irrigation condenser units also have intermediate liquid extraction tubes to release the delivery surface lower heat transfer, increased heat exchange efficiency.

![Figure 6.8. Irrigation type condenser](image)

During operation it is important to note the damage that can occur to the condenser type irrigation as follows:

- The phenomenon of staining and corrosion of the surface.
- Dirty residue in the water tank should be discharged and cleaned regularly.
- Spray holes must be checked and cleaned.
- The temperature of the water in the tank rises, affecting the heat exchange process, so always partially discharged and cold water added.
b. Advantages and disadvantages.

- **Advantages**
  
  - On the other hand in addition to the heat exchanger pipe, other auxiliary equipment such as support frame, covering the leg there is no need for low metal consumption, low cost.
  
  - Simple, sturdy construction, easy to fabricate and able to use as well as dirty water tubular ceiling is easy to clean. Therefore, the irrigation system is suitable for shallow areas the village has abundant water sources, but the quality is not high.
  
  - Water falls freely on the tube the ceiling should be completely cooled to the air, the water temperature in the tank increased so, the extra water only accounts for about 30% of the circulating water.

- **Disadvantages.**
  
  - During work, water splash around, so the rig can only be installed outside, away from the factory.
  
  - Along with the condenser tube, the condenser type of irrigation consumes quite a lot of water due to it regularly discharge water.
  
  - Due to frequent exposure to water and air, so moist the process of erosion occurs very quickly, if the tube is not dipped hot zinc will be very quickly podium, damaged.
  
  - Cooling effect is influenced by climate environment.

2.5.2.2.3 Air-cooled condenser

a. Structure and operating principle

Air condensers are divided into two types: natural convection and convection convection.

- **Natural convection condenser**

  Natural convection condensers are only used in very small systems, such as cabinets family refrigerators, commercial refrigerators. The components are quite diverse.
  
  - Spiral coils are welded steel wires perpendicular to the coils. Solvent movement in the coil and exchanger with external air. This type the fruit is not high and used in the previous family refrigerator.
  
  - Plates: Including sheet metal used as a heat sink, on which there is welding coil copper.
- Panel type: It consists of 02 aluminum sheets about 1.5mm thick, which is designed for the groove circulating motion. When they were made, they rolled two plates together, at about create grooves, people apply special media to the two sheets do not stick together, then blown water or air pressure (about 40 to 100 bar) in special molds, two plates will swell up into the groove.

![Figure 6.9. Condenser air convection natural](image)

The heat transfer coefficient of the natural convection condenser is about $6 \div 7 \text{ W/m}^2\text{K}$.

- **Forced convection condenser**

  The forced air convection condenser is used extensively in life and industry. The structure consists of a heat exchanger tube made of steel or copper pipes aluminum wing or wing outside, wings in the range of 3?10mm. Air is blowing, horizontal movement outside through the tube at a fairly large speed. Stretcher condensers are usually axial fans. The heat flux density of the air condenser is reached $180 \div 340 \text{ W/m}^2$, heat transfer coefficient $k = 30 \div 35 \text{ W/m}^2\text{K}$, temperature difference $\Delta t = 7 \div 8^\circ\text{C}$.

  During use it should be noted: condensers are often dust, dirt, reduce efficiency heat exchanger should be cleaned regularly with a brush or water. When the gas does not stop into the frame will increase the condensing pressure. Shielding the sun for the condenser, avoid placement of many solar radiation to affect the efficiency of heat exchanger.
Figure 6.10. Air suspension for forced coercion

b. Advantages and disadvantages.

- **Advantages**
  - No use of water, so operating costs decrease. This is very appropriate in places water shortages such as urban areas and crowded residential areas.
  - Do not use the pump system, cooling tower, expensive and cause humidity in the area shop. Air condenser has little impact on the surroundings and can be installed in many places position in the works such as hanging wall, laying on the roof etc.
  - The system uses air-cooled condensers with more simple and easy-to-use equipment.
  - Compared with water-cooled condensers, the condenser air is less damaged and less corrosive.

- **Disadvantages.**
  - Low thermal conductivity, so the structure is rather cumbersome and only suitable for public systems small and medium capacity.
  - The cooling effect is highly dependent on climatic conditions. The days are high very high condensing pressure. For example, the system uses R22, in the central, summer days outdoor air temperature can reach 40°C, corresponding
condensation temperature can reach 48°C, the corresponding condensing pressure is 18.5 bar, equal to the set value of high pressure relays. If in these days there are no special measures, the system can not work activated by the HP relay. For low-efficiency convection heat exchangers, the efficiency is low.

2.5.3 Calculation select Condenser

- Condensing capacity:

\[ Q'_k = \sum Q_0 + \sum N_u \]

In which:

\( \sum Q_0 \): Cooling capacity of compressor \([kW]\)

\( \sum N_u \): Shaft compression capacity \([kW]\)

\( Q'_k \): Condensing capacity \([kW]\)

\[ \sum Q_0 = Q_0 \times 2 = 1622.8 \times 2 = 3245.6 \ [kW] \]

\[ \sum N = N_U = 386 \times 2 = 772 \ [kW] \]

We have:

\[ Q'_k = (3245.6 + 772) \times 1.1 = 4419.36 \ [kW] \]

- With condensing temperature \( t_c = 35^\circ \text{C} \) and wet bulb temperature \( t_{wb} = 28^\circ \text{C} \) (Ho Chi Minh City), From catalog of Evapco we have heat rejection factors = 1.9 (see index 2.5)

  We have condensing capacity is:

\[ Q_k = Q'_k \times 1.9 = 4419.36 \times 1.9 = 8396.784 \ [kW] \]

Conclution: From above data we choose evaporating condensers have model is: 967E-1g (see index 2.6)

- Parameters of evaporating condensers 967E-1g: (we select two condenser)

<table>
<thead>
<tr>
<th>Model No.*</th>
<th>R-717 kW</th>
<th>Fan (quality: 1) kW</th>
<th>Pump (quality: 1) kW</th>
<th>Weight (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>967E-1g</td>
<td>4166</td>
<td>45</td>
<td>7.5</td>
<td>15600</td>
</tr>
</tbody>
</table>

Size of Evaporative Condensers:
2.6 Calculation to select Surge drum (SD)

2.6.1 Introduction about Surge drum (SD)

To prevent liquid flooding on the compressor, on the suction side of the machine compressed, liquid separators are arranged. The liquid separator will separate the remaining dropletssteam before the compressor.

Liquid separators work in accordance with the same principles as oil separators, including:

- Dramatically decreases the flow rate from high speed to low speed of 0.5 ÷ 1.0 m / s. When the decreases the sudden drop of liquid droplets and falls to the bottom of the tank.

- Change the direction of the fluid flow suddenly. Flow of the substance put in a non-straight way that usually turns at certain angles.

- Use shields to prevent droplets. When the flow of the moving media bumps into the the dashboard loses kinetic energy and falls.

- In combination with heat recovery, the vapors of the heat exchanger will evaporate completely.

❖ Scope to use

Most refrigeration systems use liquid separators. In some systems there is one if liquid splitting equipment is available, liquid separators may not be used. For example, in a system with a low-pressure container, a level container, these containers are constructed to be loose should be able to use a liquid separator. In small and very small systems due to the gas circulation is not large so people rarely use the liquid separator.

❖ Structure

Because the principle of liquid separation is very similar to the oil separation, the liquid separator usually has a structure similarly oil separator. The other most distinctive feature of the jar is the liquid separator working temperature range. Oil separator works at high temperature and liquid separator is made the low temperature range should cover the insulation, oil separator placed on the push line, the liquid separator is placed on the suction pipe.

❖ Calculation for liquid Separator
The liquid separator must be large enough to allow the gas speed in the tank to be sufficient.

- Determine inside diameter \( D_t \) of tank:

\[
D_t = \sqrt{\frac{4V_h}{\pi \omega}}, \text{ m} \quad (8.8)
\]

\( V_h \) – Volumetric flow rate through the liquid separator, \( \text{m}^3/\text{s} \);
\( \omega \) - The speed of the vapor in the tank , \( \text{m/s} \).

The speed of the vapor in the tank is small enough to separate liquid particles, \( \omega = 0,5 \div 1,0 \text{ m/s} \).

The vapor volume of the vapor passing through the vase is determined by the formula:

\[
V = G \cdot v_h \quad (8.9)
\]

\( G \) – Mass flow rate of refrigerant in tank, \( \text{kg/s} \);
\( v_h \) - Volumetric flow rate through the liquid separator, similar to suction vapor of compressor, \( \text{m}^3/\text{kg} \)

- The thickness body and bottom of tank:

\[
\delta = \frac{p_{TK} D_t}{200 \varphi \sigma_{CP} - p_{TK}} + C \quad (8.10)
\]

\( p_{TK} \) – Design pressure, \( \text{kG/cm}^2 \). For oil separator \( p_{TK} = 16,5 \text{ kG/cm}^2 \);
\( D_t \) – Inside diameter, \( \text{mm} \);
\( \varphi \) - Coefficient weld strength vertical body. If arc welding\( \varphi = 0,7 \), if intact tube, no welding \( \varphi = 1,0 \);
\( \sigma_{CP} \) - Allowable stresses of material
\( C \) - Additional thickness coefficient ( \( C = 2 \div 3 \text{mm} \))
2.6.2 Classify
2.6.2.1 Cap type Liquid separator

![Diagram of Cap type Liquid separator]

1 – Hơi vào
2 – Vành gía cương
3 – Hơi ra
4 – Nón chấn trên
5 – Cửa hơi xà vào bình
6 – Nóng chấn dưới
7 – Đầu vẻ bình chứa dầu

Figure 8-6: Cap type Liquid separator

Liquid-type separator is constructed similarly to the oil-separator oil-separator. The principle of liquid separation is similar to the oil separator. The other thing is that the casket-type separator does not have a bottom cone, since the cowl the steam is sucked into the liquid separator that does not straighten to the bottom of the tank causing the liquid to distort this is not necessary. The liquid separation principle is similar to the oil separator. Liquid-type separators are widely used in public refrigeration systems large capacity, especially NH₃ refrigeration system.

![Diagram of Shield-type liquid separator]

Hình 8-7: Shield-type liquid separator
Suction pipe to compressor; 2- Vapor pipe in; 3- Cap; 4- Liquid in; 5- Liquid pipe; 6- Hole
oil and liquid retention; 7- Liquid out; 8- heat recovery pipe
2.6.2.2 Liquid separator for heat recovery

Liquid separators are often used for refrigeration systems. Binh has two positions power:

- Liquid separator for vacuum aspiration.
- Too cold flow before the throat to reduce throttling losses.

The heat recovery in the liquid separator increases cooling capacity simultaneously enhances the liquid splitting effect, since a liquid part in the heat exchanger has turned up steam.

The steam from the evaporator is drawn into the nozzle 2 and goes to the bottom of the cone 3. At the bottom of the heat exchanger with liquid motion in the coil, the droplets remain moist it will vaporize and ensure the steam from the liquid separator will have a certain degree of overtemperature. If the moisture droplets have not been vaporized, the caps will separate the liquid drops when the steam flows upward.

The suction pipe on the compressor is bent to the bottom of the tank, where one hole is drilled small = 3 - 4mm to draw oil and loose it inside the liquid separator. Such suction does not cause a lot of flooding and is partially vaporized due to throttling when passing through the holedrill.

The liquid extracted at the bottom of the bottle can also be brought to the indoor unit from the liquid discharge 5.

2.6.2.3 Other liquid separators

In addition to liquid-cooled and heat-recovery flasks, in cold systems there are also other liquid separators. Here is a good form used in small refrigeration systems. In structure similar to a liquid separator heat, but not inside the blanket and heat recovery spiral clusters.
2.6.2.4 Liquid and liquid separator tank

In some types of flooded flooded cooling systems, a level holding tank must be used provides and maintains fluid levels in the evaporator. In addition to keeping the level of translation for evaporators, the tank also has the function of separating loose steam on the compressor. So called level holder - liquid separation.

Liquid separators are used in many different refrigeration systems: Cabinets winter, stone machine, stone breaker, wind freezer etc ... There are different names on the name functionality is the same.

Figures 8-9 and 8-10 show the structure and principle of the liquid separator installation commonly used for stone plant systems. In terms of composition, jars include body and legs cylinder, with liquid shields on top. The panels are inclined at an angle of 30 ° from the direction horizontal, on the drill holes for passing steam. On the tank with the float valve to stop maximum fluid level in the tank to avoid vacuum on the compressor, safety valve, manometer and pipe in and out.

The discharge from the tank to the cooler is done by the hydrostatic pressure column. Liquid in the indoor unit heat up with salt water, vaporise and exit the tube above and into the jar level. The result of the liquid level in the evaporator drops down and the liquid from the tank keeps the input level the evaporator evaporates from the bottom, creating a circulation.

Use a level flask to dispense the coolant that has advantages in the evaporator always fluid is always filled so the efficiency of heat exchange is quite large. However liquid liquid in the refrigeration system of this system convection of natural convection. Convection velocity depends much on the speed of vaporization and generally small speed, so more or less affect the effect heat exchanger. Want to further strengthen the heat exchanger to do the opposite forced forced pump.
Figure 8-9: Liquid and liquid separator tank

1- Refrigerant pipe out; 2- throttling pipe in; 3- Gas in; 4- Float valve and pressure gauge; 5- suction pipe to compressor; 6- Plate stop liquid; 7,8- Float valve pipe; 9- drain pipe; 10- Foot tank

Hình 8-10: Installation Liquid and liquid separator tank
**Refrigerants Mass flow rate in SD**

\[ m'_2 = \frac{1.10 \times Q}{\Delta i} = \frac{1.1 \times Q}{(i_1' - i_5) \times 2}, [kg/s] \]

In Which:

- \( Q \) : Cooling capacity of Evaporator(kw)
- \( m'_2 \) : Refrigerants mass flow rate in SD \([kg/s]\)
- \( i_1' - i_5 \) : Entanpy \( (kJ/kg)\)

\[ \Rightarrow m'_2 = \frac{1.1 \times 3204.122}{(1451.8 - 353.22) \times 2} = 1.60413 [kg/s] \]

**Volumn flow rate:**

\[ G \left[ m^3/s \right] = m'_2 \left[ kg/s \right] \times \vartheta_1' \left[ m^3/kg \right] \]

- \( \vartheta_1' \) : Specific volumn of refrigerants at point saturation 1'. \( (m^3/kg) \)
- \( m'_2 \) : Refrigerants mass flow rate in SD \( (kg/s) \)
- \( G \) : Volumn flow rate \( (m^3/s) \)

\[ \Leftrightarrow G = 1.60413 \times 0.3871 = 0.621 \left[ m^3/s \right] \]

The velocity of refrigerant in SD: \( \omega = 0.2 \div 0.25 \left[ m/s \right] \). We choose \( \omega = 0.35 \left[ m/s \right] \)

The area of vapor:

\[ S = \frac{G}{\omega} \]

- \( S \) : Area of vapor \( (m^2) \)
- \( G \) : Volumn flow rate \( (0.621 \ m^3/s) \)
- \( \omega \) : The velocity of refrigerants \( (0.25 \ m/s) \)

\[ S = \frac{G}{\omega} = \frac{0.621}{0.25} = 2.484 \ m^2 \]
**Diameter for SD:**

\[
\frac{\pi \times d^2}{4} - 0.1535 \times d^2 = S
\]

- **d**: Inside diameters of SD (mm)
- **S**: Area of vapor (m²)

\[
0.1535 \times d^2 : \text{Area of liquid (0.621 m³/s)} \quad (\text{Height of liquid by } \frac{1}{4} \text{d})
\]

\[
\frac{\pi \times d^2}{4} - 0.1535 \times d^2 = S
\]

\[\Leftrightarrow d^2 (\frac{\pi}{4} - 0.1535) = 2.484\]

\[\Leftrightarrow d^2 = 3.931\]

\[\Leftrightarrow d = 1.983\]

- Choose diameters follow standard ASTM: \(d = 1828.8 \text{[mm]}\)

**The thickness of body tank:**

\[
s = \frac{p \times D}{200 \times \phi \times \delta_{cp} - p} + C
\]

\[\Leftrightarrow s = \frac{12 \times 1828.8}{200 \times 0.8 \times 15.69 - 12} + 5 = 13.78 \text{[mm]}\]

In Which:

- **p**: Design pressure for SD. 12 [bar]
- **\(\phi\)**: Coefficient weld strength vertical body. \(\phi = 0.8\) (ông hàn).
- **\(\delta_{cp}\)**: Allowable stresses of material \(\delta_{cp} = 15.69\) (SS 400)
- **C**: Additional thickness coefficient (we choose 5)
- **D**: Inside diameters of SD [mm]

- Follow thickness standard, we choose thickness steel:

\[s = 14.3 \text{[mm]} = SCH XS\]

**The Length between cap and body SD:**

\[h_0 = 0.255 \times d + 0.365 \times t\]

In Which:

- **\(h_0\)**: The length between cap and body SD (mm)
- **d**: Inside diameters of SD (mm)
t : The thickness body (14.3 mm)

\[ \iff h_0 = 0.255 \times 1828.8 + 0.365 \times 14.3 = 471.5635 \text{[mm]} \]

- **The thickness of cap**:

\[ s = \frac{p \times D}{400 \times z \times \delta_{cp}} \times \frac{D}{2 \times h_0} + C \]

Conditions to apply above formula is: \( \frac{h_0}{D} \geq 0.2 \)

In Which:

\( h_0 \) : The length between cap and body SD (mm)

\( D \) : Inside diameters of SD [mm]

\[ \iff \frac{h_0}{D} = \frac{471.5635}{1828.8} = 0.26 \geq 0.2 \]

So:

\[ s = \frac{p \times D}{400 \times z \times \delta_{cp}} \times \frac{D}{2 \times h_0} + C \]

\[ \iff s = \frac{12 \times 1828.8}{400 \times 1 \times 15.69} \times \frac{1828.8}{2 \times 471.5635} + 5 = 11.77 \text{[mm]} \]

In Which:

- \( p \) : Design pressure for SD. 12 [bar]
- \( z = 1 \)
- \( \delta_{cp} \) : Allowable stresses of material \( \delta_{cp} = 15.69 \text{ (SS 400)} \)
- \( C \) : Additional thickness coefficient (we choose 5)
- \( h_0 \) : The length between cap and body SD (mm)
- \( D \) : Inside diameters of SD [mm]

To ensure the safety of Surge drum, select the thickness of body and cap is 14.3 mm.

- **The length from body to cap**:

\[ h_1 = 3 \times s \]

In Which:

\( h_1 \) : The length from body to cap (mm)

\( s \) : The thickness body (mm)

\[ \iff h_1 = 3 \times s = 3 \times 14.3 = 42.9 \text{[mm]} \]
• **Total length from body to top of cap**: 

\[ h = h_1 + h_0 \]

In Which:
- **h**: Total length from body to top of cap (mm)
- **h₁**: The length from body to cap (mm)
- **h₀**: The length between cap and body SD (mm)

\[ h = h_1 + h_0 = 42.9 + 471.5635 = 514.4635 \text{ [mm]} \]

• **The length of body SD**: 

Because: \( L = (2 \sim 3) \cdot d \) (select \( L = 2.74 \) )

In Which:
- **L**: The length of body surge drum (m)
- **d**: Inside diameters of SD (m)

\[ \rightarrow \text{Select } L = 2 \times 1828.8 = 3657.6 \text{ [m]} . \]

• **Total length of SD**: 

\[ L_t = 2 \times h + L \]

In Which:
- **\( L_t \)**: Total length of SD (m).
- **h**: Total length from body to top of cap (m)
- **L**: The length of body surge drum (m)

\[ H_t = 2 \times h + H = 2 \times 0.5145 + 3.6576 = 4.7 \text{ [m]} . \]

We choose Total length of SD is: 5000 m
2.7 Thermosyphon tank (TR)
2.7.1 Introduction about Thermosyphon tank
2.7.2 Calculation for Thermosiphon

- **Oil Cooling Capacity**:
  \[ Q_{oil} = ( Q_{MN} + N_e ) \times K_1 \times K_2 \]

  In Which:
  
  \( Q_{oil} \): Oil Cooling Capacity (kW)
  
  \( Q_{MN} \): Cooling capacity of compressor (kW)
  
  \( N_e \): Absorbed power (kW)
  
  \( K_1 \): Safe factor
  
  \( K_2 \): Actual factor follow condensing temperature 35°C and evaporative temperature -8°C (see index 2.7)

  \[ Q_{oil} = (1622.8 \times 2 + 386 \times 2) \times 1.05 \times 8\% \]
  \[ Q_{oil} = 337.48 \text{ (Kw)} \]

- **Mass flow rate of refrigerants liquid to cooling oil**:
  \[ m = \frac{Q_{oil}}{i} \]

  In Which:
  
  \( m \): Mass flow rate of refrigerants liquid to cooling oil (kg/s).
  
  \( i \): Latent heat at 35°C (kJ/kg).

  \[ m = \frac{337.48}{1125.5} = 0.29985 \text{ (kg/s)} \]

- **Volumn flow rate**:
  \[ G \left[ m^3/s \right] = m \left[ kg/s \right] \times \vartheta_3 \left[ m^3/kg \right] \]

  In Which:
  
  \( \vartheta_3 \): Specific volumn of refrigerants at liquid saturation point 3 (m³/kg)
  
  \( m \): Mass flow rate of refrigerants liquid to cooling oilin TR (kg/s)
  
  \( G \): Volumn flow rate (m³/s)
\( G = 0.29985 \times 0.0017 = 5.09745 \times 10^{-4}[m^3/s] \)

- **Volumn of TR:**

The volumn in TR have ensure enough to liquid to supply to cooling oil maintain in 5 minute

\[
V = G \times t
\]

In Which :

\( V \) : The volume liquid in TR \((m^3)\)

\( G \) : Volumn flow rate \((m^3/s)\)

\( t \) : Time to maintain liquid cooling oil \((s)\)

\[
V = 5.09745 \times 10^{-4} \times 5 \times 60 = 0.153 \ (m^3)
\]

- **Actual volumn of TR tank:**

We choose \( \frac{1}{2} \) is liquid và \( \frac{1}{2} \) is vapor.

\[
V_{tt} = V \times 2
\]

In Which :

\( V \) : The volume liquid in TR \((m^3)\)

\( V_{tt} \) : Actual volume of TR tank \((m^3)\)

\[
V_{tt} = 0.153 \times 2 = 0.306 \ (m^3)
\]

- **The size of TR tank là:**

We select ratio length and diameter \( \frac{L}{d} = (2 - 5) \)

Select diameter of TR tank :

\[
d = 609.6 \ mm
\]

Length is \( L \):

\[
L = d \times 2 = 609.6 \times 2 = 1219.2 \ mm
\]

Radius of TR tank :

\[
R = \frac{d}{2} = \frac{609.6}{2} = 304.8 \ mm
\]

The volumn of TR tank :

\[
V = \pi \times r^2 \times L
\]
$V = \pi \times r^2 \times L$

$V = 3.14 \times 0.304^2 \times 1.2192$

$V = 0.354 \text{ (m}^3\text{) } > V_{tt} = 0.306 \text{ (m}^3\text{)}$

We choose volume of tank greater than actual volume:

Select $d = 609.6 \text{ m, } L = 1.2192 \text{ m, } V = 0.354 \text{ (m}^3\text{)}$

- **The thickness of body tank**:

  $$s = \frac{p \times D}{200 \times \varphi \times \delta_{cp} - p} + C$$

  $$\Leftrightarrow s = \frac{18 \times 609.6}{200 \times 0.8 \times 15.69 - 18} + 5 = 9.4 \text{ [mm]}$$

  In Which:

  - $p$ : Design pressure for TR. 18 [bar]
  - $\varphi$ : Coefficient weld strength vertical body. $\varphi = 0.8$ (ông hàn).
  - $\delta_{cp}$ : Allowable stresses of material $\delta_{cp} = 15.69$ (SS 400)
  - $C$ : Additional thickness coefficient (we choose 5)
  - $D$ : Inside diameters of TR [mm]

- Follow thickness standard, we choose thickness steel:

  $$s = 10.3 \text{ [mm]} = SCH XS$$

- **The Height between cap and body SD**:

  $$h_0 = 0.255 \times d + 0.365 \times t$$

  In Which:

  - $h_0$ : The height between cap and body TR [mm]
  - $d$ : Inside diameters of TR [mm]
  - $t$ : The thickness body (10.3 mm)

  $$\Leftrightarrow h_0 = 0.255 \times 609.6 + 0.365 \times 10.3 = 159.2075 \text{ [mm]}$$

- **The thickness of cap**:

  $$s = \frac{p \times D}{400 \times z \times \delta_{cp}} \times \frac{D}{2 \times h_0} + C$$

  Conditions to apply above formula is: \[\frac{h_0}{D} \geq 0.2\]

  In Which:
$h_0$ : The height between cap and body TR (mm)

$D$ : Inside diameters of TR [mm]

\[ h_0 = \frac{159.2075}{609.6} = 0.261 \geq 0.2 \]

So :

\[ s = \frac{p \times D}{400 \times z \times \delta_{cp}} \times \frac{D}{2 \times h_0} + C \]

\[ \Leftrightarrow s = \frac{18 \times 609.6}{400 \times 1 \times 15.69} \times \frac{609.6}{2 \times 159.2075} + 5 = 8.35 \text{ [mm]} \]

In Which :

✓ $p$ : Design pressure for TR. 18 [bar]
✓ $z = 1$
✓ $\delta_{cp}$ : Allowable stresses of material $\delta_{cp} = 15.69$ (SS 400)
✓ $C$ : Additional thickness coefficient (we choose 5)
✓ $h_0$ : The length between cap and body TR (mm)
✓ $D$ : Inside diameters of TR [mm]

To ensure the safety of TR, select the thickness of body and cap is 10.3 mm.

- **The height from body to cap** :

  \[ h_1 = 3 \times s \]

In Which :

$h_1$ : The height from body to cap (mm)

$s$ : The thickness body (mm)

\[ \Leftrightarrow h_1 = 3 \times s = 3 \times 10.3 = 30.9 \text{ [mm]} \]

- **Total height from body to top of cap** :

  \[ h = h_1 + h_0 \]

In Which :

$h$ : Total height from body to top of cap (mm)

$h_1$ : The height from body to cap (mm)

$h_0$ : The height between cap and body TR (mm)

\[ h = h_1 + h_0 = 30.9 + 159.2075 = 190.1075 \text{ [mm]} \]
• **The height of body TR:**

\[ H = (2 \sim 3) \cdot d \ (\text{select } H = 2) \]

In Which:

- \( H \): The height of body TR (m)
- \( d \): Inside diameters of TR (m)

\[ \rightarrow H = 2 \times 0.6096 = 1.2192 \ [m] . \]

• **Total height of TR:**

\[ H_t = 2 \times h + H \]

In Which:

- \( H_t \): Total height of TR (m).
- \( h \): Total height from body to top of cap (m)
- \( H \): The height of body TR (m)

\[ H_t = 2 \times h + H = 2 \times 0.19011 + 1.2192 = 1.59942 \ [m] . \]

### 2.8 Liquid Separator (LT)

#### 2.8.1 Introduction about Liquid Separator (LT)

In order to prevent liquid flooding, compressors are placed on the suction side of the compressor. The liquid separator removes the remaining droplets from the steam before returning to the compressor.

Liquid separators work in accordance with the same principles as oil separators, including:

- Dramatically decreases the flow rate from high speed to low speed of 0.5 ÷ 1.0 m / s. when the

Decreases the sudden drop of liquid droplets and falls to the bottom of the tank.
- Change the direction of the fluid flow suddenly. Flow of the substance

Put in a non-straight way that usually turns at certain angles.

- Use shields to prevent droplets. When the fluid flow hits the droplets, the droplet loses its kinetic energy and falls off.

- Combination of liquid heat recovery, the vapor of the heat exchanger will evaporate completely.
The scope of use

Most refrigeration systems use liquid separators. In some systems there are some liquid separators that may not be used. For example, in a system with a low-pressure container, a level container, these containers are constructed to be able to separate the liquid so it may not be possible to use the liquid separator. In small and very small systems due to the large amount of gas circulation, it is rarely used for liquid separators.

Structure

Because the principle of liquid separation is very similar to the oil separation, the liquid separator usually has the same effect as the oil separator. The most distinctive feature of the cylinders is that the separator is the working temperature range. The oil separator works at a high temperature and the liquid separator works at low temperature so it is necessary to insulate the oil separator on the discharge line while the liquid separator is placed on the suction pipe.

2.8 Calculation for Liquid trap (LT)

- **Mass flow rate of refrigerants vapor after cooling oil**.

  \[
  m = \frac{Q_{\text{oil}}}{i}
  \]

  in which :

  \( m \) : Mass flow rate of refrigerants vapor after cooling oil (kg/s).

  \( i \) : Ethalpy of vapor at 35°C (kJ/kg).

  \[
  m = \frac{337.48}{1487.8} = 0.22683 \text{ (kg/s)}.
  \]

- **Volumn Flow rate**:

  \[
  G_h \left[ \frac{m^3}{s} \right] = m \left[ \frac{kg}{s} \right] \times \vartheta_3 \left[ \frac{m^3}{kg} \right]
  \]

  in which :

  \( \vartheta_3 \) : Specific volumn of refrigerants at status vapor 35°C (m³/kg).

  \( m \) : Mass flow rate of refrigerants vapor after cooling oil (kg/s).

  \( G_h \) : Volumn Flow rate (m³/s).

  \[
  \Leftrightarrow G_h = 0.22683 \times 95.96 \times 10^{-3} = 0.0218 \left[ \frac{m^3}{s} \right]
  \]
- **Diameter of vapor pipe:**

\[ D = \sqrt{\frac{4 \times G_h}{\pi \times \omega}} = \sqrt{\frac{4 \times 0.0218}{\pi \times 2}} = 0.11781 \text{ m} = 117.81 \text{ mm} \]

\( \Rightarrow \) We select vapor pipe is : DN100 and \( d_i = 102.26 \), \( \omega = 2.65 \text{ m/s} \)

- **Diameter of LT tank:**

\[ \omega_h \times D_h^2 = \omega_{LT} \times D_{LT}^2 \]
\[ \Leftrightarrow 2.65 \times 0.10226^2 = 0.5 \times D_{LT}^2 \]
\[ \Leftrightarrow D_{LT} = 0.235 \text{ [m]} \]

\( \rightarrow \) Select diameter follow standard ASTM : \( d = 273 \text{ [mm]} \).

- **The height of tank:**

We choose radio diameter and height : \( \frac{H}{d} = (2 - 5) \)

So Height :

\[ H = d \times 3 = 273 \times 3 = 819 \text{ mm} \]

- **The thickness of body tank:**

\[ s = \frac{p \times D}{200 \times \varphi \times \delta_{cp} - p} + C \]
\[ \Leftrightarrow s = \frac{18 \times 273}{200 \times 0.8 \times 15.69 - 18} + 5 = 6.97 \text{ [mm]} \]

In Which:

- \( p \): Design pressure for LT. 18 [bar]
- \( \varphi \): Coefficient weld strength vertical body. \( \varphi = 0.8 \) (ông hàm).
- \( \delta_{cp} \): Allowable stresses of material\( \delta_{cp} = 15.69 \) (SS 400)
- \( C \): Additional thickness coefficient (we choose 5)
- \( D \): Inside diameters of LT [mm]

\( \Rightarrow \) Follow thickness standard, we choose thickness steel :

\[ s = 7.09 \text{ [mm]} = SCH XS \]

- **The Height between cap and body LT:**

\[ h_0 = 0.255 \times d + 0.365 \times t \]

In Which:

\( h_0 \): The height between cap and body LT (mm)
d : Inside diameters of LT (mm)

t : The thickness body (7.09 mm)

\[
\Rightarrow h_0 = 0.255 \times 273 + 0.365 \times 7.09 = 72.2 \text{[mm]}
\]

- **The thickness of cap**:

\[
s = \frac{p \times D}{400 \times z \times \delta_{cp}} \times \frac{D}{2 \times h_0} + C
\]

Conditions to apply above formula is: \( \frac{h_0}{D} \geq 0.2 \)

In Which:

\( h_0 \) : The height between cap and body LT (mm)

\( D \) : Inside diameters of LT [mm]

\[
\Leftrightarrow \frac{h_0}{D} = \frac{72.2}{273} = 0.2645 \geq 0.2
\]

\[
s = \frac{18 \times 273}{400 \times 1 \times 15.69} \times \frac{273}{2 \times 72.2} + 5 = 6.48 \text{[mm]}
\]

In Which:

\( p \) : Design pressure for LT. 18 [bar]

\( z = 1 \)

\( \delta_{cp} \) : Allowable stresses of material \( \delta_{cp} = 15.69 \text{[SS 400]} \)

\( C \) : Additional thickness coefficient (we choose 5)

\( h_0 \) : The length between cap and body LT (mm)

\( D \) : Inside diameters of LT [mm]

To ensure the safety of LT, select the thickness of body and cap is 7.09 mm.

- **The height from body to cap**:

\[
h_1 = 3 \times s
\]

In Which:

\( h_1 \) : The height from body to cap (mm)

\( s \) : The thickness body (mm)

\[
\Leftrightarrow h_1 = 3 \times s = 3 \times 7.09 = 21.27 \text{[mm]}
\]
- **Total length from body to top of cap**:  
  \[ h = h_1 + h_0 \]
  
  In Which:
  
  \( h \): Total height from body to top of cap (mm)
  
  \( h_1 \): The height from body to cap (mm)
  
  \( h_0 \): The height between cap and body LT (mm)
  
  \[ h = h_1 + h_0 = 21.27 + 72.2 = 93.47 \text{ } [mm] \]

- **The height of body LT**:  
  
  - So: \( H = (2.5 \sim 3) \cdot d \) (select \( H = 3 \))
  
  In Which:
  
  \( H \): The height of body LT (m)
  
  \( d \): Inside diameters of LT (m)
  
  \[ \text{Select} H = 3 \times 273 = 819 \text{ } [m] \]

- **Total height of LT**:  
  
  \[ H_t = 2 \times h + H \]
  
  In Which:
  
  \( H_t \): Totalheight of LT(m).
  
  \( h \): Totalheight from body to top of cap(m)
  
  \( L \): Theheight of body LT (m)
  
  \[ H_t = 2 \times h + H = 2 \times 0.09347 + 0.819 = 1 \text{ } [m] \]
2.9 Oil Receiver:
In the NH3 refrigeration system, the oil is collected on an oil recovery tank. Oil reclaimed tank is composed of high pressure tank containing the following parts: cylindrical body, the elliptical bottom, the upper is fitted with hydraulic oil level gauge, safety valve, pressure gauge, oil return line about, the pipe connected to the straw and the bottom flush.

![Diagram of Oil Receiver](image)

Figure 8-11 : Oil receiver

1- Liquid Glasses; 2- Pressure gauge ; 3- safe valve ; 4- Suction pipe ; 5- oil pipe ; 6- oil drain

To recover the oil from the oil recovery equipment, first of all pressurize the container with the compressor connection line. Then open the oil drainage valve of the device to oil automatically flows to the tank. The oil is then rinsed out and treated or discarded, before the oil is drained, lowering the pressure in the tank to approximately atmospheric pressure. It is not allowed to vacuum the oil in the tank when the oil is discharged, as this will not only prevent the oil from leaking, but also allow the air to escape into the system.

The capacity of oil recovery tanks is typically 60 to 100 liters. In the central refrigeration systems, larger cylinders can be used.

We choose Receive oil Tank size : 325 x 1000 mm.
2.10 Calculation for ethylene glycol solution tank

We have formula:

\[ V = \pi \times r^2 \times H \]

In Which:

\( V \): [90 (m^3)] Volume of tank
\( D \): [3.5 (m)] Diameter
\( R \): [(m)] Radius
\( H \): [(m)] Height of tank

**Radius of tank**:

\[ r = \frac{d}{2} = \frac{3.5}{2} = 1.75 \text{ m} \]

**Height of tank**:

\[ V = \pi \times r^2 \times H \quad \Rightarrow \quad H = \frac{V}{\pi \times r^2} = \frac{90}{3.14 \times 1.75^2} = 9.4 \text{ m} \]

- **Thickness of body tank**:

\[
 s = \frac{p \times D}{200 \times \varphi \times \delta_{cp} - p} + C
\]

\[
 \Leftrightarrow s = \frac{1.01325 \times 3500}{200 \times 0.8 \times 15.69 - 1.01325} + 5 = 6.413 \text{ [mm]}
\]

In Which:

- \( p = 1.01325 \text{[bar]} \), design pressure for tank.
- \( \varphi \): Coefficient weld strength vertical body. \( \varphi = 0.8 \) (ông hàn).
- \( \delta_{cp} \): Allowable stresses of material \( \delta_{cp} = 15.69 \text{ (SS 400)} \)
- \( C \): Additional thickness coefficient (we choose 5)
- \( D \): Inside diameters of Tank [mm]

- Follow thickness standard, we choose thickness steel:

\[
 s = 8 \text{[mm]} = SCH XS
\]

- **The height between cap and body Tank**:

\[
 h_0 = 0.255 \times d + 0.365 \times t
\]

In Which:

\( h_0 \): The height between cap and body Tank (mm)
Inside diameters of Tank (mm)

The thickness body (8 mm)

\[ h_0 = 0.255 \times 3500 + 0.365 \times 8 = 895.42 [mm] \]

- **The thickness of cap**:

\[
s = \frac{p \times D}{400 \times z \times \delta_{cp}} \times \frac{D}{2 \times h_0} + C
\]

Conditions to apply above formula is: \( \frac{h_0}{D} \geq 0.2 \)

In Which:

- \( h_0 \): The height between cap and body tank (mm)
- \( D \): Inside diameters of tank (mm)
- \( p \): Design pressure for tank (bar)
- \( z \): 1
- \( \delta_{cp} \): Allowable stresses of material \( \delta_{cp} = 15.69 \) (SS 400)
- \( C \): Additional thickness coefficient (we choose 5)
- \( h_0 \): The length between cap and body tank (mm)
- \( D \): Inside diameters of tank (mm)

To ensure the safety of Tank, select the thickness of body and cap is 8 mm.

- **The height from body to cap**:

\[ h_1 = 3 \times s \]

In Which:

- \( h_1 \): The height from body to cap (mm)
- \( s \): The thickness body (mm)

\[ h_1 = 3 \times s = 3 \times 8 = 24 [mm] \]

- **Total height from body to top of cap**:
\[ h = h_1 + h_0 \]

In Which:

\( h \) : Total height from body to top of cap (mm)

\( h_1 \) : The height from body to cap (mm)

\( h_0 \) : The height between cap and body tank (mm)

\[ h = h_1 + h_0 = 24 + 895.42 = 919.42 \ [mm] \]

- **The height of body tank:**

So:\( H = (2 \sim 5) \cdot d \) (Select \( H = 3 \))

In Which:

\( H \) : The height of body Tank (m)

\( d \) : Inside diameters of tank (m)

\[ \rightarrow \text{Select} \ H = 2.68 \times 3500 = 9.38 \ [m] . \]

- **Total height of tank:**

\[ H_t = 2 \times h + L \]

In Which:

\( H_t \) : Total height of Tank (m)

\( h \) : Total height from body to top of cap (m)

\( L \) : The height of body Tank (m)

\[ H_t = 2 \times h + H = 2 \times 0.92 + 9.38 = 11.22 \ [m] . \]

We choose total height of Tank is : 11 m
2.11 Calculation diameter pipe.

Diameter pipe after cooling oil:

- Mass flow rate of refrigerant at vapor after cooling oil is:
  \[ m = \frac{Q_{oil}}{i} \]
  
  In Which:
  - \( m \): Mass flow rate of refrigerant of vapor after cooling oil (kg/s)
  - \( i \): Enthalpy of vapor at 35°C (kJ/kg)
  
  \[ m = \frac{337.48}{1487.8} = 0.2268 \text{ (kg/s)} \]

- Volumn flow rate:
  \[ G_h \left[ \frac{m^3}{s} \right] = m \left[ \frac{kg}{s} \right] \times v \left[ \frac{m^3}{kg} \right] \]

  In Which:
  - \( v \): Specific volumn of vapor at 35°C (m³/kg)

  \[ m : \text{Mass flow rate of refrigerant at vapor after cooling oil (kg/s)} \]
  \[ G_h : \text{Volumn flow rate (m³/s)} \]
  \[ \Leftrightarrow G_h = 0.2268 \times 95.96 \times 10^{-3} = 0.0218 \left[ \frac{m^3}{s} \right] \]

- Diameter vapor pipe after cooling oil:
  \[ D = \sqrt{\frac{4 \times G_h}{\pi \times \omega}} = \sqrt{\frac{4 \times 0.0218}{\pi \times 2}} = 0.11781 \text{ m} = 117.81 \text{ mm} \]

→ Select DN100 : \( d_i = 102.26 \text{ mm} \omega = 2.65 \text{ m/s (see index 1.5)} \)

- Mass flow rate of refrigerant at liquid after cooling oil is:
  \[ m = \frac{Q_{oil}}{i} \]

  In Which:
  - \( m \): Mass flow rate of refrigerant of liquid after cooling oil (kg/s)
  - \( i \): Enthalpy of liquid at 35°C (kJ/kg)
\[ m = \frac{337.48}{362.33} = 0.93142 \text{ (kg/s)} \]

- Volumn flow rate:
  \[ G_l [m^3/s] = m \left[ \frac{kg}{s} \right] \times \vartheta_3 \left[ \frac{m^3}{kg} \right] \]

Trong đó:

\( \vartheta_3 \) : Specific volumn of liquid at 35\(^\circ\)C. \( \left( \frac{m^3}{kg} \right) \)

\( m \) : Mass flow rate of refrigerant of liquid after cooling oil \( \left( \frac{kg}{s} \right) \)

\( G_l \) : Volumn flow rate \( \left( m^3/s \right) \)

\[ \Leftrightarrow G_l = 0.93142 \times 0.0017 = 1.58341 \times 10^{-3} [m^3/s] \]

- Diameter liquid pipe after cooling oil connect to cooling oil pipe:

\[ D = \sqrt{\frac{4 \times G_{h}}{\pi \times \omega}} = \sqrt{\frac{4 \times 1.58341 \times 10^{-3}}{\pi \times 0.5}} = 0.0635\text{m} = 63.5\text{mm} \]

\( \Rightarrow \) Select DN50 : \( d_i = 52.48\text{mm} \ \omega = 0.732\text{ m/s} \) \( \text{(see index 1.5)} \)

Total mass of liquid and vapor after cooling oil:

\[ G = G_{h} + G_{l} = 0.0218 + 1.58341 \times 10^{-3} = 0.0234 \left[ m^3/s \right] \]

- Diameter pipe after cooling oil:

\[ D = \sqrt{\frac{4 \times G}{\pi \times \omega}} = \sqrt{\frac{4 \times 0.0234}{\pi \times 2.5}} = 0.10917 \text{ m} = 109.17\text{mm} \]

\( \Rightarrow \) Select DN100 : \( d_i = 102.26\text{ mm} \ \omega = 2.85\text{ m/s} \) \( \text{(see index 1.5)} \)

Total mass of liquid and vapor after cooling oil of one compressor:

\[ G = \frac{G_{h} + G_{l}}{2} = \frac{0.0218 + 1.58341 \times 10^{-3}}{2} = 0.0117 \left[ m^3/s \right] \]

- Diameter Branch Pipe after cooling oil:

\[ D = \sqrt{\frac{4 \times G}{\pi \times \omega}} = \sqrt{\frac{4 \times 0.0117}{\pi \times 2.5}} = 0.0772 \text{ m} = 77.2\text{mm} \]

\( \Rightarrow \) Select DN80 : \( d_i = 77.92\text{ mm} \ \omega = 2.454\text{ m/s} \) \( \text{(see index 1.5)} \)
Diameter main pipe cooling oil:

- Mass flow rate of refrigerant of liquid to cooling oil:
  \[ m = \frac{Q_{oil}}{i} \]

In which:

- \( m \) : Mass flow rate of refrigerant of liquid (kg/s).
- \( i \) : Latent heat at 35°C. (kJ/kg).

\[ m = \frac{337.48}{1125.5} = 0.29985 \text{ (kg/s)} \]

- Volum flow rate:
  \[ G_l \left[ \frac{m^3}{s} \right] = m \left[ \frac{kg}{s} \right] \times \vartheta_3 \left[ \frac{m^3}{kg} \right] \]

In which:

- \( \vartheta_3 \) : Specific volum of liquid at liquid saturation 35°C. \( \left[ \frac{m^3}{kg} \right] \)
- \( m \) : Mass flow rate of refrigerant of liquid in tank \( \left[ \frac{kg}{s} \right] \)
- \( G_l \) : Volum flow rate \( \left[ \frac{m^3}{s} \right] \)

\[ \Leftrightarrow G_l = 0.29985 \times 0.0017 = 5.09745 \times 10^{-4} \left[ \frac{m^3}{s} \right] \]

- Diameter liquid pipe cooling oil:
  \[ D = \sqrt{\frac{4 \times CR \times G_l}{\pi \times \omega}} = \sqrt{\frac{4 \times 3 \times 5.09745 \times 10^{-4}}{\pi \times 0.3}} = 0.08056 \text{ m} = 80.56 \text{ mm} \]

\( \Rightarrow \) Select DN80 : \( d_i = 77.92 \text{mm} \) \( \omega = 0.33 \text{ m/s} \) (see index 1.5)

Diameter branch pipe cooling oil:

- Mass flow rate of refrigerant of liquid to cooling oil:
  \[ m = \frac{337.48}{1125.5} = 0.29985 \text{ (kg/s)} \]

In which:

- \( m \) : Mass flow rate of refrigerant of liquid (kg/s).
- \( i \) : Enthalpy (kJ/kg).

\[ m = \frac{337.48}{1125.5} = 0.29985 \text{ (kg/s)} \]

- Mass flow rate of refrigerant of liquid to cooling oil for one compressor:
\[ m = \frac{m_1}{2} = \frac{0.29985}{2} = 0.15 \text{ (kg/s)} \]

- Volum flow rate:

\[ G_t [m^3/s] = m \left[ \frac{kg}{s} \right] \times \vartheta_3 \left[ m^3/kg \right] \]

In which:

\( \vartheta_3 \) : Specific volume of liquid at liquid saturation 35°C \( (m^3/kg) \)

\( m \) : Mass flow rate of refrigerant of liquid in tank \( (kg/s) \)

\( G_t \) : Volume flow rate \( (m^3/s) \)

\[ \Leftrightarrow G_t = 0.15 \times 0.0017 = 2.55 \times 10^{-4} \text{ [m}^3/\text{s}] \]

- Diameter liquid pipe cooling oil:

\[ D = \sqrt{\frac{4 \times CR \times G_t}{\pi \times \omega}} = \sqrt{\frac{4 \times 3 \times 2.55 \times 10^{-4}}{\pi \times 0.3}} = 0.05698 \text{ m} = 56.98 \text{ mm} \]

\( \Rightarrow \) Select DN50 : \( d_i = 52.48 \text{mm} \) \( \omega = 0.354 \text{ m/s} \) (see index 1.5)

**Diameter pipe supply to TR tank:**

- Condensing capacity.

\[ Q_{k1} = 8396.784 \text{ [kW]} \]

- Mass flow rate of refrigerant of liquid supply to TR:

\[ m = \frac{Q_k}{i_2-i_4} \]

In which:

\( m \) : Mass flow rate of refrigerant of liquid \( (kg/s) \).

\( i_2, i_4 \) : Enthalpy \( (kJ/kg) \).

\[ m = \frac{8396.784}{1679.52-353.22} = 6.331 \text{ (kg/s)} \]

- Volum flow rate:

\[ G_t [m^3/s] = m \left[ \frac{kg}{s} \right] \times \vartheta_4 \left[ m^3/kg \right] \]

In which:

\( \vartheta_4 \) : Specific volume of liquid at liquid saturation 33°C \( (m^3/kg) \)

\( m \) : Mass flow rate of refrigerant of liquid \( (kg/s) \)
\( G_l \): Volum flow rate \((m^3/s)\)
\[ \Leftrightarrow G_l = 6.331 \times 0.0016933 = 0.01072 \ [m^3/s] \]

- Diameter pipe supply to TR tank:
\[ D = \sqrt{\frac{4 \times G_l}{\pi \times \omega}} = \sqrt{\frac{4 \times 0.01072}{\pi \times 0.6}} = 0.15083 \text{ m} = 150.83 \text{ mm} . \]

\( \Rightarrow \) Select DN125 : \( d_l = 128.2 \text{ mm} \) \( \omega = 0.83 \text{ m/s} \) \((\text{see index 1.5})\)

**Diameter pipe supply to HPR:**

- Condensing capacity.
\[ Q_k = 8396.784 \ [kW] \]

- Mass flow rate of refrigerant of liquid supply to HPR :
\[ m = \frac{Q_k}{t_2-t_4} \]

In which:

- \( m \): Mass flow rate of refrigerant of liquid \((\text{kg/s})\).
- \( t_2, t_4 \): Enthalpy \((\text{kJ/kg})\).

\[ m = \frac{8396.784}{1679.52-353.22} = 6.331 \ \text{(kg/s)}. \]

- Volum flow rate:
\[ G_l [m^3/s] = m [kg/s] \times \vartheta_4 [m^3/kg] \]

In which:

- \( \vartheta_4 \): Specific volum of liquid at liquid saturation 33°C. \((m^3/kg)\)
- \( m \): Mass flow rate of refrigerant of liquid \((\text{kg/s})\)
- \( G_l \): Volum flow rate \((m^3/s)\)

\[ \Leftrightarrow G_l = 6.331 \times 0.0016933 = 0.01072 \ [m^3/s] \]

- Diameter pipe supply to HPR :
\[
D = \sqrt{\frac{4 \times G_l}{\pi \times \omega}} = \sqrt{\frac{4 \times 0.01072}{\pi \times 0.6}} = 0.15083 \text{ m} = 150.83 \text{ mm}.
\]

⇒ Select DN125 : \(d_l = 128.2 \text{ mm} \omega = 0.83 \text{ m/s} \) (see index 1.5)
Diameter pipe supply to Surge Drum:

- Cooling Capacity of two compressor:
  \[ \sum Q_{mn} = Q_{mn} \times 2 = 1622.8 \times 2 = 3245.6 \text{ [kW]} \]

- Mass flow rate of refrigerant of liquid:
  \[ m = \frac{Q_{mn}}{\Delta t} = \frac{Q_{mn}}{i_{10} - i_5} \]

In which:
- \( m \): Mass flow rate of refrigerant of liquid (kg/s).
- \( i \): Elthanpy (kJ/kg).

\[ m = \frac{3245.6}{1451.8 - 353.22} = 2.9544 \text{ (kg/s)}. \]

- Volumn flow rate:
  \[ G_l \left[ \frac{m^3}{s} \right] = m \left[ \frac{kg}{s} \right] \times g_3 \left[ \frac{m^3}{kg} \right] \]

In which:
- \( g_3 \): Specific volume of liquid at liquid saturation 35°C. \( \left( \frac{m^3}{kg} \right) \)

\( m \): Mass flow rate of refrigerant of liquid \( \left( \frac{kg}{s} \right) \)

\( G_l \): Volumn flow rate \( \left( \frac{m^3}{s} \right) \)

\[ \Leftrightarrow G_l = 2.9544 \times 0.0017 = 5.02248 \times 10^{-3} \left[ \frac{m^3}{s} \right] \]

- Diameter pipe supply to SD:
  \[ D = \sqrt{\frac{4 \times G_l}{\pi \times \omega}} = \sqrt{\frac{4 \times 5.02248 \times 10^{-3}}{\pi \times 0.5}} = 0.11309 \text{ m} = 113.09 \text{ mm}. \]

\[ \Rightarrow \text{ Select DN100}: d_i = 102.26 \text{ mm} \quad \omega = 0.6115 \text{ m/s} \text{ (see index 1.5)} \]

Diameter pipe supply to Evaporator:

- Cooling Capacity of two compressor:
  \[ \sum Q_{mn} = Q_{mn} \times 2 = 1622.8 \times 2 = 3245.6 \text{ [kW]} \]

- Mass flow rate of refrigerant of liquid:
  \[ m = \frac{Q_{mn}}{\Delta t} = \frac{Q_{mn}}{i_{10} - i_6} \]

In which
m : Mass flow rate of refrigerant of liquid (kg/s).

\[ i: \text{Elthanpy (kJ/kg).} \]

\[ m = \frac{3245.6}{1451.8 - 163.55} = 2.52 \text{ (kg/s).} \]

- Mass flow rate of refrigerant of liquid supply to evaporator.

\[ m_1 = m \times 1.1 = 2.52 \times 1.1 = 2.772 \text{ (kg/s)} \]

- Volumn flow rate:

\[ G_l \left[ \frac{m^3}{s} \right] = m \left[ \frac{kg}{s} \right] \times v \left[ \frac{m^3}{kg} \right] \]

In which:

\[ v : \text{Specific volumn of liquid at -8°C.} \left( \frac{m^3}{kg} \right) \]

\[ m : \text{Mass flow rate of refrigerant of liquid} \left( \frac{kg}{s} \right) \]

\[ G_l : \text{Volume flow rate} \left( \frac{m^3}{s} \right) \]

\[ \iff \quad G_l = 2.772 \times 1.5399 \times 10^{-3} = 4.27 \times 10^{-3} \left[ \frac{m^3}{s} \right] \]

- Diameter pipe:

\[ D = \sqrt{\frac{4 \times G_l}{\pi \times \omega}} = \sqrt{\frac{4 \times 4.27 \times 10^{-3}}{\pi \times 0.5}} = 0.1043 \text{ m} = 104.3 \text{ mm} \]

⇒ Select DN100: \[ d_i = 102.26 \text{ mm} \quad \omega = 0.52 \text{ m/s (see index 1.5)} \]

**Diameter suction pipe of compressors**:

- Cooling Capacity of two compressor:

\[ \sum Q_{mn} = Q_{mn} \times 2 = 1622.8 \times 2 = 3245.6 \text{ [kW]} \]

- Mass flow rate of refrigerant of vapor:

\[ m = \frac{Q_{mn}}{\Delta i} = \frac{Q_{mn}}{i_{1f} - i_{5}} \]

In which:

\[ m : \text{Mass flow rate of refrigerant of vapor} \left( \text{kg/s} \right) \]

\[ i: \text{Elthanpy (kJ/kg).} \]

\[ m = \frac{3245.6}{1451.8 - 353.22} = 2.9534 \text{ (kg/s).} \]

- Volumn flow rate:
\[ G_h \left[ \frac{m^3}{s} \right] = m \left[ \frac{kg}{s} \right] \times v \left[ \frac{m^3}{kg} \right] \]

in which:
\[ v \]: Specific volume of vapor at -3°C. \( \left[ \frac{m^3}{kg} \right] \)
\[ m \]: Mass flow rate of refrigerant of vapor \( \left[ \frac{kg}{s} \right] \)
\[ G_h \]: Volumn flow rate \( \left[ \frac{m^3}{s} \right] \)

\[ \Leftrightarrow G_h = 2.9534 \times 0.396408 = 1.171 \left[ \frac{m^3}{s} \right] \]

- Diameter pipe:

\[ D = \sqrt{\frac{4 \times G_h}{\pi \times \omega}} = \sqrt{\frac{4 \times 1.171}{\pi \times 15}} = 0.315274 \text{ m} = 315.274 \text{ mm} . \]

\[ \Rightarrow \text{Select DN300: } d_i = 303.28 \text{ mm } \omega = 16.21 \text{ m/s (see index 1.5)} \]

**Diameter suction pipe of one compressor:**

- Mass flow rate of refrigerant of vapor:

\[ m = \frac{Q_{mn}}{\Delta t} = \frac{Q_{mn}}{t_{17} - t_5} \]

In which:
\[ m \]: Mass flow rate of refrigerant of vapor \( \left( \text{kg/s} \right) \).
\[ i \]: Elthanpy \( \left( \frac{kJ}{kg} \right) \).

\[ m = \frac{1622.8}{1451.8 - 353.22} = 1.4772 \left( \text{kg/s} \right) \]

- Volumn flow rate:

\[ G_h \left[ \frac{m^3}{s} \right] = m \left[ \frac{kg}{s} \right] \times v \left[ \frac{m^3}{kg} \right] \]

in which:
\[ v \]: Specific volume of vapor at -3°C. \( \left[ \frac{m^3}{kg} \right] \)
\[ m \]: Mass flow rate of refrigerant of vapor \( \left[ \frac{kg}{s} \right] \)
\[ G_h \]: Volumn flow rate \( \left[ \frac{m^3}{s} \right] \)

\[ \Leftrightarrow G_h = 1.4772 \times 0.396408 = 0.586 \left[ \frac{m^3}{s} \right] \]

- Diameter pipe:

\[ D = \sqrt{\frac{4 \times G_h}{\pi \times \omega}} = \sqrt{\frac{4 \times 0.586}{\pi \times 15}} = 0.22303 \text{ m} = 223.03 \text{ mm} . \]
Select DN200: \( d_i = 202.74 \text{mm} \omega = 18.152 \text{m/s} \) (see index 1.5)

**Diameter discharge pipe of compressors:**

- Cooling Capacity of two compressor:
  \[
  \sum Q_{mn} = Q_{mn} \times 2 = 1622.8 \times 2 = 3245.6 \text{[kW]}
  \]

- Mass flow rate of refrigerant of vapor:
  \[
  m = \frac{Q_{mn}}{\Delta I} = \frac{Q_{mn}}{t_{1T} - t_s}
  \]

In which:

- \( m \): Mass flow rate of refrigerant of vapor (kg/s).
- \( i \): Elthanpy (kJ/kg).
  \[
  m = \frac{3245.6}{1451.8 - 353.22} = 2.9534 \text{(kg/s)}.
  \]

- Volumn flow rate:
  \[
  G_h \left[ \frac{m^3}{s} \right] = m \left[ \frac{kg}{s} \right] \times v \left[ \frac{m^3}{kg} \right]
  \]

In which:

- \( v \): Specific volume of vapor at point 2. \((\frac{m^3}{kg})\)
- \( m \): Mass flow rate of refrigerant of vapor (\(\frac{kg}{s}\))
- \( G_h \): Volume flow rate (\(\frac{m^3}{s}\))
  \[
  \Leftrightarrow G_h = 2.9534 \times 127.91 \times 10^{-3} = 0.378 \text{[m}^3\text{/s]}.
  \]

- Diameter pipe:
  \[
  D = \frac{4 \times G_h}{\pi \times \omega} = \sqrt{\frac{4 \times 0.378}{\pi \times 15}} = 0.17912 \text{ m} = 179.12 \text{mm}.
  \]

Select DN200: \( d_i = 202.74 \text{ mm} \omega = 11.71 \text{ m/s} \) (see index 1.5)

**Diameter discharge pipe of compressor:**

- Lưu lượng khối lượng của mọi chất lạnh đang hơi.
  \[
  m = \frac{Q_{mn}}{\Delta I} = \frac{Q_{mn}}{t_{1T} - t_s}
  \]
In which:

- \( m \): Mass flow rate of refrigerant of vapor \((\text{kg/s})\).
- \( i \): Elthanpy \((\text{kJ/kg})\).

\[
m = \frac{1622.8}{1451.8 - 353.22} = 1.4772 \text{ (kg/s)}
\]

- Volumn flow rate:

\[
G_h \left[ \frac{m^3}{s} \right] = m \left[ \frac{kg}{s} \right] \times v \left[ \frac{m^3}{kg} \right]
\]

in which:

- \( v \): Specific volumn of vapor at point 2. \( \left[ \frac{m^3}{kg} \right] \)
- \( m \): Mass flow rate of refrigerant of vapor \( \left[ \frac{kg}{s} \right] \)
- \( G_h \): Volumn flow rate \( \left[ \frac{m^3}{s} \right] \)

\[
\Leftrightarrow G_i = 1.4772 \times 127.91 \times 10^{-3} = 0.189 \left[ \frac{m^3}{s} \right]
\]

- Diameter pipe:

\[
D = \sqrt{\frac{4 \times G_i}{\pi \times \omega}} = \sqrt{\frac{4 \times 0.189}{\pi \times 15}} = 0.12666 \text{m} = 126.66 \text{ mm}.
\]

\( \Rightarrow \) Select DN125: \( d_i = 128.2 \text{ mm} \omega = 14.64 \text{ m/s} (\text{see index 1.5}) \)

**Diameter pipe supply to ethylene glycol solution tank**

We use formula: \( G = \frac{d_i^2 \times \pi}{4} \cdot \omega \)

\[
\Rightarrow d_i = \sqrt{\frac{G \times 4}{\pi \times \omega}}
\]

In which:

- \( d_i \): [\( \text{(mm)} \)] inside diameter
- \( G \): [374 (\text{m}^3)] Ethylene glycol solution Flow rate
- \( \omega \): [2 (\text{m}^2/s)] The velocity of ethylene glycol solution.

Diameter pipe at head pump:

\[
d_i = \sqrt{\frac{G \times 4}{\pi \times \omega}} = \sqrt{\frac{374 \times 4}{\pi \times 2 \times 3600}} \times 1000 = 181.85(\text{mm}) \text{ select DN200.}
\]

(see index 1.5)
We create a spreadsheet according to the same formula as above.

<table>
<thead>
<tr>
<th>STT</th>
<th>Calculation Parameters</th>
<th>Actual Parameters</th>
<th>Pipe position</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Velocity ($m/s$)</td>
<td>Inside Diameter(mm)</td>
<td>Velocity($m/s$)</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>257.17</td>
<td>2.04126</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>181.85</td>
<td>1.6091</td>
</tr>
<tr>
<td>3</td>
<td>2</td>
<td>245.2</td>
<td>1.8557</td>
</tr>
<tr>
<td>4</td>
<td>2</td>
<td>173.39</td>
<td>1.463</td>
</tr>
</tbody>
</table>
2.12 High pressure Receiver (HPR)

2.12.1 Introduction for high pressure receiver

High pressure receiver have function contain liquid to provide stable liquid for the system, Simultaneous release of the heat exchanger surface for the condenser. When repairing the tank High pressure can hold all the amount of the system.

![Diagram of High Pressure Receiver]

Figure 8-14 : High pressure receiver

1- Gas glasses ; 2- Installation pipe for safe valve 3- Pressure gauge; 4- Liquid pipe in 5- Balanced pipe ; 6- Liquid pipe out; 7- discharge pipe

According to the function of the container, the capacity of the high pressure tank must meet the requirements:
- When the system is operating, the remaining liquid in the tank is at least 20% capacity jar.
- When repairing, maintenance, the tank is able to contain all of the media used in the system and only about 80% of the average volume.
Combining these two conditions, the volume of high pressure tank about 1.25 ÷ 1.5 volume of the lip. The refrigerant of the whole system is satisfactory.
To determine the amount of the substance in our system based on the amount of the substance devices when the system is operating.
- Volumn of tank :

\[ V = K_{dt} G v \]  \hspace{1cm} (8.11) \\

\( K_{dt} \) – safe factor, \( K_{dt} = 1,25 \div 1,5; \)

\( G \) – Mass of refrigerant in the system, kg ;

\( v \) – Specific volume of the liquid medium at the normal working temperature of the container, there is can get \( t = t_k = 35 \div 40^\circ C. \)
To calculate the amount of liquid to be charged to the system, it must be based on the amount of fluid that is to be delivered in devices when the system is operating. Each device translates to one billion percentage of that compared to their capacity. For example, when the system is running, it contains 100% liquid. The amount of liquid in the air substantially, additional calculation is made only after calculating the entire fluid mass system. Data pointing to the percentage of fluid in the equipment for accommodation Chapter 11. Most refrigeration systems have to use high pressure tanks, in some cases it is possible to use a condenser as a high pressure container. For small systems, due to the low gas consumption (few hundred mg to a few kg) people do not use a container that uses a manifold or the end of a condenser to contain liquid. When the tank capacity is too large, it is safe to use some vases. Yes between the jars should also communicate to balance the amount of fluid in the tank.

### 2.12.2 Calculation for HPR

#### 1. The Area of liquid in SD

\[ S = 0.1535 \times d^2 \]

\( S \) : The Area of liquid in SD \( (m^2) \)

\( d_i \) : Inside diameter of SD \( (m) \) (Liquid by \( \frac{1}{4} d_i \))

\[ S = 0.1535 \times d^2 \]

\( \Leftrightarrow S = 0.1535 \times (1.824^2) \)

\( \Leftrightarrow S = 0.51 \, m^2 \)

#### 2. The volume of liquid in SD

\[ V_1 = S \times \frac{1}{2} d_i \]

\( V_1 \) : The volume of liquid in SD \( (m^3) \)

\( S \) : The Area of liquid in SD \( (m^2) \)

\( \frac{1}{2} d_i \) : Inside diameter of SD \( (m) \)

\[ V_1 = S \times \frac{1}{2} d_i = 0.51 \times 5 = 2.55 \, m^3 \]

### 1. The volume of liquid in liquid Pipe
We use pipe have inside diameter is : $102.26 \text{ mm} = 0.10226 \text{ (DN 100)}$

We have length of liquid pipe is : $30 \text{ m}$

$$V_2 = S \times L$$

$V_2$ : The volume of liquid in pipe $(m^3)$

$S$ : The area of pipe $(m^2)$

$L$ : The length of pipe (m)

$$V_2 \Leftrightarrow V_2 = \left( \frac{\pi \times d^2}{4} \right) \times L$$

$$\Leftrightarrow V_2 = \left( \frac{\pi \times 0.10226^2}{4} \right) \times 30$$

$$\Leftrightarrow V_2 = 0.2464 \text{ (m}^3)$$

2. The volume of HPR tank.

$$V_3 = (V_1 + V_2) \times \frac{1.2}{0.8}$$

In Which :

1.2 : safe factor

0.8 : Factor because 80% HPR is liquid, 20% is Vapor

$V_3$ : The volume of HPR tank $(m^3)$

$$V_3 = (V_1 + V_2) \times \frac{1.2}{0.8} = (2.55 + 0.2464) \times \frac{1.2}{0.8} = 4.2 \text{ (m}^3)$$

Select diameter of HPR tank follow standard ASTM is : $D_i = 1.219 \text{ m}$

The length and diameter follow ratio : $\frac{L}{d} = (2 - 5)$ select $\frac{L}{d} = 4$

Radius of tank :

$$r = \frac{d}{2} = \frac{1.219}{2} = 0.6095 \text{ m.}$$

$$L = 1.219 \times 4 = 4.2665 \text{ m}$$
We have formula:

\[ V = \pi \times r^2 \times L \]

In Which:

\[ V \]: [(m\(^3\)]The Volumn of tank
\[ D \]: [1.219 (m)]The Diameter of tank
\[ R \]: [ (m)]TheRadius of tank
\[ L \]: [4.2665 (m).]The length of tank

The height of tank:

\[ V = \pi \times r^2 \times L \iff V = \pi \times 0.6095^2 \times 4.2665 = 4.98 \, m^3 > 4.2 \, m^3 \]

So diameters \( D = 0.6095 \, m \) and length is \( L = 4.2665 \, m \).

- **The thickness of body tank**:

\[
s = \frac{p \times D}{200 \times \varphi \times \delta_{cp} - p} + C
\]

\[
\iff s = \frac{18 \times 1219}{200 \times 0.8 \times 15.69 - 18} + 5 = 13.8 \, [mm]
\]

In Which:

- \( p \): Design pressure fortank. 18 [bar]
- \( \varphi \): Coefficient weld strength vertical body. \( \varphi = 0.8 \) (ông hàn).
- \( \delta_{cp} \): Allowable stresses of material\( \delta_{cp} = 15.69 \) (SS 400)
- \( C \): Additional thickness coefficient (we choose 5)
- \( D \): Inside diameters of tank[mm]

- Follow thickness standard, we choose thickness steel:

\[ s = 14.27 \, [mm] = SCH \, XS \]

- **The Length beween cap and body tank**:

\[ h_0 = 0.255 \times d + 0.365 \times t \]
In Which:

\( h_0 \): The length between cap and body tank (mm)

\( d \): Inside diameters of tank (mm)

\( t \): The thickness body (14 mm)

\[ h_0 = 0.255 \times 1219 + 0.365 \times 14.27 = 316.054 \text{ [mm]} \]

- **The thickness of cap**:

\[ s = \frac{p \times D}{400 \times z \times \delta_{cp}} \times \frac{D}{2 \times h_0} + C \]

Conditions to apply above formula is: \( \frac{h_0}{D} \geq 0.2 \)

In Which:

\( h_0 \): The length between cap and body HPR (mm)

\( D \): Inside diameters of HPR [mm]

\[ \frac{h_0}{D} = \frac{316.054}{1219} = 0.26 \geq 0.2 \]

So:

\[ s = \frac{p \times D}{400 \times z \times \delta_{cp}} \times \frac{D}{2 \times h_0} + C \]

\[ \frac{18 \times 1219}{400 \times 1 \times 15.69} \times \frac{1219}{2 \times 316.054} + 5 = 11.74 \text{ [mm]} \]

In Which:

- \( p \): Design pressure for tank. 18 [bar]
- \( z = 1 \)
- \( \delta_{cp} \): Allowable stresses of material \( \delta_{cp} = 15,69 \) (SS 400)
- \( C \): Additional thickness coefficient (we choose 5)
- \( h_0 \): The length between cap and body (mm)
- \( D \): Inside diameters of tank [mm]

To ensure the safety of HPR, select the thickness of body and cap is 14.27 mm.

- **The length from body to cap**:

\[ h_1 = 3 \times s \]
In Which:

- $h_1$: The length from body to cap (mm)
- $s$: The thickness body (mm)

\[
\Rightarrow h_1 = 3 \times s = 3 \times 14.27 = 42.81 \text{ [mm]}
\]

- *Total length from body to top of cap:*

\[
h = h_1 + h_0
\]

In Which:

- $h$: Total length from body to top of cap (mm)
- $h_1$: The length from body to cap (mm)
- $h_0$: The length between cap and body tank (mm)

\[
h = h_1 + h_0 = 42.81 + 316.054 = 358.864 \text{ [mm]}
\]

- *Total length of HPR:*

\[
L_t = 2h + H
\]

In Which:

- $L_t$: Total length of HP R (m).
- $h$: Total length from body to top of cap (m)
- $L$: The length of body HPR (m)

\[
H_t = 2h + H = 2 \times 0.359 + 4.2665 = 4.9845 \text{ [m]}
\]

### 2.13 Calculate select pump.

#### 2.13.1 Select the cooling water pump to the work equipment.

We will select two pump running and one standby pump (pump 50% water flow)

Ta có: We have

- Pressure: 4 bar = 41 $m_{H2O}$
- Flow rate: 170 $m^3/h$

*From the above parameters, we choose the pump according to the catalog: (See index2.8)*

- Brand: Grundfos
- Model: NK100-400/360 EUP A1-F-K-E-BQEE
- Type: Centrifugal
- Flow rate: 171 $m^3/h$
- Pressure: 4.09bar
- Frequency : 50Hz.
- Pump Inlet : DN125
- Pump Outlet : DN100
- Motor Capacity: 30kW/ 3Pha/ 50Hz

**Check calculations pump:**

- **Capacity on the shaft of the pump:**
  \[ N = \frac{\gamma \times Q \times H}{102 \times \eta} \]
  
  \( N \) : [(kw)] Capacity on the shaft of the pump  
  \( H \) : [41(\text{mH}_2\text{O} \text{m}^3)] The pressure of pump  
  \( Q \) : \[ \frac{170}{3600} \text{ (m}^3/\text{s}) \] Flow Rate of the pump.  
  \( \eta \) : Efficient of pump (0.725) (See index 2.8)  
  \( \gamma \) : Density of ethylene glycol solution [1053 (Kg / m^3)] (See index 2.8)  
  
  \[ N = \frac{1053 \times \frac{170}{3600} \times 41}{102 \times 0.725} = 27.57 \text{ (kW)} \]

- **Motor power of pump :**
  \[ P = k \times \frac{N}{\eta_m \times \eta_{tr}} \]
  
  \( P \) : (kw) Motor power of pump  
  \( N \) : [(kw)] Capacity on the shaft of the pump  
  \( \eta_m \) : Efficient of pump  
  \( \eta_{tr} \) : Efficient of pump (direct drive by hard coupling) The efficiency of the pump is 1 (because it is a direct drive by a liquid coupling)  
  \( \gamma \) [1000(Kg / m^3)] Density of ethylene glycol solution  
  \( k \) : [1.15] safe factor (See index 1.10)  
  
  \[ P = k \times \frac{N}{\eta_m \times \eta_{tr}} = 1.15 \times \frac{27.57}{0.923 \times 1} = 34.35 \text{ (kw)} \]

2.13.2 Select pump coolant to PHE.

We will select a pump running and one standby pump (pump 50% water flow)

- Flow rate : 205 m^3/h

- **The pressure pump is calculated as follows :**

  - Determine the kinematic viscosity of ethylene glycol solution at 3°C.
\[ v = 3.55 \times 10^{-6} \text{ (m}^2/\text{s}) \] (See index2.9)

**Determine the resistance Reynolds (Re):**

\[ \text{Re} = \frac{\omega \times d_i}{v} \]

\(\text{Re} : \) Coefficient of resistance

\(\omega : [1.6091 \text{ (m/s)}] \) Velocity in pipes

\(d_i : [0.20274 \text{ (mm)}] \) The inside diameter of the ethylene glycol solution pipe

\(v : [3.55 \times 10^{-6}] \) Kinematic viscosity at 41°C

\[ \text{Re} = \frac{\omega \times d_i}{v} = \frac{1.6091 \times 0.20274}{3.55 \times 10^{-6}} = 91895.47437 \]

**Coefficient of friction \(f\).**

Determine \(f\) based on \(F_{DASHBOARD}\)

When \(f = F_{DASHBOARD} \ (F_{DASHBOARD} > 0.018)\)

\[ f = 0.85 \times F_{DASHBOARD} + 0.0028 \ (\ F_{DASHBOARD} \leq 0.018) \]

We have:

\[ F_{DASHBOARD} = 0.11 \times \left( \frac{\varepsilon}{d} + \frac{68}{\text{Re}} \right)^{0.25} \]

\(f : \) Coefficient of resistance on the pipe

\(F_{DASHBOARD} : \) Factor to determine \(f\).

\(\varepsilon : [0.15 \text{(mm)}] \) Roughness of galvanize pipe

\(d : [202.74 \text{(mm)}] \) The inside diameter of the pipe

\(\text{Re} : [91895.47437] \) Coefficient of resistance

\[ F_{DASHBOARD} = 0.11 \times \left( \frac{0.15}{202.74} + \frac{68}{91895.47437} \right)^{0.25} = 0.004232 \]

So \(f = 0.85 \times F_{DASHBOARD} + 0.0028 = 0.85 \times 0.004232 + 0.0028 = 6.3972 \times 10^{-3} \)
Determine the resistance to friction of the pipe

Figure 1.1: The suction height of the pump from suction head to tank.
Figure 1.2: The total length of the horizontal of the suction pump.
Figure 1.3: The height of head discharge pump.
Figure 1.4: The total length horizontally of the piped discharge the pump.
Total length of the suction pipe: 15.198 m. (See figure 1.1 and See figure 1.2)
Height of suction pipe: 6.224 m. (See figure 1.1)
Height of discharge pipe: 4.64 m. (See figure 1.3)
Total length of the discharge pipe: 41.121 m. (See figure 1.3 and See figure 1.4)

\[\text{Determination of resistant factor of valves and fittings at suction pipe (see index1.11)}\]

Butterfly valve DN200: \(\zeta = 2 \times 1 = 2\).
Strainer valve: \(\zeta = 2 \times 1 = 2\).
Reducer: \(\zeta = 0.25 \times 1 = 0.25\).
Tee: \(\zeta = 0.4 \times 2 = 0.8\).
Elbow: \(\zeta = 0.6 \times 6 = 3.6\).

We calculate the total suction pressure of the pump.

\[\text{Pressure loss of water through the pipe and locally is:}\]
\[H_{loss} = f \times \frac{1}{d_l} \times \frac{\omega^2}{2 \times g} + k \times \frac{\omega^2}{2 \times g}\]

In which:
- \(f\): Coefficient of resistance on the pipe \([6.3972 \times 10^{-3}]\)
- \(d_l\): The inside diameter of the pipe \([202.74 (mm)]\)
- \(\omega\): The velocity of the ethylene glycol solution \([1.6091 \text{ (m/s)}]\)
- \(g\): Gravitational acceleration \([9.81 \text{ (m/s²)}]\)
- \(l\): Total length of suction pipe \([(m)]\)
- \(k\): Coefficient of friction

\[H_{loss} : (m_{H_2O})\) Pressure loss of ethylene glycol solution through the pipe and locally

\[H_{loss} = f \times \frac{1}{ds} \times \frac{\omega^2}{2 \times g} + k \times \frac{\omega^2}{2 \times g} = 6.3972 \times 10^{-3} \times \frac{15.198}{202.74} \times \frac{1.6091^2}{2 \times 9.81} + (2+0.25+0.4+1.8) \times \frac{1.6091^2}{2 \times 9.81} = 0.9145 \text{ (m_{H_2O})}\]

\[\text{Determine the pressure of Ethylene glycol solution at 3°C (See index2.10)}\]

<table>
<thead>
<tr>
<th>T (°C)</th>
<th>1.9</th>
<th>3</th>
<th>9.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\rho) [Pa]</td>
<td>42.8</td>
<td>X</td>
<td>50.4</td>
</tr>
</tbody>
</table>

Using a method of interpolation we have:
\[
\frac{3-1.9}{9.2-1.9} = \frac{X-42.8}{50.4-42.8} \\
X = 43.95 \text{[ Pa]}
\]

- **Total pressure at the suction pipe is:**

\[H_s = h_s + \frac{P_a - P_v}{\rho \times g} - H_{loss}\]

- **Determination of resistant factor of valves and fittings at the discharge pipe (See appendix 1.11)**

- **We calculate the total discharge pressure of the pump**

- **Pressure loss of water through the pipe and locally is :**

\[H_{loss} = f \times \frac{1}{d_i} \times \frac{\omega^2}{2 \times g} + k \times \frac{\omega^2}{2 \times g}\]

In which :

- \(f\) : Coefficient of resistance on the pipe
- \(d_i\) : The inside diameter of the pipe [202.74 (mm)]
- \(\omega\) : The velocity of the ethylene glycol solution [1.6091 (m/s)]
- \(g\) : Gravitational acceleration [(9.81 m²/s²)]
- \(l\) : Total length of discharge pipe (m)
- \(k\) : Coefficient of friction
$H_{loss}$: Pressure loss of ethylene glycol solution through the pipe and locally [$m_{H_2O}$]

$$H_{loss} = f \cdot \frac{1}{\Delta s} \cdot \frac{\omega^2}{2 \times g} + k \cdot \frac{\omega^2}{2 \times g} = 6.3972 \times 10^{-3} \times \frac{41.121}{202.74} \times \frac{1.6091^2}{2 \times 9.81} + (2 + 2 + 0.25 + 0.4 + 0.6) \times \frac{1.6091^2}{2 \times 9.81} = 0.864 \ (m_{H_2O})$$

- **Total discharge pressure in the pipe:**

\[ Hd = hd + \frac{P_a - P_v}{\rho \times g} - H_{loss} + H_{tb} \]

- \(Hd\): Total pressure in the discharge pipe [$m_{H_2O}$]
- \(hd\): Height of discharge pipe [$4.64 \ (m_{H_2O})$]
- \(P_a\): Environment pressure [$101325 \ (Pa)$]
- \(P_v\): Vapor pressure of ethylene glycol solution [$43.95 \ (Pa)$]

- **$H_{loss}$**: Pressure loss of ethylene glycol solution through the pipe and locally [$0.882 \ (m_{H_2O})$]

\[ H_{tb}: \ \text{Pressure loss of equipment} \ (8 \ m_{H_2O}) \]

\[ Hd = hd + \frac{P_a - P_v}{\rho \times g} - H_{loss} + H_{tb} \]

\[ \Rightarrow Hd = 4.64 + \frac{101325 - 43.95}{1051 \times 9.81} - 0.864 + 8 = 21.6 \ (m_{H_2O}) \]

- **The working pressure of pump is:**

\[ H = H_d - H_h = 21.6 - 15.133 = 6.47 \ (m_{H_2O}). \]

In order to work, the working pressure of the pump must be at least 1 bar.

We choose 1.5 bar is the working pressure minimum of pump.

\[ \text{Ta 1.5 bar} = 15.296 \ (m_{H_2O}) \]

**From the data above we choose the pump according to the catalog:** *(See index 2.9)*

- **Brand**: Grundfos
- **Model**: NK125-315/338 EUP A1-F-A-E-BQQE
- **Type**: Centrifugal
- **Flow rate**: 189 $m^3/h$
- **Pressure**: 1.535 bar
- **Frequency**: 50Hz.
Pump Inlet : DN150
Pump Outlet : DN125
Motor Power : 15 Kw kW/ 3Pha/ 50Hz

- **Calculation check pump**:
  - **Capacity on the shaft of the pump (See index 2.9)**
    \[ N = \frac{y \times Q \times H}{102 \times \eta} \]

  \( N \) : Motor power of pump [(kw)]
  \( H \) : The pressure of pump [15.296 (mH2O)]
  \( Q \) : Flow rate of the pump \( \frac{187}{3600} \) (m^3/s)
  \( \eta \) : Efficient of pump [0.794] *(See index 2.9)*
  \( y \) : Density of ethylene glycol solution [1051 (Kg/m^3)]

  \[ N = \frac{1051 \times \frac{187}{3600} \times 15.296}{102 \times 0.794} = 10.312 \ (kW) \]

- **Motor Capacity of pump**:
  \[ P = k \times \frac{N}{\eta_{td} \times \eta_{tr}} \]

  \( P \) : [(kw)] Motor power of pump
  \( N \) : [(kw)] Motor power of pump
  \( \eta_{td} \) : The efficient of the pump [0.912] *(See index 2.9)*
  \( \eta_{tr} \) : Efficient of pump *(direct drive by hard coupling)* The efficiency of the pump is 1 (because it is a direct drive by a riquid coupling)
  \( y \) : Density of ethylene glycol solution [1051 (Kg/m^3)]
  \( k \) : Safety factor of capacity [1.15] *(See index 1.10)*

  \[ P = 1.15 \times \frac{10.312}{0.912 \times 1} = 13.0031 \ (kw) \]

### 2.13.3 Check cavitation phenomenon

- ***We check pump from tank to PHE.***
  According to the pump data \( i.e, NPSH_{rp} \) of the pump is 0.23bar = 2.3 (mH2O) *(see index 2.9)*
  To avoid cavitation \( NPSH_A \geq NPSH_r \)
  We have the formula:
  \[ NPSH_r = NPSH_{rp} + S \]

In which:
\( NPSH_r \): The lowest pressure suction pump can be suctioned. \([m_{H2O}]\)

\( NPSH_{rp} \): The suction pressure of macfactuner \([2.3 (m_{H2O})]\).

\( S \): Safe factor \([0.5(m_{H2O})]\)

\[
NPSH_r = NPSH_{rp} + S.
\]

\[
NPSH_r = 2.3 + 0.5.
\]

\[
NPSH_r = 2.8 (m_{H2O})
\]

To avoid cavitation we use the formula \( NPSH_A \geq NPSH_r \)

\[
NPSH_A = hs + \frac{Pa}{\rho \times g} - \frac{Pv}{\rho \times g} - H_{loss}
\]

In which:

\( NPSH_A \): Absolute pressure \([m_{H2O}]\)

\( hs \): Height of suction pipe \([6.224 (m_{H2O})]\)

\( H_{loss} \): Pressure loss of through the pipe and locally \([0.9177 (m_{H2O})]\)

\( Pa \): Suction pressure at free liquid surface \([101325(Pa)]\)

\( Pv \): Vapor pressure of ethylene glycol solution \([43.95(Pa)]\)

\( g \): Gravitational acceleration \([9.81 (m^2/s)]\)

\( \rho \): Density of ethylene glycol solution \([1051(kg/m^3)]\)

\[
NPSH_A = hs + \frac{Pa}{\rho \times g} - \frac{Pv}{\rho \times g} - H_{loss} = 6.224 + \frac{101325}{1051 \times 9.81} - \frac{43.95}{1051 \times 9.81} - 0.9145 = 15.13 (m_{H2O})
\]

So:

\[
NPSH_A = 15.13 (m_{H2O}) \geq NPSH_r = 2.8 (m_{H2O})
\]

\[This pump does not occur the phenomenon of erosion\]

\[\textbf{We check the pump from tank to the working equipment.}\]

We have formula:

\[\text{Flow rate} : 205(m^3/h)\]

Calculation for pressure of pump:

The kinematic viscosity of Ethylene glycol solution at \(-5^\circ C\)

\[V = 4.78 \times 10^{-6} (m^2/s)\]

\[\textbf{Determine the resistance Reynolds (Re)}:\]

\[Re = \frac{\omega \times d_i}{v}\]
Re : Coefficient of resistance

\( \omega \) : [1.8557 ( m/s )] Velocity in pipes

\( d_i \) : [0.20274 ( mm )] The inside diameter of the solution pipe

\( v \) : [4.78 \times 10^{-6}] Kinematic viscosity at -5°C

\[
\text{Re} = \frac{\omega \times d_i}{v} = \frac{1.8557 \times 0.20274}{4.78 \times 10^{-6}} = 78708.08
\]

\( \text{Coefficient of friction } f : \)

Determine \( f \) based on \( F_{DASH} \)

When \( f = F_{DASH} \ (F_{DASH} > 0.018) \)

\( f = 0.85 \times F_{DASH} + 0.0028 \ (F_{DASH} \leq 0.018) \)

We have:

\[
F_{DASH} = 0.11 \times \left( \frac{\varepsilon}{d} + \frac{68}{\text{Re}} \right)^{0.25}
\]

\( f \) : Coefficient of resistance on the pipe

\( F_{DASH} \) : Factor to determine \( f \).

\( \varepsilon \) : [0.15 (mm)] Roughness of galvanize pipe

\( d \) : [202.74 (mm)]. The inside diameter of the pipe

\( \text{Re} \) : [78708.08] Coefficient of resistance

\[
F_{DASH} = 0.11 \times \left( \frac{0.15}{202.74} + \frac{68}{78708.08} \right)^{0.25} = 0.022
\]

So :

\( f = F_{DASH} = 0.022 \ (F_{DASH} > 0.018) \)
Determine the resistance to friction of the pipe:

The total length of the horizontal of the suction pump: 19.052 m.
The suction height of the pump: 2.735 m.
\textbf{Determination of resistant factor of valves and fittings at suction pipe (see index 1.11)}

Butterfly valve DN200: $\zeta = 2 \times 1 = 2$.

Strainervalve: $\zeta = 2 \times 1 = 2$

Reducer: $\zeta = 0.25 \times 1 = 0.25$

Tee: $\zeta = 0.4 \times 4 = 1.6$

Elbow 90: $\zeta = 0.6 \times 4 = 2.4$

\textbf{We calculate the total suction pressure of the pump.}

\textit{Pressure loss of water through the pipe and locally is:}

$$H_{loss} = f \times \frac{1}{d_i} \times \frac{\omega^2}{2g} + k \times \frac{\omega^2}{2g}$$

In which:

- $f$ : [0.022] Coefficient of resistance on the pipe
- $d_i$ : [202.74 (mm)] The inside diameter of the pipe
- $\omega$ : [1.764 (m/s)] The velocity of the water flow
- $g$ : [9.81 (m$^2$/s)] Gravitational acceleration
- $l$ : [(m)] Total length of suction pipe.
- $k$ : Coefficient of friction
- $H_{loss}$ : [(m$^2$/s$^2$)] Pressure loss of water through the pipe and locally

$$H_{loss} = 0.022 \times 19.052 \times \frac{1.8557^2}{2 \times 9.81} + (2 + 2 + 0.25 + 1.6 + 2.4) \times \frac{1.8557^2}{2 \times 9.81} = 1.811.$$

\textbf{Determine the pressure of ethylene glycol solution at 3°C (See index 2.10)}

<table>
<thead>
<tr>
<th>T (°C)</th>
<th>-8.1</th>
<th>-5</th>
<th>1.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\rho$ [Pa]</td>
<td>33.9</td>
<td>X</td>
<td>42.9</td>
</tr>
</tbody>
</table>

Using a method of interpolation we have:

$$\frac{-5 - (-8.1)}{1.9 - (-8.1)} = \frac{x - 33.9}{42.9 - 33.9}$$

$$x = 36.69 \text{ Pa}$$
Total pressure at the suction pipe is:

\[ H_s = h_s + \frac{P_a - P_v}{\rho \times g} - H_{loss} \]

Hs : [(m\textsubscript{H2O})] Total pressure at the suction pipe
hs : [2.735 (m\textsubscript{H2O})] Height of suction pipe
P\textsubscript{a} : [101325(Pa)] Environment Pressure
P\textsubscript{v} : [36.69 (Pa)] Vapor pressure of water
H\textsubscript{loss} : Pressure loss of water through the pipe and locally

\[ H_s = h_s + \frac{P_a - P_v}{\rho \times g} - H_{loss} \]

\[ <= > H_s = 2.735 + \frac{101325 - 36.69 	imes 1053}{1053 \times 9.81} - 1.811 = 10.73 \text{ m\textsubscript{H2O}} \]

According to the pump data is \( NPSH_{rp} \) of the pump is 0.23 bar = 2.3 (m\textsubscript{H2O}) (see index 2.8)
To avoid cavitation \( NPSH_A \geq NPSH_r \)
We have the formula:

\[ NPSH_r = NPSH_{rp} + S \]

In which:

\( NPSH_r \) : The lowest pressure suction pump can be suctioned. [(m\textsubscript{H2O})]
\( NPSH_{rp} \) : The suction pressure of manufacturer [2.3 (m\textsubscript{H2O})].
S : Safe factor [0.5(m\textsubscript{H2O})]

\[ NPSH_r = NPSH_{rp} + S \]
\[ NPSH_r = 2.3 + 0.5 \]
\[ NPSH_r = 2.8 \text{ (m\textsubscript{H2O})} \]

To avoid cavitation we use the formula \( NPSH_A \geq NPSH_r \)

\[ NPSH_A = h_s + \frac{P_a}{\rho \times g} - \frac{P_v}{\rho \times g} - H_{loss} \]

In which:

\( NPSH_A \) : Absolute pressure [(m\textsubscript{H2O})]
hs : Height of suction pipe [2.735 (m\textsubscript{H2O})]
H\textsubscript{loss} : Pressure loss of ethylene glycol solution through the pipe and locally [1.83 (m\textsubscript{H2O})]
P\textsubscript{a} : Suction pressure at free liquid surface [101325(Pa)]
P\textsubscript{v} : Vapor pressure of ethylene glycol solution [36.69 (Pa)]
g : Gravitational acceleration [9.81 (m\textsuperscript{2}/s)]
\( \rho \) : Density of ethylene glycol solution [1053(kg/m\textsuperscript{3})]

\[ NPSH_A = h_s + \frac{P_a}{\rho \times g} - \frac{P_v}{\rho \times g} - H_{loss} = 2.735 + \frac{101325}{1053 \times 9.81} - \frac{36.69}{1053 \times 9.81} - 1.811 = 10.73 \text{ (m\textsubscript{H2O})} \]
So:

\[ NPSH_A = 10.73 \, (m_{H_2O}) \geq NPSH_r = 2.8 \, (m_{H_2O}) \]

This pump does not occur the phenomenon of erosion

2.14. Calculation for valve of the NH3 system.

✓ We choose main pipe:

From parameters, we choose valve:

- Cooling capacity : 3204 kW
- Condensing temperature : 35°C \( \rightarrow P_c = 13.504 \)
- Evaporative temperature : -8°C \( \rightarrow P_e = 3.152 \)
- Superheat : 5°C
- Subcooling : 2°C
- Type Supply to liquid : Gravity
- Selection criteria : 100%

✓ We choose Expansion float : (see index 2.11)

\[ \Delta P = P_c - P_e = 13.504 - 3.152 = 10.352 \text{ bar} \]

Factor \( k = 1.01 \) (because subcooling = 2°C).

Correct Capacity : \( Q = Q_0 \times 1.01 = 3204 \times 1.01 = 3236.04 \text{ kW} \)

We choose cooling capacity follow \( \Delta P = 8 \text{ bar} \) and Evaporating temperature:

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>0</th>
<th>-8</th>
<th>-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling capacity</td>
<td>3570</td>
<td>x</td>
<td>3500</td>
</tr>
</tbody>
</table>

\[
\frac{-8-0}{-10-0} = \frac{x - 3570}{3500 - 3570}
\]

\[ X = 3514 \text{ kw} \]

We choose cooling capacity follow \( \Delta P = 12 \text{ bar} \) and Evaporating temperature:

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>0</th>
<th>-8</th>
<th>-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling capacity</td>
<td>4140</td>
<td>x</td>
<td>4090</td>
</tr>
</tbody>
</table>

\[
\frac{-8-0}{-10-0} = \frac{x - 4140}{4090 - 4140}
\]

\[ X = 4100 \text{ kw} \]
We choose cooling capacity follow $\Delta p = 10.352$ bar and Evaporating temperature :

<table>
<thead>
<tr>
<th>$\Delta p$ ( bar )</th>
<th>8</th>
<th>10.352</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cooling capacity</td>
<td>3514</td>
<td>x</td>
<td>4100</td>
</tr>
</tbody>
</table>

$$\frac{10.352 - 8}{12 - 8} = \frac{x - 3514}{4100 - 3514}$$

$$X = 3858.568 \text{ kW}$$

We choose Expansion Float : PMFL – 125 ( see index 2.11 )

We check valve by Danfoss Valve

- Expansion Float is : PMFL – 125 ( see index 2.12 )
- Stop valve : SVA 100 angle ( see index 2.13 )
- Straight strainer : FIA 125-150 straight angle ( see index 2.14 )
- Float valve : SV4 angle
- Float switch : AKS38 angle ( see index 2.15 )
- Solenoid valve : EVRA 32 ( see index 2.16 )
- We choose branch pipe :

From parameters, we choose valve :

- Cooling capacity : 3204 kW
- Condensing temperature : 35°C $\rightarrow P_c = 13.504$
- Evaporative temperature : $-8^\circ C$ $\rightarrow P_e = 3.152$
- Superheat : 5°C
- Subcooling : 2°C
- Type Supply to liquid : Gravity
- Selection criteria : 100%

- We choose Manual Expansion valve: ( see index 2.17 )

Electric Expansion Valve is : REG 25 – A straight ( see index 2.17 )

2.15. Calculation thickness for pipe .
We choose temperature and humidity outdoor is : 32°C, RF = 75

$\Rightarrow$ We have dew temperature : $t_{ds} = 27^\circ C$
• We calculate in case temperature in pipe is: -8°C

We have Formula: 

\[ A = 0.95 \times \frac{t_1 - t_{ds}}{t_1 - t_0} \]

\[ \Rightarrow A = 0.95 \times \frac{32 - 27}{32 - (-8)} \]

\[ \Rightarrow A = 0.11875 \]

We have formula: 

\[ F = \left(\frac{1}{A} - 1\right) \times \frac{(2 \times \lambda_{in})}{\alpha_1 \times d} = B \ln B \]

\[ A \quad : \text{Factor of heat transfer} \]

\[ t_1 \quad : \text{Temperature at outdoor (32°C)} \]

\[ t_{ds} \quad : \text{Temperature at outdoor (27°C)} \]

\[ t_0 \quad : \text{Temperature in pipe (−8°C)} \]

\[ A = 0.95 \times \frac{32 - 27}{32 - (-8)} \]

\[ \Rightarrow A = 0.11875 \]

\[ F = \left(\frac{1}{0.11875} - 1\right) \times \frac{(2 \times 0.024)}{23.3 \times 0.2191} \]

\[ \Rightarrow F = 0.0697764 \]

We choose \( B = 1.067545 \Rightarrow F' = 0.0697764 = F \)

So B is true, \( D = B \times d = 1.067545 \times 219.1 = 233.9 \) mm

\[ D \quad : \text{Outside diameter of insulation (mm)} \]

\[ d \quad : \text{Outside diameter of pipe (mm)} \]

\[ D = B \times d \]

\[ \Rightarrow D = 1.067545 \times 219.1 = 233.9 \text{ mm} \]

\[ \Rightarrow D = 233.9 \text{ mm} \]

\[ \delta = \frac{D - d}{2} = \frac{233.9 - 219.16}{2} = 7.37 \text{ mm} \]
\[ \delta : \text{Thickness of insulation} \ (\text{mm}) \]

\[ \Rightarrow \delta_{tt} = 7.37 \times 8 = 58.96 \text{ mm} \]

\[ \delta_{tt} : \text{Thickness of insulation after calculator} \ (\text{mm}) \]

Because Insulation of PU foam follow standard, so I select thickness PU : 75 mm

- **We calculate in case temperature in pipe is : 3°C**

We have Formula: \( A = 0.95 \times \frac{t_1 - t_{ds}}{t_1 - t_0} \)

\( A \) : Factor of heat transfer

\( t_1 \) : Temperature at outdoor (32°C)

\( t_{ds} \) : Temperature at outdoor (27°C)

\( t_0 \) : Temperature in pipe (3°C)

\[
A = 0.95 \times \frac{32 - 27}{32 - 3}
\]

\[
\Rightarrow A = 0.164
\]

We have formula: \( F = \left( \frac{1}{A} - 1 \right) \times \frac{2 \times \lambda_{in}}{\alpha_1 \times d} = B \ln B \)

\( A \) : Factor of heat transfer

\( \lambda_{in} \) : Heat transfer factor (0.024 W/m.k PU)

\( \alpha_1 \) : Heat Factor outdoor (23.3 W/m².k)

\( d \) : Outside diameter of pipe (219.1 mm)

\[
B = \frac{D}{d}
\]

\[
\Rightarrow F = \left( \frac{1}{A} - 1 \right) \times \frac{2 \times \lambda_{in}}{\alpha_1 \times d}
\]

\[
\Rightarrow F = \left( \frac{1}{0.164} - 1 \right) \times \frac{2 \times 0.024}{23.3 \times 0.2191}
\]

\[
\Rightarrow F = 0.0479298
\]

We choose \( B = 1.04685 \Rightarrow F' = F \)

So B is true,

\[
D = B \times d
\]
δ : Thickness of insulation ( mm )

\[ \delta = \frac{D - d}{2} = \frac{229.365 - 219.16}{2} = 5.1025 \text{ mm} \]

\[ \Rightarrow \delta_{tt} = 5.1025 \times 8 = 40.82 \text{ mm} \]

\( \delta_{tt} \) : Thickness of insulation after calculator ( mm )

Because Insulation of PU foam follow standard, so I select thickness PU : 50 mm

3. Calculation electrical system

3.1 Interview about electrical equipment

3.1.1 Control equipment

To do the task of control, open the machine in the circuit people use many various electrical appliances

3.1.2 Aptomat ( MCCB)

For occasional interruptions in the circuit, people use the aptomat. The aptomat consists of a system of contacts with arc cutters, automatic parts, circuit breaker to protect overload and short circuit. Electric circuit breaker according to the maximum current. When the current exceeds the value, it will cut off the circuit to protect device.

Aptomatis used to close, disconnect the circuit and protect the device in case of overload.

Automatic open or close (aptomat)

3.1.3 Thermal Relay protects over current and overheat (OCR)

Thermal relay used to protect overcurrent or overheat. When the current is too large or for some reason the motor winding temperature is too high. Thermal relay to circuit