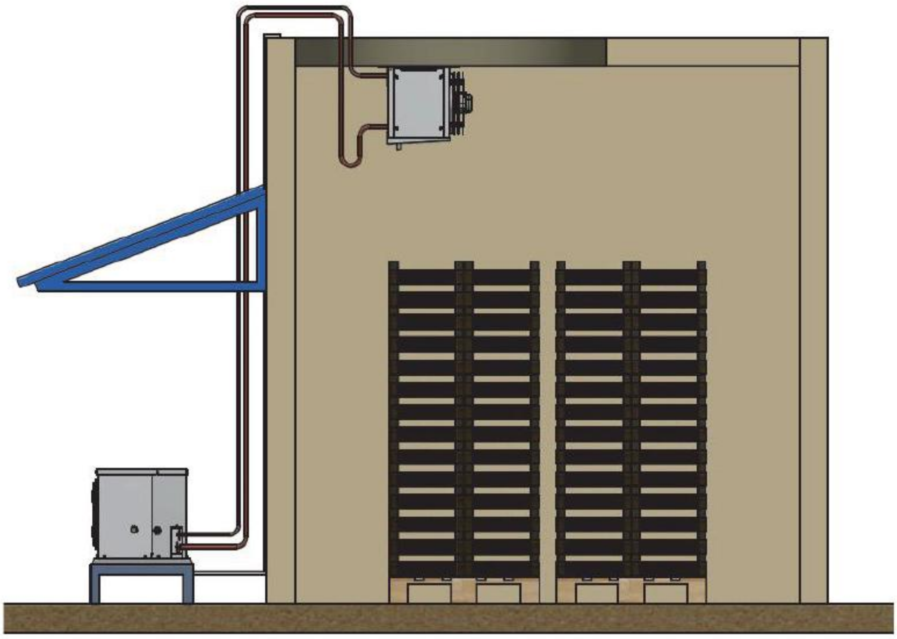
How is the cooling load calculated?
What's a cold room?

The cold room is used to slow down the deterioration of the rapidly deteriorating products, such as fruit vegetables and meat, and keep it fresh for as long as possible. Heat is a factor that accelerations of product degradation. For this reason, the heat in the atmosphere in the cold rooms are removed and the products are cooled.

Cooling systems are needed to ensure that the temperature is accurately and automatically controlled to keep the heat away from the environment and store the stored products as long as possible.

To remove heat from the environment and to perform an appropriate cooling process, it is necessary to calculate what the cooling load will be. cooling load; The product stored in the warehouse, the area where the warehouse will be installed varies throughout the day according to the way the warehouse is used, so in most ***cases the average cooling*** load is calculated and the cooling capacity of the system to be established is calculated accordingly.



Cold Room heat sources

In cold rooms, heat recovery is usually 5-15% thro**ugh transmis**sion loads. So there's a thermal energy flowing into the cold room from the roof, walls and floor of the warehouse.
Heat always flows from hot to cold, and the inner part of the cold room is much colder than the surrounding environment, so heat always tries to get into the area due to this temperature difference. If the cold storage is exposed directly to sunlight, the heat transfer will be higher.

Another factor affecting the cooling load is th**e load from the products placed in the** tank. The cooling loads from the products constitute 55-75% of the total heat gain. In addition, this will create additional cooling load if the product is cooled, such as a second shock, freezing or advanced cooling.
When making a heat gain account, it is also necessary to consider packaging, because the package of the product will also be exposed to cooling in the warehouse.

Also, if the fruits and vegetables are to be cooled, these products must be taken into account because they are alive and produce some heat in the breathing environment.

The next thing to consider is the internal loads that are ar**ound 10-**20%. This is a heat gain from equipment such as heat, forklifts, lighting from people working in the cold room. For this reason, factors such as the equipment to be used to load and unload the products in storage, the number of personnel employed in the warehouse, the amount of time spent on loading/unloading should be included in the heat gain account.
In addition, we need to take into consideration the cooling equipment in the room, which will f**orm approximately 1-**10% of the total cooling load. To do this, it is necessary to know the degree of fan motors and how long it will work every day and to include the heat that the evaporator gives to the environment while defrost.
The last thing to consider is air leaking into the room affecting 1-10% of the **cooling l**oad. This happens when the cold room door is opened. The other issue is ventilation. Because fruits and vegetables expose carbon dioxide, some warehouses require ventilation fans. This air must also be included in the heat gain account as it should be cooled.

Example of cooling load calculation

Let's make an example of a simplified cooling load calculation for a cold room:

Transmission Load Account

- The size of our cold storage is 6m long, 5m wide and 4m high.
- Ambient air (the location where the depot is located) is 30 °c with 50% RH, Inner air (the air condition required to be in the tank) is 95% relative humidity 1 °c.
- Walls, roofs and floors, U 0.28 w/m2. The value of K is insulated with 80 mm polyurethane.
- The floor temperature is 10 °c.

To calculate the transmission load, we will use a formula like this:

Q = U x A x (external temperature − internal temperature) x 24 ÷ 1000

- **Q** = kWh/G heat load
- **u =** U Insulation value (we already know this value) (W/m2. K
- **A =** wall, roof and ground surface area (we will calculate this) (M2)
- **Internal temper**ature = air temperature inside the room (° C)
- **External tempera**ture = ambient air temperature (° C)
- **24 =** number of hours in a day
- **1000 =** conversion from Watt to KW.

"A" is very easy to calculate:

1. Wall = 6m x 4m = 24m2
2. Wall = 6m x 4m = 24m2
3. Wall = 5m x 4m = 20m2
4. Wall = 5m x 4m = 20m2

Roof = 5m x 6m = 30m2

Floor = 5m x 6m = 30m2

You must calculate the floor separately from the wall and ceiling, because the temperature difference is different under the floor, so heat transfer will be different.

Walls and roof

Q = U x A x (external temperature − internal temperature) x 24 ÷ 1000
Q = 0.28 w/m2. K x 148m2 x (30 °c-1 °c) x 24 ÷ 1000
Q = 28.8 kWh/day
[148m2 = 24m2 + 24m2 + 20m2 + 20m2 + 30m2 + 30m2]

Floor
Q = U x A x (external temperature − internal temperature) x 24 ÷ 1000

Q = 0.28 w/m2. K x 30m2 x (10 °c-1 °c) x 24 ÷ 1000
Q = 1.8 KWh/day
Total daily transmission temperature gain = 28.8 kwh/day + 1.8 kwh/day = 30.6 kwh/day

Product Installation-cooling load account from product change

In the next step, we will calculate the cooling load according to the temperature coming from the new product replacement in the cold room.

We're going to store the apples for this sample. If you are going to perform operations such as freezing, advanced cooling, as well as cooling the products, you need to make their heat gain calculations separately. We're just cooling in this example.

The new Apple of 4,000 kg, with a temperature of 5 °c and 3.65 KJ/kg, comes to the warehouse every day.

We can use the following formula for this account:

Q = m x Cp x (product inlet temperature – in-store temperature)/3600

- **Q** = kWh/day
- **CP =** specific heat capacity of the product (KJ/kg. °c)
- **m =** mass of newly added products (kg)
- **Product input temperature =** input temperature of the products (°c)
- **In-store temperature =** temperature inside the store (°c)
- **3600** = Convert from KJ to KWh

Calculation

Q = m x Cp x (product inlet temperature − in-tank temperature)/3600

Q = 4,000 kg x 3.65 KJ/kg °c x (5 °c-1 °c)/3600

Q = 16kwh/day

Cooling load account from product inhaler

The next step is the cooling load account from the product respiration. In this example, we use the product's respiratory temperature on average daily 1.9 kj/kg, but the rate varies with time and temperature. In this example, because this cooling load is not considered critical, we only apply a single value to simplify the calculation. In this example, an apple of 20,000 kg is preserved in the warehouse.

To calculate this, we will use the following formula:

Q = m x RESP/3600

- **Q** = kWh/day
- **m =** Product quantity in storage (kg)
- **RESP = r**espiratory temperature of the product (1.9 kj/kg)
- **3600** = converts KJ to kWh.

Q = m x RESP/3600

Q = 20,000 kg x 1.9 kj/kg/3600

Q = 10.5 kWh/day

So when we calculate the cooling load from the new product entering the warehouse and the cooling burden of the product due to its respiratory; ***In total, we have*** achieved a cooling load of 26.5 kWh/day.

Internal heat load – the cooling load account from people

The next step is to calculate the heat loads from the people working in the warehouse. Assuming there are 2 people working 4 hours a day in the cold storage, we can predict that they can create 270 watts of heat per hour.

We will use the following formula:

Q = number of employees x time x Heat/1000

- **Q** = kWh/day
- **Number of employees =** number of people working in the repository
- **Time =** per capita, length of time spent in the repository (hours)
- **Heat** = heat loss per hour (watts)
- **100**0 = only converts watt to KW

Calculation:
Q = number of employees x time x Heat/1000
Q = 2 x 4 hours x 270 Watts/1000

Q = 2.16 KWh/day

Internal heat load – cooling load account from illumination

In the next step, we will calculate the heat generated by lighting. This is quite simple and we can use the following formula.

Q = lamp x Time x Watt/1000

- **Q** = kWh/day,
- **Lights = nu**mber of lamps in the cold room
- **hou**r = Day of Use
- **Watts** = Power rating of lamps
- **1000** = converts Watt to KW.

If each of them has 3 lamps at 100w, if it works 4 hours a day, the calculation is as follows:

Q = lamp x Time x Watt/1000

Q = 3 x 4 hours x 100w/1000

Q = 1.2 kwh/day

Total internal load: Heat load from people (2.16 kwh/day) and Lighting heat load (1.2 kwh/day) We get a total of 3.36 kwh/day.

Equipment load-cooling load account from Fan Motors

Now, let's calculate the heat gain from the evaporators ' fan motors.

Q = fans x time x Watt/1000

- **Q =** kWh/day
- **Fans =** Fan number
- **Time =** daily working time of the fan (hours)
- **Watt** = nominal power of Fan Motors (Watts)

- **1000** = convert from Watt to KW.

In this cold room evaporator, each one uses a 200w value of 3 fans and we assume they will work 14 hours a day.

Calculation:

Q = fans x time x Watt/1000

Q = 3 x 14 hours x 200 W/1000

Q = 8.4 kwh/day

Equipment load-cooling load account from Fan motors defrost

We will now calculate the heat load resulting from the evaporator's ice thaw. To calculate this, we use the following formula:

Q = power x time x defrost cycle x efficiency

- **Q** = kWh/day,
- **Power =** Power rating of the heating element (KW)
- **Time =** Defrost working time (hours)
- **Defrost cycle = Th**e number of times the defrost cycle occurs in a day
- **efficiency = Pe**rcentage of heat transferred to the environment

In this example, in our cold room, an electric heating element with a value of 1.2 kw is used. It works 3 times a day, 30 minutes, and 30% of all the energy consumed is transferred to the cold room.

Q = 1.2 kw x 0.5 hours x 3 x 0.3

Q = 0.54 kwh/day
The total equipment cooling load is equivalent to the fan heat load (8.4 kwh/day) plus defrost heat load (0.54 kwh/day), 8.94 kwh/day.

Cooling load Account from infiltration

Now we need to calculate the heat load from the air infiltration (leakage). If we use a simplified formula:

Q = volume x Energy x change x (external temperature – internal temperature)/3600

- **Q** = kWh/D
- **Change =** number of volume changes in the day
- **Volume =** cold Storage Volume
- **Energy =** Centigrade degree of energy per cubic meter
- **External tempera**ture = ambient air temperature
- **Internal temperat**ure = Cold room temperature

- **3600 =** only converts from KJ to KWh.

Assuming that the door will create 5 volume air changes per day due to product entry to the warehouse, the volume is calculated as 120m3, each cubic metre of new air 2kj/°c, air 30 °c outside and the air in the tank 1 °c

Q = change x Volume x Energy x (external temperature – internal temperature)/3600
Q = 5 x 120m3 x 2kj/°c x (30 °c-1 °c)/3600

Q = 9.67 kWh/day

Total cooling Load

To calculate the total cooling load, we will only collect all the calculated values.

Transmission load: 28.8 kwh/day

Product Download: 26.5 kWh/day

Internal load: 3.36 kwh/day

Equipment Load: 8.94 kWh/day

Infiltration load: 9.67 kWh/day

Total = 77.27 kWh/day
Safety factor
To take into account the errors and variations in the design, we must also apply a safety factor to the calculation. A deviation of 10% to 30% can be added to calculate this.

In this example, we use a 20% safety factor. Therefore, if we multiply the cooling load with the 1.2 safety factor, we **will have a** total cooling load of 92.7 kWh/day.

Cooling capacity Calculator

The last thing we need to do is calculate the cooling capacity that is necessary to remove this heat gain from the environment. For this, the calculated total cooling load is divided into 14, based on the operation of the device 14 hours per day. This means that the capacity required by our re**frigeration u**nit should be 92,7/14 = 6, 6kw.