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Study of cold storage design and the impact of basic variables on its effectiveness

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Abstract

In this paper, we study the different types of cooling and freezing stores that can actually be used to store and preserve foodstuffs, as well as the types of heat-insulating materials and moisture-insulating materials that are used in the structural composition of these stores, in addition to the method of calculating the various items that constitute the thermal load of these stores. For the purpose of evaluating and calculating the thermal loads of cold stores in big Market for storing table egg sand foodstuffs.[5] In this research paper, the first and second warehouses were chosen for these stores. To complete these calculations, the design conditions (temperature) for the air outside the stores were determined based on the temperatures that were recorded for a period of 6 days from (11 am to 5 pm) and the temperatures that were taken. From the meteorological station, the design conditions inside the warehouse were determined depending on the quality and grades of the stored food items Suitable storage temperature. Design calculations have been performed and practical readings have been recorded, and through the study it is clear that the capacity of the evaporators is much greater than the capacity of the stored materials.[4]
Keywords: Insulating materials, Thermal load storage, Temperature design conditions

Introduction

When planning the design of cooling stations, you must know the type of cold stores to be constructed. They may be seasonal cold stores, or they may be cooling stations that operate for a specific period of the year to preserve agricultural products. Seasonal warehouses are usually located near places of agricultural production or distribution warehouses.[12] They are refrigeration stations that operate permanently to cool, freeze, and preserve food supplies until they are distributed. They are usually located in cities to serve residential communities[4].. They can also be port warehouses, which are cold stores that work to adjust the cooling or freezing degree of imported foodstuffs and then preserve them until they are transported to distribution stores in cities or transportation stores, which are mobile refrigerators in the form of trucks or railway cars used to transport foodstuffs from Port warehouses to distribution stores in cities,[11] Calculating thermal loads for cold stores. Loads Refrigeration is the thermal energy that must be expelled from the store, to maintain the appropriate conditions for the store, and by calculating these loads, it is possible to choose the appropriate cooling devices with their various parts, so that they give the highest work efficiency and the best storage conditions for all refrigerated store rooms and in All weather conditions and seasons throughout the year.[1] The designer's greatest interest is in calculating the maximum loads because they determine the capacity of the devices, and at the same time they must respond to the cold and hot weather.[4]

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1- The thermal sources of the cooling load are: - 1 - Heat transfer load. 2 - Heat load. Solar radiation. 3- Food load. 4- Air renewal load. 5- Services load. These sources are all functions of time, that is, they change with time, from one hour to another, and from day to day throughout the year. Evaporators and expansion valves are chosen for the maximum load. Cooling for each room or cold store separately, while condensers are selected While condensers and compressors are selected for the maximum cooling load for all cold stores combined. [1]

2-: The heat transfer load transferred through the walls, ceilings and floor of cold stores, as a result of the normal temperature difference between the air inside and outside the cold stores, ranges between 10 and 20 watts per square meter and can be determined by the following equation: (W)[4]

$$Q_T = [UA(t_o - t_i)] \quad (1)$$

Where: A - The surface area through which heat is transferred (²m). U - The heat transfer coefficient for the wall, ceiling or floor section and its equation: -

ho - heat transfer coefficient for the external surfaces of cold stores (W/m2. cº). hi - heat transfer coefficient for the internal surfaces of cold stores (W/m2. cº).

it is preferable to use the following relationship to determine the design temperature of the outside air. (2)

$$t_o = (0.4t_{a.H} + 0.6t_H) \quad (2)$$

Where: th- is the highest air temperature for the hottest month for the same geographical location. H,a t - is the average air temperature for the same geographical location.

3- Normal air temperature difference. Figure (1) shows a horizontal projection of a refrigerator consisting of a cooling compartment at 5°C, a freezer storage area at -20°C, an inlet, an outlet and a passage. The air temperature outside the refrigerator is 35°C.[6]

$$\Delta t_n = (35 - 5) = 30\,^{\circ}C$$

4- The inner wall is not exposed to the outside air, but rather to the air present in the entrance, corridor or exit, as the air temperature for them is lower than the air temperature outside the refrigerator and greater than the air temperature in the cooling house, and therefore the temperature difference must be less than 30 m, The following relationships can be used when designing refrigerators: A - for walls perpendicular to the external wall t = 0.7 Δ tn

B - For the internal wall that is not connected to the external environment (ef): t = 0.4 Δ tnΔ. C - For the floor connected to the external wall: t = 0.6 Δ tnΔ. D - For the floor not connected to the external environment): t = 0.5 Δ tnΔ By substitution, the temperatures for the walls (af) and (ed) are 21 m, for the wall (ef) 12 m, for the floor (afgh) 18 m, and (efhk) 15 m.

̊c = (35 + 20) = 55 tn Δ. For freezer storage

5- Floor heat load: Since the soil temperature is usually lower than the outside air temperature, the heat will transfer from the outside air to the soil, and since the air temperature inside the freezing house is lower than the soil temperature, the heat will leak from the interior of the floor to The freezer holds through the floor of the ground floor at a significant rate for the freezing holds and at

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a small rate for the cooling holds and can be neglected.[3] The heat escaping through the floor can be calculated with the following equation

whereas: (4-2) - UA ∑ t_n Δ= Q , Δ $t_{n;}$- Normal temperature difference (ºC).

$$\frac{1}{U} = R + \left(\frac{\delta}{k}\right)_I \quad -(3)$$

A- Area, (²m). U - the total heat transfer coefficient for any area and its equation: (3)(m2.ºc/W)

Where – thermal insulation thickness (m). k - The coefficient of thermal conductivity of thermal insulation, (c m / W). R - The thermal resistance of the area. The heat escaping through the floor of cold stores can be determined. With the following relationship: -

Q = W ($t_s - t_I$) (A .U) (4)

Where: ti - air temperature inside the house (ºc). ts - soil temperature, determined according to geographical location. A - House floor area (²m). U - Total heat transfer coefficient for the floor of the house (. ºc2m / W).

6- The effect of the internal wall. Figure (2) shows a portion of the cold storages of the house (A) at -15 m and the house (B) at -20 m. To demonstrate the effect of the internal wall that separates the two houses (A and B), we assume that the temperature The air surrounding the two houses is equal to the temperature of the air inside the house.

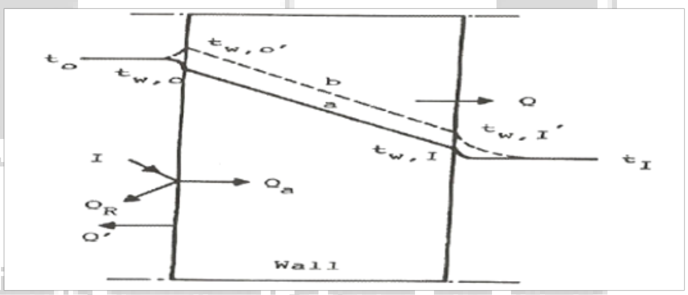

Figure (1) Part of the cold stores.

∈Evaporator load: for house(A) Q = [0.3 40 (25+15)] = 480W

Q = Total load of evaporators = Q∑:∈30 (25+20) + 0.5∈For amber (B). [0.3 30 (-15 + 20)] = 480W 60W

.[0.3×40 (25+15) + 0.3×30 (25 + 20)] = 885 WQ =Compressor load

The thermal equilibrium equation for sunlight falling on the outer surface is the amount of heat returned and absorbed, respectively, and its equation

$Q_a = \alpha I$, - +Q_R) Q = (Q_a،I = (α + R) ،، Qα ,Q_R: Q=I Q_R =[(1 – α)I]

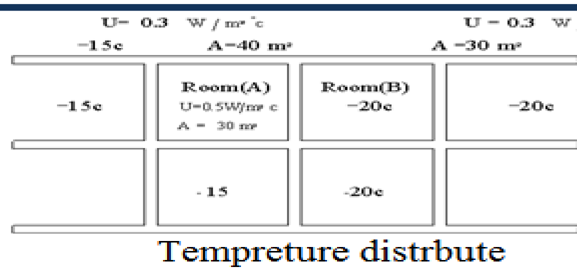

figure (2) temperature distribution through rooms

7- <u>The inner surface of the wall</u> is: -

$$Q = A\left[\alpha I - h_o\left(t_o{}' - t_o\right)\right]$$

$$= A[K(t_o{}' - t_I{}')] = A[h_I(h_I{}' - t_I)]$$

$$\therefore -\left(t_o{}' - t_o\right) = \left[\frac{1}{h_o}\left(\frac{Q}{A} - \alpha I\right)\right]$$

$$\left(t_i{}' - t_i\right) = \left[\frac{1}{h_o}\left(\frac{Q}{A}\right)\right] \left(t_o{}' - t_i{}'\right) = \left[\frac{\delta}{K}\left(\frac{Q}{A}\right)\right]$$

By summing the previous three equations:

$$\therefore -(t_o - t_i) = \left[\frac{Q}{A}\left(\frac{1}{h_o} + \frac{\delta}{k} + \frac{1}{h_i}\right) - \left(\frac{\alpha . I}{h_o}\right)\right]$$

The equation for heat transfer through the wall becomes

$$Q = A\left[U(t_o - t_i) + U\left(\frac{\alpha . I}{h_o}\right)\right]$$

And in general= [UA (Δt_n + Δt_s)]= Q = [QT +Qsun](5)

9-Heat transferred through the wall as a result of the normal temperature difference Q_T= (U A Δt_n), (W) (6)

10<u>- Heat transmitted through the wall as a result of sun light</u> Qsun= (U A ΔT_s) (7)

That is, the additional heat as a result of sunlight is calculated with the same heat transfer equation, with the value of (Δts) being substituted instead of (Δtn), where Δ tn = (to – ti) Δ, and Δts is the additional temperature difference as a result of sunlight and its equation.

$$\Delta t_s = \left(\frac{\alpha . I}{h_o}\right)$$ (8) Where: α - the absorption

11<u>- coefficient of the surface</u>. I - the intensity of solar radiation, (W/m²) ho - the heat transfer coefficient of the outer surface (ºc.²m / W). Table (2) gives the average values of the intensity of solar radiation, and the number of hours of exposure. to the sun's rays on a daily basis and the additional temperature difference resulting from the sun's rays on light-colored surfaces, white and yellow in the summer. From the reference it is clear that the intensity of solar radiation is great for the eastern and western walls, so to reduce the effect of the sun's rays, the cooling stores must be planned in the form of a rectangle so that the smallest in the eastern direction and the larger side in the northern direction.[8] In practice, the ratio of the length of the eastern side to the length of the northern side is 1:3 or 1:4, and since the external surfaces of the cooling and freezing stores do not all of them are exposed to sunlight at the same moment, so the daily solar heat load for the entire wall must be calculated with the equation:

$$Q_{sun} = (U . A\,\Delta_{Ts}. Z)\ (W - h) \qquad (9)$$

Where: Z - is the number of hours the roof is exposed to sunlight per day. The solar heat load that must be taken into account is the load on the roof in addition to the wall that has the largest Q sun possible.
The equation of heat required to be withdrawn for super freezing cooling is: -

$$QP = \frac{m}{\tau} C_{a \cdot f} (t_1 - t_2) \quad (kw) \qquad (10)$$

Where: m - the mass of the substance to be cooled, (kg). Ca.f - the specific heat of the substance above freezing (ºc. KJ/kg).τ - the cooling period (s). t1 - the initial temperature of the substance (ºc). t2 - degrees Final temperature of the substance (ºC). [4]
12 -Subfreezing cooling load Subfreezing cooling is the process of lowering the temperature of a substance to a temperature below the freezing point. Examples of this are hardening meat, poultry, fish, vegetables, and ice cream.[7]
The heat equation that must be extracted from the materials to be hardened is:

$$Q_P = \frac{m}{\tau} C_{bf} (t_f - t_4) \ (k\,w) \qquad (11)$$

Where: -t_f the freezing point of the substance (ºC). $C_{b.f}$ - Specific heat of the substance under freezing (KJ/kg)..
13- Conveying the heat of respiration. Some foodstuffs remain alive after being harvested. Among these materials are fruits and vegetables. The heat resulting from a change in their state during preservation is known as the heat of respiration. Calculated by the equation

$$Q_P = (m q_R) \ (kW) \qquad (12)$$

Where: q_R - respiration heat rate of food (KW/Kg)
14-Carrying the contents during cooling, freezing, or preserving operations. The food items may be packed in contents made of cardboard, wood, or plastic. In this case, the cooling load must include carrying the contents necessary to cool the contents from the point of entry to the point of preserving the foodstuffs. The load of the contents is determined by the equation:

$$Qc = \left[m_c C_c (t_1 - t_2) \frac{m}{\tau} \right] \quad (kw) \quad (13)$$

Where: mc - the mass of the contents, which ranges between 10% and 20% of the mass of the food according to its quality. Cc - the specific heat of the content material, which is 0.6 for wood, 0.35 for cardboard and 0.2 (kj/kg ºC) for plastic. t_1 - 15-Initial temperature of the contents (ºC). t_2 - Degree of preservation of contents (ºC). τ - Cooling period of foodstuffs (s)
For every worker the ventilation load equation for workers is:

$$QA = (5 \times 10^{-3}) \frac{n}{V_o} (h_o - h_i) \text{ (KW)} \qquad (14)$$

Where: n - the number of workers. V0 - the specific volume of fresh air outside (m³/kg). ho, hi - the specific enthalpy of the air outside and inside the rooms, respectively (kJ / kg). Most food items such as fruits and vegetables give off a second gas. Carbon dioxide and water vapor. Some foodstuffs, such as guava and fish, give off odors, so it is necessary to constantly renew the air.[10] The equation for renewing ventilation for foodstuffs is:

$$QA = \left[\frac{\xi}{24 \times 60 \times 60} \left(\frac{V_c}{V_o} \right) (h - h_i) \right] \quad (15) \quad \text{(KW)}$$

Where: Vc - the volume of the cold store minus the volume occupied by food materials. - ξ The number of times the air is changed per day, which depends on the size and temperature of the cold store

15 -: Outlet leakage load When the doors of cold stores are opened, cold air comes out of the houses and is replaced by relatively warmer air. The leakage load depends on the size of the house, the purpose of its use and the temperature of the air outside the house. The leakage load is determined by the equation:

$$Q_A = [Q_E \cdot A_f \cdot 10^{-3}] \qquad (16)$$

Where: A_F - floor area of the house (²m). Q_E - rate of leakage air temperature.

The service load means the load of lighting, motors, workers, and heaters, which is everything that can generate heat inside the cold store. The capacity of the cooling evaporator must be increased to get rid of these loads. [1]

16- Lighting load Cold stores, corridors, production and food processing areas need lighting. The lighting rate for cold stores is about 3 watts/square meter of floor area, and for corridors and production places about 8 watts/square meter of floor area. The corridors and production areas are lit with fluorescent lamps, while the cold stores are illuminated with sodium lamps that can withstand high relative humidity.

The lighting is permanent for the corridors and temporary when the doors are opened. Cold stores for shipping or distributing foodstuffs and during the production period for food processing places. The lighting load is determined by the equation: $Q_L = \eta_u . p . A_F$ (W) (17)

Where: A_F - floor area (²m). P - lighting intensity (²m / w). η_u -The utilization factor is equal to 0.6 in the case of production, and 0.35 in the case of preserving refrigerated and frozen materials.

The utilization factor is equal to 0.6 in the case of production, and 0.35 in the case of preserving refrigerated and frozen materials.

17- Loading motors are used in food processing places to operate processing equipment and to manage evaporator and ventilation fans. Motors are used in cold stores to manage evaporator fans, ventilation fans and cranes when transporting and stacking food materials, and fans of pressure-equalizing devices between the wards and corridors of pre-fabricated warehouses. The motor load is determined by the equation:

$$Q_m = (\Sigma \eta_u . \eta_m . p) \quad (W) \quad (18)$$

Where: p - motor power (w). -η_m Motor efficiency. - η_u Motor utilization factor ranges between 0.6 and 0.9

The rate of heat lost by the worker))Q_O)depends on the temperature of the cold stores. The load is determined by equation

Q_w = (n . Q_o)(w) (19)

Where: n-the number of workers. Qo - the rate of heat given off by the worker (w)

18- Loading the heaters. Cold stores are equipped with heaters to warm the door frames and the frame of pressure equalizers for prefabricated warehouses to prevent water vapor condensation when air leaks from the passages into the cooling chambers. Evaporators are also usually equipped with electric heaters to melt frost from the surfaces of the evaporator during the defrost period. The electricity required to heat door frames is little, but the capacity required for evaporator heaters is large and equal to the capacity of the evaporator, and it operates for 5 to 10 minutes every hour. [1] The heater load is determined by the equation

$$Q_H = (\Sigma \eta_u . p) \quad (W) \quad (20)$$

Where: p- heater capacity (w). η_u The heater usage factor ranges between 0.1 and From the previous analysis it is clear that the service load equation is:

Q_s = Q_L + Q_m +Q_W + QH (W) (21)

19- Shipping conditions: The entry temperature of refrigerated materials ranges between 5 to 8 °C, and the entry temperature of frozen materials ranges from 6 to 8 °C. When shipping cold stores with foodstuffs that have not been previously cooled, the initial temperature of the foodstuffs is lower than the outside air temperature by about 5 to 8 mº. In such a case, the amount of heat that must be extracted from the foodstuffs is greater than expected, and therefore it is preferable to increase the evaporator load at rates of up to 240 kj/m of floor area in cold stores.

20- Evaporator capacity to calculate the evaporator capacity, you must determine the cooling load for each cooling room, determine the number of evaporators for each room, the number of hours of compressor operation per day, and the safety factor.

1- A cold room cooling load (inside a cold store). From studying the loads for heat transfer, sunlight, foodstuffs, air renewal, and services, we find that they are functions of time (τ), meaning that their value changes with time. Therefore, when calculating the cooling load for one room of the warehouse, the sum of the maximum value of these loads is taken and calculated with the equation

$$Q = [Q_T + Q_{sun} + Q_P + Q_A + Q_S]_{max} \quad (22)$$

2Compressor operating period: Compressors in refrigeration units do not operate for 24 hours a day, as they need time periods to cool the motors and defrost the evaporators. The compressor operating period ranges from 19 to 20 hours per day, depending on the defrosting system used, meaning that the operating coefficient of the compressors ranges from 19 to 20 hours per day.

Between 65 to 85% during the compressor shutdown period, heat does not stop transferring to the cooling rooms, and when it is restarted, the evaporators absorb all the heat loads, meaning that the cooling capacity of the compressor and evaporators must be increased by the number of hours per day (24) to the number Compressor operating hours per day (t). Factor of Safety: Refrigeration loads were calculated on the basis of specific assumptions, and the possibility of these assumptions changing during operation, such as increasing the shipping rates of foodstuffs. If we take into account the presence of elements that were neglected due to their small value, then the capacity of the evaporator and compressors must be increased by a percentage known as the factor of safety, ranging between 10 and 30%. The cooling load Q must be multiplied by the number (1 + safety factor). From the above, the evaporator capacity (E.C) can be calculated with the following equation.

$$E.C = (1+\delta)Q_0\left(\frac{24}{\tau}\right) \text{ (KW) TR} \qquad (23)$$

$$= (1+\delta)Q_0\left(\frac{24}{\tau}\right)\left(\frac{1}{3.5}\right)$$

Where: δ - Safety factor. τ - Compressor operating period per day the site. The egg cooling station warehouses are located in the Misrata Markets Complex, about 20 km south of the city center. The warehouses are located on an area estimated at approximately 2,100 square meters. These warehouses were designed to preserve and store eggs and other food supplies.

21- Building shape. The warehouses are buildings made of metal structures and prefabricated panels for the walls and ceilings. They consist of a layer of polystyrene, 10 cm thick, covered on both sides by sheets of galvanized sheet, 0.6 mm thick. The floor of the warehouses is 30 cm of reinforced concrete, and the warehouses are 1 m above the surface of the ground. The warehouses are located Inside a large warehouse where direct sunlight does not reach it, and the southern wall of the wards is adjacent to the warehouse wall. The warehouse is a building made of pre-fabricated panels of glass wool with a thickness of 15 cm. The roof is in the form of a truss and consists of the warehouses consist of 6 refrigeration warehouses. The internal dimensions of each warehouse are (4Î10Î19), consisting of two rows, each row containing 3 wards. The two rows are separated by a long corridor. There is a reception and supervision room, and a compressor and control room.

22- Cooling systems: The system used in these warehouses works by direct cooling through air, and each of the two houses obtains cooling energy using a single reciprocating compressor made, an open type and is managed by an external motor via a conveyor belt, and the compressor has 6 distributed pistons. It has 3 rows in the shape of the letter W, and the compressor capacity is 30 KW, operating with Freon 12. The unit is equipped with a tube-type condenser, and the condenser is supplied With service valves and two large fans to circulate the air on its pipes. The unit is equipped with a thermal expansion valve installed before each evaporator and controls the entry of the refrigerant into the evaporator according to the required load. The unit is equipped with two pipe-type evaporators, and each hold contains an evaporator. The coolness is drawn from the refrigerant and pushed into the warehouse via A centrifugal fan, and the ice is melted from its basins and coils using hot water at 40 degrees C0 using two heaters, each with a capacity of 2000W, operating for 20 minutes every 12 hours of operation.[13]

Operational data collected from Ward No. 1

FIGURE (1) Temperature inside &outside

hours							DAY	
5	4	3	2	1	12	11		
9	9	9	9	9	9	9	Internal	SUN 2023/6/11 م
30	30	31	31	27.5	27	26.5	External	
	9	9	9	9	9	9	Internal	MON 2023/6/12 م
30	31.5	30	29.5	28	27.3	26.5	External	
9	9	9	9	9	9	9	Internal	TUE 2023/6/13 م
27	29.5	29	28	27.5	26	24	External	
9	9	9	9	9	9	9	Internal	WED 2023/6/14 م
28	31	32.5	32	30	28.5	26	External	
9	9	9	9	9	9	9	Internal	THUR 2023/6/15 م
27	29.5	29	28	27.5	26	24	External	
9	9	9	9	9	9	9	Internal	SUN 2023/6/16 م
27	29.5	29	28	27.5	26	24	External	

FIGURE (2) Operational data collected from Ward No. 2

hours							DAY	
5	4	3	2	1	12	11		
9	9	9	9	9	9	9	Internal	SUN 2023/6/11م
30	31	31	29	27.5	27	26.5	External	

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9	9	9	10	15	19	19	Internal	MON 2023/6/12م
29	31.5	30	29.5	28	27.3	26.5	External	
9	9	9	9	9	9	9	Internal	TUE 2023/6/13م
27	29.5	29	28	27.5	26	24	External	
9	9	9	9	9	9	9	Internal	WED 2023/6/14م
28	31	32.5	32	30	28.5	26	External	
9	9	9	9	9	9	9	Internal	THUR 2023/6/15م
27.5	28.3	29	30	28	27.5	26.8	External	
9	9	9	9	9	9	9	Internal	SUN 2023/6/16م
30	31	32	31.5	30	29	28	External	

Calculations of thermal loads U for the two cooling houses: 1.4 The total heat transfer coefficient U for the warehouse's structural partitions (walls, ceiling, floor) is calculated from the relationship (2 4)

$$\frac{1}{U} = \frac{1}{h_o} + \sum \frac{\delta}{k} + \frac{1}{h_i} \quad (24)$$

Calculate the total heat transfer coefficient (u) for the outer wall.

$$U = 1 / [\frac{1}{25} + \frac{0.10}{0.04} + \frac{0.15}{0.04} + \frac{1}{8}] = 0.371 \ w/m^2 . c^\circ$$

Calculate the overall heat transfer coefficient (u) for the inner wall

$$U = 1 / [\frac{1}{15} + \frac{0.10}{0.04} + \frac{1}{8}] = 0.155 \ w/m^2 . c^\circ$$

Calculate the overall heat transfer coefficient (u) for the roof

$$U = 1 / [\frac{1}{7} + \frac{0.10}{0.04} + \frac{1}{6}] = 0.355 \ w/m^2 . c^\circ$$

Note: The values of the surface heat transfer coefficient (h) were taken from Table (2) of the research paper. The cooling load resulting from heat gain through the structural partitions (walls, ceiling, floor).The rate of heat transferred through the walls, ceiling, and floor is calculated from the relationship (9) Q = AU Δtn
The heat transferred through walls exposed to sunlight is calculated from a relationship(10) Q = AU Δts And value Δts Calculated from a relationship

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$$\Delta t_s = \frac{\alpha I}{h_o} = \frac{(1.474 \times 10^{-7})}{25} = 2.72\ ^{\circ}\mathrm{C} \qquad (25)$$

Where the value of α for steel is (7-10 x 1.474). I value are values from the design tables. Pay the compensation resulting from the compensation by region according to the ratios (-4)

Q = AU (ts – ti)

The heat transfer agreement U for each area is calculated

$$\frac{1}{U} = R + \frac{\delta}{k}$$

I region $U = 1/[$[illegible]$ + \frac{[illegible]}{1.28}] = 0.42 \quad w/m^2.c$

II region $U = 1/[4.30 + \frac{0.30}{1.28}] = 0.22 \quad w/m^2.c$

III region $U = 1/[8.60 + \frac{0.30}{1.28}] = 0.11 \quad w/m^2.c$

Iv region $U = 1/[14.30 + \frac{0.30}{1.28}] = 0.06 \quad w/m^2.c$

The amount of heat leaking from the floor through the first house

I REGIAN $Q = (2 \times 19)\ 0.42\ (17 - 9) = 127.68$

II REGIAN $Q = (2 \times 19)\ 0.22\ (17 - 9) = 66.88$

III REGIAN $Q = (2 \times 19)\ 0.11\ (17 - 9) = 33.44$

Iv REGIAN $Q = (4 \times 19)\ 0.06\ (17 - 9) = 36.48$

$QT = 127.68 + 66.88 + 33.44 + 36.48 = 264.48$ W

The amount of heat leaking from the floor through the second ward: -

I REGAN $Q = (2 \times 19)\ 0.42\ (17 - 10.4) = 106.9$

II REGAN $Q = (2 \times 19)\ 0.22\ (17 - 10.4) = 56.0$

III REGAN $Q = (2 \times 19)\ 0.11\ (17 - 10.4) = 28$

Iv REGAN $Q = (4 \times 19)\ 0.06\ (17 - 10.4) = 30.5$

$QT = 106.9 + 56 + 28 + 30.5 = 221.4$ W

4 The cooling load resulting from stored materials The cooling load resulting from storing materials includes the following: -

A - The cooling load for materials above freezing, calculated from relations (13) (KW)

$$Q_{P1} = \left[\frac{m}{\tau} C_{a.f} (t_1 - t_2)\right]$$

(W)($Q_{P1} = \left[\frac{20000}{24 \times 60 \times 60} 3.06(26-9)\right] = 12041$ (W) For amber (1)

For amber (2)) (WLoading -B $Q_{P1} = \left[\frac{8860}{24 \times 60 \times 60} 3.06(26 - 10.4)\right] = 4895$ (

the contents (stored material folders) and is calculated from the relationship

$$Q_C = m_c . C_C (t_1 - t_2) \frac{m}{\tau} \qquad \text{(KW)} \quad (26)$$

$$0.15\times0.35(26-9)=\frac{20000}{24\times60\times60}=0.206KW=206W$$ Q_c For amber (1)

$$0.15\times0.35(26-10.4)=\frac{8860}{24\times60\times60}=0.084KW=84W=$$ Q_c(For amber(2)

.4-Cooling load due to air change. The cooling load resulting from heat gain due to air change includes the following: - A - Ventilation load for workers. It is calculated from the relationship (18)

$$Q_{A1}=\left[(5\times10^{-3})\frac{n}{V_o}(h_o-h_i)\right]$$ kw)

$$Q_{A1}=\left[(5\times10^{-3})\frac{3}{0.923}(90-24)\right]=1.072KW=1072W$$ For amber(1)

$$Q_{A1}=\left[(5\times10^{-3})\frac{3}{0.923}(90-27)\right]=0.887KW=887W$$ For amber(2)

Where: The values of enthalpy (h) were taken from the psychometric chart in Appendix (F). B- The ventilation load for foodstuffs is calculated from the relationship
(27) . (KW)

$$Q_{A2}=\left(\frac{3.3}{24\times60\times60}\right)\frac{760-180}{0.923}(90-24)=1.575KW=1575W$$ For amber(1)

$$Q_{A2}=\left(\frac{3.3}{24\times60\times60}\right)\frac{760-82.8}{0.923}(90-27)=1.756KW=1756W$$ For amber(2)

The values of the number of times the air is changed are taken from the design table C- Carrying air leakage to the outside
It is calculated from the relationship (20)

$$Q_{A3}=\left[Q_E.A_f\times10^{-3}\right]=\left[4\times190\times10^{-3}\right]=0.76KW=760W$$ Cooling load for services A- Lighting load, calculated from the relationship (2-21)

$$Q_L=(\eta_n.p.A_F)=0.35\times1.13\times190=75.14W \qquad (28)$$

The motor load is calculated from the relationship

$$Q_m=\Sigma\eta_u.\eta_m.p=0.7\times0.72\times4.56=226.8W$$

C- The workers' load is calculated from the relationship (23) (W)

$$Q_W=(n.Q_o)$$

Qw = (3 × 200) = 600w

D- Heater load. It is calculated from the relationship (24) (W)

$$Q_H=\Sigma\eta_u.p$$

$$Q_H=0.3\times4000=1200W$$

5. Evaporator capacity (1) Cooling load of a cold room (inside a cold store). It is calculated from the relationship (25)

$Q = [Q_T + Q_{Sun} + Q_A + Q_p + Q_s]$ max kw

[4321.23+12041+206+1072+1575+760+2101] =22.076kw

[4520.51+4895+84+1023 +1756 +760+2101] =15.139 kw For amber (2)The safety factor is calculated from the relationship

$$E.C = (1+\delta)Q_0\left(\frac{24}{\tau}\right) \text{ kw} \quad (27)$$

$$E.C = (1+0.10)22.076\left(\frac{24}{23.2}\right) = 25.12KW$$ For amber(2)

Conclusion

When designing a freezing and cooling system, it is necessary to calculate the natural and industrial loads according to the environment in which the system is located, and the calculation must be precise, taking into account the safety factor and considering any emergencies or increases in loads to ensure safe operation and full efficiency of the system.

REFERENCES

1-G.F. Hundy,Trott. and Welch "Refrigeration and Air-Conditioning" Fourth edition

2-, ASHRAE, Atlanta," Fundamentals volume of the ASHRAE Handbook "GA,2005

3- Hooman Gohari " AIRCONDITIONING AND REFRIGERATION" REPAIRMADE EASY Copyright © 2010.

4-Shan K. Wang " HANDBOOK OFAIR CONDITIONINGAND REFRIGERATION McGraw-Hill - Second Edition

5- S L Hodkinson Faber & Kell " Heating and Air-Conditioning of Buildings" Tenth edition

6-Guy W. Gupton, Jr". HVAC Controls Operation & Maintenance" Third Edition

7-Mansour, M.A., Ahmed S.E., Aly, A.M. and Lee, S.W. (2015) Fluıd flow and heat transfer characteristicsof natural convection insquare nanofluid-filled enclosures saturated porous media due to discrete source-sinkspair. Lat. Am. Appl. Res.45, 165-172.

8-Akdemir, S. (2008) Designing of cold stores and choosing of cooling system elements. J Appl Sci, 8, 788-794.

9-Anonymous (2009) Chilled Water Plant Design Guide, Taylor Engineering, California

10-Anonymous (2001). Chiller Plant Design, McQuay In-trinational, Hong Kong

11-Bayboz, B., Yalcin, E. and Sava s, S. (2004) Conventional methods, unused trues and quality in cold storage .Installation Engineering, 81, 1-9.

12- Ronnel S. Nombrefia May 19, 2017 PROPOSED DESIGN OF A COLD STORAGE STRUCTURE FOR THE TOTAL PRODUCT LOAD OF MUSHROOM"

13-Murillo-DC "refrigerated container versus bulk evidence from the banana cold chain, Marit policy Manage, 2015, 42(3)228-45"