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Palestine Polytechnic University

College of Engineering

Mechanical Engineering Department

Design of Mechanical Systems for a Grand Park Hotel in Ramallah City

By:

Musab Qabaja

Mahmoud Salman

Supervisor:

Eng. Mohammad Awad

Submitted to the College of Engineering
In partial fulfillment of the requirements for the
Bachelor degree in Refrigeration & Air Conditioning Engineering

Hebron, December 2017

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أعضاء لجنة المناقشة:

الاسم	الصفة في اللجنة	التوقيع
الدكتور اياد الهشلمون	رئيس دائرة الهندسة الميكانيكية	....
المهندس محمد عوض	المشرف	....
الدكتور اسحق سدر	مناقش	....
المهندس كاظم عسيله	مناقش	....

`

الاهداء

بسم الله الرحمن الرحيم

{يرَ ْفعِ هاللهُ الهذِينَ آمَنوُا مِنكُمْ وَالهذِينَ أوُتوُا الْعِلْمَ دَرَجَا ت}

صدق الله العظيم

لروح الله فينا ، الاكرم منا جميعا،

لمعلمي الاول - سيدنا محمد - الذي عاش لكلمة اقرأ،

لوطني العزيز - فلسطين - الذي سكن عيوننا قبل أن نفتحها،

الى ينبوع العطاء الذي زرع في نفسي الطموح والمثابره - والدي العزيز

الى نبع الحنان الذي لا ينضب - أمي الغالية

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الى كل محبي العلم والمعرفة

`

الى كل من علمني ،واخذ بيدي ، وأنار لي الطريق العلم والمعرفه

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Abstract

In this project we will design this mechanical systems that will provide comfort conditions for humans for GRAND BARK hotel in Ramallah, This hotel include two basements, ground and five floors for guests, the total area of the hotel is 8500 m^2 and the number of people who can serve them are 180 persons.

The project is going to provide an integrating service to that building in regard to the air conditioning, firefighting and plumbing systems and swimming pool .Also,gray water is recycled to be used in flushing tanks and irrigation in order to save water, In this project, air conditioning system type (VRF) is used since it is efficient and economical

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CHAPTER ONE

INTRODUCTION

1.1 Introduction:

Throughout the ages the human beings tried to improve their lives to be easier and more comfortable, and as the Wisdom say: “The necessity is the mother of invention” the engineers always try to meet the needs of humans to achieve the welfare of their lives.

So HVAC engineers develop the mechanical services systems and technologies to achieve the comfort, which the humans need in the buildings.

For this reason the mechanical system will be designed and documented in this project for Grand Park hotel in Ramallah city in Palestine.

1.2 Project overview:

Since old time human was looking for comfort conditions , At this time, human has designed mechanical systems to make him in comfort conditions that he need.

and to get this conditions that make human in comfort conditions , we should controlling and maintaining of the following four atmospheric conditions that affect the human comfort:

1 -Temperature of the inside space.

2 -Humidity contents of the air.

3 - Purity and quality of the inside air.

4 -Air velocity and air circulation within the space.

In this project we will design this mechanical systems that will provide comfort conditions for humans for GRAND BARK hotel in Ramallah, This hotel include two basements, ground and five floors for guests, the total area of the hotel is 8500 m^2 and the number of people who can serve them are 180 person.

1.3 Project scope:

The scope of this project is to design and document the mechanical services systems for GRAND BARK hotel. This project can create a bridge between the engineering study and the local labour market needs.

1.4 Project objectives and cells:

The objectives of the project is to study and design the different mechanical systems needed inside the hotel building, and swimming pool, this includes the following main topics:

1- Design the mechanical systems inside the hotel building.

2- Theoretical calculations for outside and inside conditions , heating and cooling load for the hotel

4- Theoretical calculations and design of plumping system.

5- Theoretical calculations and design of swimming pool system.

6- To be familiar with the mechanical drawings for different mechanical systems. 7 - Firefighting, hot & cold water system

1.5 Project choice and justifications:

1. This project will create sufficient experiences for the students, which would assist them to have an employment opportunity after graduation.
2. Such projects provide the opportunity to review what have been studied in the last five years in college of engineering.

1.6 Symbols:

- HVAC: Heating Ventilation and Air Conditioning.
- VRV: Variable Refrigeration Flow.
- WSFU: is water supply fixture unit it's used to calculate the portable maximum water demand for the building.
- Dfu: Drainage fixture unit it's used to calculate the provision of drainage system. Gpm: gallon per minute.
- COP: coefficient of performance

1.7 Time table:

Table 1.1:First Time Table

Activity / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Selection of the project	■	■	■												
Search about information			■	■	■	■	■	■							
Search for previous projects			■	■	■	■	■	■							
Search for video for the systems in the website						■	■	■							
Cooling Load Calculations								■	■						
WSFU Calculations										■					
Studying the Fire Fighting Systems											■	■	■		
Project Documentation					■	■	■	■	■	■	■	■	■	■	
Project Printing														■	

Table 1.2:Second Semester Time Table

Activity / Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Complete Design The Mechanical Services System for The Building	■	■	■	■	■	■	■	■	■	■	■				
Required drawings for the relevant systems on AutoCAD program					■	■	■	■	■	■	■	■	■		
Selecting The Pumps and Other Equipment's needed in our Systems												■	■		
Preparing a sample of B.O.Q				■	■	■	■	■	■	■	■	■	■		
Project Documentation				■	■	■	■	■	■	■	■	■	■		
Project Printing														■	■

CHAPTER TOW

HEATING LOAD CALCULATIONS

2.1 Introduction

2.2 Human comfort

2.3 Calculation of overall heat transfer coefficient (U)

2.4 Outdoors and indoors design conditions

2.1 Introduction:

The main objective of the air conditioning is to maintain the environment in enclosed spaces at conditions that induced the feeling of comfort to all occupants of the space. This feeling of comfort is influenced by a number of main related parameters which are the inside temperature, the humidity and the outside design condition.

2.2 Human comfort

2.2.1 Introduction of human comfort

The process of comfort heating and air conditioning is simply a transfer of energy from one substance to another. This energy can be classified as either sensible or latent heat energy.

Sensible Heat is heat energy that, when added to or removed from a substance, results in a measurable change in dry-bulb temperature.

Latent Heat (hidden) heat energy that is absorbed or released when the phase of a substance is changed. For example, when water is converted to steam, or when Steam is converted to water.

The necessity for comfort air conditioning system from the fact that the metabolism of the human body normally generates more heat than it needs. This heat is transferred by convection and radiation to the environment surrounding the body. The average adult, seated and working, generates excess heat at the rate of approximately 450 Btu/hr. [132 W]. About 60% of this heat is transferred to the surrounding environment by convection and radiation, and 40% is released by perspiration and respiration. As the level of physical activity increases, the body generates more heat in proportion to the energy expended. When engaged in heavy labor, as in a factory for example, the body generates 1.450 Btu/hr. [425 W]. At this level of activity, the proportions reverse and about 40% of this heat is transferred by convection and radiation and 60% is released by perspiration and respiration.

In order for the body to feel comfortable, the surrounding environment must be of suitable temperature and humidity to transfer this excess heat. If the temperature of the air surrounding the body is too high, the body feel uncomfortably warm. The body responds by increasing the rate of perspiration in order to increase the heat loss through evaporation of body moisture. Additionally, if the surrounding air is too humid, the air is nearly saturated and it is more difficult to evaporate body moisture. If the temperature of the air surrounding the body is too low, however, the body loses more heat than it can produce. The body responds by constricting the blood vessels of the skin to reduce heat loss.

2.2.2 Factor affecting human comfort

1. Dry Air: air that has a low relative humidity.

2. Moist Air: air that is a mixture of dry air and any amount of water vapor generally, air with a high relative humidity.

3. Humidity: is the amount of water vapor in the air.

4. Saturation: the state of being saturated or the action of saturating.

5. Dry Bulb Temperature: temperature that is usually thought of as air temperature.

6. Wet Bulb Temperature: is the temperature a parcel of air would have if it were cooled to saturation (100% relative humidity) by the evaporation of water into it.

7. Dew-Point Temperature: the temperature at which water vapor starts to condense out of the air (the temperature at which air becomes completely saturated). Above this temperature the moisture will stay in the air.

2.3 calculations of overall heat transfer coefficient U:

The overall heat transfer coefficient depends on the layers that the walls, floor and roof consist of and the inside and outside conviction heat transfer coefficients. So the overall heat transfer coefficient can be calculated by applying the following equation:

$$U=\frac{1}{\Sigma\ Rth}=\frac{1}{Rin+\sum\frac{\Delta x}{k}+Rout}$$

Where:

Δx: the thickness of the wall. [m].

Rin: inside film resistance.R [m^2.C/W].

Rout: Outside film resistance.. R [m^2.C/W].

2.3.1 The heat overall heat transfer coefficient (U):

Calculation of overall heat transfer coefficient for walls, ceiling, floor, glass and door

1- For external wall

Table 2.1: Construction of external walls

1	Stone	...0	**7.1**
2	concrete	..1	**7.11**
3	Cement break	...0	**9.0**
4	Polyurethane	...3	**9.90**
5	Plaster	...2	**7.1**

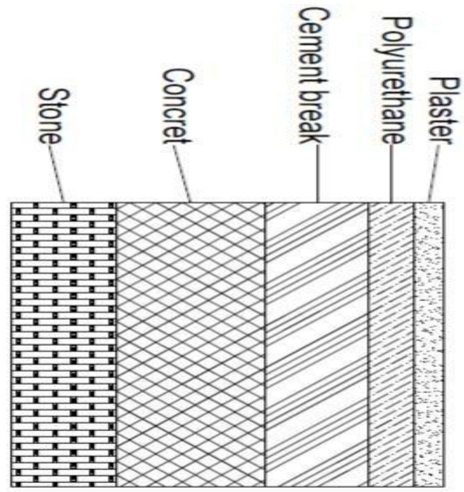


Figure 2.1: External wall construction

R in and Rout for the external walls as 0.12 and 0.04(m^2/W.°C), respectively from table (A-27)

$$U=\frac{1}{Rin+\frac{\Delta x(st)}{k(st)}+\frac{\Delta x(con)}{k(con)}+\frac{\Delta x(cem)}{k(cem)}+\frac{\Delta x(poly)}{k(poly)}+\frac{\Delta x(plas)}{k(plas)}+Rin}$$

U=

2-For Internal Wall:

Table 2.2: Construction of internal walls

1	Plaster	...2	**7.1**
2	Cement break	..1	**7**
3	Plaster	...2	**7.1**

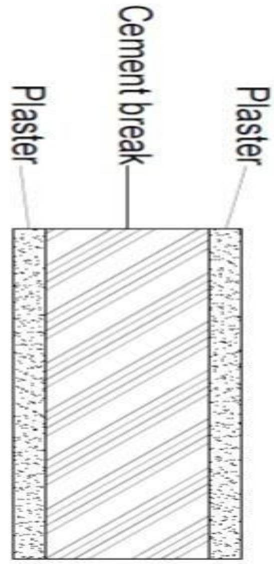


Figure 2.2: internal wall construction

$$U=\frac{1}{Rin+\frac{\Delta x(pla)}{k(pla)}+\frac{\Delta x(cem)}{k(cem)}+\frac{\Delta x(pla)}{k(pla)}+Rin}$$

$$U=\frac{1}{0.12+\frac{0.02}{1.2}+\frac{0.1}{1}+\frac{0.02}{1.2}+0.12}=2.68 (W/m^2.°C)$$

3-For Ceiling:

Table 2.3: Construction of celling

1	Asphalt	0.02	**0.8**
2	Concrete	0.05	**1.75**
3	Polystyrene	...5	**9.90**
4	concrete	...0	**7.11**
5	Brick	..14	**9.01**
0	Plaster	...2	**7.1**

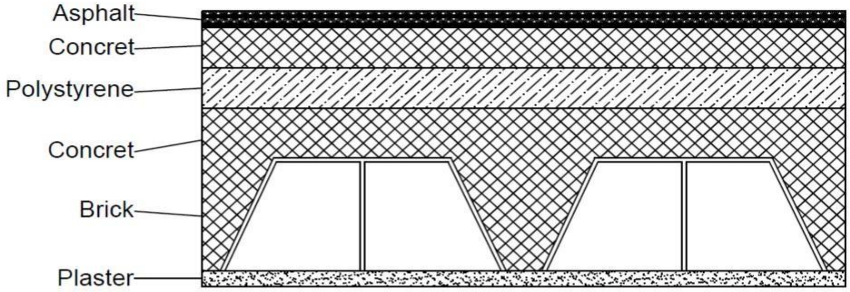


Figure 2.3: Ceiling construction

Because of its construction, the ceiling is divided into two overall heat transfer coefficient one with brick and the other without.

Rin and Rout for the ceiling are 0.1 and 0.04$(W/m^2.\,°C)$, respectively from table (A-27)

$$U1=\frac{1}{Rin+\frac{\Delta x(Asph)}{k(Asph)}+\frac{\Delta x(con)}{k(con)}+\frac{\Delta x(poly)}{k(poly)}+\frac{\Delta x(con)}{k(con)}+\frac{\Delta x(Bri)}{k(Bri)}+\frac{\Delta x(pla)}{k(pla)}+Rin}$$

$$U1=\frac{1}{0.1+\frac{0.02}{0.8}+\frac{0.05}{1.75}+\frac{0.05}{0.03}+\frac{0.06}{1.75}+\frac{0.14}{0.95}+\frac{0.02}{1.2}+0.04}=0.516(W/m^2.\,°C)$$

Similarly, U2 =0.953 $(W/m^2.\,°C)$

4- For floor :

Table 2.4: Construction of floor

1	Terrazzo	...2	**7.0**
2	Mortar	...2	**9.70**
3	Sand	..1	**9.1**
4	concrete	..15	**7.11**

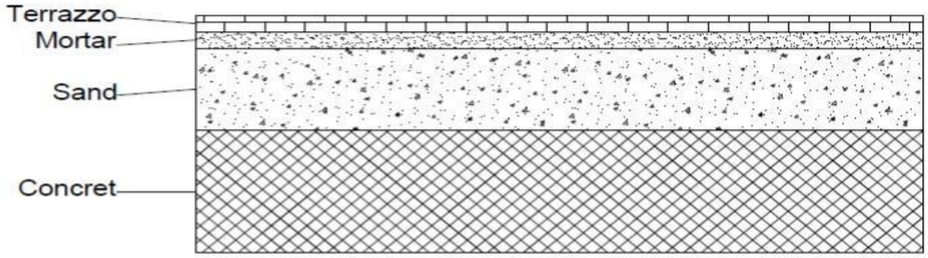


Figure 2.3: Floor construction

Rin = 0.15$(W/m^2.°C)$, from table (A-27)

$$U=\frac{1}{Rin+\frac{\Delta x(Ter)}{k(Ter)}+\frac{\Delta x(Mor)}{k(Mor)}+\frac{\Delta x(Sand)}{k(Sand)}+\frac{\Delta x(con)}{k(con)}}$$

$$U=\frac{1}{0.15+\frac{0.02}{1.4}+\frac{0.02}{0.16}+\frac{0.1}{0.7}+\frac{0.15}{1.75}}=1.93\ (W/m^2.°C)$$

5- For glass From table (A-28), Ug = 3.2$(W/m^2.°C)$for double glass aluminum frame.

6- For door From table (A-29) , Ud = 3.6$(W/m^2.°C)$ for wood door type.

2.4 Outdoors and indoor design conditions:

These conditions include the dry bulb temperature, relative humidity, and the average air speed. These values were obtained from the Palestinian code and the psychometric chart.

Table 2.5: Outdoors design condition

	Summer	Winter	Summer	Winter
Temp	24	24	3.	4.0
R.H	5.	45	50	02
Wind Speed	-	-	1.4	1.4

2.4.1 Heat loss calculations:

The main resources of heat loss come from the walls, floor, ceiling, doors, windows and also comes from the infiltration. To calculate each one of them the following equations are to be use:

$$Q=A\times U\times \Delta T \qquad \textbf{(2.2)}$$

Where:

Q : Is the heat transfer rate. [kW]

A: Is the area of the layer which heat flow through it. [m^2]

ΔT: Is the difference between the inside and outside temperatures [℃]

U: Is the overall heat transfer coefficient. [W/m.℃]

2.4.2 Total heat load calculations

Total heat load calculations for the sample room:

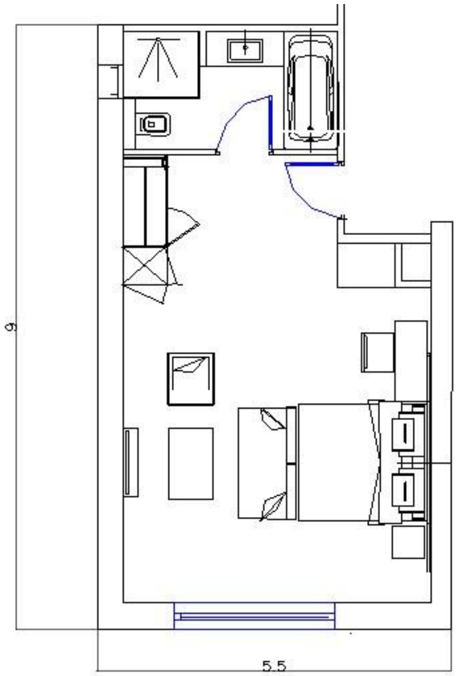


Figure 2.4: Sample room

Heat loss through ceiling (Q_c):

Because of its construction, the ceiling is divided into two areas which are area A1 and area A2 as showing n Figure (2.5).

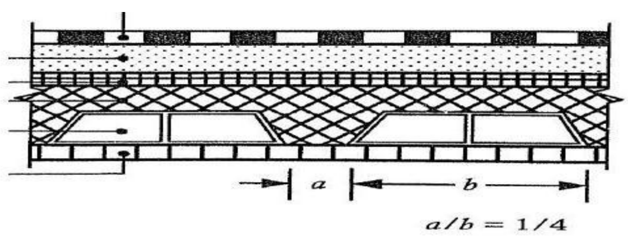


Figure 2.5: Ceiling construction

<u>The area A1 is equal to:</u>

Ac= 9*5.5 = 49.5 m^2 A1=

$\frac{4}{5}$Ac

A1= $\frac{4}{5}$ 49.5= 39.6 m_2

<u>And the area A2 is equal to:</u>

$A2= \frac{1}{5}Ac$

$A2= \frac{1}{5}49.5= 9.9m_2$

Q c =Uc Ac(Ti - To)

=(U1A1 +U2A2)(Ti - To) Q c =

(0.516 ×39.6 + 0.953×9.9)(24 - 4.7)

Q c = 576.46W

Heat loss through walls (Qw):

The external wall area is

Aw,ex1 = (5.5*3.10)-(2.5×1.8) =12.55 m^2

Aw,ex2 = (9*3.10)=27.9 m^2

The heat loss from external wall is

Qw,ex1 = (Uw,ex* Aw,ex1)(Ti - To)

= (12.55×0 .9) (24-4.7) = 218W

Qw,ex2 = (Uw,ex* Aw,ex2)(Ti - To)

= (27.9×0 .9) (24-4.7) = 484.6W

Qw,ex= Qw,ex1+ Qw,ex2= 702.6 W

There are two spaces beside the guest room are unconditioned, so heat loss from unconditioned walls:

$Q_{w,un.} = Q_{w,un.}$

The unconditioned temperature is calculate by equation (2.3)

T_{un}= 0.5 (Ti - To) **(2.3)**

= 0.5 (24 - 4.7) = 9.65 °C

<u>There are two internal walls and the area of internal walls is</u> :

Aw,in1= 5.5*3.10= 17.05 m^2

Aw,in2=(9*3.5)-(0.9*2)=26.1 m^2

<u>The heat loss from internal walls is</u>:

$Q_{w,in1}$ = (Uw,in* Aw,in1)(Ti – T_{un})

= 655.7 W $Q_{w,in2}$= (Uw,in* Aw,in2)(Ti – T_{un})

= 1003.7 W

$Q_{w,in} = Q_{w,in1} + Q_{w,in2}$ = 1659.4 W

Heat loss through windows (Q_g):

Q_g = Ug Ag (Ti - To)

= (3.2) (2.5×1.8) (24-4.7) = 278 W

Heat loss through external door (Q_d):

Q_d = Ud Ad (Ti - Tun.)

= (3.6)(2× 0.9)(24-9.65) = 93 W

Heat loss through infiltration (Q_{inf}):

Infiltration is the leakage of outside air through cracks and clearances around the windows and doors. The amount of infiltration depends mainly on the tightness of the windows and doors on the outside wind velocity or the pressure difference between the outside and inside of the room.

The total heat load due to infiltration is given by the equation :

$$Q_{inf}= \frac{1250}{3600} * v_f * \Delta T \quad \textbf{(2.4)}$$

Where:

Tin: inside design temperature (°C).

Tout: outside design temperature (°C)

Vf: The volumetric flow rate of infiltrated air in (m3/h)

$$Vf= k*L\ [0.613(S1*S2*v_0)2]\ 2/3 \quad \textbf{(2.5)}$$

Where:

K: the infiltration air coefficient

.

L: the crack length in meter.

$S1$: Factor that depends on the topography of the location of the building

$S2$: Coefficient that depends on the height of the building.

VO: measured wind speed (m/s)

The value of K, $S1$ and $S2$ is obtained from tables (A-13), (A-19) and (A-20) Respectively

.

K =0.43

$S1$ =1

$S2$ =0.94

VO= 1.4 (m/s) from Palestinian code and

L= 2W + 2H   for door

$L_d = 5.8$

$L = 2W + 3H$ for double sliding window

$L_w = 10.4$

Therefore; Vf_d= 0.43*5.8 [0.613(1*0.94*1.4)^2] $^{2/3}$

= 2.6 m^3/h

Vf_w= 0.43*10.4 [0.613(1*0.94*1.4)^2] $^{2/3}$ = 4.65 m^3/h

$Qinf_d = \frac{1250}{3600} * Vf_d * \Delta T = \frac{1250}{3600} * 2.6 * (24-9.65) = 13$ W

$Qinf_w = \frac{1250}{3600} * Vf_w * \Delta T = \frac{1250}{3600} * 4.65 * (24-4.7) = 31.2$ W

$Qinf = Qinf_d + Qinf_w = 44.2$ W

Heat gain due to ventilation

The ventilation is used for maintaining a healthy indoor air by introducing a fresh air from outside of the building. And this kind of heat gain can be calculated by using the following equations:

Q_{vent}.= × p_{air} × $(To\text{-}Tin)$ **(2.6)** Where:

: mass flow rate of ventilation air (kg/s).

$= \frac{\text{Rate of ventilation air}}{\text{vo}}$ **(2.7)**

Rate of ventilation = Room Area × Requirement outside ventilation air **(2.8)**

= 9×5.5×10 = 495 L/s = 0.495 m^3 /s.

$v\,o$= 0.791 m3 /kg.

= 0.926kg/s.

Cp_{air} : Specific heat of air, Cp_{air} = 1.005 kJ/kg.° .

Q_{vent}.= 0.926 × 1.005 × (24-4.7) = 18 W

$Q_{tot} = Q_c + Q_{w,in} + Q_{w,ex} + Q_g + Q_d + Q_{inf} + Q_{vn}$

$= 576.46 + 702.6 + 1659.4 + 278 + 93 + 44.2 + 18 = 3371.7W$

Take a safety factor of 15 % for each space of the residence to cover the miscellaneous and emergency heating loads then :

$Q_{tot} = 3371.7\times 1.15 = 3708.8$ W.

$= 3.7$ kW

Heating Load Summary is listed in the following table:

Table 2.6: Heating load for each floor in the building

Ground	**40**
First	**52**
Second	**51.5**
Third	**51.5**
Forth	**51.5**
Roof	**103.5**

CHAPTER THREE

COOLING LOAD CALCULATION

3.1 Introduction

3.2 Cooling load

3.3 Sample calculation

3.4 Variable Refrigerant Flow System(VRF)

3.1 Introduction

The cooling load is defined as the rate at which heat energy must be removed from a space in order to maintain a given inside design condition.

To achieve the human comfort conditions it is needed to do some calculation to select the proper equipment to have the conditions that it is needed and the cooling load is the most important load that can helps in selecting the equipment's that needed correctly.

3.2 Cooling load

The total cooling load of a structure involves:

1. Sensible heat gain through walls, floors and roof.

2. Sensible heat gain through windows.

3. Sensible heat and latent heat gain from ventilation.

4. Sensible and latent heat due occupancy.

5. Sensible heat gain from the equipment.

3.2.1 Cooling load calculations:

Total cooling load calculations for the sample room:

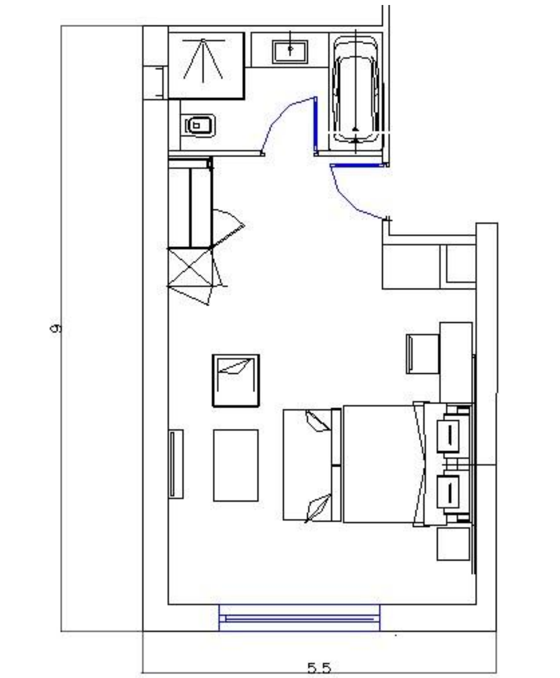


Figure 3.1: Sample room

Direct and diffused solar radiation that absorbed by walls and roofs result in raising the temperature of these surfaces. Amount of radiation absorbed by walls and roofs depends upon time of the day, building orientation, types of wall construction and presence of shading.

The heat transfer rate through sunlit walls or sunlit roofs is calculated from the following equation:

$$Q = UA\,(CLTD)_{corr.} \qquad \textbf{(3.1)}$$

Where:

(LTD) corr.: corrected cooling load temperature difference, ° ,

$$(CLTD)_{corr.} = (CLTD + LM)\,k + (25.5 - T_{in}) + (T_{o,m} - 29.4)\,f \qquad \textbf{(3.2)}$$

Where:

LTD: cooling load temperature difference, ° , from Table (A-3)

LM: latitude correction factor, from Table (A-25)

k: color adjustment factor .

Tin: inside comfort design temperature, ˚

f: attic or roof fan factor.

To,m: outdoor mean temperature, ˚

$$T_{o,m} = (T_{max} + T_{min}) / 2 \qquad \textbf{(3.3)}$$

Where:

Tmax: maximum average daily temperature, ˚

Tmin: minimum average daily temperature, ˚

Tmax = 35 ˚ and Tmin = 13.8 ˚ are obtained from Palestinian ode.

Applying these values in equation (3.3) to obtain the outdoor mean temperature

To,m = 24.8 ˚ .

3.3 Sample Calculation:

Calculation the heat gain from the Guest room in the last floor as a sample :

Heat gain through sunlit roof (Q Roof):

LTD = 14 ˚

LM = 5

k = 0.83 for permanently light colored roofs.

f = 1 there is no attic or roof fan.

$$(CLTD)_{corr.} = (14 + 5)\, 0.83 + (25.5 - 24) + (24.8 - 29.4)\, 1$$

$$= 12.67^{\circ}$$

$$Q_{Roof} = (U1\, A1 + U2\, A2)\, (CLTD)_{corr} \qquad \textbf{(3.4)}$$

$$Q_{Roof} = (0.516 \times 39.6 + 0.953 \times 9.9)\, (12.67)$$

$$= 378.43 \text{ W}$$

Heat gain through sunlit walls (Q Wall):

LTD at 14:00 o'clock … from Table (A-8)

CLTD =15 c

LM =0

N = 0.0

k = 0.83 for permanent medium color walls.

(CLTD) corr.E, = (15+0) 0.83+ (25.5-24) + (24.8-29.4) × 1

= 9.35 $^{\circ}$

$\dot{Q}$ Wall = $\dot{Q}$ E = U* A* CLTD

= 0.9*12.55*9.35

= 105.6 W

$\dot{Q}$ Wall = $\dot{Q}$ E = U* A* LTD

= 0.9*27.9*9.35

= 234.77 W

$\dot{Q}$ Wall = U* A* ΔT

= 2.68*26.1* (27-24)

= 209.8 W

$\dot{Q}$ Wall = U* A* ΔT

= 2.68*17* (27-24)

=136.68 W

$\dot{Q}$ Wall = 686.85 W

Heat gain due to glass (Q Glass):

Solar radiation which falls on glass has three components which are:

1- Transmitted component: it represents the largest component, which is transmitted directly into the interior of the building or the space. This component represents about 42% to 87% of incident solar radiation, depending on the glass transmissibility value. **2-** Absorbed component: this component is absorbed by the glass itself and raises its temperature. About 5 to 50% of solar radiation it absorbed by the glass, depending on the absorptive value of the glass

3- Reflected component: this component is reflected by the glass to the outside of the building. About 8% of the solar energy is reflected back by the glass.

The amount of solar radiation depends upon the following factors:

1- Type of glass (single, double or insulation glass) and availability of inside shading.

2- Hour of the day, day of the month, and month of the year.

3- Orientation of glass area. (North, northeast, east orientation, etc).

4- Solar radiation intensity and solar incident angle.

5- Latitude angle of the location.

The maximum cooling load due to the glass window Q Glass, consists of transmitted (Q tr.) and convected (Q conv.) cooling loads as follows:

Q Glass = Q tr. + Q conv. **(3.5)**

Where:

Qtr.: transmission heat gain, W

Qconv.: convection heat gain, W

SHG: Solar heat gain factor: this factor represents the amount of solar energy that would be received by floor, furniture and the inside walls of the room and can be extracted , from Table (A-12)
SC: Shading coefficient: this factor accounts for different shading effects of the glass wall or window and can be extracted from Table (A-10) for single and double glass without interior shading or from Table (A-11)for single and double glass as well as for insulating glass with internal shading .

CLF: Cooling load factor : which Represent the effect of the internal walls, floor, and furniture on the instantaneous cooling load, and extracted from Table (A-8), and (A-9) for glass, and from Table (A-5) and (A-6), for lights and occupants respectively.

The transmitted cooling load is calculated as follows:

Q tr. = A (SHG) (SC) (CLF) **(3.6)**

SHG in W/m2 … from Table (A-12)

A = 4.5 m2

SHG = 795 W/m m

S = 0.57… reflective double from Table A (2.14)

CLF = 0.84 at 14:00 o'clock … from Table A (2.16)

Qtr. N = 4.5 × 795 × 0.57 × 0.84

= 1712.9 W

Q conv. = UA (CLTD) corr. **(3.7)**

Where:

U: Over all heat transfer coefficient of glass ($W/m^2.K$).

A: Out windows Area of heat conduction. (m^2).

(CLTD) corr.: is calculated as the same of walls and roofs and the CLTD value for

glass is obtained from Table (A-7)
LTD = 7 ˚ at 14:00 o'clock

k = 1 for glass

f = 1 for glass

Q conv. = U× A× CLTD

= 3.2×4.5×7

=100.8 W

Q Glass = Q tr. + Q conv.

=1712.9+100.8

=1813.7W

Heat gain due to lights ($\dot{Q}$ Lt.):

Heat gains due to lights are sensible loads and are calculated by the following equation:

$\dot{Q}$ Lt. = light intensity × A × (LF) Lt. **(3.8)**

Where:

light intensity = 10-30 W/ m^2 for apartment, so we will take 30W/ m^2

A: floor area = 49.5 m^2

(CLF)Lt.: cooling load factor for lights.

(LF)Lt. = 0.82 … from Table (A-5)

Q Lt. = 30 × 49.5 × 0.82

= 1217.7 W

Heat gain due to infiltration (Q f):

As the same way in heating load

$Q_{inf.,g} = \frac{1250}{3600} Vf\ (Ti - To)$ **(3.9)** Where:

Vf: The volumetric flow rate of infiltrated air in (m_3/s)

$Vf = K \times L\ [0.613(S1*S2*v_0)_2]\ _{2/3}$ **(3.10)**

Where:

K: the infiltration air coefficient.

L: the crack length in meter.

$S1$: Factor that depends on the topography of the location of the building

$S2$: Coefficient that depends on the height of the building.

VO: measured wind speed (m/s)

The value of K, $S1$ and $S2$ is obtained from tables (A-13), (A-19) and (A-20) respectively.

K =0.43

$S1$ =1

$S2$ =0.94

Through door

$Vf_d = 0.43*5.8\ [0.613(1*0.94*1.4)^2]^{2/3} = 2.65\ m^3/h$

$Q_{inf} = \frac{1250}{3600} Vf\ (Ti - To)$

$= \frac{1250}{3600} *2.65*(30-24)$

= 5.4 W

Through Window

$Vf_w = 0.43*10.4\ [0.613(1*0.94*1.4)^2]^{2/3} = 4.65\ m^3/h$

$Q_{inf} = \frac{1250}{3600} Vf\ (Ti - To)$

$=\frac{1250}{3600}$ *4.65*(30-24)

=9.68W

Qinf = inf d+Qinf w

=5.4+9.68

=15.08W

Heat gain due to occupants (Q oc.):

Sensible and latent heat gains from occupants must be removed from the conditioned space. The heat gain due to occupants is the following:

Q oc. = Q sensible + Q latent **(3.11)** Q

sensible = heat gain sensible × No. of people × (CLF) oc. **(3.12)**

Where: (CLF) oc.: cooling load factor due to occupants.

heat gain sensible = 70 very light work … from Table A(2.18)

No. of people = 2

(CLF) oc. = 0.84 at 9 hours after each entry into space is obtained from Table (A-21)

Q sensible = 70 × 2× 0.84

= 117.6 W

Q latent = heat gain latent × No. of people **(3.13)**

heat gain latent = 44… very light work from Table (A-21)

Q latent = 44 × 2

= 88W

Q oc. = 117.6 + 88

= 205.6 W

Heat gain due to ventilation (Qvn.):

Mechanical ventilation is required for places in which the inside air is polluted due to activities that place in these spaces as factories, restaurants, closed parking areas, etc. The amount of outside fresh air recommended for mechanical ventilation for different applications. The sensible and total cooling loads required to cool the ventilated air to the inside room temperature is calculating by the following equation:

$\dot{Q}$ vn. = m ×Cp air × (Tout -Tin) **(3.14)**

Where:

m: mass flow rate of ventilation air, kg/s

Cp air: specific heat of air = 1.005 kJ/kg .k

$$m = \frac{\text{rate of ventilation air}}{\text{vo}}$$

(3.15) rate of ventilation air = A room × requirement outside ventilation air

(3.16)

A room = 49.5 m^2

requirement outside ventilation air = 10 L/s/ m^2 … from Table (A-26)

rate of ventilation air = 49.5 × 10

= 495 L/s

= 0.495 m^3 /s

vo = 0.879 m^3 /kg

m= 0.495/0.879

= 0.563 kg/s

Qvn. = 0.563 × 1.005 × (30 – 4.7)

=14.315W

The total heat loss from Sample Room is:

QTot = Q Roof + QWall + Q Glass + Q Lt + Qf + Q oc. + Q vn.

=378.43 W+686.85 W+1813.7W+ 1217.7 W+15.08W +205.6 W +14.315W

= 4331.67W

Take a safety factor of 15 % for each space of the residence to cover the miscellaneous and emergency cooling loads then:

QTot = 4331.67W *1.15

= 4981.42W

= 4.98 kW

Cooling Load Summary is listed in the following table:

Table 3.1: Cooling load for each floor in the building

Ground	**70**
First	**98**
Second	**97.5**
Third	**97.5**
Forth	**97.5**
Roof	**185.97**

3.4 Variable Refrigerant Flow System(VRF)

Overview

The primary function of all air-conditioning systems is to provide thermal comfort for building occupants. There are a wide range of air conditioning systems available, starting from the basic window-fitted units to the small split systems, to the medium scale package units, to the large chilled water systems, and currently to the variable refrigerant flow (VRF) systems.

Variable refrigerant flow (VRF) is an air-conditioning system configuration where they're isone outdoor condensing unit and multiple indoor units. The term variable refrigerant flow refers to the ability of the system to control the amount of refrigerant flowing to the multiple evaporators (indoor units), enabling the use of many evaporators of differing capacities and configurations connected to a single condensing unit. The arrangement provides an individualized comfort control, and simultaneous heating and cooling indifferent zones.

Currently widely applied in large buildings especially in Japan and Europe, these systems are just starting to be introduced in the U.S. The VRF technology/system was developed and designed by Daikin Industries, Japan who named and protected the term variable refrigerant volume (VRV) system so other manufacturers use the term VRF "variable refrigerant flow". In essence both are same.

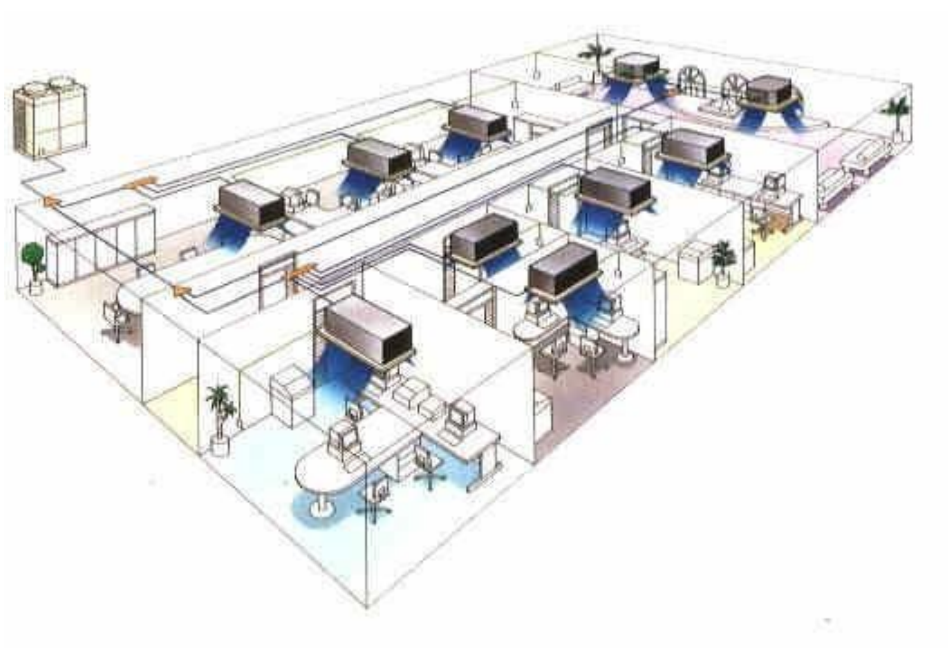


Figure 3.2: Sample for VRF system

Refrigerant modulation in a VRF system

VRV/VRF technology is based on the simple vapour compression cycle (same as conventional split air conditioning systems) but gives you the ability to continuously control and adjust the flow of refrigerant to different internal units, depending on the heating and cooling needs of each area of the building. The refrigerant flow to each evaporator is adjusted precisely through a pulse wave electronic expansion valve in conjunction with an inverter and multiple compressors of varying capacity, in response to changes in the cooling or heating requirement within the air conditioned space.

VRF systems are engineered systems and use complex refrigerant and oil control circuitry. The refrigerant pipe-work uses a number of separation tubes and/or headers.

A separation tube has 2 branches whereas a header has more than 2 branches. Either of the separation tube or header, or both, can be used for branches. However, the separation tube is never provided after the header because of balancing issues.

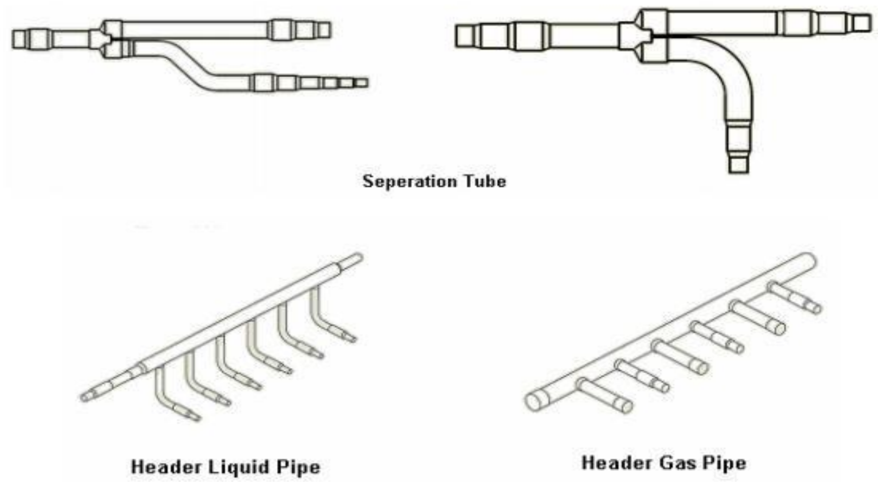


Figure 3.3: Separation and header tubes

Building Load Profile

When selecting a VRF system for a new or retrofit application, the following assessment tasks should be carried out:

- Determine the functional and operational requirements by assessing the cooling load and load profiles including location, hours of operation, number/type of occupants, equipment being used, etc.

- Determine the required system configuration in terms of the number of indoor units and the outdoor condensing unit capacity by taking into account the total capacity and operational requirements, reliability and maintenance considerations

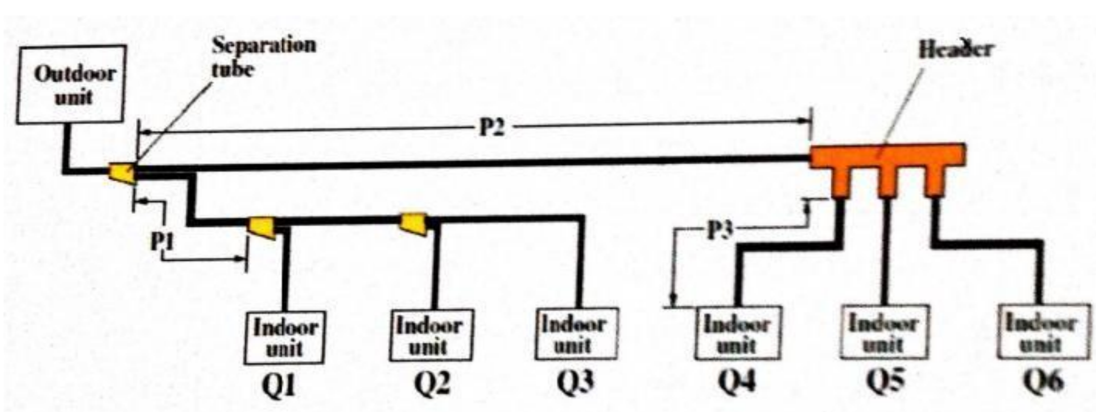


Figure 3.4: Indoor and outdoor capacity

- Size of P1: Depends on the total capacity of (Q1+Q2+Q3)

- Size of P2: Depends on the total capacity of (Q4+Q5+Q6)
- Size of P3: Depends on the total capacity of (Q4)

VRF systems have several key benefits, including:

1. Installation Advantages.
   VRF systems are lightweight and modular. Each module can be transported easily and fits into a standard elevator.
2. Design Flexibility.
   A single condensing unit can be connected to many indoor units of varying capacity (e.g., 0.5 to 4 tons [1.75 to 14 kW]) and configurations (e.g., ceiling recessed, wall mounted, floor console). Current products enable up to 20 indoor units to be supplied by a single condensing unit. Modularity also makes it easy to adapt the HVAC system to expansion or reconfiguration of the space, which may require additional capacity or different terminal units.
3. Maintenance and Commissioning**.**
   VRF systems with their standardized configurations and sophisticated electronic controls are aiming toward near plug-and-play commissioning.

4. Comfort.
   Many zones are possible, each with individual set point control. Because VRF systems use variable speed compressors with wide capacity modulation capabilities, they can maintain precise temperature control, generally within ±1°F (±0.6°C), according to manufacturers' literature.
5. Energy Efficiency.
   The energy efficiency of VRF systems derives from several factors. The VRF essentially eliminates duct losses, which are often estimated to be between (10-20) % of total airflow in a ducted system.VRF systems typically include two to three compressors, one of which is variable speed, in each condensing unit, enabling wide capacity modulation. This approach yields high part-load efficiency, which translates into high seasonal energy efficiency, because HVAC systems typically spend most of their operating hours in the range of 40% to 80% of maximum capacity.

6. Refrigerant piping runs of more than 200 feet (60.96 m) are possible and outdoor units are available in sizes up to 240,000 Btu/ h (60478.98 kW).

3.1.4 Selection units

This section talks about selection of outdoor and indoor units of VRF system, depending on the "Samsung VRFcatalogue", since this company product exists in Ramallah.

Outdoor and indoor units are selected according to the thermal load of the building.

Outdoor unit

Table 3.2: Outdoor Unit Details for Ground Floor

Unit g-1	20	68.81	RD200HHXGA	1295 x1695 x765

Table 3.3: Outdoor Unit Details for First Floor

Unit f-1	16	97.3	RD160HHXGA	1295 x 1695 x 765
Unit f-2	14	97.3	RD140HHXGA	1295 x 1695 x 765

Table 3.4: Outdoor Unit Details for Second Floor

Unit s-1	16	97.3	RD160HHXGA	1295 x 1695 x 765
Unit s-2	14	97.3	RD140HHXGA	1295 x 1695 x 765

Table 3.5: Outdoor Unit Details for Third Floor

Unit th-1	16	97.3	RD160HHXGA	1295 x 1695 x 765
Unit th-2	14	97.3	RD140HHXGA	1295 x 1695 x 765

Table 3.6: Outdoor Unit Details for Fourth Floor

Unit f-1	16	97.3	RD160HHXGA	1295 x 1695 x 765
Unit f-2	14	97.3	RD140HHXGA	1295 x 1695 x 765

Table 3.7: Outdoor Unit Details for Roof Floor

Unit r-1	12	185.97	RD120HHXGA	880 x 1695 x 765
Unit r-2	20	185.97	RD200HHXGA	1295 x1695 x765
Unit r-3	20	185.97	RD200HHXGA	1295 x1695 x765

Indoor unit

In this project there are two types of indoor units selected, which are split and cassette units. The split unit is used for bedrooms, and the cassette units are used for meeting room..

The figure below shows the two types of selected units:

Figure 3.5: Indoor Unit

The selected indoor units for the basement and ground floor are listed in the tables below:

Table 3.8: Indoor Unit Details

Split	6.8	ND071QHXE	1,065 x 298 x 218
Cassette (4 way)	4.5	ND0454HXEA	840 x 204 x 840
Cassette (4 way)	14	ND1404HXEA	840×288×840

CHAPTER FOUR

PLUMBING SYSTEM

4.1 Introductions

4.2 Water system

4.3 Pipe size calculations

4.4 Water tank volume

4.5 pump selection

4.6 Sanitary Drainage System

4.1 Introduction

There are two main functions of using plumping systems:

1- Water supply system; which provides the building with the required amount of water.

2- Sanitary drainage system; which removes all the usable water from the building

. It is the plumbing technologists' responsibility to design the entire water service and distribution systems for all uses, recognizing the pressure and flow limitations.

In the project up feed distribution system will be used for both cold and hot water systems. Fixture units at the building are designed for private and general uses, flush tanks used for water closets because it needs low pressure, steel pipes will be used for hot and cold water systems, seven risers will be used for cold and hot water supply systems, The critical fixture unit in the system is the lavatory fixture unit which is located at the fourth floor of the building .

4.2 Water Supply system

4.2.1 Introduction

The main objective of water supply system is to provide the building with the needed amount of water for daily use, such as drinking, cooking, washing and flushing, fire fighting, bathing, and irrigation.

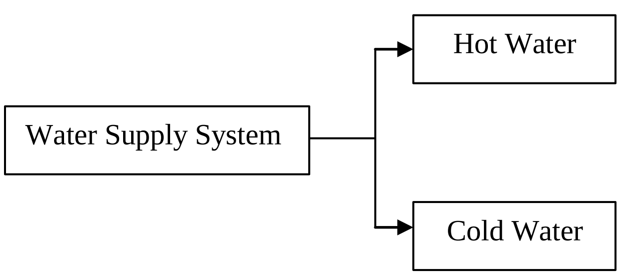


Figure 4.1: Water supply system

4.2.2 Design procedure

Step1: Determine if the suitable system is up-feed or down-feed

.

Step2: Determine the number of riser needed and their location.

Step3: Calculate the total water supply fixture unit (WSFU), and then convert to gallon per minute (gpm). From table (A-16)

Step4: Determine the minimum flow pressure for the critical fixture unit (fu). From table (A-22)

Step5: Calculate the total static head.

Step6: Calculate the pipe friction and equivalent length of the system.

Step7: Use the chart to determine the recommended pipe size.

4.2.3 Calculation of hot and cold water supply system

Water supply fixture units load (WSFU)

The total amount of water required for the building is calculated by using the water supply fixture unit technique (WSFU). This technique is used because there are a large number of fixture units in the system and this makes the technique more accurate.

Total WSFU for the first riser

Tables (4.1, 4.2) below show the total number of fixture units and the total water supply fixture unit (WSFU) for the first riser.

Table 4.1: Total number of fixture units of the Second riser in each floor

First floor	2	2	2	**1**
Second floor	2	2	2	**1**
Third floor	2	2	2	**1**
Forth floor	2	2	2	**1**

Roof floor	2	2	2	**1**
Total	1.	1.	1.	**79**

The figure 4.2 shows the Second riser diagram .

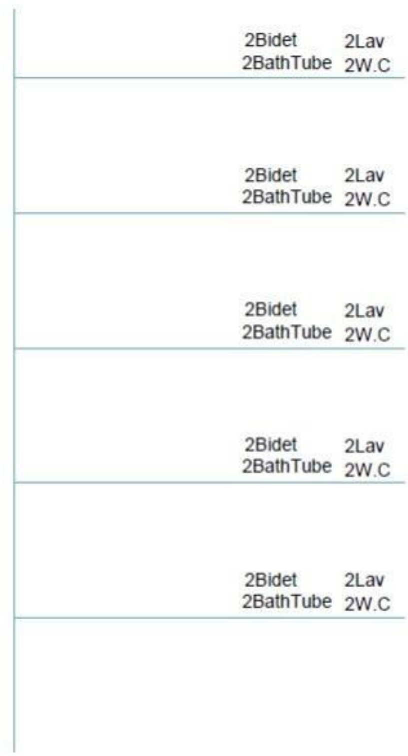


Figure 4.2: Second riser diagram

Table 4.2: Total WSFU of the Second riser

Lavatory	1.	1	1.	$1\times\frac{3}{4}=0.75$	$1\times\frac{3}{4}=0.75$	0.5	**1.1**
Water closet	1.	3	3.	3	.	3.	**9**
Bathtub	1.	2	2.	$2\times\frac{3}{4}=1.5$	$2\times\frac{3}{4}=1.5$	15	**71**
Bidet	1.	3	3.	3	.	3.	**9**

Total WSFU	-	-	0.	-	-	52.5	**11.1**

WSFU at the fifth riser

Tables (4.3, 4.4) below show the total numbers of fixture units and the total water supply fixture unit (WSFU) for the fifth riser.

Table 4.3: Fixture unit's number of the tenth riser in each floor

Third floor	1	.	1	.	.	**9**
First floor	0	2	.	2	.	**9**
Ground floor	.	2	.	2	1	**9**
Basement	.	3	.	3	0	**1**
Total	1	0	1	0	5	**1**

Figure 4.3 shows the tenth riser diagram.

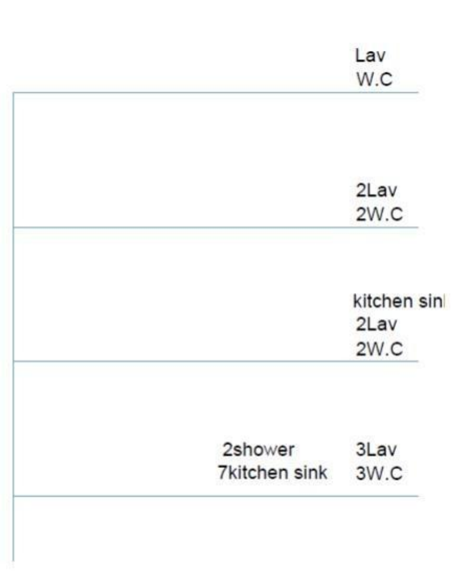


Figure 4.3: Tenth riser diagram

Table 4.4: Total WSFU of the Tenth riser

Lavatory (private)	1	1	1	$\frac{3}{4} =$ .75 1×	0 $\frac{3}{4} =$ .75 1× 0	..05	**9.11**
Lavatory (general)	0	2	14	$2\times\frac{3}{4} = 1.5$	$2\times\frac{3}{4} = 1.5$	1..5	**79.1**
Water closet (private)	1	3	3	3	.	3	**9**
Water closet (general)	0	5	35	5	.	35	**9**
Kitchen sink	5	4	32	$4\times\frac{3}{4} = 3$	$4\times\frac{3}{4} = 3$	24	**10**
Shower	2	4	5	$4\times\frac{3}{4} = 3$	$4\times\frac{3}{4} = 3$	0	**0**
Total WSFU				-	-	03	- -

Table 4.5: Total WSFU of each cold water riser

1st riser section	**101.25**
2nd riser section	**82.5**
3rd riser section	**51.1**
4th riser section	**51.1**
5th riser section	**00**
6th riser section	**00**
7th riser section	**00**
8th riser section	**00**
9th riser section	**00**
10th riser section	**10.11**
11th riser section	**700.11**
12th riser section	**777**
Total	**7901.11**

Table 4.6: Total WSFU of each hot water riser

1st riser section	**26.25**
2nd riser section	**11.1**
3rd riser section	**11.1**
4th riser section	**11.1**
5th riser section	**75**
6th riser section	**75**
7th riser section	**75**
8th riser section	**75**
9th riser section	**75**
10th riser section	**07.11**
11th riser section	**10.11**
12th riser section	**17**
Total	**091.11**

4.3 Pipe Size calculation

In order to calculate the size of each pipe in the water supply system, friction head must be calculated by using the up-feed distribution system equation:

Main pressure (pump pressure) = Static head + Pipe friction + Flow pressure (4.1)

Where:

Static head: is to overcome the height from the source to the critical fixture unit outlet.

Pipe friction: caused by the friction of the moving water inside pipes.

Flow pressure: to overcome the minimum flow pressure, and to impart kinetic energy to the water.

But, some of the above equation parameters can be determined or estimated as following:

1- It is indicated that the minimum flow pressure required for the critical fixture unit (lavatory) is 8.0 psi.

2- It is indicated that main pressure (pump pressure) is 50.0 psi.

3- The estimated water meter loss is 5.0 psi
Static pressure:

As indicated previously that the building consists of four floors and basement (floor to floor height is 3.8 meters (, then as shown in the figure below it appears that the total vertical length from the pump source to the critical fixture (lavatory) is 18 m.

The figure (4.4) shows the static head of the building

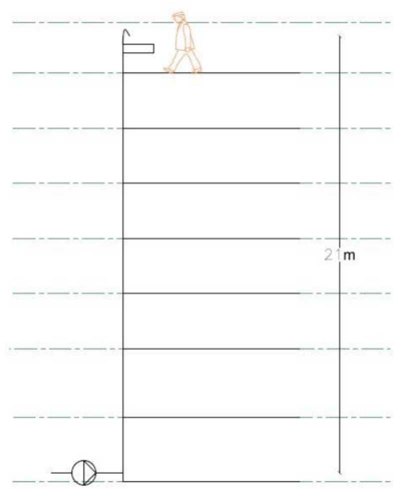


Figure 4.4: Static head of the building

Static pressure = 21 × 0.433 /0.33 = 27.55 psi (4.2)

By using the above equation, the pipe friction can be calculated by moving some terms from right to lift to get the following equation:

Pipe friction = Main pressure (pump pressure) - Static head - Flow pressure (4.3)

= 50.0 – 27.55 – 8.0 = 14.75 psi

The estimated water meter loss is 5.0 psi, so:

Friction head= Pipe friction – Water meter loss (4.4)

= 14.75 – 5.0 = 9.45 psi

On the other hand, One more thing must be calculated which is the total equivalent length (TEL). It appears from the mechanical drawings that the length of the first riser is 86 meter.

TEL $= \frac{\text{Total length (m)} \times 1.5}{0.303} = 80 \times 1.5 / 0.303 = 396$ ft (4.5)

Uniform design friction loss = $\frac{9.45 * 100}{396} = 2.38$ psi/100 ft (4.6)

Table 4.7: Properties of cold water riser

1st riser	101.25	44.5	2	**0**
2nd riser	82.5	4.	2	**0**
3rd riser	52.5	4.	2	**0**
4th riser	52.5	4.	2	**0**
5th riser	00	35	2	**0**
6th riser	00	35	2	**0**
7th riser	00	35	2	**0**
8th riser	00	35	2	**0**
9th riser	00	35	2	**0**
10th riser	00.25	30	2	**0.7**
11th riser	103.25	55	2.5	**0.1**
12th riser	111	40	2	**0.0**

Table 4.8: Properties of hot water riser

1st riser	26.25	10.5	1.25	**0**
2nd riser	22.5	15	1.25	**0**
3rd riser	22.5	15	1.25	**0**
4th riser	22.5	15	1.25	**0**
5th riser	15	13	1.25	**0**
6th riser	15	13	1.25	**0.1**
7th riser	15	13	1.25	**0.1**
8th riser	15	13	1.25	**0.1**
9th riser	15	13	1.25	**0.1**
10th riser	41.25	25.5	1.5	**0.1**
11th riser	20.25	2.	1.25	**0**

12th riser	51	20.5	1.5	**0**

4.4 Water tank volume

Water tank volume can be determined by multiplying the amount of gpm by 3 as a factor to ensure the availability of water source.

Then, 208.5 gpm are the total demand for the building. So: 208.5×3 = 625.5 gpm.

Converting 625.5 gpm the result is 120 cubic meters that will the underground tank

volume for water building demand.

4.5 Pump selection

Pumps selection depends on two main properties and these properties are: head (H) and flow rate (Q). Starting selection with:

1) Cold water pump:

By converting WSFU to GPM to m^3 /hour, the 1032 WSFU equal 214 Gpm from all the cold water risers equals 48.6 m^3 /hour.

Total flow rate = 48.6 m^3 /hour

Head estimation

Height of the building = 26 m convert to psi equals 36.97 psi

then convert from psi to bar : 36.97 psi = 2.55 bar

Adding 1 bar for fittings losses the value is almost 3.05 bar

Head = 3.55 bar

Using (dp-select) software and with filling data into brackets as follow:-

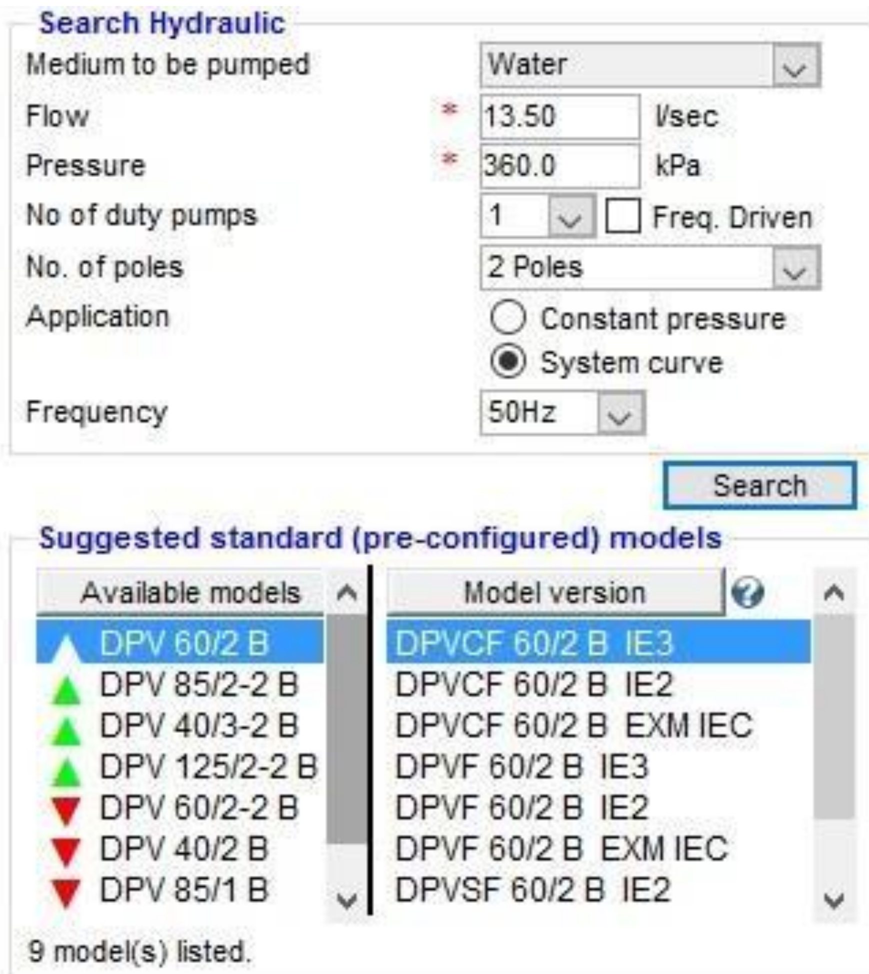


Figure 4.5: Cold pump data

The pump model selected "DPV 60/2 B"

The characteristic curves of this pump as follow:

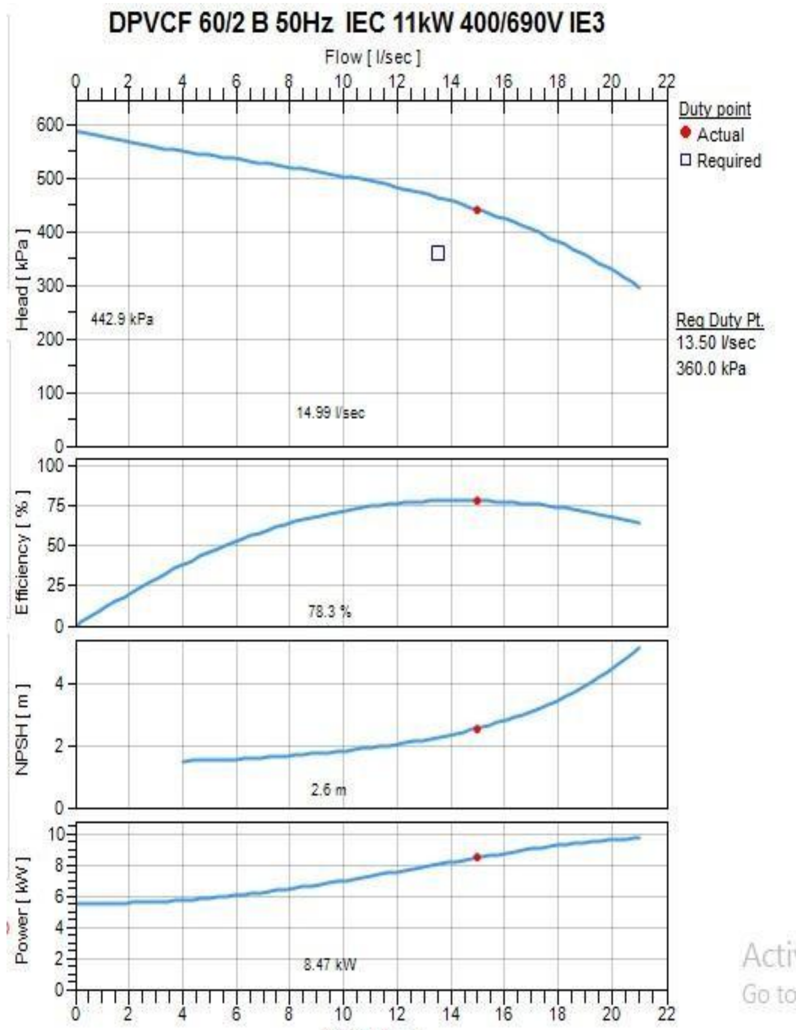


Figure 4.6: Cold pump characteristic curves

2) Hot water pump:

By converting WSFU to GPM to m^3/hour, the 305.25 WSFU equal 87 Gpm from all the hot water risers equals 19.7 m^3/hour.

Total flow rate = 19.7 m^3 /hour.

Head = 3.55 bar.

Using (dp-select) software and with filling data into brackets as follow:-

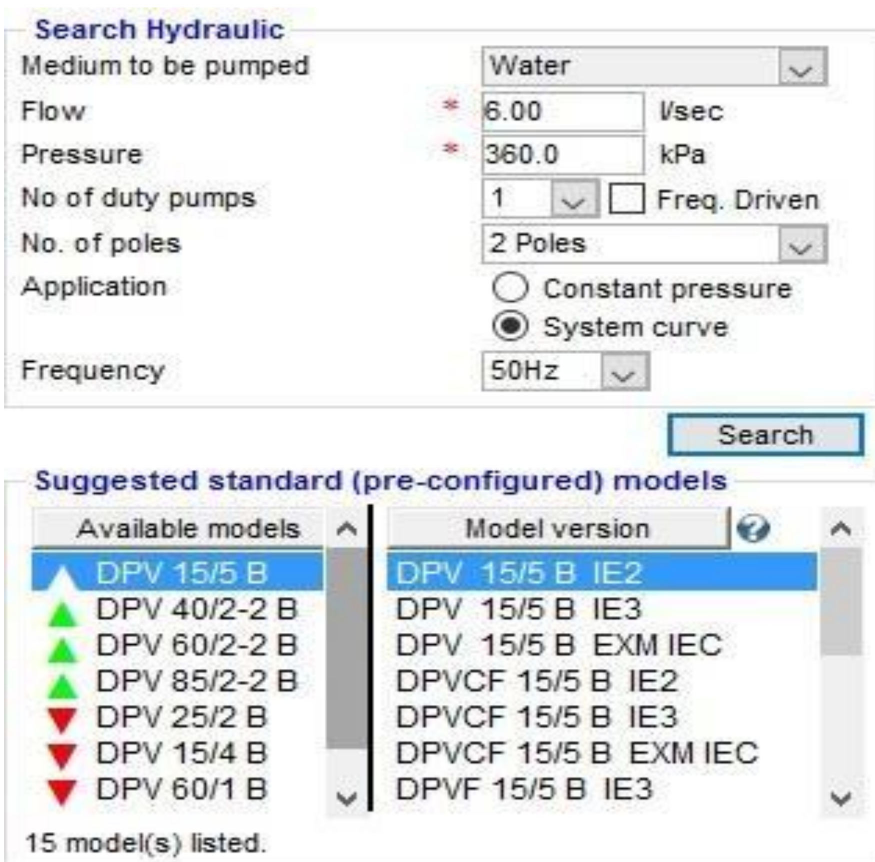


Figure 4.7: Hot pump data

The pump model selected “DPV 15/5 B "

The characteristic curves of this pump as follow:

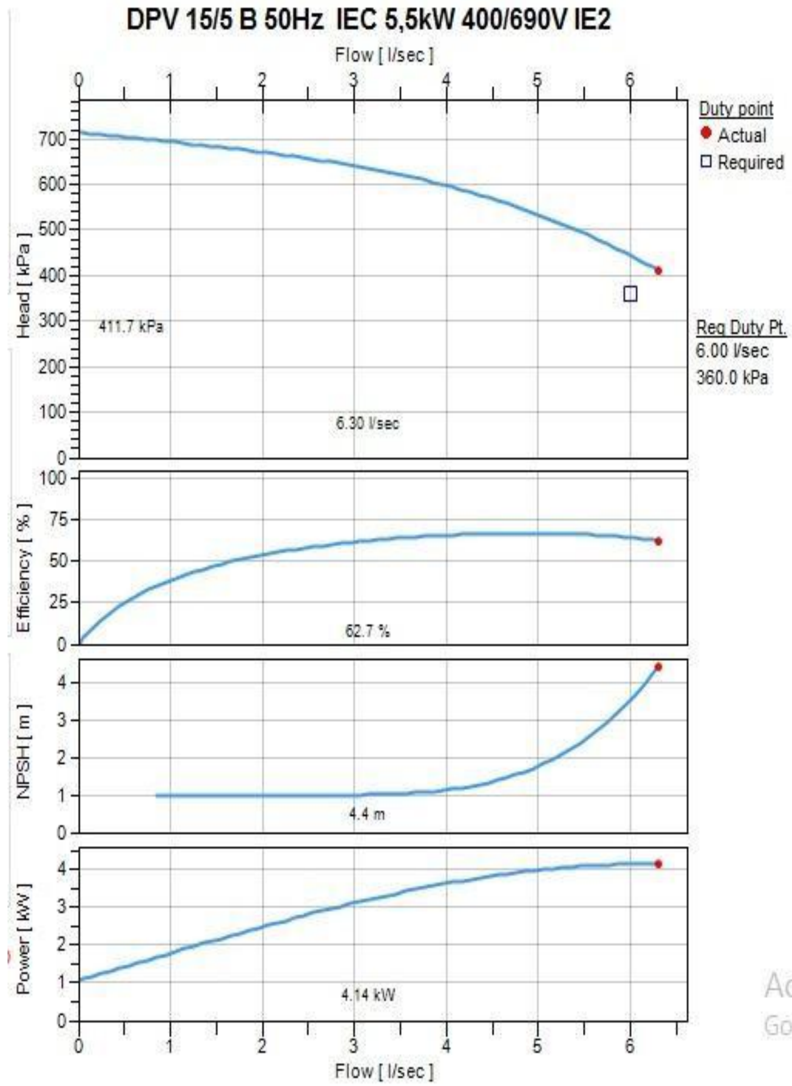


Figure 4.8: Hot pump characteristic curves

4.6 Sanitary Drainage System

The main objective of drainage system is to carry the waste water from the fixture unit to manhole and from the manhole to the septic tank or to the municipal sewage system.

The provision of drainage systems:

- Sanitary drainage
- Storm drainage

Drainage system components

The main components of drainage system are:

1) Fixture units
2) Trap
3) Clean out
4) Drainage pipe
5) Stack and vent pipes
6) Manholes
7) Septic tank or municipal sewage system
8) Accessories

Sanitary drainage

Design procedure and pipe sizing

Pipe size is calculated by using a concept of fixture units (DFU) instead of using gpm of drainage water. This unit takes into account not only the fixtures water use but also its frequency of use, which is the DFU has a built–in diversity factor. This enables us, exactly as for water supply to add DFU of various fixtures to obtain the maximum expected drainage flow. Drainage pipes sized for a particular number of drainage fixture units, according to Tables ((A-23),(A-24)) These tables are built into the fill factors, which are:

- 50% fill in branches (horizontal pipes)
- (25-33)% fills in stack (vertical pipes)

50% fill in building and swear drains

The recommended velocity for drainage piping:

- For branches the recommended velocity is 2 ft/s
- For building pipes the recommended velocity is 3 ft/s
- For greasy flow the recommended velocity is 4 ft/s

Velocity of water flow through drainage piping depends on:

- Pipe diameter
- Slope

Minimum slope requirements for horizontal drainage piping:

- For pipes of diameter ≤ 3" the minimum slope is 1/4”/ft (2%)
- For pipes of diameter ≥ 4" the minimum slope is 1/8”/ft (4%)

Design procedure:

1) Calculation of the number of DFU for each branch by using Table (A-23)

2) Calculation of the number of DFU for each stack

3) Choosing the branch pipe diameter by using Table (A-18)

4) Choosing the stack pipe diameter by using Table (A-18)

5) Comparing the stack pipe diameter with branch diameter

6) Choosing the building drain pipe diameter by using Table (A-17)

To achieve the recommended velocities which are 3 fps in building drain, it will be chosen the slope and flow velocity in building drain by using Table (A-17) The following figure and tables shows the sizing of black water stacks:

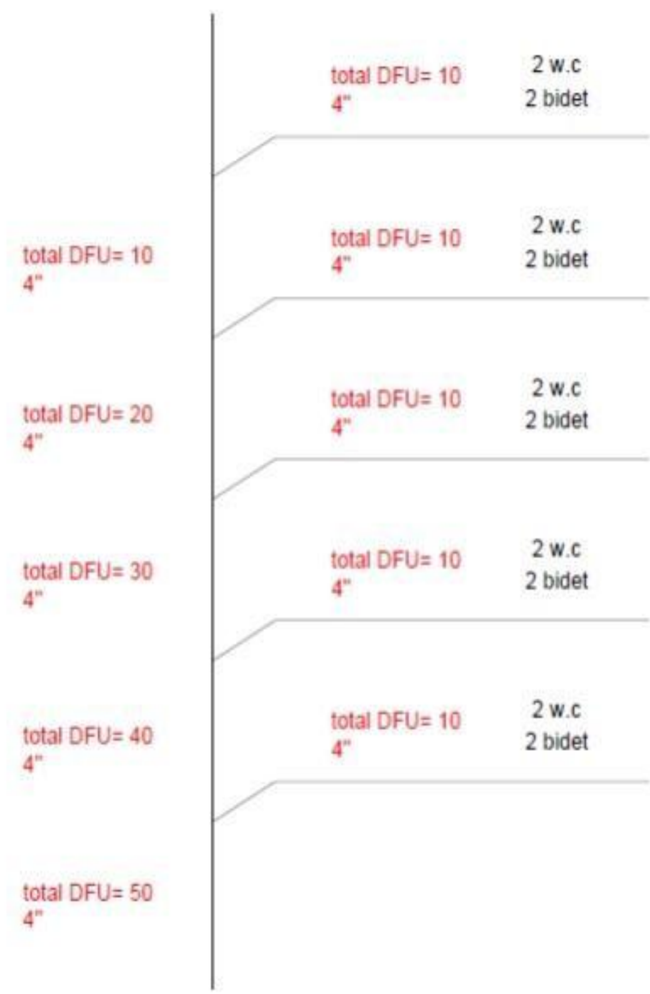


Figure 4.9: Sample of black water stack 1

Table 4.9: Sizing of black water stack 1

From roof floor	1.	**4''**
From roof to Fourth floor	1.	**4''**
From Fourth floor	1.	**4''**
From Fourth to Third floor	2.	**4''**
From Third floor	1.	**4''**
From Third to Second floor	3.	**4''**
From Second floor	1.	**4''**
From Second to First floor	4.	**4''**
From First floor	1.	**4''**
From First to Drain	5.	**4''**

Table 4.10: Sizing of black water stacks and building drain

Stack1	5.	4"	4"	1/4	**2.73**
Stack2	5.	4"	4"	1/4	**2.73**
Stack3	5.	4"	4"	1/4	**2.73**
Stack4	5.	4"	4"	1/4	**2.73**
Stack5	4.	4"	4"	1/4	**2.73**
Stack6	4.	4"	4"	1/4	**2.73**
Stack7	05	4"	4"	1/4	**2.73**
Stack8	4.	4"	4"	1/4	**2.73**
Stack9	4.	4"	4"	1/4	**2.73**
Stack10	24	4"	4"	1/4	**2.73**
Stack11	50	4"	4"	1/4	**2.73**

The following figure and tables shows the sizing of black water stacks:

Figure 4.10: Sample of gray water stack 1

Table 4.11: Sizing of gray water stack 1

From roof floor	0	**2''**
From roof to Fourth floor	6	**2''**
From Fourth floor	0	**2''**
From Fourth to Third floor	12	**3''**
From Third floor	0	**2''**
From Third to Second floor	15	**3''**
From Second floor	0	**2''**
From Second to First floor	24	**3''**
From First floor	0	**2''**
From First to Drain	3.	**3''**

Table 4.12: Sizing of gray water stacks and building drain

Stack1	30	3"	4"	1/2	**3.8**
Stack2	3.	3"	4"	1/2	**3.8**
Stack3	3.	3"	4"	1/2	**3.8**
Stack4	3.	3"	4"	1/2	**3.8**
Stack5	24	3"	4"	1/2	**3.8**
Stack6	24	3"	4"	1/2	**3.8**
Stack7	30	3"	4"	1/2	**3.8**
Stack8	24	3"	4"	1/2	**3.8**
Stack9	24	3"	4"	1/2	**3.8**
Stack10	2	2"	4"	1/2	**3.8**
Stack11	12	3"	4"	1/2	**3.8**

CHAPTER FIVE

FIRE FIGHTINF SYSTEM

5.1 Introduction

A fire fighting system is probably the most important of the building services, as its aim is to protect human life and property, strictly in that order. fire fighting systems and equipment vary depending on the age, size, use and type of building construction.

5.2 Types of fire fighting system

- Fire extinguishers.
- Fire hose reels.
- Fire hydrant systems.
- Automatic sprinkler systems.

5.2.1 Fire extinguishers

Fire extinguishers are provided for a 'first attack' fire fighting measure generally undertaken by the occupants of the building before the fire service arrives. It is important that occupants are familiar with which extinguisher type to use on which fire.

Most fires start as a small fire and may be extinguished if the correct type and amount of extinguishing agent is applied whilst the fire is small and controllable.

The principle fire extinguisher types currently available include:

1) Water

2) Foam

3) Dry powder

4) CO2

5) Wet Chemical

Figure 5.1: Fire extinguishers

5.2.2 Fire hose reel

Fire hose reel systems consist of pumps, pipes, water supply and hose reels located strategically in a building, ensuring proper coverage of water to combat a fire. The system is manually operated and activated by opening a valve enabling the water to flow into the hose that is typically 30 meters away. The usual working pressure of a firehouse can vary between 8 and 20 (116 and 290 psi).

Fire hose reels are provided for use by occupants as a first attack firefighting measure but may, in some instances, also be used by firefighters. When stowing a fire hose reel, it is important to first attach the nozzle end to the hose reel valve, then close the hose reel valve, then open the nozzle to relieve any pressure in the wound hose, then close the nozzle

Figure 5.2: Fire hose reel

5.2.3 Fire hydrate system

Fire hydrant systems are installed in buildings to help fire fighters quickly attack the fire. Essentially, a hydrant system is a water reticulation system used to transport water in order to limit the amount of hose that fire fighters have to lay; thus speeding up the firefighting process.

Fire hydrants are for the sole use of trained fire fighters (which includes factory firefighting teams). Because of the high pressures available serious injury can occur if untrained persons attempt to operate the equipment connected to such installations. Fire hydrant systems sometimes include ancillary parts essential to their effective operation such as pumps, tanks and fire service booster connections. These systems must be maintained and regularly tested if they are to be effective when needed.

Figure 5.3: Fire hydrate system

5.2.4 Automatic sprinkler system

Time is essential in the control of fire. Automatic sprinkler systems are one of the most reliable methods available for controlling fires. Today's automatic fire sprinkler systems offer state of the art protection of life and property from the effects of fire. Sprinkler heads are now available which are twenty times more sensitive to fire than they were ten years ago.

A sprinkler head is really an automatic (open once only) tap. The sprinkler head is connected to a pressurized water system. When the fire heats up the sprinkler head, it opens at a preset temperature, thus allowing pressurized water to be sprayed both down onto the fire and also up to cool the hot smoky layer and the building structure above the fire. This spray also wets combustible material in the vicinity of the fire, making it difficult to ignite, thereby slowing down or preventing fire spread and growth.

When a sprinkler head operates, the water pressure in the system drops, activating an alarm, which often automatically calls the fire brigade via a telephone connection.

Figure 5.4: Fire sprinkler

5.3 Select the most effective type

After the identification of the fire systems now the best performance for the hotel is hose reel & extinguisher.

The number of hose reels to be used in hotel is 12 firehouse reels for all floors most fire hose is designed to be stored flat to minimize the storage space required.

5.4 Fire hose cabinet

Fire hose cabinet is located at the following places:

A- Exit stairs.
B- Entrance of buildings.
C- Garages entrance.
D- Wherever travel distance exceeded 36 meter from another fire hose cabinet. It consists of:

1) Cabinet (wall mounted-recessed), there are three types of cabinets:

A- Exposed: be prominent from the wall and out of it a distance of 25 cm, and Fund riding on the surface of the wall.

B- Semi predated: be prominent from the wall a distance of 10 cm, and inside the wall 15 cm.

C- Recessed: be inside the entire wall.

2) Landing valve, valve to control the water stream, located inside or outside the building.

3) Hose (30 meter).

4) Discharge nozzle.

5) Fire extinguisher (optional).

Fire hose cabinet classes

1) Class 1: standpipe system provides 65-mm (2½-in.) hose connections to supply water for use by fire departments and those trained in handling heavy fire streams.

System limitations are pressure reach 7 bars, flow rate 250 gpm, located at all main entrance and exits of the buildings and garages, around the wall buildings and the travel distance is 45.7m with throw distance.

2) Class 2: standpipe system provides 38-mm (1½-in.) hose stations to supply water for use primarily by the building occupants or by the fire department during initial response.

System limitations are pressure reach 4.5 bars, flow rate 100 gpm, 30m travel distance and located corridors, theaters, colleges and near elevators.

3) Class 3:standpipe system provides 38-mm (1½-in.) hose stations to supply water for use by building occupants and 65mm (2½-in.) hose connections to supply a larger

volume of water for use by fire departments and those trained in handling heavy fire streams.
Class two didn't need any experience to deal with a system for any user on contrast with class one, for this reason class 2 is more popular and that is the selected class for cabinet.

Technical specifications of fire hose cabinet

The following specifications are installed according to code NFPA 14 for class 2 F.H.C:

- The maximum pressure at any point in the system at any time shall not exceed 24.1 bar (350 psi).
- Maximum Residual Pressure for (1½-in.) Diameter F.H.C=6.9 Bar.
- Hydraulically designed standpipe systems shall be designed to provide the water flow rate required at a minimum residual pressure of4.5 bar (65 psi) at the outlet of the hydraulically most remote 38-mm (1½-in.) hose station.
- Standpipes size shall be at least 100 mm (4 in.) (Main riser).
- Hose stream demand and water supply duration requirement for hydraulic calculation system as in the NFPA14 code.

Firefighting pumps

A continuous water and pumping station supply should always be available and ready to fight fire, the following three pumps should be connected to a suction header (from water tank), and discharged to a discharge header (to firefighting network).

Pumping stations should include:

1. Electrical firefighting pump.
2. Stand-by Diesel Firefighting Pump (No need if an extra electric pump is connected to an electric generator).

Diesel pump works if:

- The electrical pump is out of service, or if there is a lack of electricity.

• The electrical pump is working but can't satisfy system water requirements.

3. Jockey Pump: works to make up the system pressure in case of leakage or during the first seconds of fire.

Pumps are selected to supply the system demands on the basis of three key points relative to their rated flow and rated pressure most fire pumps are sized to exceed its duty point requirement.

Types of pumps

1- Horizontal split case pumps:

This is also called a double suction fire pump because the water pathways direct water to both sides of the impeller. It is also the most common fire pump on the market partly because of the ratings available in this style of pump 250 GPM through 5000 GPM.

Figure 5.5: Horizontal split case pump

2- Inline fire pumps

These pumps have expanded in use in the last five years for several reasons, space savings, Increase in ratings allowable by NFPA 20 from max of 499 GPM, and then to 750 GPM, to today which is unlimited rating. The largest currently available is 1500 GPM, Cost of installation –these are typically less expensive to install because there is no base plate that requires grouting.

Figure 5.6: Inline fire pump

3- End suction pumps

End suction fire pumps not widely used mostly because they are limited in size per code ,They are also slightly more expensive than inline pumps ,The one pump application where it is used is small diesel driven applications 500 GPM or l less.

Figure 5.7: End suction pump

4- Vertical turbine pumps

These are used for water supplies that are below the suction flange of a fire pump; NFPA 20 states that you have to have a positive suction pressure to a fire pump.

Figure 5.8: Vertical turbine pump

5.5 Flow rate and head calculations

There are two main factors in GPM calculations:

1. Area calculation

2. Standpipe calculation

The standpipe calculation is the selected calculation, so according to NFPA 14 states that the

GPM required for the first standpipe is 500 GPM

Each additional standpipe requires 250 GPM with a maximum GPM of 1000 GPM

If a building has 2 standpipes the pump GPM would be 750 GPM, 500 GPM for the first and 250 for the second.

If a building has 3 standpipes the pump GPM would be 1000 GPM, 500 GPM, 250 for the second, and 250 for the third.
Any building with more standpipes would be 1000 GPM as that is the maximum allowable by code.

So, this building need 500 GPM according to code, with two standpipes the amount of flow rate equal to 750 GPM.

Flow rate calculation:

= No of FHC * 250 GPM for each FHC

2*250 = 500 GPM

Pressure head calculation:

$$H_{Pump} = H_{St.} + H_{Res.} + H_f \qquad \textbf{(5.1)}$$

H_{Pump}= the pressure of the pump.

$H_{Res.}$ = the residential building FHC = 4.5bar.

H_f = the friction head.

$$H\ f = \frac{4.5 * Q^{1.85}}{C^{1.85} * D^{4.85}} = \frac{4.5 * 500^{1.85}}{120^{1.85} * 0.101^{4.85}}$$

= 1 bar

$H_{St.}$= the static head.

$H_{St.}$= 21 m = 2.1 bar.

So:

H_{Pump}= 4.5 + 2.1 + 1 = 7.6 bar.

5.6 Pump selection

Total flow rate 500 GPM equal to 113.5m^3/h and amount of head 7.6 bars.

Using (dp-select) software and with filling data into brackets as follow:-

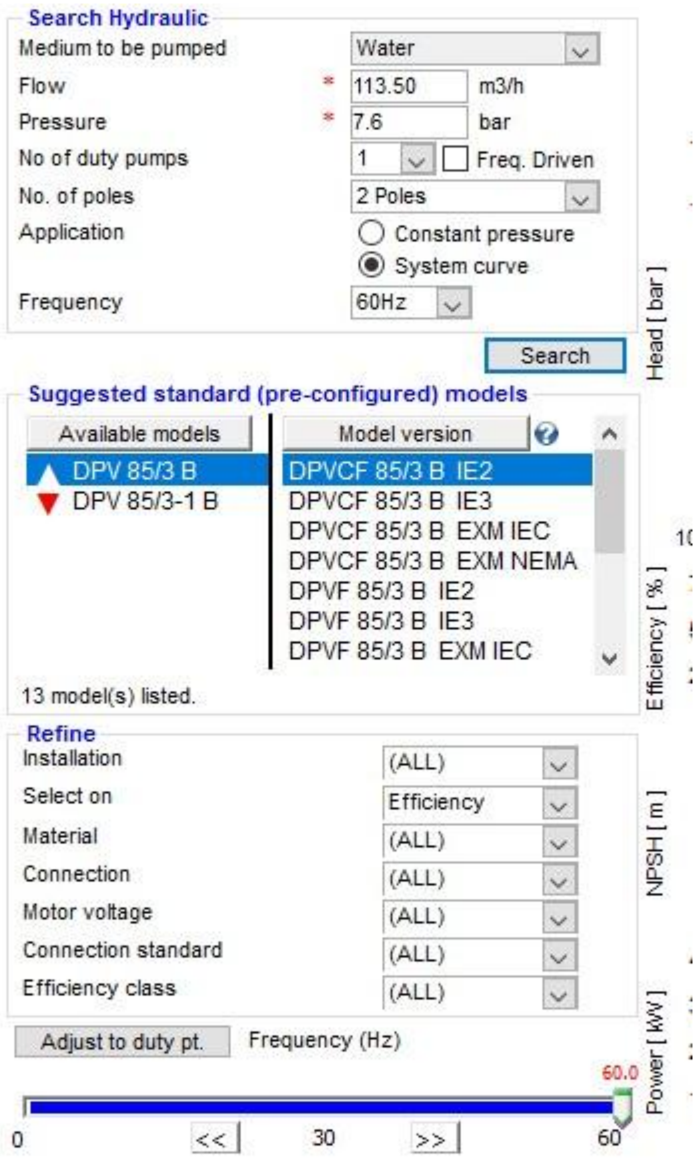


Figure 5.9: Pump details

The pump model selected “DPV85/3 B”

The characteristic curves of this pump as follow:

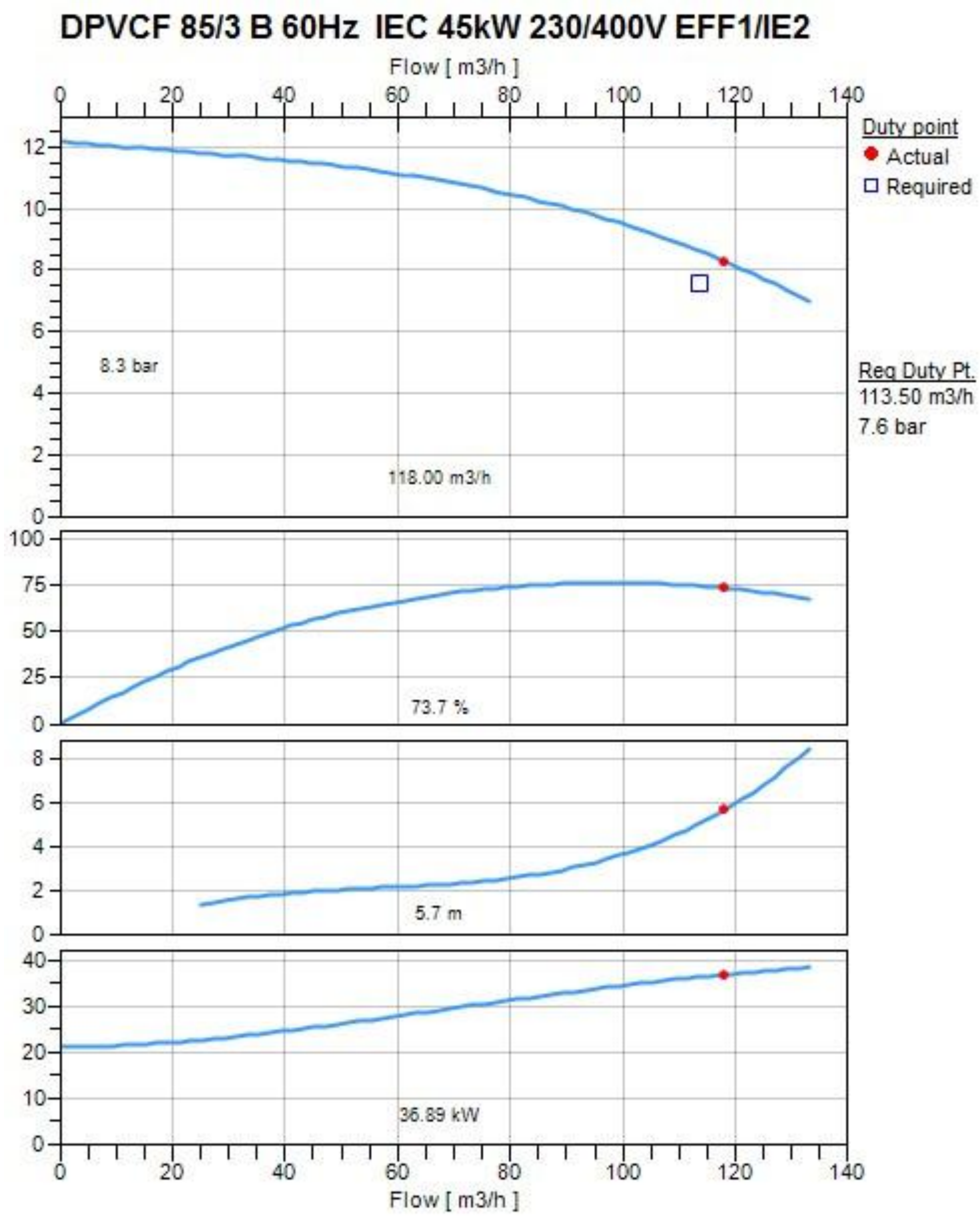


Figure 5.10: Pump characteristi

CHAPTER SIX

SWIMMING POOL

6.1 introductions

Swimming pools consider as one of the most places that attract human to reduce the daily work pressure, and daily troubles.

Swimming pools in general must have appropriate design for all ages and different level of swimming skills, also it must have a clean ,good water quality.

6.2 swimming pool components

1- Skimmer: machine that separates a liquid from particles floating on it or from another liquid

Figure 6.1: Swimming pool skimmer

2- main drain : are usually located on the lowest point in the pool, Most of the dirt and debris that sinks exits the pool through these drains, he drains are almost always covered with grates or antivortex covers (a cover that diverts the flow of water to prevent a dangerous vortex from forming).

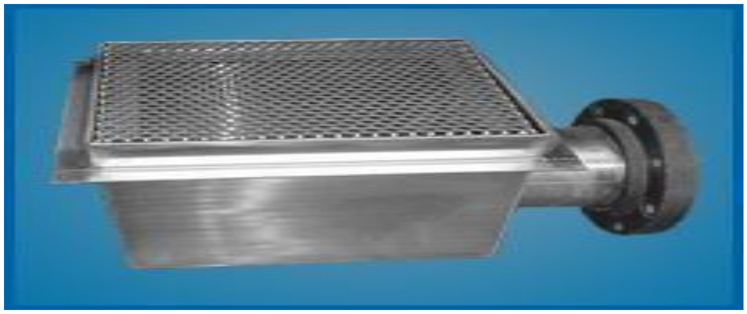


Figure 6.2: Swimming pool main drain

3- Pump : pulls water from one or more suction ports (i.e., skimmer & main drain), and then pushes it through the filter & heater**.**

Figure 6.3: Swimming pool pump

4- Return inlet : Pool water returns are places in the pool where water comes back in from the circulation system**.**

Figure 6.4: Swimming pool return inlet

5- Filter : Pool water comes from the circulation pump into the filter where small debris particles are removed**.**

Figure 6.5: Swimming pool filters

6- Suction inlet : used primarily as a suction port for vacuuming the pool

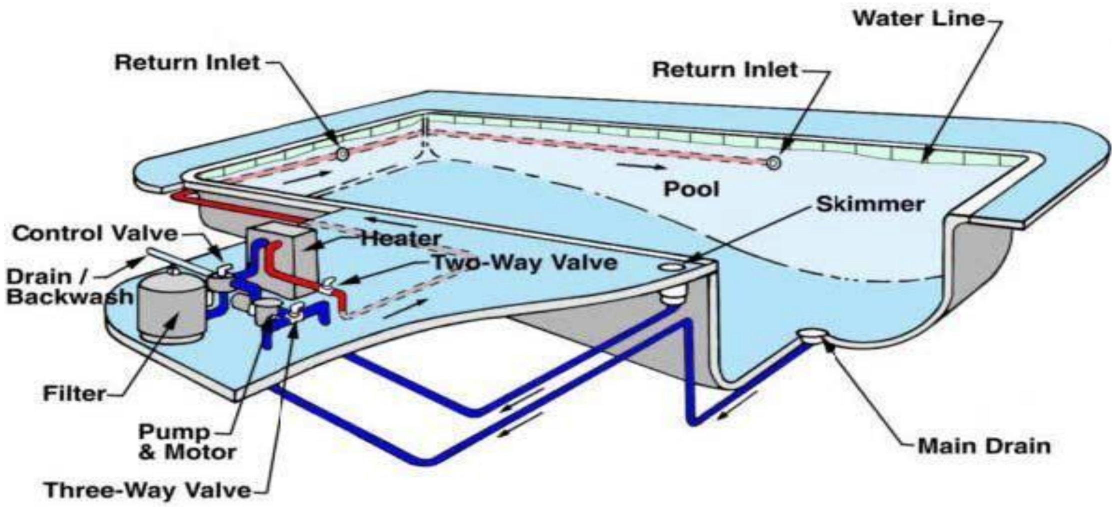


Figure 6.6: General swimming pool components

6.3 Pool Capacity Calculations

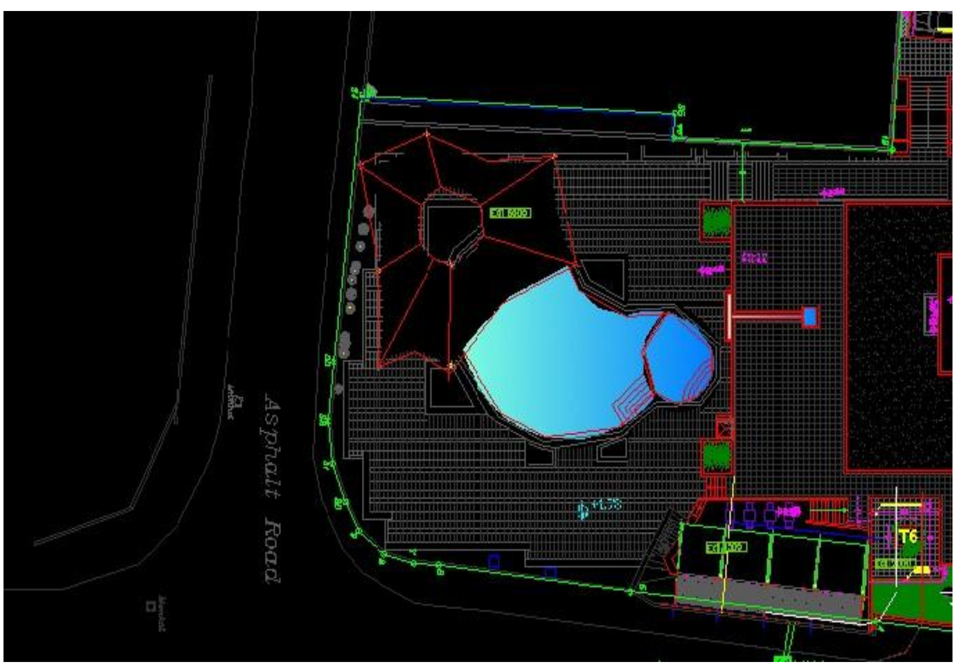


Figure 6.7: Swimming pool top view

Average depth = (Shallow end depth + deep end depth)/2 **[6.1]**

= (3 + 1)/2 = 2m .

Volume of water = area * average depth **[6.2]**

= (144)*2 = 288 m^3.

Turn Over Time**:**

In Hebron the turn over time is 5 hr in hotel pools.

6.4 Filter Sizing and Selection

Filter flow rate = Total Water Circulation rate (m^3/hr)

$$= \left[\frac{Pool\ water\ volume\ (m^3)}{Pool\ turn\ over\ period\ (hr)}\right]$$ **[6.3]**

= 288/5

= 57.6 (m^3/hr)

For a filtration velocity of 20 m/hr, the efficiency is 100%.

For a filtration velocity of 30m/hr, the efficiency is 70%.

For a filtration velocity of 40 m/hr, the efficiency is 50%.

The filter efficiency between 70-100%, so a 25 m/hr filtration velocity

Filter surface area = $\left[\frac{Filtration\ flow\ rate}{Filtration\ velocity}\right]$ **[6.4]**

=

57.6/25

= 2.3 m^2

6.5 Skimmers and main drain selection

● Number of skimmers =(50% X Total flow rate)/capacity of each skimmer

= pool surface area / 25 **[6.5]**

= 144/25

= 6 skimmers are required .

Flow rate of each skimmer = (50% $\times$ flow rate)/number of skimmers **[6.6]**

= (50% $\times$ 57.6) / 6

= 4.8 m^3/hr = 21.2 gpm.

Flow rate of main drain = 50% $\times$ flow rate **[6.7]**

= 50% $\times$ 57.6

= 28.8 m^3/hr = 126.8 gpm.

Number of main drains = (flow rate $\times$ 50%)/ flow rate of main drain **[6.8]**

= (57.6 $\times$ 50%)/28.8

= 1 main drain required.

6.6 Selection of return inlets:

Number of required return inlets = $\left[\frac{Filtration\ flow\ rate}{Flow\ rate\ of\ each\ inlet}\right]$ **[6.9]**

= pool perimeter / 5

= 50/6

= 9 return inlets.

Flow rate of each return inlet = $\left[\frac{Filtration\ flow\ rate}{\text{Number of required return inlets}}\right]$ **[6.10]**

=

57.6/9

$$= 6.4 \quad m^3/hr$$

$$= 28.2 \text{ gpm.}$$

6.7 swimming pool control room components:

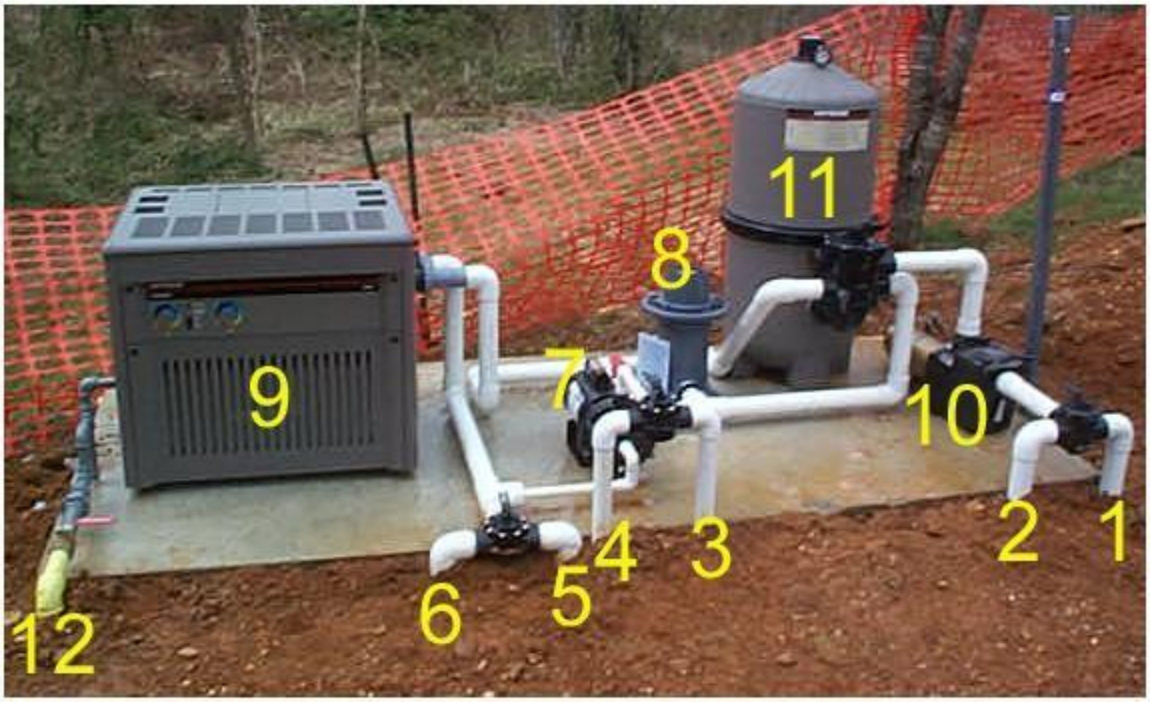


Figure 6.8: Swimming pool control room main components

1. Swimming Pool Skimmer Line
2. Swimming Pool Main Drain Line
3. Swimming Pool Slide Line
4. Automatic Pool Cleaner Line
5. Swimming Pool Return Line

6. Swimming Pool Return Line

7. Automatic Pool Cleaner Motor

8. Auto Sanitizer

9. Swimming Pool Heater

10. Swimming Pool Pump

11. D.E. Pool Filter

12. Pool Heater Gas Supply Line

6.8 Pump selection

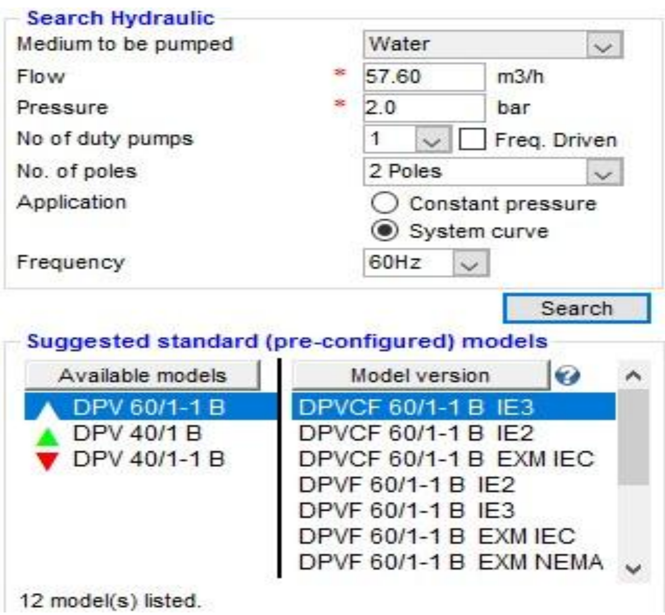


Figure 6.9: Swimming Pool Pump Data

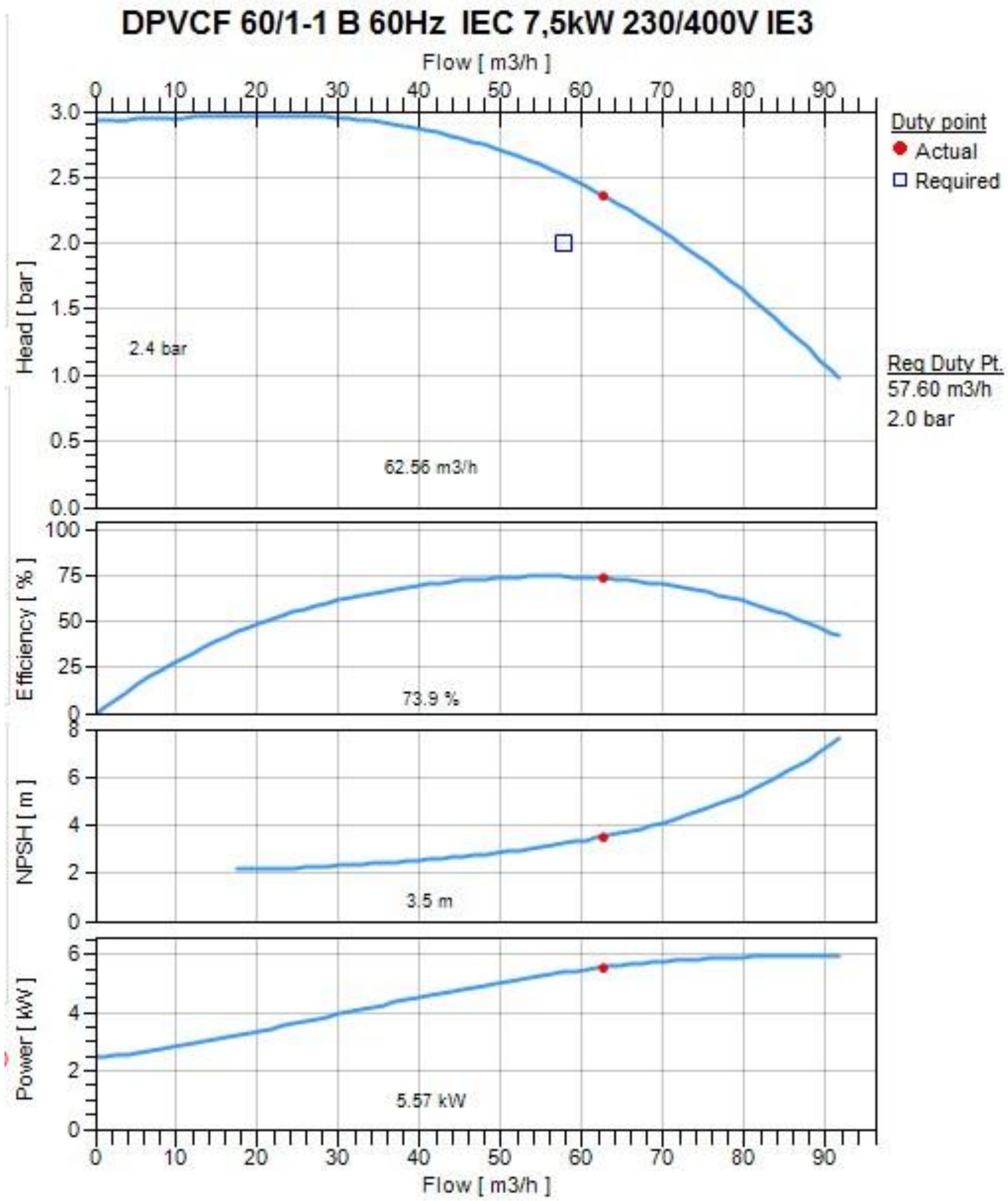


Figure 6.10: Swimming Pool Pump Characteristic Data

CHAPTER SEVEN

REFREGRATORS

7.1 Cooling Load Calculation for refrigeration

7.1.1 The Overall heat transfer coefficient 7.1.2 Cooling Load Calculation For rooms 7.1.3 Compressor selection

7.1.4 Condensers selection

7.2 Cooling Load calculation for freezer

7.2.1 Use this law to find Cooling Load Calculation

7.2.2 Cooling Load Calculation For rooms

7.2.3 Compressor selection

7.2.4 Condensers selection

7.1 Cooling Load Calculation for refrigeration

Use this law to find Cooling Load Calculation:

$Q = U A \Delta T$

Q : Cooling Load in [kW] .

U : Overall heat transfer coefficient in [W/m^2. ˚C] .

$$U = \frac{1}{\frac{1}{h_{in}} + \frac{\Delta X}{K} + \frac{1}{h_{out}}} \quad \textbf{(7.1)}$$

h_{in} : is the Inside Convection Coefficient { 9.37 $W/m^2.^oC$ } . h_{out}

: is the Outside Convection Coefficient { 22.7 $W/m^2.^oC$ } .

K: is the thermal conductivity for material in [$W/m.^oC$] .

ΔX: is the Thickness of the material in [m] .

A: Surface area in [m^2] .

A=Length * Width.

ΔT: The difference in temperature [^oC] .

Temperature surrounding {Tsur } :

$T_{sur} = 30\ ^oC$

Room Temperature {TRoom } :

$T_{Room} = T_{in} + 2/3\ (T_{sur} + T_{in})$

$T_{in:}$ is the storage temperature of product = 5 ^oC .

$T_{Room} = 5 + 2/3\ (30 + 5)$

T_{Room} = 28.3 ^oC.

7.1.1 The Overall heat transfer coefficient

1. External Wall:

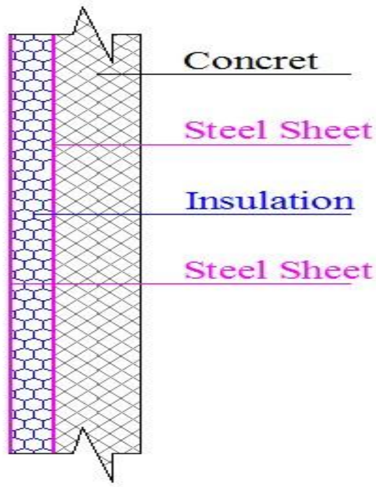


Figure 7.1: External wall details

Table 7.1: variable of heat transfer coefficient for External wall

Concrete	1.750	0.300
Steel Sheet	16.00	0.002
Insulation	0.050	0.070
Steel Sheet	16.00	0.002

Thickness of the wall = 0.37 m .

1

U

$$\frac{1}{\frac{1}{9.37} + \frac{0.3}{1.75} + \frac{0.002}{16} + \frac{0.07}{0.05} + \frac{0.002}{16} + \frac{1}{22.7}}$$

$= 0.58/m^2.^oC$.

$\Delta T = T_{sur} - T_{in}$

$= 30 – 5 = 25\ ^oC$.

$A_{External\ Wall} = 3.8 * 4 = 15.2\ m2$.

$Q_{External\ Wall-1} = 0.58 * 25 * 15.2 = 220\ W = 0.220\ kW$

2. Internal Wall

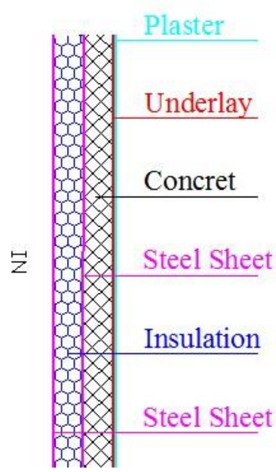


Figure 7.2: internal wall details

Table 7.2: variable of heat transfer coefficient for Internal Wall

Plaster	1.200	0.002

Underlay	0.980	0.008
brick	1.00	0.100
Steel Sheet	16.00	0.002
Insulation	0.050	0.10
Steel Sheet	16.00	0.002

Thickness of the wall = 0.214 m .

$$U = \frac{1}{\frac{1}{37} + \frac{0.002}{1.2} + \frac{0.008}{0.98} + \frac{0.1}{1.00} + \frac{002}{16} + \frac{0.1}{0.05} + \frac{002}{16} + \frac{1}{37}}$$

0.0.

9.9.

= 0.43 $W/m^2.^oC$

$\Delta T = T_{Room} - T_{in}$

= 28.3 – 5 = 23.3 ^oC .

$A = A_{Internal\ Wall} – A_{Door}$

= (2 * 3.8) -(1 * 2)

= 5.6 m^2 .

$Q_{Internal\ Wall}$ = 0.43 * 23.3 * 5.6 = 38W = 0.038 kW .

3. Internal Wall

The same propriety of Internal Wall-1 but the aria is deferens

$A = A_{Internal\ Wall}$

= (4 * 3.8)   = 15.2 m^2 .

$Q_{Internal\ Wall} = 0.43 * 23.3 * 15.2 = 152W = 0.152\ kW$.

4. Internal Wall

The same propriety of Internal Wall-1 but the aria is deferens

$A = A_{Internal\ Wall-3}$

= (2 * 3.8

= 7.6 m^2 .

$Q_{Internal\ Wall-3} = 0.43 * 23.3 * 7.6 = 76W = 0.076\ kW$.

5. Internal Wall Consists

of :

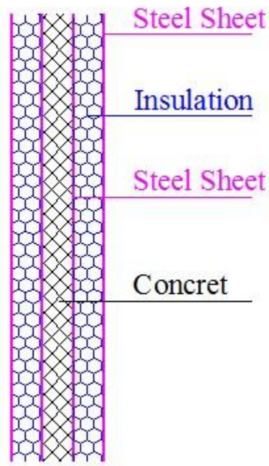


Figure 7.3: Internal wall

Table 7.3: variable of heat transfer coefficient for Internal Wall

Steel Sheet	16.0	0.002
Insulation	0.05	0.070

Steel Sheet	16.0	0.002
Concrete	1.75	0.100
Steel Sheet	16.0	0.002
Insulation	0.05	0.070
Steel Sheet	16.0	0.002

Thickness of the wall = 0.248 m .

$$U = \frac{1}{\frac{1}{9.37} + \frac{0.002}{16} + \frac{0.07}{0.05} + \frac{0.002}{16} + \frac{0.1}{1.75} + \frac{0.002}{16} + \frac{0.07}{0.05} + \frac{0.002}{16} + \frac{1}{9.37}}$$

$= 0.325\ W/m^2.^oC.$

$\Delta T = T_{Room} - T_{in}$

$= 5 - -18 = 23\ ^oC.$

$A = A_{Internal\ Wall}$

$= (4 * 3.8)$

$= 15.2\ m^2.$

$Q_{Internal\ Wall-2} = 0.325 * 23 * 15.2 = 114W = 0.114\ kW$.

6.Ground

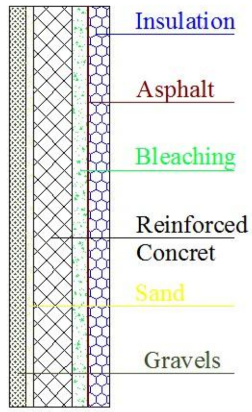


Figure 7.4: Ground Details

Table 7.4: variable of heat transfer coefficient for Ground

Insulation	0.05	0.100
Asphalt	0.30	0.002
Bleaching	0.98	0.050
Reinforced Concrete	0.88	0.200
Sand	0.68	0.020
Gravels	0.58	0.050

Thickness of the wall = 0.377 m .

$$U = \frac{1}{\frac{1}{9.37} + \frac{0.1}{0.05} + \frac{0.002}{0.3} + \frac{0.05}{0.98} + \frac{0.2}{0.88} + \frac{0.02}{0.68} + \frac{0.05}{0.58}}$$

= 0.399 $W/m^2.^oC$.

A = (2 * 2)

= 4m^2.

Q $_{ground}$ = 0.399 * 23.3 * 4= 38W = 0.020 kW.

7. Ceiling

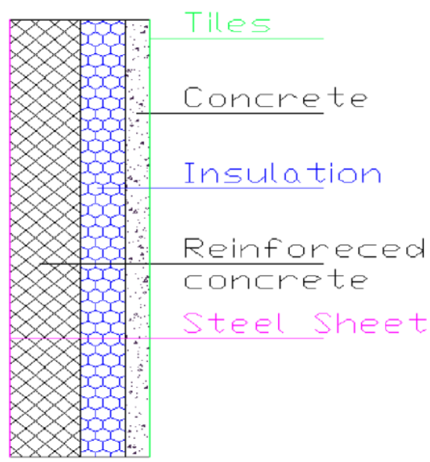


Figure 7.5: Ceiling details

Table 7.5: Variable of heat transfer coefficient for Celling

Tiles	1.10	0.005
Concrete	1.75	0.050
Insulation	0.05	0.096
Concrete	1.75	0.15
Steel Sheet	16.0	0.002

Thickness of the Ceiling = 0.362 m .

$$U = \frac{1}{\frac{1}{9.37} + \frac{0.005}{1.1} + \frac{0.05}{1.75} + \frac{0.096}{0.05} + \frac{0.15}{1.75} + \frac{0.002}{16} + \frac{1}{37}}$$

9.

$= 0.444 \ W/m^2.^oC$.

$\Delta T = 28.3 - T_{in}$

$= 28.3 - 5 = 23.3 \ ^oC$.

$A = 2 * 2 = 4 \ m^2$.

$Q_{Ceiling} = 0.444 * 23.3 * 4 = 50W = 0.050kW$.

8. Door

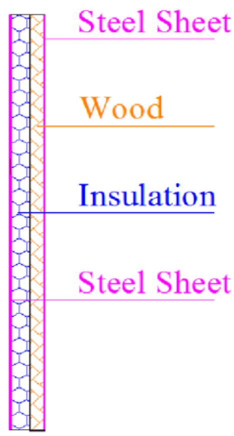


Figure 7.6: Door Details

Table 7.6: variable of heat transfer coefficient for Door

Steel Sheet	16.0	0.002
Insulation	0.05	0.056
Wood	0.16	0.040
Steel Sheet	16.0	0.002

Thickness of the Door = 0.1 m .

1

U

$$\frac{1}{\;} \quad \frac{0.002}{16} \quad \frac{0.056}{0.05} \quad \frac{0.04}{0.16} \quad \frac{0.002}{16} \quad \frac{1}{37}$$

□ □ □ □ □ 9.37

9.

$= 0.631\ W/m^2.^oC$

$\Delta T = T_{Room} - T_{in} =$

$28.3 - 5 = 23.3\ ^oC$.

$A = 1 * 3.8 = 3.8\ m^2$.

$Q_{Door} = 0.631 * 23.3 * 3.8 = 55\ W = 0.055kW$.

7.1.2 Cooling Load Calculation For rooms

Use this law to calculate cooling load for rooms:

$Q_{Total} = Q_{Envelope} + Q_{Product} + Q_{Air} + Q_{Service} + Q_{Respiration}$. **(7.2)** For

Refrigerator:

$Q_{Envelope}$ Calculation:

$Q_{Envelope}$: heat gain from walls, doors, windows, floor and ceiling.

$Q_{Envelope} = Q_1 + Q_{Solar}$.

$Q_{Wall} = Q_{External\ wall-1} + Q_{Internal\ Wall-1} + Q_{Internal\ Wall-3} + Q_{Internal\ Wall}$

$= 0.022+0.038 + 0.076 +0.114 = 0.448$.

$Q_1 = Q_{WallS} + Q_{Door} + Q_{Floor} + Q_{Ceiling}$. **(7.3)**

$Q_1 = 0.448 + 0.055 + 0.038 + .050 = 0.6$ kW.

$Q_{Solar} = 0$

$Q_{Envelope} = 0 + 0.6 = 0.6$kW .

$Q_{Product}$ Calculation:

$Q_{Product} = Q_{2*} + Q_{2**} + Q_{Packaging}$. **(7.4)**

$Q_2^* = m^o \, cp \, \Delta T$.

When:

$m^o = (m_{Product} \; / \;$ Time Cooling) Time

Cooling: Working Time Per a Day .

$\Delta T = \Delta T_{sur} = 30\ ^oC$.

Table 7.7: Product used

Product	cp	m	m*	Q2*
Apple	3.64	40	0.000694	
Avocados	3.01	40	0.000694	
Bananas	3.35	40	0.000694 3.43	
Bass		30	0.000521	
Black Barry	3.64	20	0.000347	
Butter	2.72	30	0.000521 3.94	
Cabbage		50	0.000868 3.81	
Carrots		20	0.000347 3.27	
cheese		40	0.000694 2.72	
Chicken		80	0.001389	
		100		
		90		
		50		
		50		
		60		

cucumber	4.1		0.001736	0.062708
eggs	3.18		0.000521	0.069792
Eggplant	3.98		0.000868	0.053594
Grapes	3.6		0.000868	0.037917
Lemons	3.81		0.001042	0.0425
Milk	3.81		0.000694	0.102604
Tomatoes	3.98	120	0.002083	0.039688
				0.068125
				0.113333
				0.213542
				0.049688
				0.103646
				0.09375
				0.119063
				0.079375
				0.24875
Watermelon	3.94	100	0.001736	0.205208
	$\sum$			1.653281

$Q_2^{*} = 1.65$ kW .

$Q_2^{**} = 0$ {Used to freeze}

$Q_{Packaging} = (m_{Material}$ / Time Cooling) * cp * ΔT . **(7.4)** When:

$m_{Material} = m * N$.

m : is the mass of one pallet = 10 kg . N: is the number of pallets in the room = 30. $m_{Material}$ = 10 * 30 = 300 kg .

cp : is the Specific Heat for Pallet = 0.67 kJ/kg.K .

$\Delta T = \Delta T_{sur} = 30\ ^{o}C$.

$Q_{Packaging}$ = (300 / (4 * 16 * 3600)) * 0.67 * 30 = 0.105 kW .

$Q_{Product}$ = 1.65 + 0 + 0.105 = 1.755kW.

Q_{Air} Calculation:

$Q_{Air} = Q_{Infiltration} + Q_{Ventilation}$. **(7.5)**

$Q_{Infiltration} = 0$ kW.

Prove it :

$Q_{Infiltration} = (1250 / 3600) * v_o * (T_{Room} – T_{in}) v^o$

$= K * L * \{ 0.613 * (S_1 * S_2 * v_o)^2 \}^{(3/2)}$

L : Perimeter of the door .

L = 2 * 3 + 2 * 3 = 12 m .

K

: The infiltration air coefficient = 0.25 .

S_1 : Factor that depend on the topography of the location of the building = 0.9 .

S_2: Coefficient that depend on the height of the building and the term of its location = 0.74 .

Vo : The wind velocity = 0.5 mL / sec .

$v_o = 0.25 * 12 * 10^{-3} * \{ 0.613 * (0.9 * 0.74 * 0.5)^2 \}^{(3/2)}$

$= 5.3 * 10^{-5}$ mL / sec .

$Q_{Infiltration} = (1250 / 3600) * 5.3 * 10^{-5} * (25.1 – 0) = 0.0004 \approx 0$ kW .

$Q_{Ventilation} = Q_{Product} + Q_{People}$ **(7.6)**

$Q_{Product} = m^o * (hout – h_{in})$ From

Psychometric Chart:

h_{out} = 72 J / kg.^{o}C   @ T_{out} = 30 ^{o}C & R.H = 56 %

. h_{in} = 17 J/kg.^{o}C   @ T_{in} = 5^{o}C & R.H =85 % .

$m_o = \rho_{Air} * v_o$ ρ_{Air}: it is the density of the air = 1.2

kg/m^2.

Vo = v * a.

V : Volume of the room in [m^3] .

V = 2 * 4 * 3.8 = 30.4m^3.

a : number of air change each second , it depend for the volume of the room .

from interpolation a = 11.3 L/s . [Table 10-7] m^o

= 1.2 * 30.4 * (11.3 / 1000) = 0.5 m^3/s .

$Q_{Product}$ = 0.5 * (72 – 17) = 27.5 W = 0.0275kW .

$Q_{People} = m^o * (h_{out} – h_{in}) * (\text{hour occupied} / 24) *a$

When:

a : The number of people inside the room = 2 .

$m^o = \rho_{Air} * v^o$ Vo

= 20 m^3/h .

m^o = 1.2 * (20/3600) = 6.66 * 10^{-3} kg/s . hour occupied: is the

time needed to work in the room = 2 hours .

Q_{People} = 6.66 * 10^{-3} * 55* (2/24) * 2 = 0.061 W = 6.1 * 10^{-5} kW .

$Q_{Ventilation}$ = 0.0275+ 6.1 * 10^{-5} = 0.0276 kW .

Q_{Air} = 0 + 0.0276 = 0.0276 kW .

$Q_{Service}$ Calculation:

$Q_{Service} = Q_{People} + Q_{Light}$.

$Q_{People} = n * Q_{Person} * (Working\ hours / 24)$ Q

$_{Person} = 0.275$. [Table 10-14] .

$Q_{People} = 2 * 0.275 * (2 / 24) = 0.046$ kW .

$Q_{Light} = P_{Light} * CLF * N$ P

$_{Light} = 24$ W.

CLF: Cooling Load Factor of Lighting = 0.88 .

N: Number of Lights

N = 2

$Q_{Light} = 24 * 0.88 * 2 = 42.24$ W = 0.0422 kW Q

$_{Service} = + 0.046 + 0.0422 = 0.088$ KW .

$Q_{Respiration}$ Calculation:

$Q_{Respiration} = m * q_{Rips}$

$Q_{Respiration}$: is the rate of respiration .

m : is the mass of the product in the room in [kg] .

q_{Rips} : Rate of heat given off Breathing product . q

$_{Rips} = 0.029$. [Table 10-12] .

$Q_{Respiration} = 0.029 * 1000 = 29$ W = 0.029 kW

.

Consequently:

$Q_{Total} = 0.6 + 1.755 + 0.0276 + 0.088 + 0.029 = 2.5$ kW .

$Q_{Total} = 2.5 * F.S = 2.5 * 1.5 = 3.75$ Kw

From Cool pack:

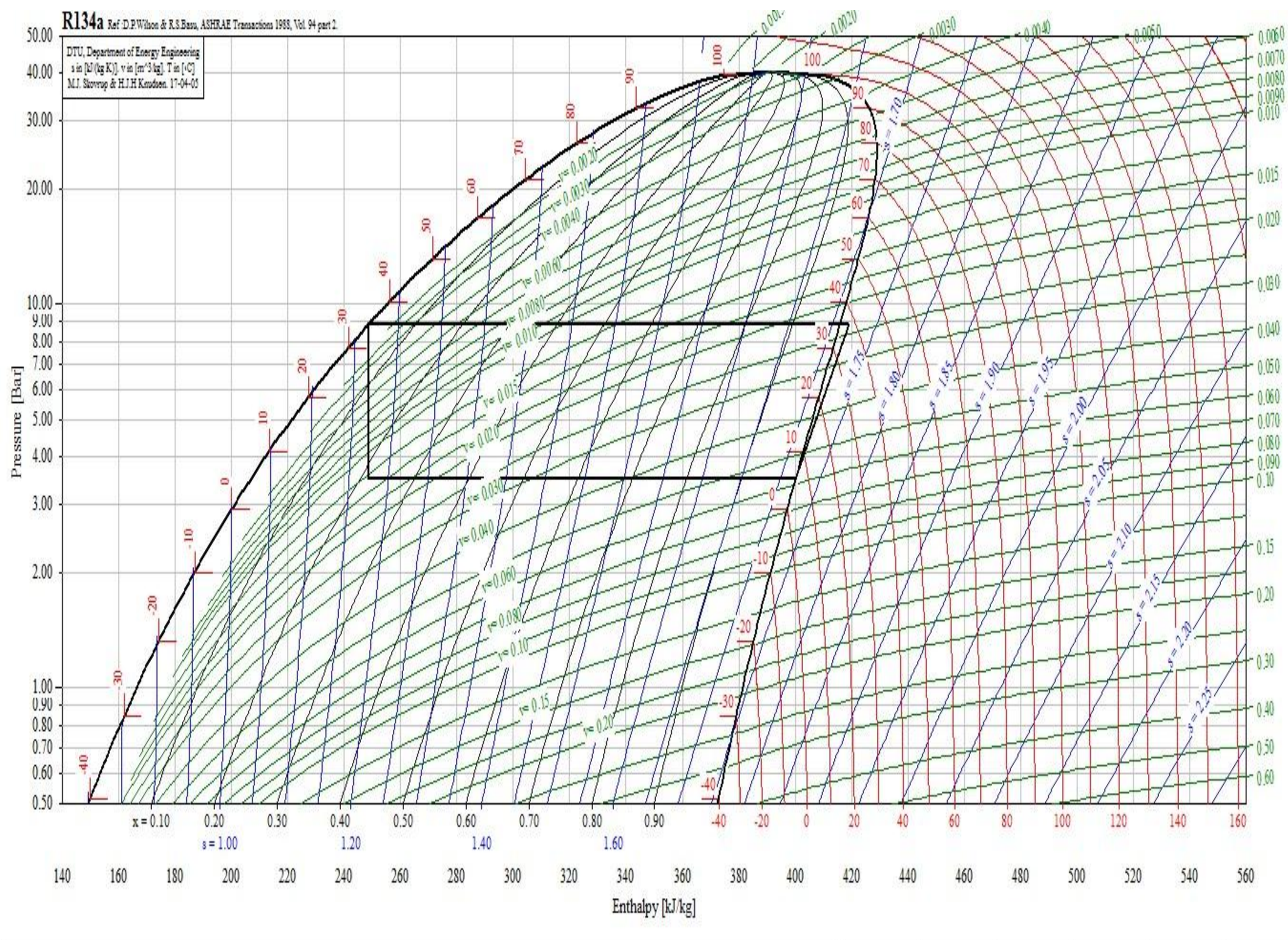


Figure 7.7: The cycle in the PH diagram

Table 7.8: The Value from PH diagram

Values at points in cycle

Values at points 1-6,15 for the selected one stage cycle

Point	T	P	v	h	s
	[°C]	[bar]	[m^3/kg]	[kJ/kg]	[kJ/(kg K)]
1	4.999	3.496	0.058019	400.073	1.7194
2	37.960	8.868	0.023373	419.252	1.7194
3	37.960	8.868	0.023373	419.252	1.7194
4	35.000	8.868	N/A	248.748	N/A
5	N/A	3.496	N/A	248.748	N/A
6	5.000	3.496	0.058015	400.073	1.7194
15	N/A	8.868	N/A	248.748	N/A

OK Print Copy Help

$q_e = h_1 – h_5$

$= 400.073– 248.748 = 151.325$ k/kg .

$q_c = h_2 – h_4$

$= 419.252 – 248.748 = 170.504$ w . w_c

$= h_2 – h_1$

$= 419.252 – 400.073 = 19.179$ w

$Q_e = m^o{}_R\, q_e$ $m^o{}_R = Q_e / q_e = 3.75/151.315 =$

0.02476 kg/s .

$Q_c = m_{oR}\, q_c$

$=0.02476 *170.504=4.225$ kW .

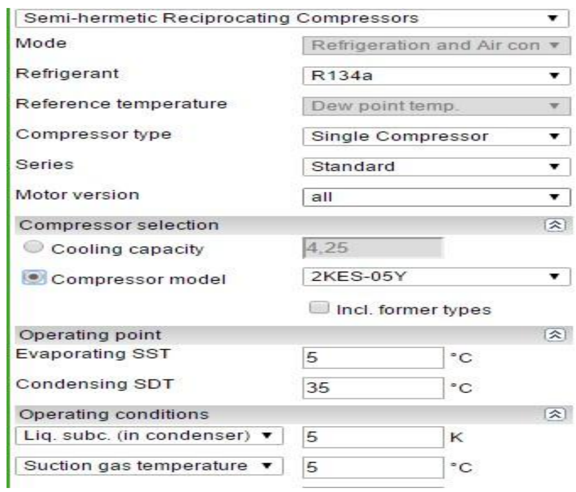
$P = m^{o}\ w_c$

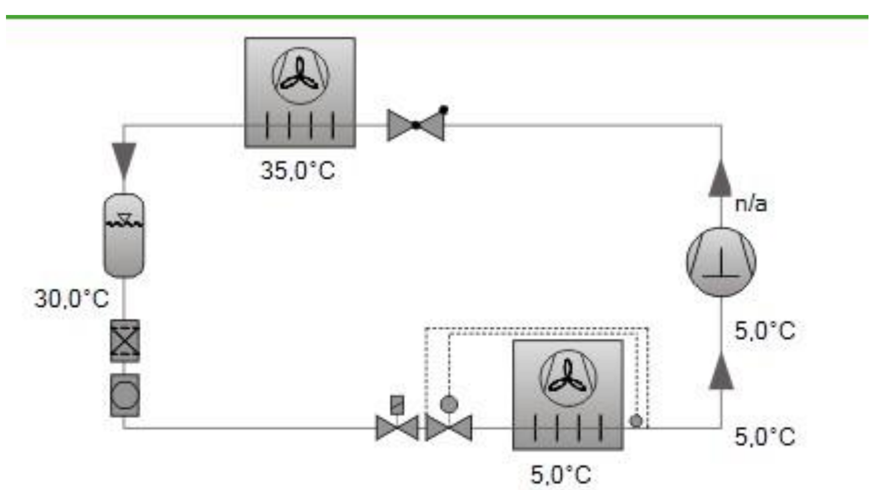
$=0.02476 * 19.179$

$= 0.474$ kW $= 0.62$ hp {hp : horsepower } .

Coefficient of performance (cop) = q_e / w = 151.315/19.179 = 7.889

7.1.3 Compressor selection





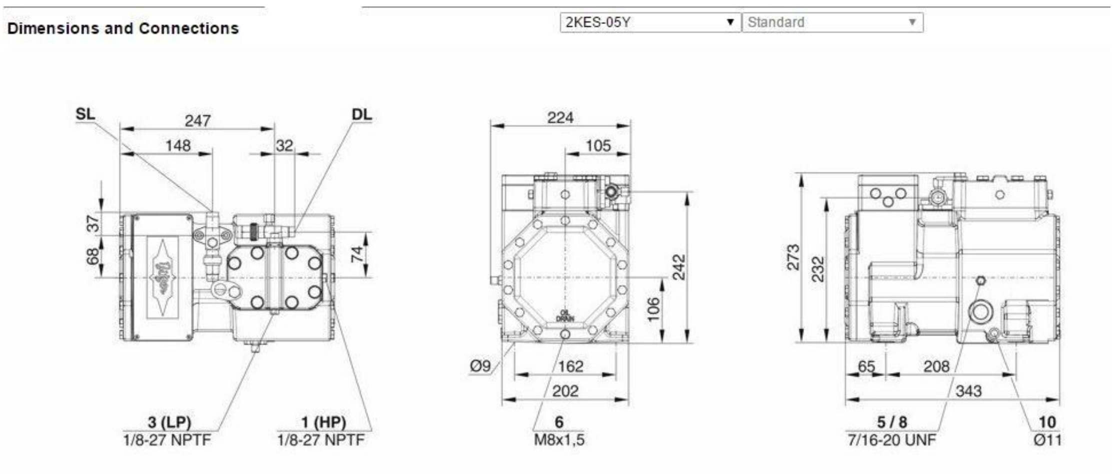
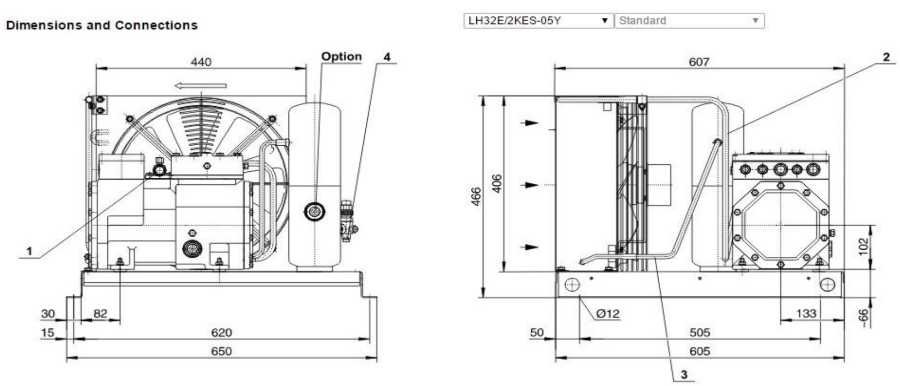
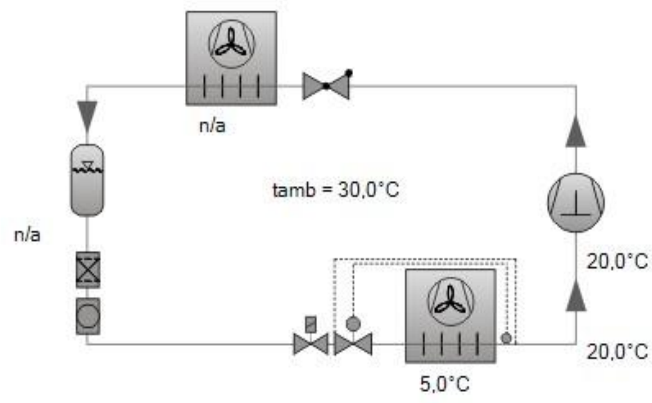


Figure 7.8: Compressor data sheet

7.1.4 Condensers selection:

By Using BITZER-Software





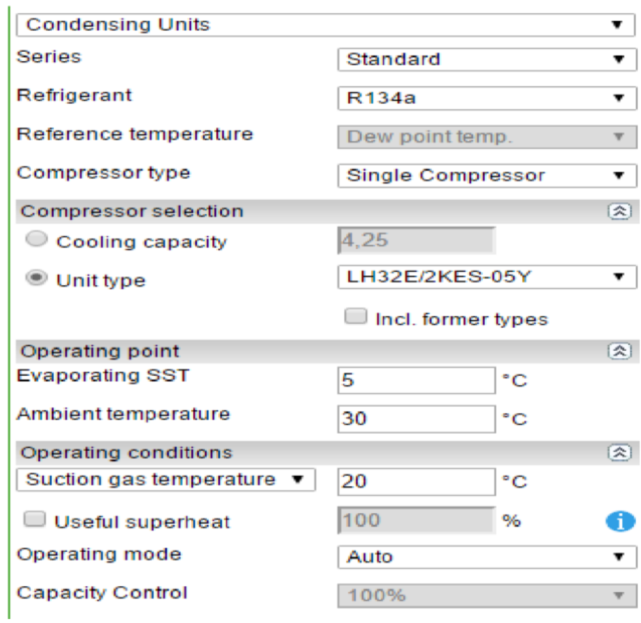


Figure 7.9: Condenser data sheet

7.2 Cooling Load Calculation for freezer

7.2.1 Use this law to find Cooling Load Calculation:

Q=U A ΔT

When:

Q : Cooling Load in [kW] .

U: Overall heat transfer coefficient in [W/m^2. ˚C]

$$U = \frac{1}{\frac{1}{\ } + \frac{\Delta X}{\ } + \frac{1}{\ }}$$

h*in* *K* *hout* h_{in} : is the Inside Convection Coefficient { 9.37 $W/m^2.^oC$ } . h_{out} : is the Outside Convection Coefficient { 22.7 $W/m^2.^oC$ } .

K: is the thermal conductivity for material in [$W/m.^oC$] .

ΔX: is the Thickness of the material in [m] .

A: Surface area in [m^2] .

A=Length * Width.

ΔT: The difference in temperature [^oC] .

1. Internal Wall

$\Delta T = T_{Room} - T_{in}$

$= 28 - -18 = 46\ ^oC$.

$A = A_{\text{Internal Wall}} - A_{\text{Door}}$

$= (2 * 3.8) - (2 * 1)$

$= 5.6\ m^2$.

$Q_{\text{Internal Wall}} = 0.038 * 46 * 5.6 = 0.015$ kW .

2. Internal Wall

$\Delta T = T_{Room} - T_{in}$

$= 24 - -18 = 42\ ^oC$.

$A = A_{\text{Internal Wall-2}}$

$= (4 * 3.8)$

$= 15.2\ m^2$.

$Q_{\text{Internal Wall}} = 0.152 * 42 * 15.2 = 97W = 0.97\ kW$.

3. Internal Wall

$\Delta T = T_{Room} - T_{in}$

$= 24 - -18 = 42\ ^oC$.

$A = A_{\text{Internal Wall-2}}$

$= (2 * 3.8)$

$= 7.6\ m^2$.

$Q_{\text{Internal Wall}} = 0.076 * 42 * 7.6 = 64W = 0.064\ Kw$

4. Internal Wall

$\Delta T = T_{Room} - T_{in}$

$= 5 - -18 = 23\ ^oC$.

$A = A_{\text{Internal Wall-2}}$

$= (4 * 3.8)$

$= 15.2\ m^2$.

$Q_{\text{Internal Wall}} = 0.114 * 23 * 15.2 = 88W = 0.088\ kW$

5. Ground

$\Delta T = T_{ground} - Tin$

$=24 - -18 = 42\ ^oC$.

$A = (2 * 4)$

$= 8\ m^2$.

$Q_{ground} = 0.399 * 42 * 8 = 0.134$ kW .

6. Ceiling

$\Delta T = 28 - T_{in}$ =

$24 - -18 = 42\ ^oC$.

$A = 2 * 4 = 8\ m^2$.

$Q_{Ceiling} = 0.55 * 42 * 8 = 0.184$ kW .

7. Door

$\Delta T = T_{Room} - T_{in}$

$= 24 - -18 = 42\ ^oC$.

$A = 2 * 1 = 2\ m^2$.

$Q_{Door} = 0.345 * 42 * 2 = 0.087$ kW .

Use this law to calculate cooling load for rooms:

$Q_{Total} = Q_{Envelope} + Q_{Product} + Q_{Air} + Q_{Service} + Q_{Respiration}$.

$Q_{Envelope}$: heat gain from walls , doors , windows , floor and ceiling .

$Q_{Envelope} = Q_{1} + Q_{Solar}$.

$Q_{Envelope} = Q_{Wall} + Q_{Door} + Q_{ground} + Q_{Ceiling} + Q_{Solar}$

$Q_{Envelope} = 0.015+0.074+0.088+0.134+0.184+0.087+0 = 0.6$ kW .

$Q_{Product}$ Calculation :

$Q_{Product} = Q_{2*} + Q_{2**} + Q_{Packaging}$. Q_2^*

$= m^o \, cp \, \Delta T$.

$m^o = (m_{Product} \; / \; Time\ Cooling)$

Time Cooling: Working Time Per a Day.

$\Delta T = \Delta T_{sur} = 30\ ^oC$.

Table 7.9: Product Used

Product	cp	m	m*	Q2*
Beef	1.59	120	0.002083	0.099375
Chicken	1.63	120	0.002083	0.101875
Clams	1.51	40	0.000694	0.031458
Codfish	1.63	70	0.001215	0.059427
Halibut	1.67	80	0.001389	0.069583
Ice cream	1.67	30	0.000521	0.026094
Lamp	1.55	50	0.000868	0.040365
Oysters	1.72	60	0.001042	0.05375
Reindeer	1.55	40	0.000694	0.032292
Salmon	1.55	80	0.001389	0.064583
Sausage	1.34	100	0.001736	0.069792
sword fish	1.67	80	0.001389	0.069583
Tripe	1.72	50	0.000868	0.044792
Veal	1.59	50	0.000868	0.041406
whitefish	1.63	60	0.001042	0.050938
				0.855313

$Q_2^* = 0.855$ kW

$Q^{**}2 = (m/time)^* \, \Delta h + (m/time)^*cp^*\Delta T$

$= (1000/11^*3600)^*47 + (1000/16^*3600)^*1.6^*(0--18)$

$= 1.18$ KW $+ 0.5$KW $= 1.68$KW

$Q_{Packaging}$ = ($m_{Material}$ / Time Cooling) * cp * ΔT .

$m_{Material}$ = m * N . m : is the mass of one pallet = 15

kg . N : is the number of pallets in the room = 20.

$m_{Material}$ = 15 * 20 = 300 kg .

cp : is the Specific Heat for Pallet = 0.67 kJ/kg.K .

$\Delta T = \Delta T_{sur} = 30\ ^oC$.

$Q_{Packaging}$ = (300 / (4 * 16 * 3600)) * 0.67 * 30 = 0.105 kW .

$Q_{Product}$ = 0.855+ 1.68 + 0.105 = 2.535kW.

Q_{Air} Calculation :

$Q_{Air} = Q_{Infiltration} + Q_{Ventilation}$.

$Q_{Infiltration}$ = 0 kW.

$Q_{Ventilation} = Q_{Product} + Q_{People}$ Q

$_{Product} = m^o * (hout – h_{in})$.

$Q_{Product}$ = 1.293 * (72 – 10) = 80.16 W = 0.08kW .

$Q_{People} = m^o * (h_{out} – h_{in}) * (\text{hour occupied} / 24) * a$

$Q_{People} = 6.66 * 10^{-3} * 55 * (2/24) * 2 = 0.061\ W = 6.1 * 10^{-5}$ kW.

$Q_{Ventilation} = 0.08 + 6.1 * 10^{-5} = 0.08$ kW.

Q_{Air} = 0 + 0.08 = 0.08 kW.

$Q_{Service}$ Calculation:

$Q_{Service} = Q_{People} + Q_{Light}$.

$Q_{People} = n * Q_{Person} * (Working\ hours / 24)$ Q

$_{People} = 2 * 0.275 * (2 / 24) = 0.046$ kW .

$Q_{Light} = P_{Light} * CLF * N$

$Q_{Light} = 24 * 0.88 * 2 = 42.24$ W = 0.0422 kW

$Q_{Service} = + 0.046 + 0.0422 = 0.088$ KW.

$Q_{Respiration}$ Calculation :

$Q_{Respiration} = m * q_{Rips}$

$Q_{Respiration}$: is the rate of respiration .

m : is the mass of the product in the room in [kg] .

q_{Risp} : Rate of heat given off Breathing product q

$_{Risp} = 0.029$. [Table 10-12] .

$Q_{Respiration} = 0.029 * 1000 = 29$ W = 0.029 kW .

Consequently:

$Q_{Total} = 0.9 + 2.535 + 0.08 + 0.088 + 0.029 = 4.3$ kW .

$Q_{Total} = 4.3*F.S = 4.3*1.5 = 6.5$KW

From Cool pack:

Table 7.10: The cycle in the PH diagram

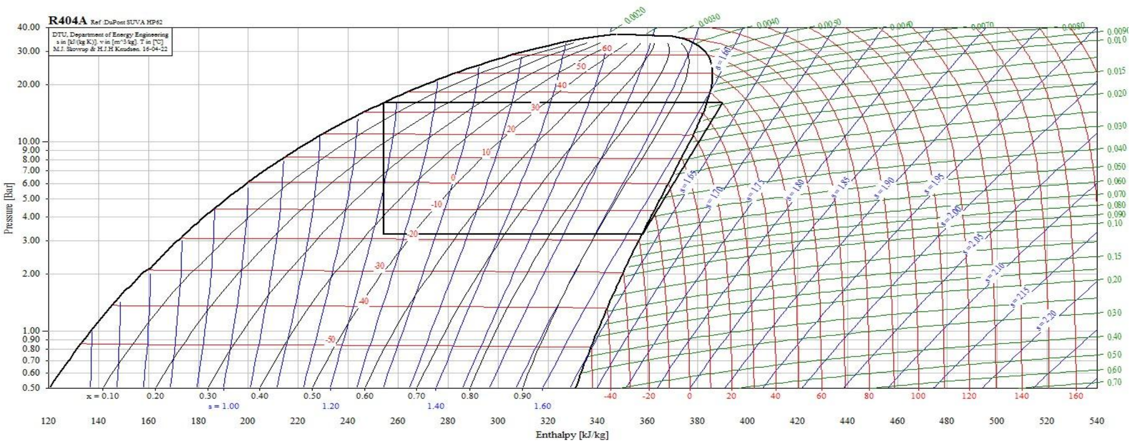


Table 7.11: The Value from PH diagram

Point	T	P	v	h	s
	[°C]	[bar]	[m^3/kg]	[kJ/kg]	[kJ/(kg K)]
1	-17.916	3.260	0.060907	357.822	1.6236
2	40.469	16.065	0.012189	389.924	1.6236
3	40.469	16.065	0.012189	389.924	1.6236
4	34.676	16.065	N/A	254.208	N/A
5	N/A	3.260	N/A	254.208	N/A
6	-17.916	3.260	0.060907	357.822	1.6236
15	N/A	16.065	N/A	254.208	N/A

$q_e = h_1 - h_5$

$= 357.822 – 254.208 = 103.14$ kj/kg .

$q_c = h_2 – h_4$

$= 389.924 – 254.208 = 135.716$ kj/kg .

$w_c = h_2 – h_1$

$= 389.924 – 357.822 = 32.102$ kj/kg

$Q_e = m^o{}_R\ q_e$ $m^o{}_R = Q_e / q_e = 6.5/103.14$

$= 0.063$ kg/s .

$Q_c = m_{oR}\ q_c$

$=0.063 * 135.716 = 8.55$ kW .

$P = m^o\ w_c$

$=0.063 * 32.102$

$= 2.02$ kW = 2.7 hp { hp : horsepower [electric] } .

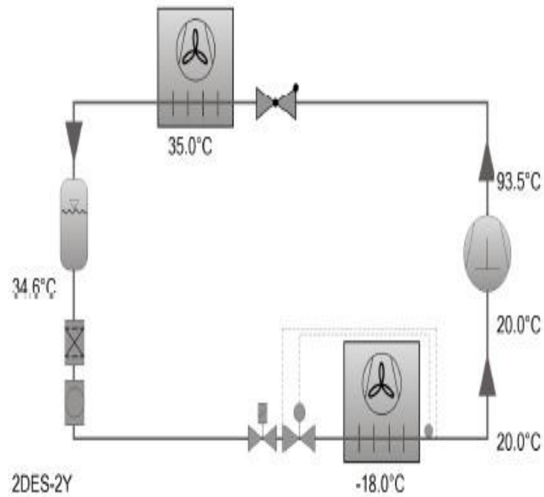
Coefficient of performance (cop) = $q_e / w = 103.14/32.102 = 3.212$

7.2.3 Compressor selection:

By Using BITZER-Software

Input Values

Cooling capacity	6.50 kW
Mode	Refrigeration and Air conditioning
Refrigerant	R404A
Reference temperature	Dew point temp.
Evaporating SST	-18.00 °C
Condensing SDT	35.0 °C
Liq. subc. (in condenser)	0 K
Suction gas temperature	20.00 °C
Operating mode	Auto
Power supply	400V-3-50Hz
Capacity Control	100%
Useful superheat	100%



Result

Compressor	2DES-2Y-40S	2CES-3Y-40S
Capacity steps	100%	100%
Cooling capacity	5.89 kW	7.30 kW
Cooling capacity *	5.89 kW	7.30 kW
Evaporator capacity	5.89 kW	7.30 kW
Power input	2.46 kW	3.01 kW
Current (400V)	4.52 A	5.73 A
Voltage range	380-420V	380-420V
Condenser Capacity	8.35 kW	10.32 kW
COP/EER	2.40	2.42
COP/EER *	2.40	2.42
Mass flow	153.0 kg/h	189.6 kg/h
Operating mode	Standard	Standard
Discharge gas temp. w/o cooling	93.5 °C	92.9 °C

Figure 7.9: Compressor data sheet

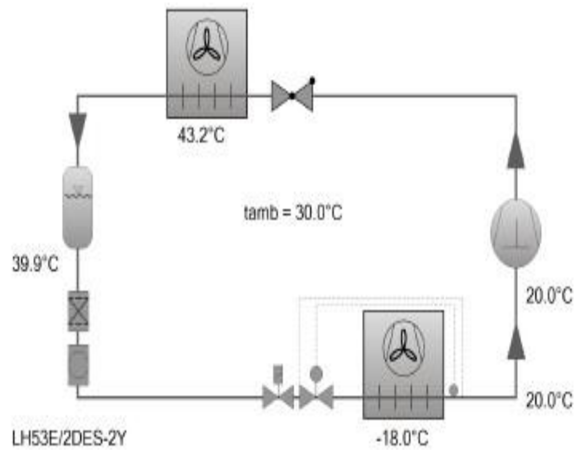
7.2.4 Condensers selection:

By Using BITZER-Software

Compressor Selection: Condensing Units

Input Values

Cooling capacity	6.50 kW
Series	Standard
Refrigerant	R404A
Reference temperature	Dew point temp.
Evaporating SST	-18.00 °C
Ambient temp.	30.0 °C
Suction gas temperature	20.00 °C
Useful superheat	100%
Operating mode	Auto
Power supply	400V-3-50Hz
Capacity Control	100%



Result

Unit type	LH53E/2DES-2Y-40S	LH64E/2DES-3Y-40S	LH64E/2CES-3Y-40S	LH84E/2CES-4Y-40S
Capacity steps	100%	100%	100%	100%
Cooling capacity	5.22 kW	5.62 kW	6.72 kW	7.11 kW
Evaporator capacity	5.22 kW	5.62 kW	6.72 kW	7.11 kW
Power input *	2.79 kW	2.88 kW	3.56 kW	3.43 kW
Current (400V)	4.74 A	5.09 A	5.98 A	5.95 A
Voltage range	380-420V	380-420V	380-420V	380-420V
Mass flow	144.5 kg/h	148.6 kg/h	182.3 kg/h	185.9 kg/h
Condensing SDT	43.2 °C	39.5 °C	41.6 °C	38.5 °C
Liquid subcooling	3.00 K	3.00 K	3.00 K	3.00 K
Operating mode	Standard	Standard	Standard	Standard

Figure 7.9: Condenser data sheet

References

[1] Palestinian code.

[2] J. A. D. W. A.Beckman, Solar Engineering of Thermal Processes, John Wiley & Sons, 2006.

[3] M. A. A. M. Ashamed, Heating and Air Conditioning for Residential Buildings, National Library Department, Jordan, 2007.

[4] J. F. Krieger, Handbook of Heating, Ventilation, and Air Conditioning, Boca Raton, CRC.Press LLC, Florida, 2001.

[5] B. Stein, Building Technology Mechanical and Electrical Systems, John Wiley & sons, Canada, 1997.

Appendix

A-1: Description of wall construction groups

TABLE 9-5 Description of wall construction groups.

Group No.	Description Of Construction	$U_{ov.}$ $W/m^2 \cdot °C$
	101.6 mm Face Brick + (Brick)	
C	Air space + 101.6 mm face brick	2.033
D	101.6 mm common brick	2.356
C	25.4 mm insulation or air space + 101.6 mm common brick	0.987-1.709
B	50.6 mm insulation + 101.6 mm common brick	0.630
B	203.2 mm common brick	1.714
A	Insulation or air space + 203.2 mm common brick	0.874-1.379
	101.6 mm Face Brick + (H.W. Concrete)	
C	Air space + 50.8 mm concrete	1.987
B	50.8 mm insulation + 101.6 mm concrete	0.658
A	Air space or insulation + 203.2 mm or more concrete	0.625-0.636
	101.6 mm Face Brick + (L.W. or H.W Concrete Block)	
E	101.6 mm block	1.811
D	Air space or insulation + 101.60 mm block	0.868-1.397
D	203.2 mm block	1.555
C	Air space or 25.4 mm insulation + 152.4 mm or 203.2 mm block	1.255-1.561
B	50.8 insulation + 203.2 mm block	0.545-0.607
	101.6 mm Face Brick + (Clay Tile)	
D	101.6 mm tile	2.163
D	Air space + 101.6 mm tile	1.595
C	Insulation + 101.6 mm tile	0.959
C	203.2 mm tile	1.561
B	Air space or 25.4 mm insulation + 203.2 mm tile	0.806-1.255
A	50.8 mm insulation + 203.2 mm tile	0.551
	L.W. Concrete Wall + (Finish)	
E	101.5 mm concrete	3.321
D	101.6 mm concrete + 25.4 mm or 50.8 mm insulation	1.136 - 0.675
C	50.8 mm insulation+101.6 mm concrete	0.675
C	203.2 mm concrete	2.782
B	203.2 mm concrete + 25.4 mm or 50.8 mm insulation	1.061 - 0.653
A	203.2 mm concrete + 50.8 mm insulation	0.653
B	304.8 mm concrete	2.390
A	304.8 mm concrete + insulation	0.642
	L.W. and H.W. Concrete Block + (Finish)	
F	101.6 mm block + air space/insulation	0.914-1.493
E	50.8 mm insulation + 101.6 mm block	0.596-0.647
E	203.2 mm block	1.669-2.282
D	203.2 mm block + air space/insulation	0.846-0.982
	Clay Tile + (Finish)	
F	101.6 mm tile	2.379
F	101.6 mm tile +air space	1.720
F	101.6 mm tile + 25.4 mm insulation	0.993
D	80.8 mm insulation + 10.4 mm tile	0.825
C	203.3 mm tile + air space/25.4 mm insulation	0.857-1.312
B	50.8 mm insulation + 203.2 mm tile	0.562
	Metal Curtain Wall	
G	With/without air space + 25.4 mm/58 to 76.2 mm insulation	0.516-1.306
	Frame Wall	
G	24.4 mm to 76.2 mm insulation	1.010 - 0.459

A-2: Approximate CLTD values for light, medium, and heavy weight construction walls

TABLE 9-6 Approximate CLTD values for light, medium, and heavy weight construction walls, °C.

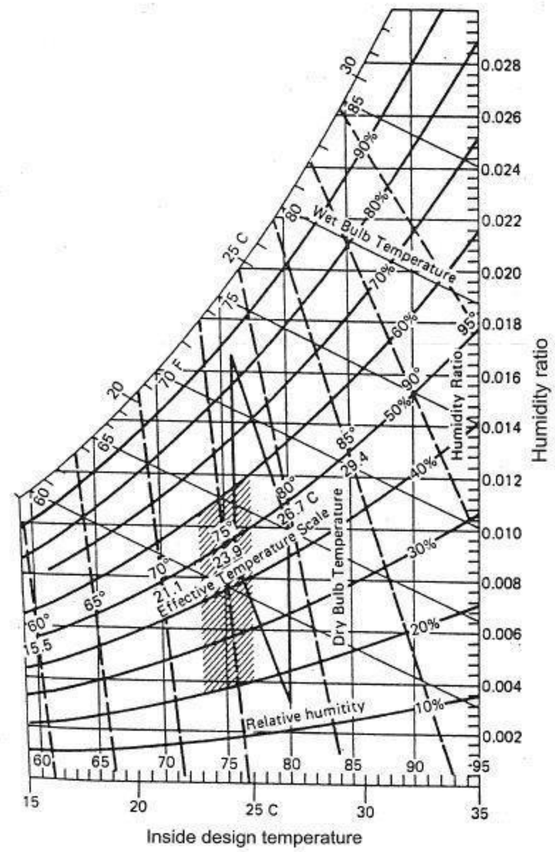
Solar Time	Wall construction											
	Light				Medium				Heavy			
	N	E	S	W	N	E	S	W	N	E	S	W
8:00	—	16	—	—	—	—	—	—	—	—	—	—
9:00	—	20	—	—	—	6	—	—	—	—	—	—
10:00	—	21	2	—	—	11	—	—	—	—	—	—
11:00	—	18	7	—	—	14	—	—	—	3	—	—
12:00	—	12	12	—	—	15	—	—	—	5	—	—
13:00	2	9	15	5	—	14	5	—	—	7	—	—
14:00	3	7	16	13	—	12	9	1	—	8	—	—
15:00	3	7	14	21	1	10	11	6	—	8	1	—
16:00	4	6	11	27	2	9	12	12	—	8	3	—
17:00	4	5	7	30	2	8	11	17	—	8	5	3
18:00	5	3	4	27	3	7	9	22	—	8	6	7
19:00	2	1	1	17	3	5	7	23	—	7	6	10
20:00	—	—	—	6	3	3	5	20	1	7	6	12

A-3: Approximate CLTD values for sunlit roofs

TABLE 9-3 Approximate CLTD values for sunlit roofs, °C.

Solar Time	Roof Construction		
	Light	Medium	Heavy
10:00	5	—	—
11:00	12	—	—
12:00	19	3	0
13:00	25	8	2
14:00	29	14	5
15:00	31	19	8
16:00	31	23	10
17:00	29	25	12
18:00	24	26	14
19:00	19	25	15
20:00	11	22	16

A-4: Inside design temperature



A-5: cooling load factor (CLF), for lights

Table (A-8) Cooling load factor (CLF)$_{Li}$, for lights. [3]

Number of hours after lights are turned On	Fixture X[c] hours of operation		Fixture Y[c] hours of operation	
	10	16	10	16
0	0.08	0.19	0.01	0.05
1	0.62	0.72	0.76	0.79
2	0.66	0.75	0.81	0.83
3	0.69	0.77	0.84	0.87
4	0.73	0.80	0.88	0.89
5	0.75	0.82	0.90	0.91
6	0.78	0.84	0.92	0.93
7	0.80	0.85	0.93	0.94
8	0.82	0.87	0.95	0.95
9	0.84	0.88	0.96	0.96
10	0.85	0.89	0.97	0.97
11	0.32	0.90	0.22	0.98
12	0.29	0.91	0.18	0.98
13	0.26	0.92	0.14	0.98
14	0.23	0.93	0.12	0.99
15	0.21	0.94	0.09	0.99
16	0.19	0.94	0.08	0.99
17	0.17	0.40	0.06	0.24
18	0.15	0.36	0.05	0.20

[3] Adapted from Stoecker and Jones, 1982, "*Refrigeration and Air Conditioning*", 2[nd] ed., MacGraw Hill. (Fixture X = not vented recessed lights and Fixture Y = vented or free-hanging light.)

[4] Adapted from Jones, 1979 "*Air Conditioning applications and Design*", Edward Arnold.

A-6: Cooling load factor due to occupants (CLF), for sensible gain

Table (A-6-2) Cooling load factor due to occupants $(CLF)_{occ.}$, for sensible heat gain.[5]

Hours after each entry into space	Total hours in space							
	2	4	6	8	10	12	14	16
1	0.49	0.49	0.50	0.51	0.53	0.55	0.58	0.62
2	0.58	0.59	0.60	0.61	0.62	0.64	0.66	0.70
3	0.17	0.66	0.67	0.67	0.69	0.70	0.72	0.75
4	0.13	0.71	0.72	0.72	0.74	0.75	0.77	0.79
5	0.10	0.27	0.76	0.76	0.77	0.79	0.80	0.82
6	0.08	0.21	0.79	0.80	0.80	0.81	0.83	0.85
7	0.07	0.16	0.34	0.82	0.83	0.84	0.85	0.87
8	0.06	0.14	0.26	0.84	0.85	0.86	0.87	0.88
9	0.05	0.11	0.21	0.38	0.87	0.88	0.89	0.90
10	0.04	0.10	0.18	0.30	0.89	0.89	0.9	0.91
11	0.04	0.08	0.15	0.25	0.42	0.91	0.91	0.92
12	0.03	0.07	0.13	0.21	0.34	0.92	0.92	0.93
13	0.03	0.06	0.11	0.18	0.28	0.45	0.93	0.94
14	0.02	0.06	0.10	0.15	0.23	0.36	0.94	0.95
15	0.02	0.05	0.08	0.13	0.20	0.30	0.47	0.95
16	0.02	0.04	0.07	0.12	0.17	0.25	0.38	0.96
17	0.02	0.04	0.06	0.10	0.15	0.21	0.31	0.49
18	0.01	0.03	0.06	0.09	0.13	0.19	0.26	0.39

A-7: Cooling load temperature differences (CLTD) for convection heat gain for glass windows

Table (A-7) Cooling load temperature differences (CLTD) for convection heat gain for glass windows.

Solar Time	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
CLTD °C	1	0	−1	−1	−1	−1	−1	0	1	2	4	5	7	7	8	8	7	7	6	4	3	2	2	1

A-8: Cooling load factor (CLF) for glass windows without interior shading

Table (A-5-1) Cooling load factors (CLF) for glass windows without interior shading, north latitudes.

Glass Facing	Building Construction	Solar Time, h																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
N Shaded	L	0.17	0.14	0.11	0.09	0.08	0.33	0.24	0.48	0.56	0.61	0.71	0.76	0.80	0.82	0.82	0.79	0.75
	M	0.23	0.20	0.18	0.16	0.14	0.34	0.14	0.46	0.53	0.59	0.65	0.70	0.73	0.75	0.76	0.74	0.75
	H	0.25	0.23	0.21	0.20	0.19	0.38	0.45	0.49	0.55	0.60	0.65	0.69	0.72	0.72	0.72	0.70	0.70
NNE	L	0.06	0.05	0.04	0.03	0.03	0.26	0.43	0.47	0.44	0.41	0.40	0.39	0.39	0.38	0.36	0.33	0.30
	M	0.09	0.08	0.07	0.06	0.06	0.24	0.38	0.42	0.39	0.37	0.37	0.36	0.36	0.36	0.34	0.33	0.30
	H	0.11	0.10	0.09	0.09	0.08	0.26	0.39	0.42	0.39	0.36	0.35	0.34	0.34	0.33	0.32	0.31	0.28
NE	L	0.04	0.04	0.03	0.02	0.02	0.23	0.41	0.51	0.51	0.45	0.39	0.36	0.33	0.31	0.28	0.26	0.23
	M	0.07	0.06	0.06	0.05	0.04	0.21	0.36	0.44	0.45	0.40	0.36	0.33	0.31	0.30	0.28	0.26	0.24
	H	0.09	0.08	0.08	0.07	0.07	0.23	0.37	0.44	0.44	0.39	0.34	0.31	0.29	0.27	0.26	0.24	0.22
ENE	L	0.04	0.03	0.03	0.02	0.02	0.21	0.40	0.52	0.57	0.53	0.45	0.39	0.34	0.31	0.28	0.25	0.22
	M	0.07	0.06	0.05	0.05	0.04	0.20	0.35	0.45	0.49	0.47	0.41	0.36	0.33	0.30	0.28	0.26	0.23
	H	0.09	0.09	0.08	0.07	0.07	0.22	0.36	0.46	0.49	0.45	0.38	0.31	0.30	0.27	0.25	0.23	0.21
E	L	0.04	0.03	0.03	0.02	0.02	0.19	0.37	0.51	0.57	0.57	0.50	0.42	0.37	0.32	0.29	0.25	0.22
	M	0.07	0.06	0.06	0.05	0.05	0.18	0.33	0.44	0.50	0.51	0.46	0.39	0.35	0.31	0.29	0.26	0.23
	H	0.09	0.09	0.08	0.08	0.07	0.20	0.34	0.45	0.49	0.49	0.43	0.39	0.32	0.29	0.26	0.24	0.22
ESE	L	0.05	0.04	0.03	0.03	0.02	0.17	0.34	0.49	0.58	0.61	0.57	0.48	0.41	0.36	0.32	0.28	0.24
	M	0.08	0.07	0.06	0.05	0.05	0.16	0.31	0.43	0.51	0.54	0.51	0.44	0.39	0.35	0.32	0.29	0.26
	H	0.10	0.09	0.09	0.08	0.08	0.19	0.32	0.43	0.50	0.52	0.49	0.41	0.36	0.32	0.29	0.26	0.24
SE	L	0.05	0.04	0.04	0.03	0.03	0.13	0.28	0.43	0.55	0.62	0.63	0.57	0.48	0.42	0.37	0.33	0.28
	M	0.09	0.08	0.07	0.06	0.05	0.14	0.26	0.38	0.48	0.54	0.56	0.51	0.45	0.40	0.36	0.33	0.29
	H	0.11	0.10	0.10	0.09	0.08	0.17	0.28	0.40	0.49	0.53	0.53	0.48	0.41	0.36	0.33	0.30	0.27
SSE	L	0.07	0.05	0.04	0.04	0.03	0.06	0.15	0.29	0.43	0.55	0.63	0.64	0.60	0.25	0.45	0.40	0.35
	M	0.11	0.09	0.08	0.07	0.06	0.08	0.16	0.26	0.38	0.58	0.55	0.57	0.54	0.48	0.43	0.39	0.35
	H	0.12	0.11	0.11	0.10	0.09	0.12	0.19	0.29	0.40	0.49	0.54	0.55	0.51	0.44	0.39	0.35	0.31
S	L	0.08	0.07	0.05	0.04	0.04	0.06	0.09	0.14	0.22	0.34	0.48	0.59	0.65	0.65	0.59	0.50	0.43
	M	0.12	0.11	0.09	0.08	0.07	0.08	0.11	0.14	0.21	0.31	0.42	0.52	0.57	0.58	0.53	0.47	0.41
	H	0.13	0.12	0.12	0.11	0.10	0.11	0.14	0.17	0.24	0.33	0.43	0.51	0.56	0.55	0.50	0.43	0.37
SSW	L	0.10	0.08	0.07	0.06	0.05	0.06	0.09	0.11	0.15	0.19	0.27	0.39	0.52	0.62	0.67	0.65	0.58
	M	0.14	0.12	0.11	0.09	0.08	0.09	0.11	0.13	0.15	0.18	0.25	0.35	0.46	0.55	0.59	0.59	0.53
	H	0.15	0.14	0.13	0.12	0.11	0.12	0.14	0.16	0.18	0.21	0.27	0.37	0.46	0.53	0.57	0.55	0.49
SW	L	0.12	0.10	0.08	0.06	0.05	0.06	0.08	0.10	0.12	0.14	0.16	0.24	0.36	0.49	0.60	0.66	0.66
	M	0.15	0.14	0.12	0.10	0.09	0.09	0.10	0.12	0.13	0.15	0.17	0.23	0.33	0.44	0.53	0.58	0.59
	H	0.15	0.14	0.13	0.12	0.11	0.12	0.13	0.14	0.16	0.17	0.19	0.25	0.34	0.44	0.52	0.56	0.56
WSW	L	0.12	0.10	0.08	0.07	0.05	0.06	0.07	0.09	0.10	0.12	0.13	0.17	0.26	0.40	0.52	0.62	0.66
	M	0.15	0.13	0.12	0.10	0.09	0.09	0.10	0.11	0.12	0.13	0.14	0.17	0.24	0.35	0.46	0.54	0.58
	H	0.15	0.14	0.13	0.12	0.11	0.11	0.12	0.13	0.14	0.15	0.16	0.19	0.26	0.36	0.46	0.53	0.56
	L	0.12	0.10	0.08	0.06	0.05	0.06	0.07	0.08	0.10	0.11	0.12	0.14	0.20	0.32	0.45	0.57	0.64

A-9: cooling load factors for glass windows with interior shading

Table (A-5-2) Cooling Load factors (CLF) for glass windows with interior shading, North latitude.

Fenestration Facing	Solar Time, *h*																
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
N	0.08	0.07	0.06	0.06	0.07	0.73	0.66	0.65	0.73	0.80	0.86	0.89	0.89	0.86	0.82	0.75	0.78
NNE	0.03	0.03	0.02	0.02	0.03	0.64	0.77	0.62	0.42	0.37	0.37	0.37	0.36	0.35	0.32	0.28	0.23
NE	0.03	0.02	0.02	0.02	0.02	0.56	0.76	0.74	0.58	0.37	0.29	0.27	0.26	0.24	0.22	0.20	0.16
ENE	0.03	0.02	0.02	0.02	0.02	0.52	0.76	0.80	0.71	0.52	0.31	0.26	0.24	0.22	0.20	0.18	0.15
E	0.03	0.02	0.02	0.02	0.02	0.47	0.72	0.80	0.76	0.62	0.41	0.27	0.24	0.22	0.20	0.17	0.14
ESE	0.03	0.03	0.02	0.02	0.02	0.41	0.67	0.79	0.80	0.72	0.54	0.34	0.27	0.24	0.21	0.19	0.15
SE	0.03	0.03	0.02	0.02	0.02	0.30	0.57	0.74	0.81	0.79	0.68	0.49	0.33	0.28	0.25	0.22	0.18
SSE	0.04	0.03	0.03	0.03	0.02	0.12	0.31	0.54	0.72	0.81	0.81	0.71	0.54	0.38	0.32	0.27	0.22
S	0.04	0.04	0.03	0.03	0.03	0.09	0.16	0.23	0.38	0.58	0.75	0.83	0.80	0.68	0.50	0.35	0.27
SSW	0.05	0.04	0.04	0.03	0.03	0.09	0.14	0.18	0.22	0.27	0.43	0.63	0.78	0.84	0.80	0.66	0.46
SW	0.05	0.05	0.04	0.04	0.03	0.07	0.11	0.14	0.16	0.19	0.22	0.38	0.59	0.75	0.83	0.81	0.69
WSW	0.05	0.05	0.04	0.04	0.03	0.07	0.10	0.12	0.14	0.16	0.17	0.23	0.44	0.64	0.78	0.84	0.78
W	0.05	0.05	0.04	0.04	0.03	0.06	0.09	0.11	0.13	0.15	0.16	0.17	0.31	0.53	0.72	0.82	0.81
WNW	0.05	0.05	0.04	0.03	0.03	0.07	0.10	0.12	0.14	0.16	0.17	0.18	0.22	0.43	0.65	0.80	0.84
NW	0.05	0.04	0.04	0.03	0.03	0.07	0.11	0.14	0.17	0.19	0.20	0.21	0.22	0.30	0.52	0.73	0.82
NNW	0.05	0.05	0.04	0.03	0.03	0.11	0.17	0.22	0.26	0.30	0.32	0.33	0.34	0.34	0.39	0.61	0.82
HORIZ.	0.06	0.05	0.04	0.04	0.03	0.12	0.27	0.44	0.59	0.72	0.81	0.85	0.85	0.81	0.71	0.58	0.42

A-10: Shading coefficient for glass with interior shading

Table (A-4-2) Shading coefficient (SC) for glass windows with interior shading.

Type of Glass	Nominal Thickness, mm	Type of Interior Shading: Venetian Blinds		Roller Shade: Opaque		Roller Shade: Translucent
		Medium	Light	Dark	White	Light
Single Glass						
Clear, regular	2.5-6.0	—	—	—	—	—
Clear, plate	6.0-12.0	—	—	—	—	—
Clear Pattern	3.0-12.0	0.64	0.55	0.59	0.25	0.39
Heat Absorbing	3	—	—	—	—	—
Pattern or Tinted(gray sheet)	5.0-5.5	—	—	—	—	—
Heat Absorbing, plate	5.0-6.0	0.57	0.53	0.45	0.30	0.36
Pattern or Tinted, gray sheet	3.0-5.5	—	—	—	—	—
Heat Absorbing Plate or Pattern Heat Absorbing	10	0.54	0.52	0.40	0.82	0.32
Heat Absorbing or Pattern	—	0.42	0.40	0.36	0.28	0.31
Reflective Coated Glass	—	0.30	0.25	0.23	—	—
	—	0.40	0.33	0.29	—	—
	—	0.50	0.42	0.38	—	—
	—	0.60	0.50	0.44	—	—
Double Glass						
Regular	3	0.57	0.51	0.60	0.25	—
Plate	6	0.57	0.51	0.60	0.25	—
Reflective	6	0.20-0.40	—	—	—	—
Insulating Glass						
Clear	2.5-6.0	0.57	0.51	0.60	0.25	0.37
Heat Absorbing	5.0-6.0	0.39	0.36	0.40	0.22	0.30
Reflective Coated	—	0.20	0.19	0.18	—	—
	—	0.30	0.27	0.26	—	—
	—	0.40	0.34	0.33	—	—

A-11: Shading coefficient for glass windows without interior shading

Table (A-4-1) Shading coefficient (SC) for glass windows without interior shading.[1]

Type of Glass	Nominal Thickness, mm	Solar Trans.	Shading Coefficient, W/m²·K	
			$h_o = 22.7$	$h_o = 17.0$
Single Glass				
Clear	3	0.84	1.00	1.00
	6	0.78	0.94	0.95
	10	0.72	0.90	0.92
	12	0.67	0.87	0.88
Heat absorbing	3	0.64	0.83	0.85
	6	0.46	0.69	0.73
	10	0.33	0.60	0.64
	12	0.42	0.53	0.58
Double Glass				
Regular	3	—	0.90	—
Plate	6	—	0.83	—
Reflective	6	—	0.20-0.40	—
Insulating Glass				
Clear	3	0.71	0.88	0.88
	6	0.61	0.81	0.82
Heat absorbing*	6	0.36	0.55	0.58

A-12: Solar heat gain factor for sunlit glass

Table (A-3) Solar heat gain factor (SHG) for sunlit glass, W/m², for a latitude angle of 32 °N.

Month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
N	76	85	101	114	120	139	126	117	104	88	76	69
NNE/NNW	76	85	117	252	350	385	350	249	110	88	76	69
NE/NW	91	205	338	461	536	555	527	445	325	199	91	69
ENE/WNW	331	470	577	631	656	656	643	615	546	451	325	265
E/W	552	647	716	716	694	675	678	691	678	615	546	511
ESE/WSW	722	764	748	691	628	596	612	663	716	738	710	688
SE/SW	786	782	716	590	489	439	473	571	688	754	773	776
SSE/SSW	789	732	615	445	213	262	303	429	596	710	776	795
S	776	697	555	363	233	189	227	350	540	678	767	795
Horizontal	555	685	795	855	874	871	861	836	770	672	552	498

A-13: Values of infiltration air coefficient for windows

TABLE 6–2 Values of infiltration air coefficient *K*.(2) for windows.

Window Type	Infiltration Air Coefficient *K*		
	Average	Minimum	Maximum
Sliding			
Iron	0.36	0.25	0.40
Aluminum	0.43	0.25	0.70
Hung			
Iron	0.25	0.10	0.60
Aluminum (side pivoted)	0.36	0.07	0.70
Aluminum (horizontal pivoted)	0.30	0.07	0.50
PVC	0.10	0.03	0.15

A-14: Infiltration rates due to door opening

TABLE 6–5 Infiltration rates due to door opening, m^3 per passage.4

№ of Passage per Hour	Doors in One Wall Only			Doors in more than One Wall		
	Single Swing	Vestibule Swinging Doors	Revolving Doors	Single Swing	Vestibule Swinging Doors	Revolving Doors
300	4.757	3.540	1.359	3.115	2.350	0.850
500	4.757	3.540	1.303	3.115	2.350	0.821
700	4.757	3.540	1.218	3.115	2.322	0.765
900	4.757	3.540	1.104	3.087	2.322	0.708
1,100	4.757	3.540	0.935	3.087	2.322	0.651
1,200	4.757	3.540	0.850	3.058	2.322	0.595
1,300	4.757	3.540	0.793	3.058	2.322	0.538
1,400	4.757	3.540	0.708	3.058	2.294	0.510
1,500	4.757	3.540	0.651	3.058	2.294	0.481
1,600	4.729	3.540	0.595	3.058	2.294	0.453
1,700	4.616	3.511	0.538	3.030	2.294	0.425
1,800	4.502	3.455	0.510	2.973	2.265	0.396
1,900	4.418	3.398	0.481	2.945	2.265	0.368
2,000	4.304	3.341	0.453	3.832	2.237	0.340

A-15: Table for estimating demand

Table (P-1): Table for Estimating Demand

Supply Systems Predominantly for Flush Tanks		Supply Systems Predominantly for Flushometers	
Load, WSFU[a]	Demand, gpm	Load, WSFU[a]	Demand, gpm
6	5	—	—
10	8	10	27
15	11	15	31
20	14	20	35
25	17	25	38
30	20	30	41
40	25	40	47
50	29	50	51
60	33	60	55
80	39	80	62
100	44	100	68
120	49	120	74
140	53	140	78
160	57	160	83
180	61	180	87
200	65	200	91
225	70	225	95
250	75	250	100
300	85	300	110
400	105	400	125
500	125	500	140
750	170	750	175
1000	210	1000	218
1250	240	1250	240
1500	270	1500	270
1750	300	1750	300
2000	325	2000	325
2500	380	2500	380
3000	435	3000	435
4000	525	4000	525
5000	600	5000	600
6000	650	6000	650
7000	700	7000	700
8000	730	8000	730
9000	760	9000	760
10000	790	10000	790

A-16: fixture units

Fixture[a]	*Use*	*Type of Supply Control*	*Fixture Units*[b]	*Min. Size of Fixture Branch*[d] *in.*
Bathroom group[c]	Private	Flushometer	8	—
Bathroom group[c]	Private	Flush tank for closet	6	—
Bathtub	Private	Faucet	2	1/2
Bathtub	General	Faucet	4	1/2
Clothes washer	Private	Faucet	2	1/2
Clothes washer	General	Faucet	4	1/2
Combination fixture	Private	Faucet	3	1/2
Dishwasher[f]	Private	Automatic	1	1/2
Drinking fountain	Offices, etc.	Faucet 3/8 in.	0.25	1/2
Kitchen sink	Private	Faucet	2	1/2
Kitchen sink	General	Faucet	4	1/2
Laundry trays (1–3)	Private	Faucet	3	1/2
Lavatory	Private	Faucet	1	3/8
Lavatory	General	Faucet	2	1/2
Separate shower	Private	Mixing valve	2	1/2
Service sink	General	Faucet	3	1/2
Shower head	Private	Mixing valve	2	1/2
Shower head	General	Mixing valve	4	1/2
Urinal	General	Flushometer	5	3/4[e]
Urinal	General	Flush tank	3	1/2
Water closet	Private	Flushometer	6	1
Water closet	Private	Flushometer/tank	3	1/2
Water closet	Private	Flush tank	3	1/2
Water closet	General	Flushometer	10	1
Water closet	General	Flushometer/tank	5	1/2
Water closet	General	Flush tank	5	1/2

Water supply outlets not listed above shall be computed at their maximum demand, but in no case less than the following values:

A-17: Approximate discharge rates and velocities in sloping drains flowing half full

Table (P-3) Approximate Discharge Rates and Velocities[a] in Sloping Drains Flowing Half Full[b]

Actual Inside Diameter of Pipe, in.	1/16 in./ft Slope		1/8 in./ft Slope		1/4 in./ft Slope		1/2 in./ft Slope	
	Discharge, gpm	Velocity, fps	Discharge, gpm	Velocity, fps	Discharge, gpm	Velocity, fps	Discharge, gpm	Velocity, fps
1 1/4							3.40	1.78
1 3/8					3.13	1.34	4.44	1.90
1 1/2					3.91	1.42	5.53	2.01
1 5/8					4.81	1.50	6.80	2.12
2					8.42	1.72	11.9	2.43
2 1/2			10.8	1.41	15.3	1.99	21.6	2.82
3			17.6	1.59	24.8	2.25	35.1	3.19
4	26.70	1.36	37.8	1.93	53.4	2.73	75.5	3.86
5	48.3	1.58	68.3	2.23	96.6	3.16	137.	4.47
6	78.5	1.78	111.	2.52	157.	3.57	222.	5.04
8	170.	2.17	240.	3.07	340.	4.34	480.	6.13
10	308.	2.52	436.	3.56	616.	5.04	872.	7.12
12	500.	2.83	707.	4.01	999.	5.67	1413	8.02

[a] Computed from the Manning Formula for 1/2-full pipe, $n = 0.015$.

[b] Half full means filled to a depth equal to one-half the inside diameter.

Note: For 1/4 full, multiply discharge by 0.274 and multiply velocity by 0.701. For 1/3 full, multiply discharge by 0.44 and multiply velocity by 0.80. For 3/4 full, multiply discharge by 1.82 and multiply velocity by 1.13. For full, multiply discharge by 2.00 and multiply velocity by 1.00. For smoother pipe, multiply discharge and velocity by 0.015 and divide by n value of smoother pipe.

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A-18: Horizontal fixture branches and stacks

Table (P-3) Horizontal Fixture Branches and Stacks

Diameter of Pipe, in.	Maximum Number of Fixture Units That May Be Connected to			
	Any Horizontal Fixture Branch,[a] dfu	One Stack of Three Branch Intervals or Less, dfu	Stacks with More Than Three Branch Intervals: Total for Stack, dfu	Stacks with More Than Three Branch Intervals: Total at One Branch Interval, dfu
1 1/2	3	4	8	2
2	6	10	24	6
2 1/2	12	20	42	9
3	20[b]	48[b]	72[b]	20[b]
4	160	240	500	90
5	360	540	1100	200
6	620	960	1900	350
8	1400	2200	3600	600
10	2500	3800	5600	1000
12	3900	6000	8400	1500
15	7000			

[a] Does not include branches of the building drain.

[b] Not more than two water closets or bathroom groups within each branch interval nor more than six water closets or bathroom groups on the stack.

Note: Stacks shall be sized according to the total accumulated connected load at each story or branch interval and may be reduced in size as this load decreases to a minimum diameter of half of the largest size required.

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A-19: Values of the factor S1

TABLE 6–3 Values of the factor S_1 of Eq. (6–7).

№	Topography of Location	Value of S_1
1	Protected locations by hills or buildings (wind speed = 0.5 m/s)	0.9
2	Unprotected locations such as sea shores, hill tops, etc.	1.1
3	Locations other than that listed in item (1) or (2) of this table.	1.0

A-20: Values of the factor S2

TABLE 6–4 Values of the factor S_2 of Eq. (6–7).

Location Class	Class 1			Class 2			Class 3			Class 4		
Building Height, m	A	B	C	A	B	C	A	B	C	A	B	C
3	0.47	0.52	0.56	0.55	0.60	0.64	0.63	0.67	0.72	0.73	0.78	0.83
5	0.50	0.55	0.60	0.60	0.65	0.70	0.70	0.74	0.79	0.78	0.83	0.88
10	0.58	0.62	0.67	0.69	0.74	0.78	0.83	0.88	0.93	0.90	0.95	1.00
15	0.64	0.69	0.74	0.78	0.83	0.88	0.91	0.95	1.00	0.94	0.99	1.03
20	0.70	0.75	0.79	0.85	0.90	0.95	0.94	0.98	1.03	0.96	1.01	1.06
30	0.79	0.85	0.90	0.92	0.97	1.01	0.98	1.03	1.07	1.00	1.05	1.09
40	0.89	0.93	0.97	0.95	1.00	1.05	1.01	1.06	1.10	1.03	1.08	1.12
50	0.94	0.98	1.02	1.00	1.04	1.08	1.04	1.08	1.12	1.06	1.10	1.14
60	0.98	1.02	1.05	1.02	1.06	1.10	1.06	1.10	1.14	1.08	1.12	1.15
80	1.03	1.07	1.10	1.06	1.10	1.13	1.09	1.13	1.17	1.11	1.15	1.18
100	1.07	1.10	1.13	1.09	1.12	1.16	1.12	1.16	1.19	1.13	1.17	1.20
120	1.10	1.13	1.15	1.11	1.15	1.18	1.14	1.18	1.21	1.15	1.19	1.22
140	1.12	1.15	1.17	1.13	1.17	1.12	1.16	1.19	1.22	1.17	1.20	1.24
160	1.14	1.17	1.19	1.15	1.18	1.21	1.18	1.21	1.24	1.19	1.22	1.25
180	1.16	1.19	1.20	1.17	1.20	1.23	1.19	1.22	1.25	1.20	1.23	1.26
200	1.18	1.21	1.22	1.18	1.21	1.24	1.21	1.24	1.26	1.21	1.24	1.27

A-21: Instantaneous heat gain from occupants

TABLE 4–2 Instantaneous heat gain from occupants in units of Watts[a].

Type of Activity	Typical Application	Total Heat Dissipation Adult Male	Total Adjusted[a] Heat Dissipation	Sensible Heat, W	Latent Heat, W
Seated at rest	*Theater*:				
	Matinee	111.5	94.0	64.0	30.0
	Evening	111.5	100.0	70.0	30.0
Seated, very light work	Offices, hotels, apartments, restaurants	128.5	114.0	70.0	44.0
Moderately active office work	Offices, hotels, apartments	135.5	128.5	71.5	57.0
Standing, light work, walking	Department store, retail store, supermarkets	157.0	143.0	71.5	71.5
Walking, seated	Drug store	157.0	143.0	71.5	71.5
Standing, walking slowly	Bank	157.0	143.0	71.5	71.5
Sedentary work	Restaurant	168.5	157.0	78.5	78.5
Light bench work	Factory	238.0	214.0	78.0	136.0
Moderate work	Small-Parts assembly	257.0	243.0	87.0	156.0
Moderate dancing	Dance halls	257.0	243.0	87.0	156.0
Walking at 1.5 m/s	Factory	286.0	285.0	107.0	178.0
Bowling (participant)	Bowling alley	428.5	414.0	166.0	248.0
Heavy work	Factory	428.5	414.0	166.0	248.0

(a) Adjusted heat dissipation is based on the percentage of men, women and children for the application.

A-22: Minimum pressure required by typical plumbing fixtures

Table 9.1 Minimum Pressure Required by Typical Plumbing Fixtures

Fixture Type	*Minimum Pressure, psi*
Sink and tub faucets	8
Shower	8
Water closet—tank flush	8
Flush valve—urinal	15
Flush valve—siphon jet-bowl	
floor-mounted	15
wall-mounted	20
Flush valve—blowout bowl	
floor-mounted	20
wall-mounted	25
Garden hose	
½-in. sill cock	15
¾-in. sill cock	30
Drinking fountain	15

Source. EPA *Manual of Individual Water Supply System, 1975* and manufacturers' data.

Table 9.2 Recommended Flow Rates for Typical Plumbing Fixtures

Fixture Type	*Flow, gpm*
Lavatory	3
Sink	4.5
Bathtub	6
Laundry tray	5
Shower	3–10
Water closets	
tank type	3
flush valve*	15–40
Urinal flush valve	15
Garden hose	
½-in. sill cock	3⅓
¾-in. sill cock	5
Drinking fountain	¾

Source. Data extracted from various sources.

*Wide range of flows; depends on flow pressure.

Table 9.4 Table for Estimating Demand

Supply Systems Predominantly for Flush Tanks		*Supply Systems Predominantly for Flushometers*	
*Load, WSFU**	*Demand, gpm*	*Load, WSFU**	*Demand, gpm*
6	5	—	—
10	8	10	27
15	11	15	31
20	14	20	35
25	17	25	38
30	20	30	41
40	25	40	47
50	29	50	51
60	33	60	55
80	39	80	62
100	44	100	68
120	49	120	74
140	53	140	78
160	57	160	83
180	61	180	87
200	65	200	91
225	70	225	95
250	75	250	100
300	85	300	110
400	105	400	125
500	125	500	140
750	170	750	175
1000	210	1000	218
1250	240	1250	240
1500	270	1500	270
1750	300	1750	300
2000	325	2000	325
2500	380	2500	380
3000	435	3000	435
4000	525	4000	525
5000	600	5000	600
6000	650	6000	650
7000	700	7000	700
8000	730	8000	730
9000	760	9000	760
10,000	790	10,000	790

*Water Supply Fixture Units

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Table 9.5 Demand at Individual Water Outlets

Type of Outlet	*Demand, gpm*
Ordinary lavatory faucet	2.0
Self-closing lavatory faucet	2.5
Sink faucet, ⅜ or ½ in.	4.5
Sink faucet, ¾ in.	6.0
Bath faucet, ½ in.	5.0
Shower head, ½ in.	5.0
Laundry faucet, ½ in.	5.0
Ballcock in water closet flush tank	3.0
1-in. flush valve (25-psi flow pressure)	35.0
1-in. flush valve (15-psi flow pressure)	27.0
¾-in. flush valve (15-psi flow pressure)	15.0
Drinking fountain jet	0.75
Dishwashing machine (domestic)	4.0
Laundry machine (8 or 16 lb)	4.0
Aspirator (operating room or laboratory)	2.5
Hose bibb or sill cock (½ in.)	5.0

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A-23: Drainage fixture unit values for various plumping fixtures

Table 10.2 Drainage Fixture Unit Values for Various Plumbing Fixtures

Type of Fixture or Group of Fixtures	*Drainage Fixture Unit Value, dfu*
Automatic clothes washer (2-in. standpipe and trap required, direct connection)	3
Bathtub group consisting of a water closet; lavatory and bathtub or shower stall:	6
Bathtub (with or without overhead shower)*	2
Bidet	1
Clinic sink	6
Clothes washer	2
Combination sink-and-tray with food waste grinder	4
Combination sink-and-tray with one 1-in. trap	2
Combination sink-and-tray with separate 1-in. trap	3
Dental unit of cuspidor	1
Dental lavatory	1
Drinking fountain	½
Dishwasher, domestic	2
Floor drains with 2-in. waste	3
Kitchen sink, domestic, with one 1-in. trap	2
Kitchen sink, domestic, with food waste grinder	2
Kitchen sink, domestic, with food waste grinder and dishwasher 1-in. trap	3
Kitchen sink, domestic, with dishwasher 1-in trap	3
Lavatory with 1-in. waste	1
Laundry tray (1 or 2 compartments)	2
Shower stall, domestic	2
Showers (group) per head	2
Sinks	
surgeon's	3
flushing rim (with valve)	6
service (trap standard)	3
service (P trap)	2
pot, scullery, etc.	4
Urinal, syphon jet blowout	6
Urinal, wall lip	4
Wash sink (circular or multiple) each set of faucets	2
Water closet, private	4
Water closet, general use	6
Fixtures not already listed	
trap size 1¼ in. or less	1
trap size 1½ in.	2
trap size 2 in.	3
trap size 2½ in.	4
trap size 3 in.	5
trap size 4 in.	6

*A shower head over a bathtub does not increase the fixture unit value.

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Table 10.3 Minimum Size of Nonintegral Traps

Plumbing Fixture	*Trap Size, in.*
Bathtub (with or without overhead shower)	1½
Bidet	1¼
Clothes washing machine standpipe	2
Combination sink and wash (laundry) tray	1½
Combination sink and wash (laundry) tray with food waste grinder unit*	1½
Combination kitchen sink, domestic, dishwasher, and food waste grinder	1½
Dental unit or cuspidor	1¼
Dental lavatory	1¼
Drinking fountain	1¼
Dishwasher, commercial	2
Dishwasher, domestic (nonintegral trap)	1½
Floor drain	2
Food waste grinder, commercial	2
Food waster grinder, domestic	1½
Kitchen sink, domestic, with food waste grinder unit	1½
Kitchen sink, domestic	1½
Kitchen sink, domestic, with dishwasher	1½
Lavatory, common	1¼
Lavatory (barber shop, beauty parlor or surgeon's)	1½
Lavatory, multiple type (wash fountain or wash sink)	1½
Laundry tray (1 or 2 compartments)	1½
Shower stall or drain	2
Sink (surgeon's)	1½
Sink flushing rim type (flush valve supplied)	3
Sink (service type with floor outlet trap standard)	3
Sink (service trap with P trap)	2
Sink, commercial (pot, scullery, or similar type)	2
Sink, commercial (with food grinder unit)	2

*Separate trap required for wash tray and separate trap required for sink compartment with food waste grinder unit.

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A-24: Horizontal fixture branches and stacks, building drains and sewers

Table 10.4 Horizontal Fixture Branches and Stacks

Diameter of Pipe, in.	Maximum Number of Fixture Units That May Be Connected to: Any Horizontal Fixture Branch,[a] dfu	One Stack of Three Branch Intervals or Less, dfu	Stacks with More Than Three Branch Intervals: Total for Stack, dfu	Stacks with More Than Three Branch Intervals: Total at One Branch Interval, dfu
1½	3	4	8	2
2	6	10	24	6
2½	12	20	42	9
3	20[b]	48[b]	72[b]	20[b]
4	160	240	500	90
5	360	540	1100	200
6	620	960	1900	350
8	1400	2200	3600	600
10	2500	3800	5600	1000
12	3900	6000	8400	1500
15	7000			

[a]Does not include branches of the building drain.
[b]Not more than two water closets or bathroom groups within each branch interval nor more than six water closets or bathroom groups on the stack.

Note: Stacks shall be sized according to the total accumulated connected load at each story or branch interval and may be reduced in size as this load decreases to a minimum diameter of half of the largest size required.

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Table 10.5 Building Drains and Sewers[a]

Diameter of Pipe, in.	Maximum Number of Fixture Units That May Be Connected to Any Portion of the Building Drain or the Building Sewer — Slope per Foot: 1/16 in.	1/8 in.	1/4 in.	1/2 in.
2			21	26
2½			24	31
3			42[b]	50[b]
4		180	216	250
5		390	480	575
6		700	840	1000
8	1400	1600	1920	2300
10	2500	2900	3500	4200
12	2900	4600	5600	6700
15	7000	8300	10,000	12,000

[a]On site sewers that serve more than one building may be sized according to the current standards and specifications of the Administrative Authority for public sewers.
[b]Not over two water closets or two bathroom groups, except that in single family dwellings, not over three water closets or three bathroom groups may be installed.

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A-25: Latitude- month correction factor LM

Table (A-2) Latitude-Month correction factor LM, as applied to walls and horizontal roofs, north latitudes.

Lat.	Month	N	NNE NNW	NE NW	ENE WNW	E W	ESE WSW	SE SW	SSE SSW	S	Horizontal Roofs
16	December	−2.2	−3.3	−4.4	−4.4	−2.2	−0.5	2.2	5.0	7.2	−5.0
	Jan./Nov.	−2.2	−3.3	−3.8	−3.8	−2.2	−0.5	2.2	4.4	6.6	−3.8
	Feb./Oct.	−1.6	−2.7	−2.7	−2.2	−1.1	0.0	1.1	2.7	3.8	−2.2
	Mar/Sept.	−1.6	−1.6	−1.1	−1.1	−0.5	−0.5	0.0	0.0	0.0	−0.5
	Apr./Aug.	−0.5	0.0	−0.5	−0.5	−0.5	−1.6	−1.6	−2.7	−3.3	0.0
	May/July	2.2	1.6	1.6	0.0	−0.5	−2.2	−2.7	−3.8	−3.8	0.0
	June	3.3	2.2	2.2	0.5	−0.5	−2.2	−3.3	−4.4	−3.8	0.0
24	December	−2.7	−3.8	−5.5	−6.1	−4.4	−2.7	1.1	5.0	6.6	−9.4
	Jan./Nov.	−2.2	−3.3	−4.4	−5.0	−3.3	−1.6	−1.6	5.0	7.2	−6.1
	Feb./Oct.	−2.2	−2.7	−3.3	−3.3	−1.6	−0.5	1.6	3.8	5.5	−3.8
	Mar/Sept.	−1.6	−2.2	−1.6	−1.6	−0.5	−0.5	0.5	1.1	2.2	−1.6
	Apr./Aug.	−1.1	−0.5	0.0	−0.5	−0.5	−1.1	−0.5	−1.1	−1.6	0.0
	May/July	0.5	1.1	1.1	0.0	0.0	−1.6	−1.6	−2.7	−3.3	0.5
	June.	1.6	1.6	1.6	0.5	0.0	−1.6	−2.2	−3.3	−3.3	0.5
32	December	−2.7	−3.8	−5.5	−6.1	−4.4	−2.7	1.1	5.0	6.6	−9.4
	Jan./Nov.	−2.7	−3.8	−5.0	−6.1	−4.4	−2.2	1.1	5.0	6.6	−8.3
	Feb./Oct.	−2.2	−3.3	−3.8	−4.4	−2.2	−1.1	2.2	4.4	6.1	−5.5
	Mar/Sept.	−1.6	−2.2	−2.2	−2.2	−1.1	−0.5	1.6	2.7	3.8	−2.7
	Apr./Aug.	−1.1	−1.1	−0.5	−1.1	0.0	−0.5	0.0	5.0	0.5	−0.5
	May/July	0.5	0.5	0.5	0.0	0.0	−0.5	−0.5	−1.6	−1.6	0.5
	June	0.5	1.1	1.1	0.5	0.0	−1.1	−1.1	−2.2	−2.2	1.1
40	December	−3.3	−4.4	−5.5	−7.2	−5.5	−3.8	0.0	3.8	5.5	−11.6
	Jan./Nov.	−2.7	−3.8	−5.5	−6.6	−5.0	−3.3	0.5	4.4	6.1	−10.5
	Feb./Oct.	−2.7	−3.8	−4.4	−5.0	−3.3	−1.6	1.6	4.4	6.6	−7.7
	Mar/Sept.	−2.2	−2.7	−2.7	−3.3	−1.6	0.5	2.2	3.8	5.5	−4.4
	Apr./Aug.	−1.1	−1.6	−1.6	−1.1	0.0	0.0	1.1	1.6	2.2	1.6
	May/July	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.5
	June	0.5	0.5	0.5	0.5	0.0	0.5	0.0	0.0	−0.5	1.1
48	December	−3.3	−4.4	−6.1	−7.7	−7.2	−5.5	−1.6	1.1	3.3	−13.8
	Jan./Nov.	−3.3	−4.4	−6.1	−7.2	−6.1	−4.4	−0.5	2.7	4.4	−13.3
	Feb./Oct.	−2.7	−3.8	−5.5	−6.1	−4.4	−2.7	0.5	4.4	6.1	−10.0
	Mar/Sept.	−2.2	−3.3	−3.3	−3.8	−2.2	−0.5	2.2	4.4	6.1	−6.1
	Apr./Aug.	−1.6	−1.6	−1.6	−1.6	−0.5	0.0	2.2	3.3	3.8	−2.7
	May/July	0.0	−0.5	0.0	0.0	0.5	0.5	1.6	1.6	2.2	0.0
	June	0.5	0.5	1.1	0.5	1.1	0.5	1.1	1.1	1.6	1.1

A-26: mechanical ventilation

TABLE A(2.20) Minimum outside air requirements for mechanical ventilation

Application	Maximum Occupancy Per 100 m²	Ventilation Air Requirements	
		L/s/Person	L/s/m²
Bath, toilets[(3)]	—	10.0	—
Hotels and motels:			
Bedrooms	—	—	7.5-15 L/s/room
Living rooms	—	—	5-10 L/s/room
Bathes	—	—	15-25 L/s/room
Lobbies	30	2.5-7.5	—
Conference rooms	50	3.5-17.5	—
Assembly rooms	120	3.5-17.5	—
Dormitory sleeping areas	20	8.0	—
Gambling casinos	120	15.0	—

A-27: inside & outside film resistance

Table A(2.2) Inside film resistance, R_i.

Element	Heat Direction	Material Type	R_i m²·°C/W
Walls	Horizontal	Construction materials	0.12
		Metals	0.31
Ceilings and floors	Upward	Construction materials	0.10
		Metals	0.21
	Downward	Construction materials	0.15

Table A(2.3) Outside film resistance, R_o.

Wind Speed		Less than 0.5 m/s	0.5 - 5.0 m/s	More than 5.0 m/s
Element	**Material Type**	**Outside Resistance R_o, m²·°C/W**		
Walls	Construction materials	0.08	0.06	0.03
	Metals	0.10	0.07	0.03
Ceilings	Construction materials	0.07	0.04	0.02
	Metals	0.09	0.05	0.02
Exposed floors	Construction materials	0.09	—	—

A-28: overall heat coefficient for windows

TABLE A(2.4) Overall Heat Transfer Coefficient for Windows, $W/m^2.°C$

Material Type and Frames	Wind Speed, m/s					
	Single Glass			Double Glass, 6mm air gap		
	< 0.5	0.5 - 5.0	> 5.0	< 0.5	0.5 - 5.0	> 5.0
Wood	3.8	4.3	5.0	2.3	2.5	2.7
Aluminum	5.0	5.6	6.7	3.0	3.2	3.5
Steel	5.0	5.6	6.7	3.0	3.2	3.5
PVC	3.8	4.3	5.0	2.3	2.5	2.7

A-29: overall heat coefficient for wood and metals door

TABLE A(2.5) Overall heat transfer coefficients for wood and metal doors, $W/m^2.°C$.

Door Type	Without Storm Door	With Wood Storm Door	With Metal Storm Door
25 mm-wood	3.6	1.7	2.2
35 mm-wood	3.1	1.6	1.9
40 mm-wood	2.8	1.5	1.8
45 mm-wood	2.7	1.5	1.8
50 mm-wood	2.4	1.4	1.7
Aluminum	7.0	—	—
Steel	5.8	—	—
Steel with:			
Fiber core	3.3	—	—
Polystyrene core	2.7	—	—
Polyurethane core	2.3	—	—

Palestinian code

جدول رقم (3/1): القيم التصميمية الخارجية للمناطق المناخية المختلفة

القيم التصميمية الخارجية		المنطقة المناخية*						
		الضفة الغربية					قطاع غزة	
		الأولى	الثانية	الثالثة	الرابعة	الخامسة	الثالثة	السادسة
درجة الحرارة (°C)	شتاءً	7	7	5	4	8	5	9
	صيفاً	39	39	32	30	34	32	31
الرطوبة النسبية (%)	شتاءً: ادنى	60	60	60	62	63	60	62
	اقصى	70	70	72	72	78	72	69
	صيفاً: ادنى	43	43	49	44	55	49	65
	اقصى	54	54	67	57	66	67	77
سرعة الرياح (m/s)		1	1	1.5	1.4	1.1	1.5	2.8
شدة الاشعاع الشمسي (W/m^2)		تعتبر قيم شدة الاشعاع القصوى للاتجاهات المختلفة في الجدولين (3/18) و (3/19) قيماً تصميمية لكافة المناطق المناخية						
درجة يوم تسخين (°C.day)		لا تتوفر معلومات عن هذه القيم حالياً						
درجة يوم تبريد (°C.day)								
* المناطق المناخية للأراضي الفلسطينية مبينة في الملحق (هـ)								

جدول رقم (1/10) معدل سرعة الرياح للمحطات المناخية في الضفة الغربية.

المحطة	1	2	3	4	5	6	7	8	9	10	11	12
القدس	16.3	18.0	18.4	18.5	18.0	19.4	20.4	18.6	17.0	13.0	14.1	16.0
نابلس	8.7	9.5	10.0	10.2	10.7	12.0	12.4	11.7	10.3	7.7	7.8	7.7
جنين	7.5	7.9	7.9	7.9	9.0	9.4	9.7	8.6	7.2	5.4	6.1	7.5
طولكرم	4.3	4.1	3.8	3.4	3.3	2.9	2.9	2.7	2.6	2.9	3.8	4.0
أريحا	8.9	10.4	13.1	16.2	15.8	15.3	16.0	14.8	12.5	9.4	7.9	7.6
الخليل	12.4	12.8	12.6	11.5	9.3	9.3	9.2	8.7	8.1	8.0	8.8	10.1
العروب	8.6	10.1	10.8	9.7	6.5	5.1	5.1	5.4	5.1	5.8	5.8	7.9
الفارعة	4.6	6.5	6.1	3.6	3.3	3.6	6.8	6.5	5.0	2.5	2.5	2.1

Floor	Room Number	Heating Load(kW)		Cooling Load(kW)		Nominal Capcity(kW)	Actual Capcity(kW)		Number Model	In Door Unit
						Cooling	Heating	Cooling		
Ground	Hall	8.39		17.11		4.5 #4 cassette	8.4	5.8	ND0454HXEA	AVXC4 4 way casstte type
	Par	12		24		4.5 #7 cassette	13.5	11.5	ND0454HXEA	AVXC4 4 way casstte type
	Reception	11.57		23		4.5 # 9 cassette	13.5	11.5	ND0454HXEA	AVXC4 4 way casstte type
	office	2.35		4.7			6.8	5.9		AVXC4 4 way casstte type
		Totel	39.4	Totel	68.81					

Design / Property	Inside Design		Outside Design	
	Summer	Winter	Summer	Winter
Temp	24	24	30	4.7
R.H	50	45	57	72
Wind Seed	-	-	1.4	1.4

Floor	Room Number	Heating Load(kW)	Cooling Load(kW)	Nominal Capcity(kW)	Actual Capcity(kW)		Number Model	In Door Unit
				Cooling	Heating	Cooling		
	201	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	202	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	203	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	204	2.1	4.8	6.8	6.8	5.9	ND071QHXE	Split type
	205	2.1	4.8	6.8	6.8	5.9	ND071QHXE	Split type

	206	2.25	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	207	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	208	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	209	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
First	210	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	211	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	212	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	213	2.25	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	214	4.3	6.7	6.8	8.4	7.3	ND071QHXE	Split type
	215	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	216	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	217	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	218	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	219	2.5	5.1	6.8	6.8	5.9	ND071QHXE	Split type
		Total 51.5	Total 97.3					

Floor	Room Number	Heating Load(kW)	Cooling Load(kW)	Nominal Capcity(kW)	Actual Capcity(kW)		Number Model	In Door Unit
				Cooling	Heating	Cooling		
	201	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	202	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	203	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	204	2.1	4.8	6.8	6.8	5.9	ND071QHXE	Split type

Second	205	2.1	4.8	6.8	6.8	5.9	ND071QHXE	Split type
	206	2.25	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	207	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	208	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	209	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	210	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	211	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	212	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	213	2.25	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	214	4.3	6.7	6.8	8.4	7.3	ND071QHXE	Split type
	215	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	216	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	217	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	218	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	219	2.5	5.1	6.8	6.8	5.9	ND071QHXE	Split type
		Total 51.5	Total 97.3					

Floor	Room Number	Heating Load(kW)	Cooling Load(kW)	Nominal Capcity(kW)	Actual Capcity(kW)		Number Model	In Door Unit
				Cooling	Heating	Cooling		
	201	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	202	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	203	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type

Third	204	2.1	4.8	6.8	6.8	5.9	ND071QHXE	Split type
	205	2.1	4.8	6.8	6.8	5.9	ND071QHXE	Split type
	206	2.25	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	207	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	208	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	209	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	210	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	211	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	212	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	213	2.25	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	214	4.3	6.7	6.8	8.4	7.3	ND071QHXE	Split type
	215	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	216	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	217	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	218	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	219	2.5	5.1	6.8	6.8	5.9	ND071QHXE	Split type
		Total 51.5	Total 97.3					

Floor	Room Number	Heating Load(kW)	Cooling Load(kW)	Nominal Capcity(kW)	Actual Capcity(kW)		Number Model	In Door Unit
				Cooling	Heating	Cooling		
	201	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	202	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	203	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type

	204	2.1	4.8	6.8	6.8	5.9	ND071QHXE	Split type
	205	2.1	4.8	6.8	6.8	5.9	ND071QHXE	Split type
	206	2.25	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	207	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	208	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	209	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
Fourth	210	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	211	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	212	2.2	5	6.8	6.8	5.9	ND071QHXE	Split type
	213	2.25	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	214	4.3	6.7	6.8	8.4	7.3	ND071QHXE	Split type
	215	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	216	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	217	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	218	2.3	5.1	6.8	6.8	5.9	ND071QHXE	Split type
	219	2.5	5.1	6.8	6.8	5.9	ND071QHXE	Split type
		Total 51.5	Total 97.3					

Floor	Room Number	Heating Load(kW)	Cooling Load(kW)	Nominal Capcity(kW)	Actual Capcity(kW)		Number Model	In Door Unit
				Cooling	Heating	Cooling		
	601	2.7	5.6	6.8	6.8	5.9	ND071QHXE	Split type
	602	2.73	5.6	6.8	6.8	5.9	ND071QHXE	Split type
	603	2.73	5.6	6.8	6.8	5.9	ND071QHXE	Split type

Roof	604	2.73		5.6		6.8	6.8	5.9	ND071QHXE	Split type
	605	2.73		5.6		6.8	6.8	5.9	ND071QHXE	Split type
	606	2.73		5.6		6.8	6.8	5.9	ND071QHXE	Split type
	607	2.73		5.6		6.8	6.8	5.9	ND071QHXE	Split type
	608	2.9		5.7		6.8	6.8	5.9	ND071QHXE	Split type
	609	2.73		5.6		6.8	6.8	5.9	ND071QHXE	Slim Duct
	610	2.73		5.6		6.8	6.8	5.9	ND071QHXE	Split type
	611	2.73		5.6		6.8	6.8	5.9	ND071QHXE	Split type
	612	2.5		5.3		6.8	6.8	5.9	ND071QHXE	Split type
	613	2.6		5.4		6.8	6.8	5.9	ND071QHXE	Split type
	roof	54.73		113.67		14 #8 cassette	13.5	11.2	ND1404HXEA	AVXC4 4 way casstte type
		Tot	103.5	Tot	185.9					

*The total requiard heating capcity for outdoor unit=350/1.3=269Kw

*The total requiard Cooling capcity for outdoor unit=645/1.3=469Kw

Catalogues

Catalogue of VRF:

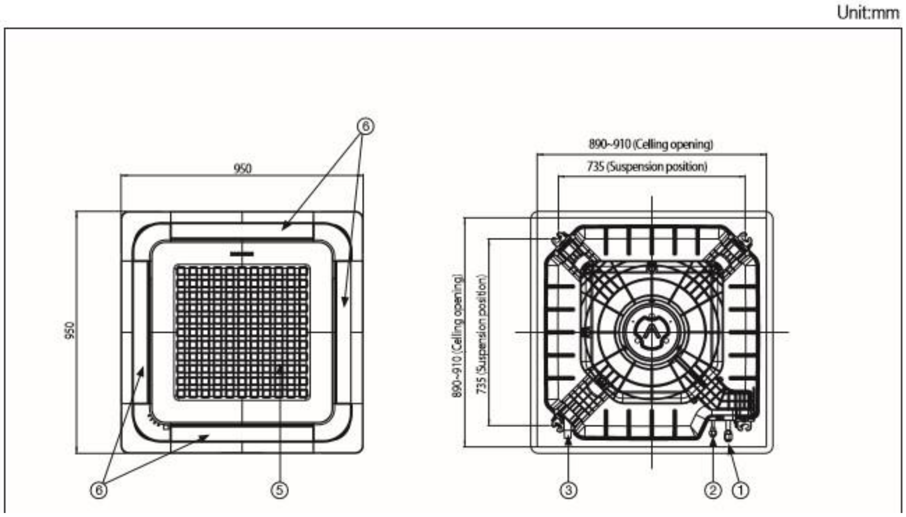
1. 4 -way cassette in door unit and dimensional drawing

4 4 way cassette S

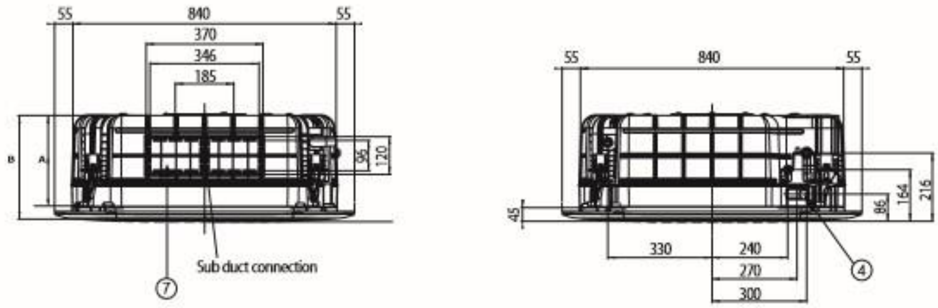
(ND✱✱✱4HXE✱)

4-4 . Dimensional drawing

Unit:mm



Indoor units



No.	Name	Description			
		4.5/5.6kW	7.1/9.0kW	11.2kW	12.8/14.0kW
①	Liquid pipe connection	Ø6.35 Flare	Ø9.52 Flare		
②	Gas pipe connection	Ø12.70 Flare	Ø15.88 Flare		
③	Drain pipe connection	ID25 Hose (OD 32, ID 25)			
④	Conduit for power supply & communication wiring	-			
⑤	Air inlet grille	-			
⑥	Air outlet louver	-			
⑦	Fresh air intake	-			
⑧	Drainage testing hole	-			

		Description			
		4.5/5.6kW	7.1/9.0kW	11.2kW	12.8/14.0kW
A	mm	204		246	288
B	mm	253		295	337

1) Technical specifications

Model				ND0454HXEA	ND0564HXEA	ND0714HXEA	ND0904HXEA	ND1124HXEA	ND1284HXEA	ND1404HXEA
Power Supply			Ø, #, V, Hz	1, 2, 220–240, 50	1, 2, 220–240, 50	1, 2, 220–240, 50	1, 2, 220–240, 50	1, 2, 220–240, 50	1, 2, 220–240, 50	1, 2, 220–240, 50
Mode*1)			-	HP / HR	HP / HR	HP / HR	HP / HR	HP / HR	HP / HR	HP / HR
	Capacity (Nominal)	Cooling*2)	kW	4.5	5.6	7.1	9.0	11.2	12.8	14.0
			Btu/h	15,400	19,100	24,200	30,700	38,200	43,700	47,800
		Heating*3)	kW	5.0	6.3	8.0	10.0	12.5	13.8	16.0
			Btu/h	17,100	21,500	27,300	34,100	42,700	47,100	54,600
Power	Power Input (Nominal)	Cooling*2)	W	40	40	45	50	50	65	80
		Heating*3)		40	40	45	50	50	65	80
	Current Input (Nominal)	Cooling*2)	A	0.19	0.19	0.21	0.23	0.23	0.30	0.36
		Heating*3)		0.19	0.19	0.21	0.23	0.23	0.30	0.36
Fan	Motor	Type	-	Turbo Fan / BLDC	Turbo Fan / BLDC	Turbo Fan / BLDC	Turbo Fan / BLDC	Turbo Fan / BLDC	Turbo Fan / BLDC	Turbo Fan / BLDC
		Output	W							
		Number of unit	EA	1	1	1	1	1	1	1
	Air Flow Rate	H/M/L (UL)	CMM	14.5	15.0	17.0	19.5	26.0	28.0	30.0
			CFM	510 / 480 / 440	530 / 490 / 460	600 / 550 / 510	690 / 640 / 580	920 / 860 / 780	990 / 920 / 810	1060 / 990 / 920
	External Pressure	Min / Std / Max	mmAq	-	-	-	-	-	-	-
			Pa	-	-	-	-	-	-	-
			WG	-	-	-	-	-	-	-
Option Code			-	01407F-156097-232D2D-30000B	01407F-1560A7-23383B-30000B	01401F-146008-234747-300008	01407F-156209-236A6A-300008	01407F-15621B-237070-300008	01407F-15622D-238080-300008	01407F-15624F-238C8C-300008
Piping Connections	Liquid Pipe		Ø, mm	6.35	6.35	9.52	9.52	9.52	9.52	9.52
			Ø, inch	1/4	1/4	3/8	3/8	3/8	3/8	3/8
	Gas Pipe		Ø, mm	12.7	12.7	15.88	15.88	15.88	15.88	15.88
			Ø, inch	1/2	1/2	5/8	5/8	5/8	5/8	5/8
	Drain Pipe		Ø, mm	ID25 Hose (OD 32, ID 25)	ID25 Hose (OD 32, ID 25)	ID25 Hose (OD 32, ID 25)	ID25 Hose (OD 32, ID 25)	ID25 Hose (OD 32, ID 25)	ID25 Hose (OD 32, ID 25)	ID25 Hose (OD 32, ID 25)
Field Wiring	Power Source Wire	Below 20m / over 20m	mm^2	1.5 / 2.5	1.5 / 2.5	1.5 / 2.5	1.5 / 2.5	1.5 / 2.5	1.5 / 2.5	1.5 / 2.5
	Transmission Cable		mm^2	0.75 / 1.5	0.75 / 1.5	0.75 / 1.5	0.75 / 1.5	0.75 / 1.5	0.75 / 1.5	0.75 / 1.5
Refrigerant	Type		-	R410A	R410A	R410A	R410A	R410A	R410A	R410A
	Control Method		-	EEV	EEV	EEV	EEV	EEV	EEV	EEV
Sound	Sound Pressure	High / Low*4)	dBA	34/29	34/30	36/30	39/32	39/32	41/35	45/38
Dimensions	Net Weight		kg	15.1	15.1	15.1	15.1	17	18.7	18.7
	Shipping Weight		kg	19.1	19.1	19.1	19.1	20.5	22.8	22.8
	Net Dimensions (WxHxD)		mm	840 x 204 x 840	840 x 204 x 840	840 x 204 x 840	840 x 204 x 840	840 x 246 x 840	840 x 288 x 840	840 x 288 x 840
	Shipping Dimensions (WxHxD)		mm	910 x 226 x 910	910 x 226 x 910	910 x 226 x 910	910 x 226 x 910	910 x 268 x 910	910 x 310 x 910	910 x 310 x 910
Panel Sts	Panel model		-	PC4NUSKA/ PC4NUSKE	PC4NUSKA/ PC4NUSKE	PC4NUSKA/ PC4NUSKE	PC4NUSKA/ PC4NUSKE	PC4NUSKA/ PC4NUSKE	PC4NUSKA/ PC4NUSKE	PC4NUSKA/ PC4NUSKE
	Panel Net Weight		kg	5.9	5.9	5.9	5.9	5.9	5.9	5.9
	Shipping Weight		kg	8.4	8.4	8.4	8.4	8.4	8.4	8.4
	Net Dimensions (WxHxD)		mm	950 x 45 x 950	950 x 45 x 950	950 x 45 x 950	950 x 45 x 950	950 x 45 x 950	950 x 45 x 950	950 x 45 x 950
	Shipping Dimensions (WxHxD)		mm	1,005 x 100 x 1005	1,005 x 100 x 1005	1,005 x 100 x 1005	1,005 x 100 x 1005	1,005 x 100 x 1005	1,005 x 100 x 1005	1,005 x 100 x 1005
Additional Accessories	Drain pump	Drain pump	- / Model	Built-in	Built-in	Built-in	Built-in	Built-in	Built-in	Built-in
		Max. lifting Height / Displacement	mm/liter/h	750 / 24	750 / 24	750 / 24	750 / 24	750 / 24	750 / 24	750 / 24
	Air Filter		-	Long life filter	Long life filter	Long life filter	Long life filter	Long life filter	Long life filter	Long life filter

2. Wall mounted in door unit and dimensional drawing:

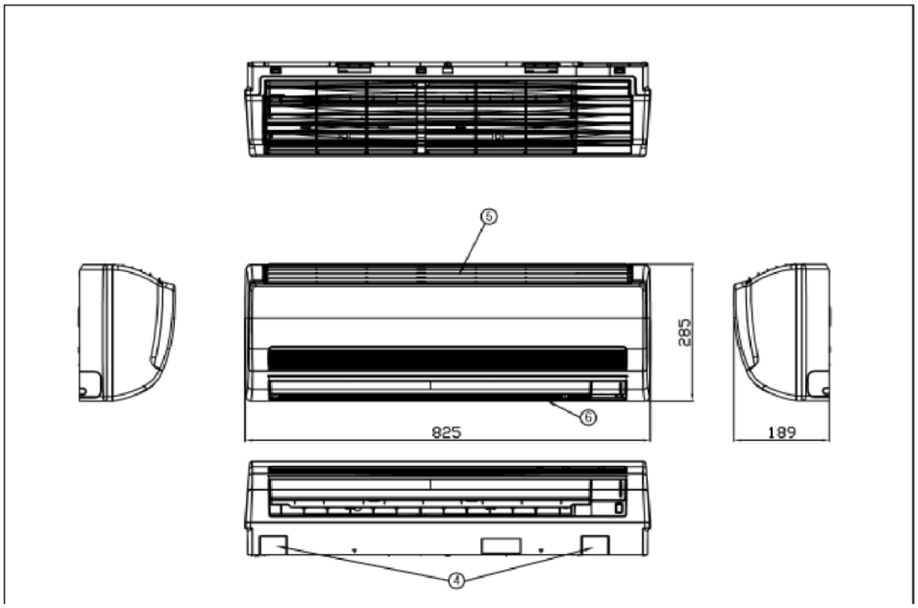
10 Neo Forte & Neo-Forte E

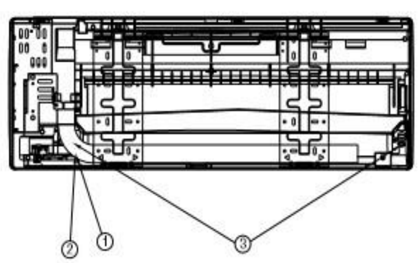
(AVXWNH∗∗∗E∗/ND∗∗∗QHXE∗)

Indoor units

10-4. Dimensional drawing

1) AVXWNH022/028/036E✳, ND022/028/036QHXE✳ Unit:mm





No.	Name	Description		
		2.2kW	2.8kW	3.6kW
①	Liquid pipe connection	Ø6.35 Flare		
②	Gas pipe connection	Ø12.70 Flare		
③	Drain pipe connection	ID18 Hose		
④	Conduit for power supply & communication wiring	-		
⑤	Air inlet grille	-		
⑥	Air outlet louver	-		

1) Technical specifications

Model				AVXWNH022E*, ND022QHXE*	AVXWNH028E*, ND028QHXE*	AVXWNH036E*, ND036QHXE*	ND045QHXE*	AVXWNH056E*, ND056QHXE*	AVXWNH071E*, ND071QHXE*
Power Supply			Ø, #, V, Hz	1, 2, 220-240, 50	1, 2, 220-240, 50	1, 2, 220-240, 50	1, 2, 220-240, 50	1, 2, 220-240, 50	1, 2, 220-240, 50
Mode [*1)]			-	HP / HR	HP / HR	HP / HR	HP / HR	HP / HR	HP / HR
	Capacity (Nominal)	Cooling [*2)]	kW	2.2	2.8	3.6	4.5	5.6	6.8
			Btu/h	7,500	9,600	12,300	15,300	19,100	23,200
		Heating [*3)]	kW	2.5	3.2	4.0	5.0	6.3	7.0
			Btu/h	8,500	10,900	13,600	17,000	21,500	23,900
Power	Power Input (Nominal)	Cooling [*2)]	W	25	25	30	40	45	50
		Heating [*3)]		25	25	30	40	45	50
	Current Input (Nominal)	Cooling [*2)]	A	0.16	0.16	0.18	0.18	0.27	0.30
		Heating [*3)]		0.16	0.16	0.18	0.18	0.27	0.30
Fan	Motor	Type	-	Crossflow Fan / SSR	Crossflow Fan / SSR	Crossflow Fan / SSR	Crossflow Fan / SSR	Crossflow Fan / SSR	Crossflow Fan / SSR
		Output	W	23	23	23	40	40	40
		Number of unit	EA	1	1	1	1	1	1
	Air Flow Rate	H/M/L (UL)	CMM	7.8 / 6.8 / 5.8	8.2 / 7.2 / 6.2	9.3 / 8.3 / 7.3	11.7 / 10.2 / 8.7	12 / 10.5 / 9	14 / 12.5 / 11
			CFM	280 / 240 / 200	290 / 250 / 220	330 / 290 / 260	410 / 360 / 310	420 / 370 / 320	490 / 440 / 390
	External Pressure	Min / Std / Max	mmAq	-	-	-	-	-	-
			Pa	-	-	-	-	-	-
			WG	-	-	-	-	-	-
Option Code			-	027602-1120FA-200000-300000	027602-1320FA-200000-300000	027602-15224d-200000-300000	026602-18223F-200000-300000	026602-1A226F-200000-300000	026602-1C228F-200000-300000
Piping Connections	Liquid Pipe		Ø, mm	6.35	6.35	6.35	6.35	6.35	9.52
			Ø, inch	1/4	1/4	1/4	1/4	1/4	3/8
	Gas Pipe		Ø, mm	12.7	12.7	12.7	12.7	12.7	15.88
			Ø, inch	1/2	1/2	1/2	1/2	1/2	5/8
	Drain Pipe		Ø, mm	ID18 Hose (OD, ID)	ID18 Hose (OD, ID)	ID18 Hose (OD, ID)	ID18 Hose (OD, ID)	ID18 Hose (OD, ID)	ID18 Hose (OD, ID)
Field Wiring	Power Source Wire	Below 20m / over 20m	mm^2	1.5 / 2.5	1.5 / 2.5	1.5 / 2.5	1.5 / 2.5	1.5 / 2.5	1.5 / 2.5
	Transmission Cable		mm^2	0.75 / 1.5	0.75 / 1.5	0.75 / 1.5	0.75 / 1.5	0.75 / 1.5	0.75 / 1.5
Refrigerant	Type		-	R410A	R410A	R410A	R410A	R410A	R410A
	Control Method		-	EEV (External) EEV (Internal)	EEV (External) EEV (Internal)	EEV (External) EEV (Internal)	EEV (Internal)	EEV (External) EEV (Internal)	EEV (External) EEV (Internal)
Sound	Sound Pressure	High / Low [*4)]	dBA	32 / 23, 35 / 26	32 / 23, 35 / 26	36 / 23, 39 / 26	39 / 33	40 / 30, 42 / 33	41 / 30, 44 / 33
Dimensions	Net Weight		kg	8	8	8	13	13	13
	Shipping Weight		kg	9	9	9	16	16	16
	Net Dimensions (WxHxD)		mm	825 x 285 x 189	825 x 285 x 189	825 x 285 x 189	1,065 x 298 x 218	1,065 x 298 x 218	1,065 x 298 x 218
	Shipping Dimensions (WxHxD)		mm	900 x 349 x 252	900 x 349 x 252	900 x 349 x 252	1,137 x 377 x 299	1,137 x 377 x 299	1,137 x 377 x 299
	Panel model		-	-	-	-		-	-
	Panel Net Weight		kg	-	-	-		-	-

Indoor units

Outdoor unit :

1) Compact (Single)

Type							
Model Name				RD080HHXGA	RD100HHXGA	RD120HHXGA	RD140HHXGA
				8	10	12	14
Power Supply			Ø, #, V, Hz	3, 4, 380~415, 50	3, 4, 380~415, 50	3, 4, 380~415, 50	3, 4, 380~415, 50
Mode			-	Heat Pump	Heat Pump	Heat Pump	Heat Pump
Performance	HP		HP	8	10	12	14
	Capacity (Nominal)	Cooling [1]	kW	22.4	28.0	33.6	39.2
			Btu/h	76,400	95,500	114,600	133,800
		Heating [2]	kW	25.2	31.5	37.8	44.1
			Btu/h	86,000	107,500	129,000	150,500
Power	Power Input (Nominal)	Cooling [1]	kW	5.20	7.04	9.20	10.10
		Heating [2]		5.46	6.89	8.50	9.65
	Current Input (Nominal)	Cooling [1]	A	8.80	13.00	20.00	20.90
		Heating [2]		11.40	12.70	18.40	19.40
	Max. Current Input			18.40	21.50	28.40	29.40
	Circuit Breaker (MCCB+ELB / ELCB)		A	30	30	40	40
COP	Nominal Cooling		-	4.31	3.98	3.65	3.88
	Nominal Heating		-	4.62	4.57	4.45	4.57
FAN	Air Flow Rate		CMM	173	173	210	226
Piping Connections	Liquid Pipe		Ø, mm	9.52	9.52	12.70	12.70
	Gas Pipe		Ø, mm	19.05	22.23	25.40	25.40
	Discharge Gas Pipe		Ø, mm	-	-	-	-
	Oil Equalizing Pipe		Ø, mm	-	-	-	-
	Installation Limitation	Max. Length	m	200	200	200	200
		Max. Height	m	50 (40)*	50 (40)*	50 (40)*	50 (40)*
Field Wiring	Power cable		mm^2	CV 1.5	CV 2.5	CV 4	CV 4
	Communication cable		mm^2	0.75~1.5	0.75~1.5	0.75~1.5	0.75~1.5
Refrigerant	Type		-	R-410A	R-410A	R-410A	R-410A
	Factory Charging		kg	5.0	5.0	5.0	7.0
Sound [5]	Sound Pressure		dB(A)	57	58	60	60
External Dimension	Net Weight		kg	237	237	240	280
	Shipping Weight		kg	253	253	256	301
	Net Dimensions (WxHxD)		mm	880 x 1695 x 765	880 x 1695 x 765	880 x 1695 x 765	1295 x 1695 x 765
	Shipping Dimensions (WxHxD)		mm	948 x 1912 x 832	948 x 1912 x 832	948 x 1912 x 832	1363 x 1912 x 832
Operating Temp. Range	Cooling		°C	-5 ~ 48	-5 ~ 48	-5 ~ 48	-5 ~ 48
	Heating		°C	-20 ~ 24	-20 ~ 24	-20 ~ 24	-20 ~ 24

Type						
Model Name				RD160HHXGA	RD180HHXGA	RD200HHXGA
				16	18	20
Power Supply			Ø, #, V, Hz	3, 4, 380~415, 50	3, 4, 380~415, 50	3, 4, 380~415, 50
Mode			-	Heat Pump	Heat Pump	Heat Pump
Performance	HP		HP	16	18	20
	Capacity (Nominal)	Cooling [1]	kW	44.8	50.4	56.0
			Btu/h	152,900	172,000	191,100
		Heating [2]	kW	50.4	56.7	63.0
			Btu/h	172,000	193,500	215,000
Power	Power Input (Nominal)	Cooling [1]	kW	12.00	15.70	17.00
		Heating [2]		11.30	12.90	14.50
	Current Input (Nominal)	Cooling [1]	A	22.00	31.30	32.80
		Heating [2]		27.20	26.70	29.10
	Max. Current Input			38.30	42.5	44.1
	Circuit Breaker (MCCB+ELB / ELCB)		A	50	60	60
COP	Nominal Cooling		-	3.73	3.21	3.29
	Nominal Heating		-	4.46	4.40	4.34
FAN	Air Flow Rate		CMM	250	270	275
Piping Connections	Liquid Pipe		Ø, mm	12.70	15.88	15.88
	Gas Pipe		Ø, mm	28.58	28.58	28.58
	Discharge Gas Pipe		Ø, mm	-	-	-
	Oil Equalizing Pipe		Ø, mm	-	-	-
	Installation Limitation	Max. Length	m	200	200	200
		Max. Height	m	50 (40)*	50 (40)*	50 (40)*
Field Wiring	Power cable		mm^2	CV 6	CV 6	CV 10
	Communication cable		mm^2	0.75~1.5	0.75~1.5	0.75~1.5
Refrigerant	Type		-	R-410A	R-410A	R-410A
	Factory Charging		kg	7.0	8.5	8.5
Sound [5]	Sound Pressure		dB(A)	60	60	61
External Dimension	Net Weight		kg	329	340	349
	Shipping Weight		kg	350	361	370
	Net Dimensions (WxHxD)		mm	1295 x 1695 x 765	1295 x 1695 x 765	1295 x 1695 x 765
	Shipping Dimensions (WxHxD)		mm	1363 x 1912 x 832	1363 x 1912 x 832	1363 x 1912 x 832

■ Description

THW-I HTE

Hoval hot water boiler

The Hoval high output hot water boilers are made of qualitysteel and are distinguished by their solid, robust and elastic construction. They particularly convince by their easy way of operation, their easy maintenance and optimal efficiency. The client receives an economical, environment friendly compact unit, ready for installation. The boilers are constructed for oil- or gasfiring.

Boiler type THW-I HTE

The type THW-I HTE classical 3 pass flame tube flue gas tube boiler with an inner fully water cooled flue gas turning chamber guarantees high efficiency. The boiler consists of a cylindric shell, the two headplates, the centric flametube including the back flue gas turning chamber with water cooled finned tube wall and the two flue gas passes. The boiler door is thermal insulated and flue gas proof for burner mounting. The boiler is completely electrically welded and provided with all required inspection openings.
The spacious designed flame tube with low thermal charges results in an excellent combustion and reduces emissions. The large water content secures an even boiler running time and thus reduces the number of boiler starts.

Admissible max. safety valve pressure / temperature

Standard pressures: 10,13 and 16 bar.
Higher pressure on request.
Max. temperature up to 210 °C.

Thermal insulation

The boiler is fully insulated including flue gas collector with rock wool insulation. The casing is made of structured aluminium plate. Sockets and cuttings are nicely framed.

Connection fittings and sockets

The connection fittings and sockets on the boiler and on the fitting pipe are meant for the attachment of:
Flow intermediate piece, Thermometer for return, return shut-off, safety valve, drain.

Large equipment

2 boiler supports
1 flue gas collector with integrated flue gas exit backward.
1 Back cleaning cover with bleeder valves
1 boiler door for burner mounting, thermal insulated and designed flue gas proof, placed on left and right swivelable hinges for the flue gas sided cleaning of boiler
1 boiler plate

Construction guiding, quality approval

The boiler is designed with all necessary inspection doors.
The construction and manufacturing of the boilers is done according to the European Pressure Equipment Directive (PED) 97/23 EC - EN12953 with CE-certificate. The ISO 9001:2000 certification and the quality approval at our factory with our Hoval quality performance department with works certificate guarantees the highest product quality. For installation and operation of the boiler the local laws and norms are to be respected.

Control panel

The control panel for the Hoval boiler can be equipped with the required control units and indicators for control and supervision of boiler and burner. The operation and alarm reports may be shown as fault indication. The control panel will be made upon customer requirements and depending on the burner to be used.

Boiler water quality

For operation the Hoval and the country specific boiler water regulations have to be respected and local waste water regulations have to be payed attention to. Detailed information for the boiler water quality can be found in the appendix.

Delivery

The pressure body is provided with a primer. Due to transport reasons the insulation can be fixed at the factory. Burner armatures and control panel are either pre-mounted (as far as transport technically possible) or packed loosely in a separate box. The mounting and wiring can be done at the factory or at site. Connection openings are covered.

On request

- Volt free contacts for BMS connection (Building Management System).

■ Technical data

THW-I HTE (10/05 - 34/25)

Technical data

Type		(10/05)	(13/08)	(17/10)	(22/15)	(27/20)	(34/25)
• Nominal output	kW	1000/ 500	1300/ 800	1700/ 1000	2200/ 1500	2700/ 2000	3400/ 2500
• Operating temperature max. (SBT)[1] • Temperature level flow/ return		depending on net pressure depending on net pressure					
• Safety valve pressure	bar bar bar	10 13 16	10 13 16	10 13 16	10 13 16	10 13 16	10 13 16
• Boiler efficiency at 120 °C (Natural gas	%	88.7/ 91.5	89.1/ 91.2	89.9/ 91.9	89.7/ 91.3	89.6/ 90.9	89.8/ 91.8
• Boiler efficiency at 120 °C (Diesel oil)	%	88.8/ 91.5	89.5/ 91.5	90.1/ 90.0	89.9/ 91.5	89.9/ 91.1	90.1/ 91.3
• Flue gas resistance	mbar	9.5/ 5.5	10.5/ 6.5	11.5/ 6.5	11.0/ 7.0	11.0/ 8.0	13.0/ 8.0
• Water content	l	1700	1900	2100	2800	3500	4500
• Flue gas temperature after boiler (Natural gas)	°C	278/ 210	238/ 219	242/ 199	255/ 219	257/ 227	251/ 222
• Flue gas temperature after boiler (Diesel oil)	°C	265/ 203	254/ 210	241/ 198	244/ 210	245/ 218	240/ 213

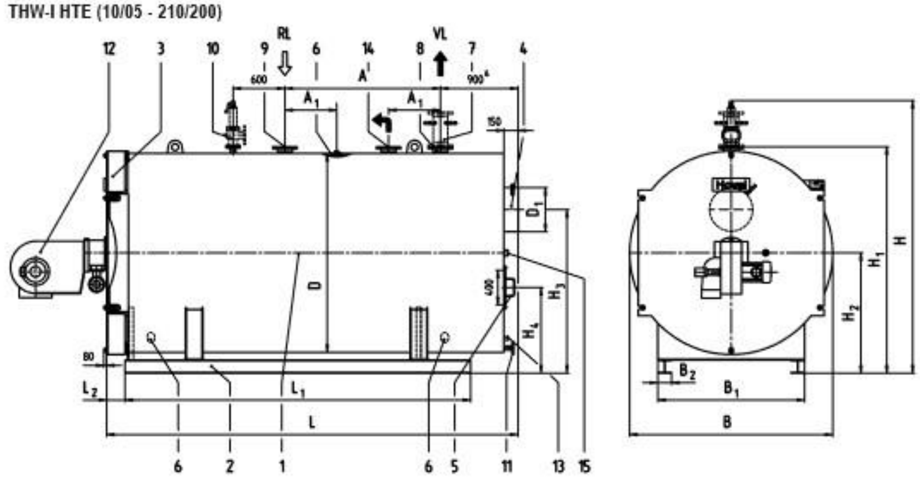
[1] Country and equipment specific

Dimensions and weights

Type			(10/05)	(13/08)	(17/10)	(22/15)	(27/20)	(34/25)
• Flame tube diameter	10 bar	mm	600	650	700	750	800	850
	13 bar	mm	600	650	700	750	800	850
	16 bar	mm	600	650	700	750	800	850
• Flame tube length with turning chamber		mm	1900	2200	2400	2800	3300	3650
• Boiler **length** with insulation, without burner		mm	2580	2880	3080	3480	3980	4330
• Boiler **width** with insulation, without armatures		mm	1550	1600	1700	1750	1850	1950
• Boiler **height** with insulation, with assembly tube		mm	2150	2285	2360	2430	2530	2630
• Diameter flue gas outlet		mm	300	350	400	450	500	500
• Transport weight **without** burner incl. equipment								
	10 bar	kg	2500	2900	3500	4500	6000	7000
	13 bar	kg	2700	3300	4000	5000	6500	8500
	16 bar	kg	3000	3500	4500	5500	7000	9000

■ Technical data

THW-I HTE (10/05 - 210/200)



1 Boiler (with flue gas collector)
2 Boiler base
(to THW-I HTE (43/35) with U-beam section,
from THW-I HTE (48/40) with I-beam section)
3 Hinged door, incl. reversal chamber
2nd./3rd. smoke gas pass
4 Flue gas outlet with 1 x ½" pipe fitting
5 Explosion flap and cleaning opening
6 Inspection opening
7 Assembly tube PN 16 / PN 25
8 Boiler flow nozzle (BF)
9 Return flow nozzle
10 Safety valve nozzle (SV)
11 Purge/ drain valve DN 40/ PN 40
12 Burner
13 Condensate drain nozzle R½"
14 Return flow heat up (BS)
15 Flame peephole

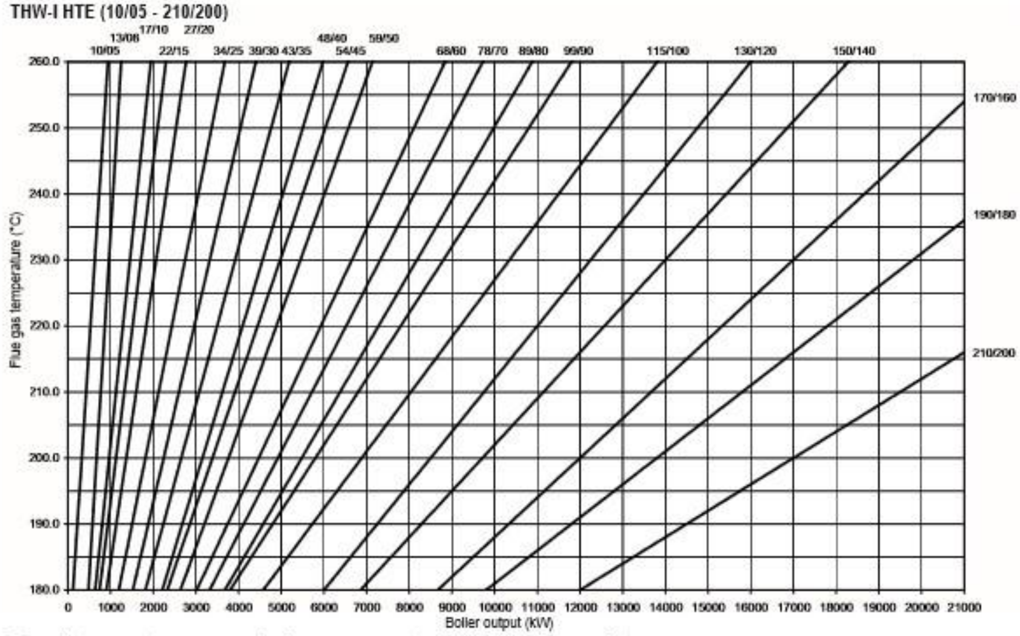
Design pressure 10,13 and 16 bar (gauge).
Dimensions for pressure stage 10 bar.
Note: Add 100 mm to H_1 for crane hooks.

Other pressure levels on request!
Dimensions incl. 100 mm insulation

Boiler Type	Main dimensions W Width	L Length	H	H_1	H_2	D	Boiler foundation L_1	L_2	B_1	B_2	Transport dim. B_{min}	H_{min}	F/R nozzle A	A_1	DN[1]	Flue gas con. H_3	D_1	H_4	SV DN[1]	BS DN[1]
(10/05)	1550	2580	2150	1700	900	1500	1500	230	1050	60	1750	2700	850	250	80	1200	300	500	32	40

■ **Technical data**
Flue gas diagram

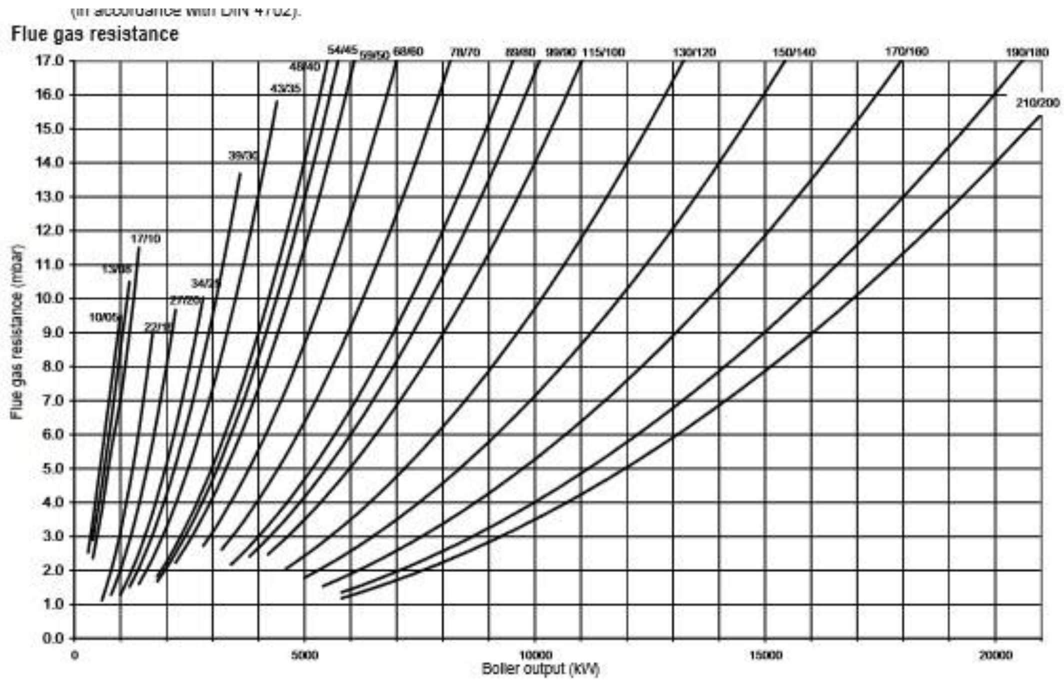
THW-I HTE (10/05 - 210/200)



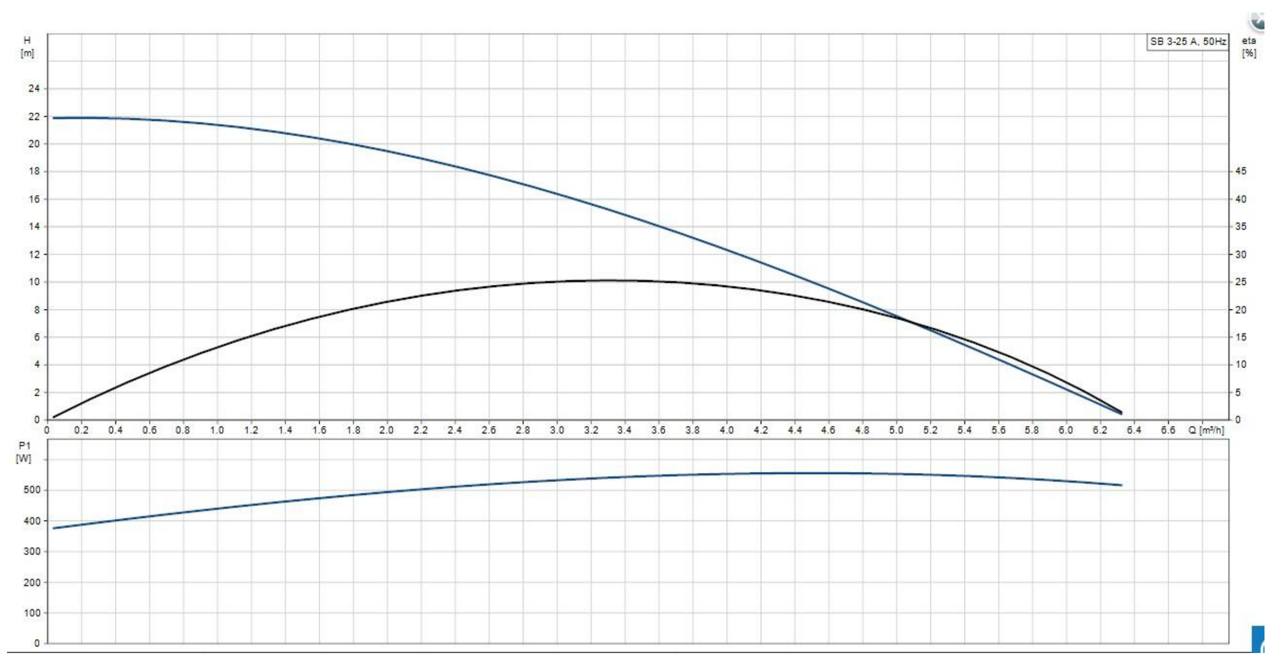
These data represent an average value from measurements with different burner manufacturers.

kW = Boiler output
°C = Flue gas temperature with cleaned heating surface, boiler flow temperature 120 °C, boiler return flow temperature 100 °C (in accordance with DIN 4702).

- Operating with natural gas, λ = 1,1 with max. burner output
- A reduction of the boiler water temperature of 10K causes a reduction of the flue gas temperature by approx. 6-8K.



Catalogue of submersible pump:



Specifications

Product name	SB 3-25 A
Product No	97686699
EAN number	5710621504102
Price	On request
Technical	
Rated flow	2.82 m³/h
Rated head	15 m
Impeller nom	102 mm
Type of impeller	CLOSED
Impellers	2
Maximum particle size	1 mm
Approvals and markings	1
Curve tolerance	ISO9906:2012 3B
Materials	
Pump housing	PP30GF
Impeller	PPO20GF
Installation	
Maximum ambient temperature	50 °C
Pump outlet	G 1"
Maximum installation depth	10 m
Type of suction	STRAINER

Liquid	
Pumped liquid	Water
Liquid temperature range	0 .. 40 °C
Q_OpFluidTemp	20 °C
Density	998.2 kg/m³
pH-value range	4-9
Electrical data	
C run	8 µF
P2	0.56 kW
Mains frequency	50 Hz
Rated voltage	1 x 220-240 V
Rated current	2.8 A
Starting current	8.5 A
Cos phi	0,89
Rated speed	2800 rpm
Capacitor size - run	8 µF/450 V
Enclosure class (IEC 34-5)	IP68
Insulation class (IEC 85)	F
Motor protec	YES
Length of cable	15 m
Cable type	H07RN-F 3G1
Type of cable plug	SCHUKO
Controls	
Flow switch	yes
Others	
Net weight	8.2 kg
Gross weight	8.95 kg
Shipping volume	0.022 m³

Catalogue of fuel tank:

Made From: **Aluminium**

Suitable For Fuel: **Diesel, Gas Oil**

Tank Type: **Single Skin, Transportable**

UN Certified / Approved for Transport under ADR: **Yes**

Capacity: **250 litres**

Weight: **37.00kg**

Dimensions (l x w x h): **750mm x 895mm x 770mm**

Comes supplies with 12/24v pump,4m hose and auto nozzle

Catalogue of 70 CFM tube fan wall mounted:

70 CFM Through-the-Wall Exhaust Fan Ventilator
★★★★☆ (63)
Wall
60
No additional Features
8
8
3.5
70

- For use in baths, laundry rooms, kitchens and more
- Direct discharge through walls from 5-1/4 to 10 inches thick
- Pair with a remote wall switch for easy operation

Catalogue of 350 CFM tube fan ducted:

Specifications

Type:	Axial Flow Fan	Electric Curren...	AC	Mounting:	Duct Fan
Blade Material:	Plastic	Place of Origin:	Guangdong, China (Mainland)	Brand Name:	SENSDAR
Model Number:	SE-A150	Voltage:	110-220v	Power:	0-30W
Air Volume:	280CFM / 476M3/H	Speed:	4200RPM	Certification:	CCC, CE, ROHS
After-sales Ser...	No overseas service provided	Color:	Blue & white	Motor type:	EC motor
Speed controll...	Yes				

Catalogue of 800 CFM tube fan ducted:

VIVOSUN 8 Inch 800 CFM Inline Duct Fan for Ventilation

8" Duct Diameter/800 CFM

Sturdy plastic fan housing and blades for very low noise (

Bill of quantities

Item No.	**Description**

MECHANICAL WORKS

Preamble

Water Tanks, Sanitary Fixtures and sanitary fixture accessories shall all be measured per piece and paid for according to their unit rates. All pipes, whether domestic and fire fighting GS pipes, supply pipes, sewage drainage UPVC pipes from sanitary fixture to the final disposing point (including vent and stack pipes), storm water UPVC drain pipes, measured at actual and paid for in linear meters according to the corresponding bill item.

Floor drains and traps, roof drains, as well as, clean-outs, and the like, shall be measured per piece and paid for accordingly and in line with the corresponding unit rate.

Manholes, gullies and the like shall be measured in numbers.
Rates of all fitting, fixtures appliances, and pipe laying shall include supply of material; workmanship; installation; testing; adjusting; balancing and commissioning. Rates to include also all pieces and fittings including by-passes, floats, automatic vents, vent and stack mesh covers, and non-return valves, all needed to complete the works according to specifications and Engineer's satisfaction. This shall also bedding, backfilling and benching and all works connected with pipe laying; all ties, sleeves, joint, tie bolts and rods, hangers and brackets, and the like.
All rates to include workshop drawings, coordinated sketches and as-built drawings, all pre-used for connecting motors to power supply.

Item No.	Description	Unit	Qty.	Unit Rate	Amount

1.1	**Air Conditioning VRF System** Supply and installation testing and commissioning of the following spilt unit, ceiling mounted cassette and wall mounted type indoor unit, complete with electrical connections,				
1.1.1	**VRF indoor unit**				
A.	6.8 kW Split	No.	90		
B.	4.5 kW (4 way) Cassette	No.	20		
C.	14 kW(4 way) Cassette	NO.	8		
1.1.2	**VRF Outdoor Unit** Supply, install, test and commission of outdoor units including all accessories, fittings, valves, and It must be Factory made and assembled. Refrigerant gas to be of zero Ozone depletion potential (ODP) as R410A. All as per Sanyo, Daikin,Samsung or EA.				
A.	16 hp	No.	4		
B.	14 hp	No	4		
C.	12hp	No.	1		
D.	20hp	No	3		
1.2	**Ventilation** Supply, install, and connect, testing and commissioning of, inline centrifugal fan, Shall include all required electrical connections as per specifications, drawings and related codes.				
A.	70 CFM tube fan wall mounted	No.	110		
B.	350 CFM tube fan wall mounted	No.	2		
C.	800 CFM tube fan wall mounted	No.	5		

1.3	**Water Supply**				
1.3.1	**Water Supply Pump Set** Supply, install, test and commission water supply pump set (factory assembled), one duty, one stand-by, P54 protection, diaphragm type. The unit price shall include pressure vessel, electric control panel, electrical wiring, galvanized steel frame, inertia base, vibration isolators, concrete base and all required valves and fittings as detailed on the drawings.	No.	5		
1.3.2	**Galvanized Steel Pipes & Fittings** Supply, install, test and commission galvanized steel pipe work to ASTMA53 grade "A", schedule (40) for the domestic hot and cold water supply pipe work up to the water outlet. The unit price shall include valves, expansion joints, pressure regulators, air vents, fittings and all accessories and works required to complete the work as shown on drawings, specifications and P.M. instructions.				
A.	Diameter 1”	ML	200		
B.	Diameter 2”	ML	180		
C.	Diameter 2.5”	ML	75		
D.	Diameter 3”	ML	30		

1.3.4	<u>**Water Meter**</u> Supply, install, test and commission water meter with totalizer, 2" diameter, including air vent, check valve, strainer, two gate valves, connection to municipality's potable water supply network, fittings, and all accessories and works required to complete the work as shown on the drawings and as per the preamble, specifications and the supervision engineer's requirements.	No.	1		

Item No.	**Description**	**Unit**	**Qty.**	**Unit Rate**	**Amount**
1.3.5	<u>**Water Collector**</u> Supply and install hot and cold water collector's type GIACOMINI or E.A				
A.	1 ¼" cold water collector	SUC.	50		
B.	¾" hot water collector	SUC.	50		
1.4	**Waste and Drainage System**				
1.4.1	<u>**Vertical and Horizontal UPVC Pipe**</u> Supply, install UPVC pipes and fittings similar to local made P.S SN 8. The rate shall include all needed connections and all types of fittings caps, all done according to drawings, specifications and the approval of the supervision engineer.				
A.	Diameter 2"	ML	300		
B.	Diameter 4"	ML	2500		
C.	Diameter 6"	ML	468		
1.4.2	<u>**Floor Trap**</u> Supply, install, testing and commissioning of, 4"chrome plated threaded 15x15cm cast brass cover, multi inlet adjustable with trap floor drain. Including, floor clean out plug, HDPE siphon or equivalent and necessary accessories, connections with fixtures and main drain pipes. As per drawings, specifications and related codes.	No.	120		

1.4.3	**Clean Out** Supply, install, testing and commissioning of the following, HDPE or equivalent , non-adjustable 15x15 cm stainless steel cover, and floor clean out with gas and water tightness ABS plug and necessary accessories as per drawings, specifications and related codes. (Ø 4")	No.	267		
1.4.4	**Manhole** Supply and install PRE-CAST concrete manholes of 15 cm thick walls and base with heavy duty cast iron covers and frames of 25 tons load strength with all necessary excavation back filling as specified to the required depth with steps of galvanized pipe of 1/2" benching and connecting it to main city				
	manholes as shown in drawing and in accordance to specifications and approval engineers.				
A.	Size 60 cm (inside diameter)	No.	4		
B.	Size 80 cm (inside diameter)	No.	3		
C.	Size 100 cm (inside diameter)	No.	1		
1.4.5	**Sanitary Fixture and Their Accessories**				

1.4.5.1	**Lavatory** Supply and installation of porcelain wash basin glazed white (from creavit or equivalent) with chrome plated mixer adoption of the supervising engineer) half leg measuring 56 × 45 cm and isolate it from the wall using the Sika Anti-gray colour of the rot with water mixer (of the finest international standards, according to the supervising engineer adoption) and Siphon and all chrome-plated The price includes valves angle 13 mm chrome holder soap of the finest varieties mirror 60 × 45 cm with aluminium frame and providing sink series and rubber stopper and all necessary for installation, operation and drainage to the nearest packet assembly floor drain , according to the specifications and plans and instructions of the supervising engineer.	No.	100		

1.4.5.2	**Water Closet** Supply, install, testing and commissioning of, floor mounted, white colour, Porcelain, siphon jet water closet/toilet with an elongated bowl, seat with open front and check hinge, and carrier. or equivalent including necessary accessories, 9-lt capacity cistern, valves, fittings, 13mm stop angle valves, chrome plated 13mm hose, heavy duty side l m length 13mm Chrome plated hand shower, connection to drainage and water systems as per drawings, specifications and related codes.	No.	250		
1.4.5.4	**Kitchen Sink (General)** Supply and install kitchen sink of size 90X40cm, complete with chrome plated kitchen mixer , chrome plated 13mm stop valve, supports, 2" waste outlet down to floor , P- trap, chrome plated 13mm hose and all required parts for water supply line, including connection to drain and water outlets, as per supervisor engineer Counter top Kitchen sink	No.	6		
1.4.5.6	**Bathtub** Install, supply, Testing, and commissioning of, white colour, Porcelain, bathtub with an elongated bowl, seat with open front and check hinge, and carrier. or equivalent including necessary accessories, capacity of water, valves, fittings, ¾ " stop angle valves, chrome plated ¾ " hose, size 75X60X190cm Chrome plated hand shower, connection to drainage and water systems as per drawings, specifications and related codes.	No.	120		

1.5	**Fire fighting** Supply and install galvanized steel pipes to ASTM-A53 grade "A" schedule-40 for fire fighting system pipework, inside building. The unit price shall include valves, fittings, and all accessories and works required to complete the work and as per preambles, specifications, and the supervision of engineer's requirements.				
A.	Diameter 4"	ML	300		
B.	Diameter 2"	ML	120		
1.5.1	**Fire Fighting Pump Set** Supply, install, test and commission fire fighting pump set(factory assembled), composed of one electric on duty pump, one stand-by electrical pump, jockey pump, and automatic control panel. The unit price shall include pressure vessel, electric control panel, electrical wiring, galvanized steel frame, inertia base, vibration isolators, concrete base, piping from water reservoir to delivery header outlet complete with test lines, and all required valves and fittings as detailed on the drawings, specifications and P.M. instructions. Galvanized steel frame, inertia base, vibration isolators, concrete base, piping from water reservoir to delivery header outlet complete with test lines, and all required valves and fittings as detailed on the drawings, specifications and P.M. instructions.	No.	3		

1.5.2	**Fire Extinguisher** Supply and install Portable Fire Extinguisher of 6 Kg. Co2 capacity each in Location as decided by the Engineer. The installation shall be complete with brackets and it should be in accordance with the Civil Defence specification.	No.	30		
	Fire Hose Reel Cabinets Supply, install, test and commission fire hose reel cabinets to, complete with 30 meters long 1 ½" diameter rubber hose of 16 bar working pressure. The unit price shall include hose cabinet, pressure-reducing valve, globe valve and automatic swinging recessed type cabinet as detailed on drawings and as per the specifications and the supervision engineer's requirements amount .	No.	20		