Palestine Polytechnic University

Design of Mechanical systems using PV cells to reduce energy usage for a Pilgrims rest building located at Jericho

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Submitted to the College of Engineering
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Bachelor degree in Refrigeration & Air Conditioning Engineering

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Refrigeration & Air Conditioning Engineering

Project Name:

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According to the project supervisor and according to the agreement of the testing committee members, this project is submitted to the Department of Mechanical Engineering at college of engineering and technology in partial fulfillment of requirement of (B.SC) degree in engineering of refrigeration and air conditioning.

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اهداء

{يَرْفَعِ اللَّهُ الَّذِينَ آمَنُوا مِنكُمْ وَالَّذِينَ أُوتُوا الْعِلْمَ دَرَجَاتٍ وَاللَّهُ بِمَا تَعْمَلُونَ خَبِيرٌ} اهداء الى الهادي نور القلوب سيدنا محمد صلى الله عليه وسلم إلى ارواح من سطروا بدمائهم منار الحرية الشهداء البررة إلى من أناروا لنا دروب الحياة إلى امهاتنا و ابائنا من كانوا سببا في وجودنا وإلى اخوتنا رياحين النفس إلى من نور الله قلوبهم بنور العلم اساتذتنا أولي الفضل د.كاظم عسيله إ لى كل طالب علم إلى كل زميل شاركنا الفرحة بعد العناء نهدي هذا العمل المتواضع في سبيل الله.

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Abstract

يهدف هذا المشروع إلى تصميم الخدمات الميكانيكية واستخدام الخلايا الشمسية لتقليل الطاقة الكهربائية المستخدمة لاستراحة حجاج في مدينة أريحا . وتصميم هذا المشروع يشمل عمل حسابات وتجهيز رسومات واختيار المواد والمعدات وحساب جدول الكميات لنظام تزويد المياه ونظام الصرف الصحي ونظام التكييف والتبريد وإطفاء الحريق والخلايا الشمسية .

This project aims to design the mechanical systems Using PV Cells To Reduce Energy Usage for Pilgrims rest building in Jericho City. The design of this project include making the calculations, drawings, material selection and determine the table of quantity for the water system, drainage system, air conditioning system , the firefighting system and solar cells .

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1 Chapter 1: Introduction :

In business, industry, schools, hospitals, hotels, theaters, restaurants and homes air conditioning is no longer auxiliary but an essential part of modern living. There are four atmospheric conditions. True air conditioning implies that all four of these atmospheric conditions for human comfort are being met.

The air conditioning system include much more than the control of the inside temperature of a given space. It include the 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 .

The main goal of plumbing design for building is to safely and reliably provide domestic water and water for fire fitting. And also to get rid of the wastes.

1.1. Project objectives

The main objectives of the project are:

1. To calculate and design air conditioning, heating and plumbing systems.
2. To prepare the required drawings for each system.
3. To select the required equipments and parts.
4. Design a suitable firefighting system that covers the requirements of the building.
5. Design Photovoltaic System .

1.2. Time table:

Table 1-1:Time table for the first semester:

tasks\week	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Choosing the building plan															
Overview previous projects															
Overall coefficient calculations for walls , ceiling , floor ,doors and windows															
Heating and cooling loads calculations															
Water supply system calculations															
Plumbing system calculations															
Printing															

Table 1-2:Time table for the second semester:

tasks\week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Editing and modifying															
Design the firefighting system															
Design the VRV system															
Design Photovoltic System															
Doing bill of quantity tables															
Printing															

1.3. Project contents :

Chapter One: Introduction

Includes an overview, the project objectives and time table .

Chapter Two: Cooling Load

Includes a sample calculation for one room in details , the other rooms loads VRV system

Chapter Three: Heating Load

Includes a sample calculation for one room in details , the other rooms loads and mechanical ventilation.

Chapter Four: Plumbing System

Includes the calculation of water supply system to determine the total required amount of water and the drainage system

.

Chapter Five : Firefighting System

Includes general introduction about each system, and the pipe size calculations for one branch.

Chapter Six : Photovoltaic System .

Includes calculation and type of photovoltic System .

Chapter Seven: Bill Of Quantity

This chapter includes the total number of quantity for each system and its cost.

2 Chapter 2: Cooling load

The main purpose of air conditioning is to provide a comfortable atmosphere for people Inside a closed space. The parameters that govern this comfort are four parameters namely air temperature, humidity, air velocity and air purity. Therefore, cooling decrease the temperature of the surrounding air, heating increase the temperature of the surrounding air, humidifying increase the moisture content in the surrounding air, and dehumidifying decrease the moisture content in the surrounding air. Ventilation renew and clean the air inside the space.

Human body temperature is normally 37˚C . We are comfortable when the heat level in our body is transferring to the surrounding air at comfort rate. The rate of this heat transfer depends on the properties of surrounding air and other factors like the type of clothes the human put on .Therefore, to maintain the correct rate of heat transfer, the surrounding air must be conditioned (i.e. changing the properties of the air to suitable ones).

An air conditioner is an appliance or mechanism designed to extract heat from humanly occupied space air temperature using refrigeration cycle. When air conditioning is available it may be central air conditioning where all parts of the building including common areas are cooled or it may be provided only in the specific spaces. In general comfort occurs when body temperature is held within narrow ranges, skin moisture is low and physiological effort of regulation is minimized. Comfortable conditions result from a desirable combination of air temperature, humidity, air velocity, and air purity.

2.1 ASHRAE comfort chart

Research studies have been conducted to show that, with a specific amount of air movement, thermal comfort can be produced with certain combinations of dry-bulb temperature and relative humidity. When plotted on a psychometric chart, these combinations form a range of conditions for delivering acceptable thermal comfort to 80% of the people in a space. This “comfort zone” and the associated assumptions are defined by ASHRAE Standard

55, Thermal Environmental Conditions for Human Occupancy. Determining the desired condition of the space is the first step in estimating the cooling and heating loads for the space. In this restaurant , We design on [24ºC] dry-bulb temperature and 40% relative humidity as the desired inside condition during the summer season from the ASHRAE Comfort Chart.

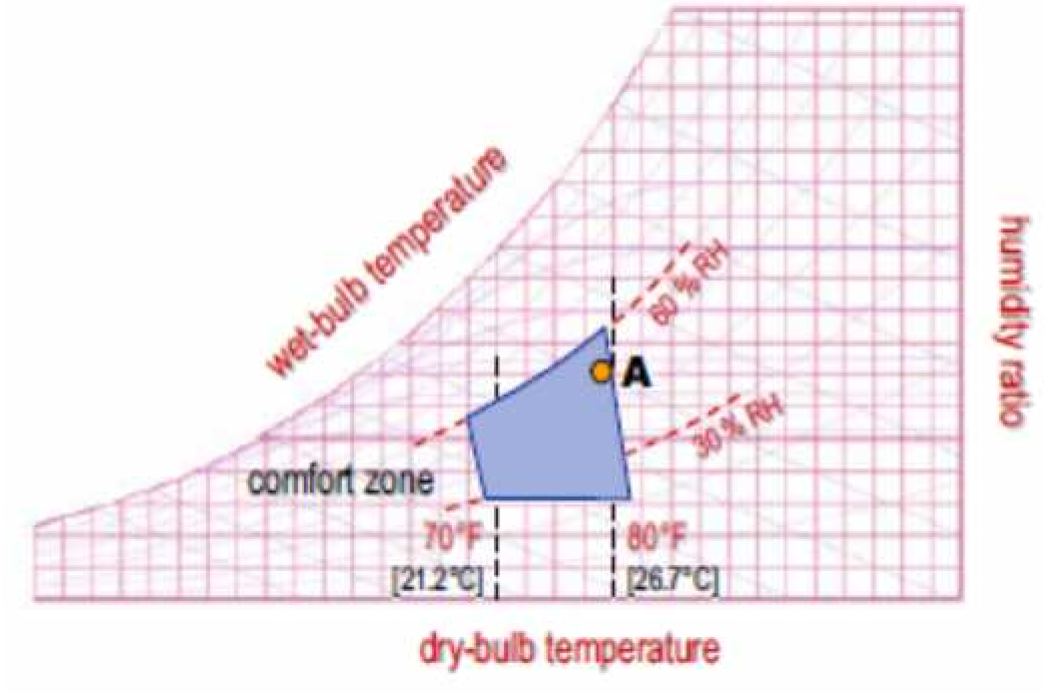


Figure 1: ASHRAE Comfort Chart

2.2Data analysis

$$(CLTD)_{corr} = (CLTD + LM)k + (25.5 - T_i) + (T_{o,m} - 29.4) f \qquad (1.1)$$

Where:

- ✓ CLTD: Is called cooling load temperature difference for medium wall construction.
- ✓ LM: Latitude correction factor for horizontal and vertical surfaces .

- ✓ K: Colors adjustment factor such that k = 1.0 for dark colored roofs, and k=0.65 for Permanently Light colored walls.

- ✓ DR: The daily temperature range which equal to the difference between the average maximum and Average minimum temperature for warmest month of the summer season.

- ✓ *f*: The factor *f* is attic or roof fan factor such that *f* =1 if there is no attic or roof fan, and the value of *f* = 0.75 if there is an attic or roof fan.

- ✓ $T_{o.m}$: The outdoor main temperature

$$T_{o.m} = T_{out} - \frac{DR}{2} \qquad (1.2)$$

Then :

$$T_{out.m} = T_{out} - \frac{DR}{2} = 36.64 - \frac{12}{2} = 30.64\ ^{\circ}C$$

The following table contains all assumptions needed for the next calculations:-

Table 2-1: Data for outside and inside temperature :

Outdoor temperature (T_o)	36.64°C From the Palestinian code
Indoor temperature (T_i)	24°C From Figure 1
Latitude(LM)	July @ latitude 32° North From Table 9-2
Day of calculations	21^{st} day of july
Color of surfaces (K)	Permanent light colour wall

In the following table is the corrected CLTD for walls and roof and its tabulated as follow:

Table 2-2 : $(CLTD)_{corr}$ for walls and roof :

Wall	CLTD From table (9-1)	LM From table (9-2)	K	F	$CLTD_{corr.}$
S	6	-1.6	0.65	0.75	9.79
SW	7	-0.5	0.65	0.75	11.155
W	8	0	0.65	0.75	12.13
NW	6	0.5	0.65	0.75	11.155
N	5	0.5	0.65	0.75	10.505
NE	9	0.5	0.65	0.75	13.105
E	12	0	0.65	0.75	14.73
SE	10	-0.5	0.65	0.75	13.105
Roof	35	0.5	1	1	44.24

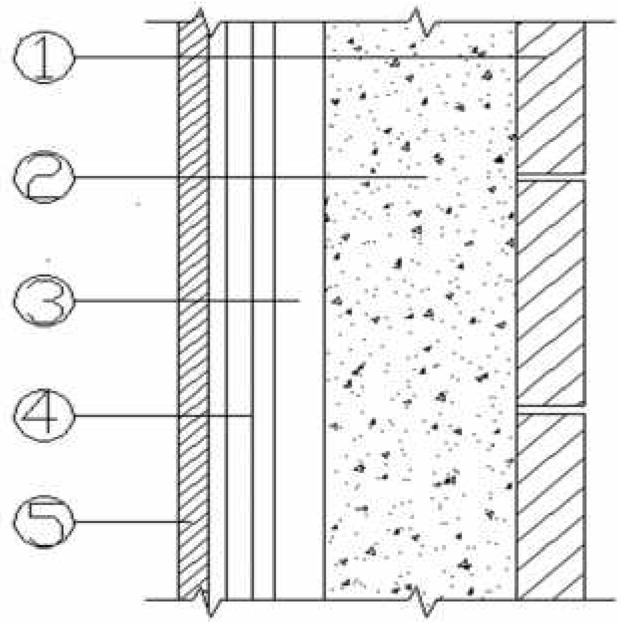
Table 2-3 : Parameters of $(CLTD)_{corr}$ for walls and roof :

Parameters	Properties
Roof	Without suspending ceiling type 2 @solar time 13h
Wall	Group B @solar time 13h
LM	JULY @Latitude 32c
K	Permanent light colour wall
f	The value of attic or roof fan factor
Type of glass	Double , thickness 3mm , without interior shading
CLF	Construction medium without inertia shading

2.3 Calculation of the overall heat transfer coefficient:

2.3.1 Overall heat transfer coefficient for external walls:

The construction of the external walls are explained in details in the following figure:-



Figuer 2: External wall

Table 2-4:External wall constructions:

Material	Thickness(m)	R-value (m². ℃ /W)
Outside air film	-------	0.12
Stone(1)	0.07	0.041
Concrete(2)	0.2	0.114
Insulation(3)	0.03	0.750
Cement Brick(4)	0.07	0.078
Plaster(5)	0.03	0.025
Inside air film	-------	0.08

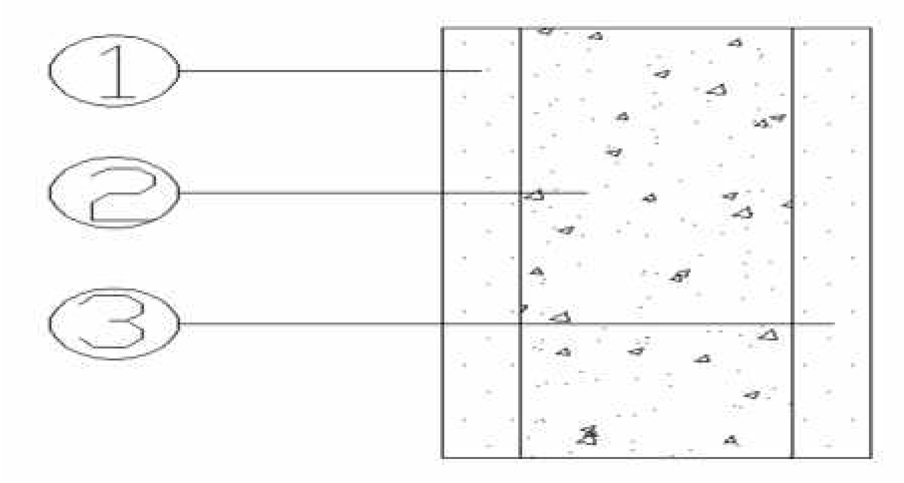
$$U_{walls,out} = \frac{1}{R_{th}} = \frac{1}{\frac{1}{h_i} + \frac{\Delta x_1}{k_1} + \frac{\Delta x_2}{k_2} + \dots + \frac{1}{h_o}} \quad (1.3)$$

$$U_{walls,out} = \frac{1}{R_{th}} = \frac{1}{0.08 + \frac{.07}{1.7} + \frac{0.2}{1.75} + \frac{0.03}{0.04} + \frac{0.07}{0.897} + \frac{0.03}{1.2} + 0.12}$$

$$U_{walls,out} = \frac{1}{R_{th}} = \frac{1}{1.2} = 0.833\ W/m^2.℃$$

2.3.2 Overall heat transfer coefficient for internal walls:

The construction of the internal walls are explained in details in the following figure:-



Figuer 3: Internal wall

Table 2-5:Internal wall constructions:

Material	Thickness (m)	R-value (m².℃ /W)
Intside air film	-------	0.12
Bleach(1)	0.02	0.02
Brick(2)	0.07	0.65
Bleach(3)	0.02	0.02
Inside air film	-------	0.12

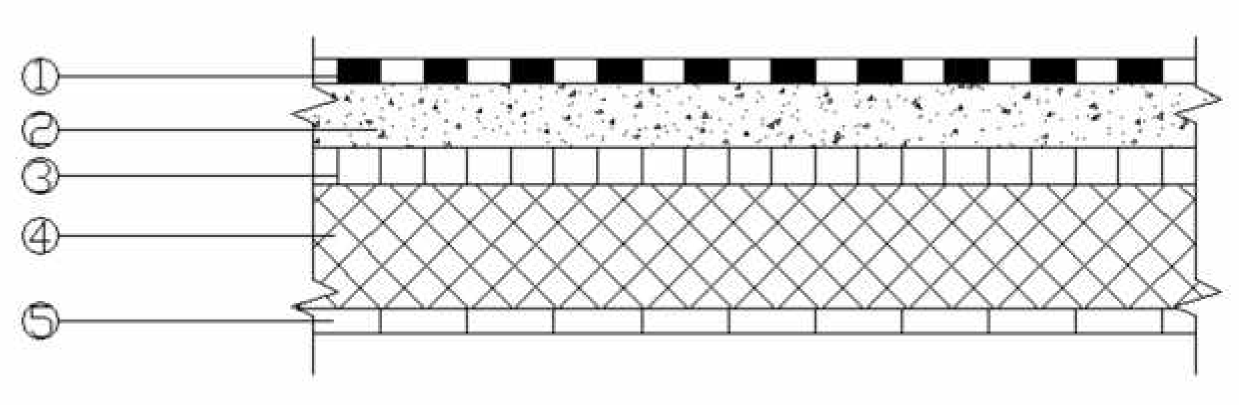
$$U_{walls,in} = \frac{1}{R_{th}} = \frac{1}{\frac{1}{h_i} + \frac{\Delta x_1}{k_1} + \frac{\Delta x_2}{k_2} + \dots + \frac{1}{h_i}}$$

$$U_{walls,in} = \frac{1}{R_{th}} = \frac{1}{0.12 + \frac{0.02}{1} + \frac{0.07}{0.107} + \frac{0.02}{1} + 0.12}$$

$$U_{walls,in} = \frac{1}{0.93} = 1.075 \ W/m^2.℃$$

2.3.3 Overall heat transfer coefficient for ceiling

The construction of the ceiling are explained in details in the following**:-**



Figuer 4: Ceiling construction

Table 2-6:Ceiling constructions:

Material	Thickness (m)	R-value (m².℃ /W)
Outside air film	-------	0.12
Alphalt Mix(1)	0.02	0.028
Concrete(2)	0.05	0.029
Insulation(3)	0.03	0.75
Reinforced Concrete(4)	0.1	0.057
Plaster(5)	0.2	0.017
Inside air film	-------	0.08

$$U_{Ceiling} = \frac{1}{R_{th}} = \frac{1}{\frac{1}{h_i} + \frac{\Delta x_1}{k_1} + \frac{\Delta x_2}{k_2} + \dots + \frac{1}{h_o}}$$

$$U_{Ceiling} = \frac{1}{R_{th}} = \frac{1}{0.08 + \frac{0.02}{0.7} + \frac{0.05}{1.7} + \frac{0.03}{0.04} + \frac{0.1}{1.75} + \frac{0.02}{1.17} + 0.12}$$

$$U_{Ceiling} = \frac{1}{R_{th}} = \frac{1}{1.08} = 0.925 \ W/m^2.\ ℃$$

2.3.4 Overall heat transfer coefficient for floor, doors and windows

The doors are made from wood, and the windows are double glass Aluminum with a wind speed range from 0.5 to 5 m/s from table 4-5.

$U_{floor} = 0.9$ W/m². ℃ $U_{windows} = 3.2$ U W/m². ℃ $U_{door} = 2.4$ W/m². ℃

2.4 Cooling load calculations

the calculations for restaurant in ground floor which is an area of 398 m² and can accommodate 100 people . In the following subsections determined the heat gain that comes from different resources. And these resources are the walls, sun, occupants, infiltration, ventilation, and windows.

2.4.1 Heat gain from walls, ceiling and the sun

Table 2-7:heat gain from walls and Ground:

Surface	Area (m²)	U (W/m². ℃)	ΔT (℃)	Q (W)
External	746	1.179	12.64	11117
Ceiling	398	0.925	12.64	4653
Ground	398	1.03	12.64	5181
			Q_{total}	**20951**

In this step determined the heat gain from the direct contact with the sun, the sun is directly contact with the all walls and the ceiling for this room, the following table shows the total amount of heat gain from the sun using the cooling load temperature difference (CLTD) corr.

Table 2-8: heat gain from the sun:

Surface	CLTD	LM	CLTDcorr	Area(m^2)	U ($W/m^2.°C$)	Q (W)
North wall	5	0.5	10.5	246.174	0.83	2141.2
South wall	6	-1.6	9.79	231	0.83	1873.2
East wall	12	0	14.73	130	0.83	1590.9
West wall	8	0	12.1	145.6	0.83	1462.8
ceiling	35	0.5	44.24	398	0.83	16286
					Q_{total}	**23355**

2.4.2 Heat gain from the solar transmitted through windows

In the selected room the all wall is exposed to the sun. heat gain due to solar transmission through glass window and glass door is estimated by using table 9-7 to 9-11. The values of the variables are taken from the inserted tables in the appendix.

$$Q_g = A \times (SHG) \times (SC) \times (CLF) \quad (1.4)$$

Where:

- ✓ SHG : Solar heat gain factor
- ✓ SC : Shading coefficient
- ✓ CLF : Cooling load factor

Table 2-9:Heat gain from solar transmitted through the glass:

Surface	Area (m^2)	SHG From table (9-7)	SC From table (9-8)	CLF From table (9-10)	Q(W)
S-glass	1	227	0.9	0.57	116
E-glass	15.2	678	0.9	0.35	3246
W-glass	1	478	0.9	0.19	116
				Q_{total}	**3478**

2.4.3 Sensible & latent heat gain from the occupants

The heat gain from the occupants depend on the number of occupants inside the restaurant .

$$Q_{oc} = Q_{oc,sens} + Q_{oc,latent} \quad (1.5)$$

$$Q_{oc,sens} = \text{\# Of Occupants} \times \text{sensible heat} \times CLF_{occ} \quad (1.6)$$

CLF_{occ} cooling load factor due to occupants , for sensble heat gain , From Table 9_ 16

Sensible and Latent heat From Table 4 – 2

$$Q_{oc,sens} = 100 \times \frac{70}{1000} \times 0.62 = 4.43 \text{ kW}$$

$$Q_{oc,sens} = \text{\# Of Occupants} \times \text{latent heat}$$

$$Q_{oc,latent} = 100 \square \frac{44}{1000} = 4.4 \text{ kW}$$

2.4.4 Heat gain from the lights:

there is Twenty lights through this restaurant, so:

$$Q_{lights} = N \times P \times CLF_{lights} \times \text{Diversity factor} \quad (1.7)$$

Where:

N: The number of lights.

P : The power for the lights.

CLF lights : Cooling load factor for the lights , From Table 9 - 14.

CLF_{lights} = 0.69

Q_{lights} = 20 × 70 × 0.69 × 0.5 = 0.483 kW.

2.4.5 Heat loss due to infiltration:

Infiltration is the leakage of the outside air through cracks or clearances around the windows and doors. We use the crackage method to calculate it as follow:

For Windows :

$$Q_{infiltration} = m_f \times (h_o - h_i) \quad (1.8)$$

$$m_f = \frac{V_f}{v_0} \quad (1.9)$$

$$V_f = \text{crack length(L)} \times \text{Infiltration through windows} \quad (1.10)$$

Where V_f is obtained from table 6-1 at 8 km/h as $2m^3/h$ per meter of crack. the crack length of the five double hung metal windows is :

$L = 5 \times 2 \times \; 1.1 + 3 \; = 41$ m .

Therefore ;

$V_f = 41 \times 2 = 82 \frac{m^3}{h} = \frac{82}{3600} = 0.02277 \frac{m^3}{s}$.

Also, from the psychrometric chart, at the given outside conditions then the specific volume v_0 of outside air is :

v_0 = 0.907 m^3/kg

$m_f = \frac{0.02277}{0.907}$ = 0.02511 Kg/s.

Then total heat loss due to infiltration is :

$Q_{infiltration}$ = 0.02511 × 1 × (85 - 46) = 0. 979 kW

For Doors :

$$Q_{infiltration} = m_{inf} \times (h_o - h_i)$$

$$m_{inf} = \frac{V_f}{v_0}$$

V_f = crack length × Infiltration through doors .

Where V_f is obtained from table 6-1 at 8 km/h as 5.4 m^3/h per meter of crack. the crack length of the tow poorly fitted foor is :

$$L = 2 \times 2 \times \; 2 + 3 \; + 2 \times \; 1.25 + 3 \; = \; 28.5 \text{ m} .$$

$v_0 = 0.907 \ m^3/kg$

$$V_f = 28.5 \times 5.4 = 153.9 \frac{m^3}{h} = \frac{153.9}{3600} = 0.0427 \frac{m^3}{s} .$$

$m_f = \frac{0.0427}{0.907}$ = 0.0471 Kg/s.

Then total heat loss due to infiltration is :

$Q_{infiltration}$ = 0.0471 × 1 × (85 - 46) = 1.838 kW

2.4.6 Heat gain due to ventilation:

$$Q_{ventilation} = m_v \times (h_o - h_i) \quad (1.11)$$

$$m_v = \frac{V_v}{v_0} \quad (1.12)$$

V_v = minimum outside air requirements ventilation × No.of persosn (1.13)

minimum outside air requirements ventilation from Table 4-5

V_v = 8 × 100=800 l/s. = 0.8 m^3/s.

$v_0 = 0.907 \ m^3/kg$

$m_v = \frac{0.8}{0.907} = 0.89$ Kg/s.

Then total heat loss due to ventilation is :

$Q_{ventilation}$ = 0.89 × 1000 × (85 - 46) = 34.6 kW.

❖ Finally, the total load for this restaurant is the summation of all the heat gain resources .

$$Q_{total} = 73.5 \text{ kW}$$

Table 2-10:The cooling load for each room of the building:

Name of room	Cooling load (kW)	Area (m²)	Name of room	Cooling Load (kW)	Area (m²)
Ground Floor			**First Floor**		
shop	70	369.45	**room1**	5.6	33.01
restaurant	73.5	398	**room2**	5.1	31.5
mosque	41.5	167.57	**room3**	5.4	31.5
room1	7	33.31	**room4**	5.2	31.5
room2	6.7	31.5	**room5**	5.5	33
room3	6.3	31.5	**room6**	6.1	33.3
room4	6.6	31.5	**room7**	5.6	31.5
room5	6.9	31.5	**room8**	5.4	31.5
room6	7	33.31	**room9**	5.2	31.5
majlis1	25.7	66.03	**room10**	5.3	31.5
majlis2	23.9	80.34	**room11**	6	33.3
			account	4.5	16.5
			manag	4.3	12.4
			secer	3.6	10.2
			room	5	21.6

2.5 The VRF system and its calculations

2.5.1 VRF system

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-condition system configuration where there is 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 in different zones

.

VRF systems operate on the direct expansion (DX) principle meaning that heat is transferred to or from the space directly by circulating refrigerant to evaporators located near or within the conditioned space. Refrigerant flow control is the key to many advantages as well as the major technical challenge of VRF systems.

2.5.2 VRV components

The VRV system have some of main components :

1) outdoors units.

2) indoors units.

3) piping connection

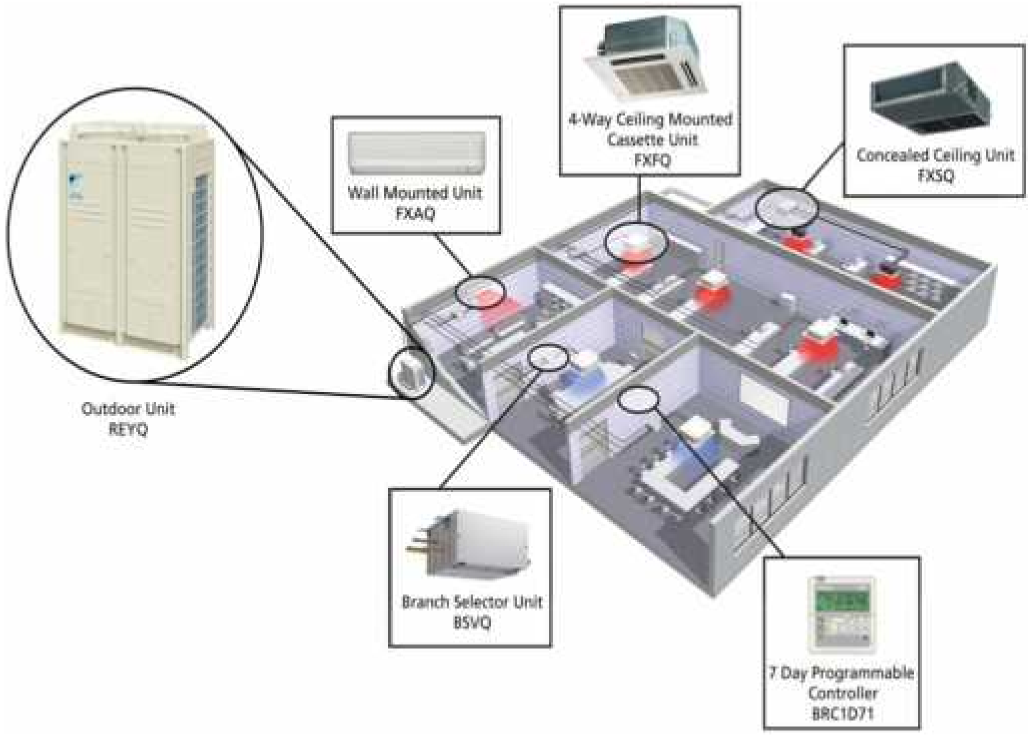


Figure 5: The VRV system components

-Outdoors units.

The outdoor unit contains a heat pump , A heat pump is a machine that by reversing it's refrigeration cycle can provide heating instead of cooling. Because a heat pump uses refrigerant it can upgrade the heat in air at even -15ºC to a usable heat source to heat buildings.

-Indoor Units:

The indoor units were developed to be highly efficient, compact, low noise, and to have user friendly operation. Care was also taken with the design to make that go well with the interior decoration and tobe easy to install and maintain. Further, a variety of options are available to achieve an air conditioning environment that is more desirable from the user's perspective.

-Expansion valve controller:

Thermostatic Expansion Valves (TXV) is very important part to control the flow in vrv system As the thermostatic expansion valve regulates the rate at which liquid refrigerant flows into the evaporator, it maintains a proper supply of refrigerant by matching this flow rate against how quickly the refrigerant evaporates (boils off)in the evaporator coil.

2.5.3 Advantages of VRV

- Comfort:

Comfort by providing “even” cooling or heating when and where it is required. Multiple types of fan coils and sizes provides design flexibility for different applications. Design software simplifies selecting and piping design.

- Energy savings:

No energy loss due to moving conditioned air in duct work. Equipment handling –Smaller wire sizes and disconnects Smaller pipe sizes when compared to chilled water.

2.5. 4 Design of VRV system

There are two method to design of VRV according to daikin company system:

* By xpress program.

*By Table.

*what is the Xpress program?

“Xpress” is a selection software for VRV systems And it can helps your quick selection for quotation with easy operation.

This program is made from daikin company , the program can help you to choose a lot of very important thing about VRV system .

* Table is made from daikin company , the table can help you to choose a pipes size , refent joint, header joint and other thing .

2.5.5 Selection of outdoor and indoor units:

This tables show the characteristics of used unit and cooling load for each room :

Table2-11:Specification of outdoor and indoor unit for riser 1:

Name of the room	Cooling load (kW)	Name of indoor unit	Capacity of indoor unit (kW)	Num. of indoor unit	Dim.of indoor unit (mm)	Specifications Of outdoor unit
mosque	41.5	FXFQ63A	7.1	6	60X950X950	Capacity range : 50 hp Cooling load : 140 kW Heating capacity : 156 kW
room1	7	FXFQ63A	7.1	1		
room2	6.7	FXFQ63A	7.1	1		
room3	6.3	FXFQ63A	7.1	1		
room4	6.6	FXFQ63A	7.1	1		
room5	6.9	FXFQ63A	7.1	1		
room6	7	FXFQ63A	7.1	1		
majlis1	25.7	FXFQ50A	5.6	5		
majlis2	23.9	FXFQ50A	5.6	4		

Table2-12:Specification of outdoor and indoor unit for riser 2:

Name of the room	Cooling load (kW)	Name of indoor unit	Capacity of indoor unit (kW)	Num. of indoor unit	Dim.of indoor unit (mm)	Specifications Of outdoor unit
shop	70	FXFQ63A	7.1	10	60X950X950	Capacity range : 54 hp Cooling load : 150 kW Heating capacity : 168 kW
restaurant	73.5	FXFQ63A	7.1	11		

Table2-13:Specification of outdoor and indoor unit for riser 3:

Name of the room	Cooling load (kW)	Name of indoor unit	Capacity of indoor unit (kW)	Num. of indoor unit	Dim. of indoor unit (mm)	Specifications Of outdoor unit
room1	5.6	FXFQ50A	5.6	1	60X950X950	Capacity range : 30 hp Cooling load : 83.5 kW Heating capacity : 93.5 kW
room2	5.1	FXFQ50A	5.6	1		
room3	5.4	FXFQ50A	5.6	1		
room4	5.2	FXFQ50A	5.6	1		
room5	5.5	FXFQ50A	5.6	1		
room6	6.1	FXFQ50A	5.6	1		
room7	5.6	FXFQ50A	5.6	1		
room8	5.4	FXFQ50A	5.6	1		
room9	5.2	FXFQ50A	5.6	1		
room10	5.3	FXFQ50A	5.6	1		
room11	6	FXFQ50A	5.6	1		
account	4.5	FXFQ40A	4.5	1		
manag	4.3	FXFQ20A	2.2	2		
secer	3.6	FXFQ32A	3.6	1		
room	5	FXFQ50A	5.6	1		

2.5.6 Selection of pipes and joints

This table show the characteristics of pipes and joints for VRV system .

Table2-14:Specification of pipes and joints for riser 2 .

Name of the room	Dim. from indoor to header (in)	Dim. from header to refnet joint(in)	Dim. From refnet joint to refnet joint(in)	Dim. From refnet joint to outdoor(in)
shop	5/8 X 3/8	1 1/8 X 1/2	-------	1 5/8 X 3/4
restaurant	5/8 X 3/8	1 3/8 X 3/4	-------	

Table2-15:Specification of pipes and joints for riser 1 .

Name of the room	Dim. from indoor to header (in)	Dim. from header to refnet joint(in)	Dim. From refnet joint to refnet joint(in)	Dim. From refnet joint to outdoor(in)
mosque	5/8 X 3/8	1 1/8 X 1/2	------	1 5/8 X 3/4
room1	5/8 X 3/8	1 1/8 X 1/2	1 3/8 X 3/4	
room2	5/8 X 3/8			
room3	5/8 X 3/8			
room4	5/8 X 3/8			
room5	5/8 X 3/8			
room6	5/8 X 3/8			
majlis1	5/8 X 3/8	7/8 X 3/8	1 1/8 X 5/8	
majlis2	5/8 X 3/8			

Table2-16:Specification of pipes and joints for riser 3 .

Name of the room	Dim. from indoor to header (in)	Dim. from header to refnet joint(in)	Dim. From refnet joint to refnet joint(in)	Dim. From refnet joint to outdoor(in)
room1	5/8 X 3/8	7/8 X 3/8	1 3/8 X 3/4	1 3/8 X 3/4
room2	5/8 X 3/8			
room3	5/8 X 3/8			
room4	5/8 X 3/8			
room5	5/8 X 3/8			
room6	5/8 X 3/8	1 1/8 X 1/2	-------	
room7	5/8 X 3/8			
room8	5/8 X 3/8			
room9	5/8 X 3/8			
room10	5/8 X 3/8			
room11	5/8 X 3/8			
account	5/8 X 3/8	3/4 X 3/8	1 3/8 X 3/4	
manag	5/8 X 3/8			
secer	5/8 X 3/8			
room	5/8 X 3/8			

3 Chapter 3: Heating load

3.1 Outdoor and indoor design conditions

These conditions are include the dry bulb temperature, relative humidity, and the average air speed. We obtain this values from Meteorological and the psychometric chart.

Table 3-1: Outdoor design conditions:

Season	T_{out} (°C)	ϕ_{out}%	v_{out} (m^3/kg dry air)	h_{out} (kj/kg)
Heating	10	66.4	0.845	49

Table 3-2:Indoor design conditions:

Season	T_{in} (°C)	ϕ_{in}%	h_{out} (kj/kg)
Heating	24	40	46

3.2 Heat loss calculations

The main resources of heat losses comes from the walls, floor, ceiling, doors, and windows. To calculate each one of them we use the following equation:

$$Q = A \times U \times (T_{in} - T_{out}) \quad (3.1)$$

Where:

Q : The heat transfer rate (W).

A : Area of the layer which heat flow through it (m^2).

ΔT : The difference between the inside and outside temperatures (°C).

U: The overall heat transfer coefficient (W/ m^2 . °C).

3.2.1 Rate of heat transfer from the external walls:

From Table 2-4 and Figure 2 we know the construction of the external walls, then by using equation (3.1), we can determine the rate of heat transfer for the restaurant as follow :

$$Q_{walls.out} = U_{walls.out} \times A_{walls.out} \times \ T_{in} - T_{out}$$

$$Q_{walls.out} = 0.833 \times 746 \times \ 24 - 10$$

$$Q_{walls.out} = 11.8 \text{ kW}$$

3.2.2 Rate of heat transfer from the ceiling:

From Table 2-6 and Figure 4 we know the construction of the ceiling, then by using equation (3.1), we can determine the rate of heat transfer for the restaurant from the ceiling as Follow :

$$Q_{Roof} = U_{Roof} \times A_{Roof} \times \ T_{in} - T_{out}$$

$$Q_{Roof} = 0.925 \times 398 \times \ 24 - 10$$

$$Q_{Roof} = 6.9 \text{kW}$$

3.2.3 Rate of heat transfer from the ground:

by using the equation (3.1), we can determine the rate of heat transfer for the restaurant from the ground as Follow :

$$Q_{Ground} = U_{Ground} \times A_{Ground} \times \ T_{in} - T_{out}$$

$$Q_{Ground} = 1.038 \times 398 \times \ 24 - 16$$

$$Q_{Ground} = 7.8 \text{ kW}$$

3.2.4 Rate of heat transfer from the doors and windows:

By using the equation (3.1), we can determine the rate of heat transfer for the restaurant from the doors and windows as follow:

Doors:

$$Q_{door} = U_{door} \times A_{door} \times T_{in} - T_{out}$$

$$Q_{door} = 2.4 \times 16.5 \times 24 - 10$$

$$Q_{door} = 0.75 \text{ kW}$$

Windows:

$$Q_{windows} = U_{windows} \times A_{windows} \times T_{in} - T_{out}$$

$$Q_{windows} = 3.2 \times 15.2 \times 24 - 10$$

$$Q_{windows} = 0.9 \text{ kW}$$

3.2.5 Heat loss due to infiltration:

Infiltration is the leakage of the outside air through cracks or clearances around the windows and doors. We use the crackage method to calculate it as follow:

For windows :

$$Q_{infiltration} = m_{inf} \times (h_o - h_i) \quad (3.2)$$

$$m_f = \frac{V_f}{v_0} \quad (3.3)$$

$$V_f = \text{crack length} \times \text{Infiltration through windows} \quad (3.4)$$

Where V_f is obtained from table 6-1 at 8 km/h as $2m^3/h$ per meter of crack. the crack length of the five double hung metal windows is :

$$L = 5 \times 2 \times \ 1.1 + 3 \ = \ 41 \text{ m} .$$

$$V_f = 41 \ \times 2 = 82 \frac{m^3}{h} = \frac{82}{3600} = 0.02277 \ \frac{m^3}{s} .$$

$$m_f = \frac{0.02277}{0.846} = 0.0269 \text{ Kg/s}.$$

$v_0 = 0.907 \ m^3/kg$

Then total heat loss due to infiltration is :

$$Q_{infiltration} = 0.0269 \times 1 \ \times (49 - 46) = 4.3 \ \text{kW}$$

<u>For Doors :</u>

$$Q_{infiltration} = m_f \ \times (h_o - h_i)$$

$$m_f = \frac{V_f}{v_0}$$

$$V_f = \text{ crack length} \times \text{Infiltration through doors}$$

$$L = 2 \times 2 \times \ 2 + 3 \ + 2 \times \ 1.25 + 3 \ = \ 28.5 \text{ m} .$$

$$V_f = 28.5 \ \times 5.4 \ = 153.9 \frac{m^3}{h} = \frac{153.9}{3600} = \ 0.0427 \ \frac{m^3}{s} .$$

Where V_f is obtained from table 6-1 at 8 km/h as $5.4 \ m^3/h$ per meter of crack. the crack length of the tow poorly fitted foor is :

$$m_f = \frac{0.0427}{0.846} = 0.05 \text{ Kg/s}.$$

$v_0 = 0.907 \ m^3/kg$

Then total heat loss due to infiltration is :

$Q_{infiltration}$ = 0.05 × 1 × (49 - 46) = 2.8 kW

3.2.6 Heat loss due to ventilation:

$$Q_{ventilation} = m_{ventilation} \times h_{out} - h_{in} \quad (3.5)$$

$$m_v = \frac{V_v}{v_o} \quad (3.6)$$

V_v = minimum outside air requirements ventilation × No.of persosn (3.6)

minimum outside air requirements ventilation from Table 5-4

Also, from the psychrometric chart, at the given outside conditions then the specific volume v_0 of outside air is :

$v_0 = 0.846\ m^3/kg$

$$m_v = \frac{75 \square (7l/s)}{0.846(1000)} = 0.62\ kg/s$$

Then total heat loss due to ventilation is :

$Q_{ventilation} = 0.62 \times 1000 \times 49 - 46$

$Q_{ventilation} = 1.86\ kW$

Finally, the total load for this restaurant is the summation of all the heat gain resources .

$$\mathbf{Q_{total} = 11.8 + 6.9 + 7.8 + 0.75 + 0.9 + 6.2 + 1.86}$$

$$\mathbf{Q_{total} = 36.2\ kW}$$

Table 3-3: The heating load for each room in the building:

Name of room	Cooling load (kW)	Area (m²)	Name of room	Cooling Load (kW)	Area (m²)
Ground Floor			**First Floor**		
shop	31.15	369.45	**room1**	3.2	33.01
restaurant	36.2	398	**room2**	2.7	31.5
mosque	14.9	167.57	**room3**	2.9	31.5
room1	4.1	33.31	**room4**	2.8	31.5
room2	3.4	31.5	**room5**	3	33
room3	3.4	31.5	**room6**	3.1	33.3
room4	3.4	31.5	**room7**	2.6	31.5
room5	3.4	31.5	**room8**	2.8	31.5
room6	4.1	33.31	**room9**	2.7	31.5
majlis1	7.1	66.03	**room10**	2.4	31.5
majlis2	8.4	80.34	**room11**	2.9	33.3
			account	3	16.5
			manag	2.6	12.4
			secer	1.9	10.2
			room	2.8	21.6

3.3 Mechanical ventilation

The purpose of ventilation is to provide fresh air for comfort and to ensure healthy indoor air quality by diluting contaminants to provide fresh air, moisture, odors, and other pollutants can build up inside a home.

Mechanical ventilation systems circulate fresh air using ducts and fans, rather than relying on air flow through small holes or cracks in a home's walls, roof, or windows. Homeowners can breatheeasier knowing their home has good ventilation...

3.3.1 How ventilation system work?

A variety of mechanical ventilation systems are available to select, based on local climate and the home's heating and cooling system. In addition to one of the primary systems described below, "spot" ventilation fans should also be provided for kitchens and baths to remove the concentrated moisture and odors that can occur in these rooms.

3.3.2 Ventilation benefits

• Better Indoor Air Quality. Indoor air can be many times more polluted than outdoor air. Ventilation systems can significantly improve a home's air quality by removing allergens, pollutants, and moisture that can cause mold problems.

• More Control. When homes rely on air flow through walls, roofs, and windows for ventilation, there is no control over the source or amount of air that comes into the house. In fact, air leaking into the house may come from undesirable areas such as the garage. Mechanical ventilation systems provide proper fresh air flow along with appropriate locations.

• Improved Comfort. Mechanical ventilation systems allow a constant flow of outside air into the home and can also provide filtration, dehumidification, and conditioning of the incoming outside air.

3.3.3 Design air ventilation

we used Ventilation Rates Calculator 2015 program to calculate required Ventilation for Kitchen and bathrooms.

Space	L/s.person	L/s.m²	Occ Density
Media center	2.5	0.6	25
Music/theater/dance	2.5	0.3	35
Multi-use assembly	2.5	0.3	100
Restaurant dining rooms	2.5	0.9	70
Cafeteria/fast-food dining	2.5	0.9	100
Bars, cocktail lounges	2.5	0.9	100
Kitchen (cooking)	2.5	0.6	20

Figure 6:Calculation the Ventilation by program for kitchen

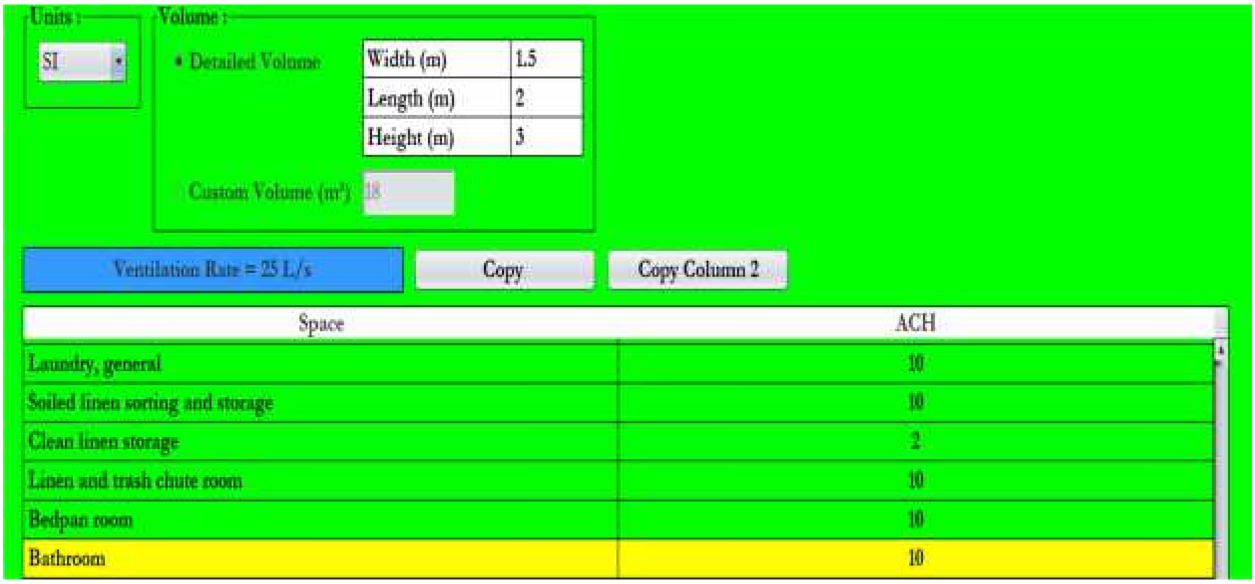


Figure 7:Calculation the Ventilation by program for bathroom

Table 3-4 Description of fans used for air change

Type fan	Flow Rate (L/s)	Working principle	Dimension (cm)
Lineo 100 Q V0	43.1	Polluted air outlet	15X23
M 100/4	25	Fresh air inlet and Polluted air outlet	15X16
M 120/5	48.6	Fresh air inlet and Polluted air outlet	17X18

4 Chapter 4 : Plumbing System

4.1 Water supply system

4.1.1 Fixture unit load calculations:

In this section calculate the total amount of cold and hot water in the that required for the restaurant. By using the water supply fixture unit technique. We use this technique because we have a huge number of fixture units and that make this technique more accurate.

4.1.1.1 Fixture unit load for the collector in restaurant

Table 4-1:The fixture units load for collector A:

Fixture Type	No. of Fixture unit	Load per Fixture unit	Total load for cold water	Total load for hot water
Water closet (G)	3	5	15	0
Lavatory (G)	3× 3/4	2	6	4.5
		Total (FU)	**21**	**4.5**
		Total (gpm)	**15**	**5**

Table 4-2:The fixture units load for collector B:

Fixture Type	No. of Fixture unit	Load per Fixture unit	Total load for cold water	Total load for hot water
Water closet (G)	3	5	15	0
Lavatory (G)	3× 3/4	2	6	4.5
		Total (FU)	**21**	**4.5**
		Total (gpm)	**15**	**5**

Table 4-3:The fixture units load for collector C:

Fixture Type	No. of Fixture unit	Load per Fixture unit	Total load for cold water	Total load for hot water
Water closet (G)	2	5	10	0
Lavatory (G)	2 × 3/4	2	4	3
Kitchen Sink	1 × 3/4	4	4	3

Shower head (G)	1 × 3/4	5	5	3.75
		Total (FU)	**23**	**9.75**
		Total (gpm)	**16**	**8**

Table 4-4:Table for estimating demand for collector 1:

The total amount of cold and hot water	Total load WSFU	Total Demand gpm
Total demand for cold water	21	---
Total demand for hot water	4.5	---
Total (FU)	25.5	17

Table 4-5:Table for estimating demand for collector 2:

The total amount of cold and hot water	Total load WSFU	Total Demand gpm
Total demand for cold water	21	---
Total demand for hot water	4.5	---
Total (FU)	25.5	17

Table 4-6:Table for estimating demand for collector 3:

The total amount of cold and hot water	Total load WSFU	Total Demand gpm
Total demand for cold water	23	---
Total demand for hot water	9.75	---
Total (FU)	32.75	22

The total amount of cold and hot water supply fixture unit for collector 3 is 23 WSFU and 9.75 WSFU. After determined the amount of WSFU we use the table for estimating demand to calculate the total required amount of cold and hot water which is 22 gallon per minute (gpm).

4.1.2 Friction method

The water velocity in the piping system in building is not preferred to exceed 8fps. Outside building it may exceed 8 fps. Note: (1m = 3.28 ft).

Calculate sizing pipe for collector1 cold water.

1) The maximum instantaneous cold water demand is 21, And from table 9-4 by interpolation : 45FU = 15 gpm

2) Static head = floor to floor height + tank outlet height – sink faucet outlet height

Static head =((2 + 7.95 – 1)/0.33 ×0.433 = 11.74 ft

3) Total Equivalent length (TEL) = ((2 + 1.3+7.95+4.6+1)/0.33) × 1.5 = 77ft

4) Minimum flow pressure at the critical fixture = 8psi , from table 9-1

5) friction head = static pressure +min. flow pressure

friction head = 11.74 – 8 = 3.74 psi

6) friction loss = friction head / TEL

=3.74/(0.77 × 100) = 4.85 psi/100ft

7) From figure 9-5 steel pipes :-

Flow rate = 15 gpm
Friction head loss = 4.85 psi/100ft } pipe size = 1"

Calculate sizing pipe for collector1 hot water:-

1) The maximum instantaneous hot water demand is 21, And from table 9-4 by interpolation : 4.5FU = 5 gpm

2) Static head = floor to floor height + tank outlet height – sink faucet outlet height

Static head =((2 + 7.95 – 1)/0.33 ×0.433 = 11.74 ft

3) Total Equivalent length (TEL) = ((2 + 1.5+7.95+2.4+1)/0.33) × 1.5 = 68 ft

4) Minimum flow pressure at the critical fixture = 8psi , from table 9-1

5) friction head = static pressure +min. flow pressure

friction head = 11.74 – 8 = 3.74 psi

6) friction loss = friction head / TEL

=3.74/(0.68 × 100) = 5.5 psi/100ft

7) From figure 9-5 steel pipes :-

Flow rate = 5 gpm
Friction head loss = 5.5 psi/100ft } pipe size = 3/4"

4.1.3 Calculation of branch and riser :-

4.1.3.1 Table shows the sizing pipe for cold water

Table 4-7 : The sizing pipe for cold water on the ground floor :

Riser	Flow rate (gpm)	Total equivalent length (ft)	Friction (psi/100ft)	Pipe size (inch)	Velocity (fps)
Riser1	15	77	4.85	1"	5
Riser2	15	77	4.85	1"	5
Riser3	16	68	5.5	3/4"	5
Riser4	18	111	6.3	1 1/4"	6
Riser5	18	115	6	1 1/4"	6
Riser6	19	165	3.8	1 1/4"	5
Riser7	19	102	6.17	1 1/4"	6
Riser8	19	90	7	1 1/4"	6

Table 4-8 : The sizing pipe for cold water on the first floor :

Riser	Flow rate (gpm)	Total equivalent length (ft)	Friction (psi/100ft)	Pipe size (inch)	Velocity (fps)
Riser9	17	99	1.2	1 1/2"	3
Riser10	23	94	1.3	1 1/2"	5
Riser11	29	169	0.7	2"	3
Riser12	29	151	0.8	2"	3
Riser13	29	72	1.6	2"	4
Riser14	9	77	3.2	1"	4

4.1.3.2 Table shows the sizing pipe for hot water

Table4-9: The sizing pipe for hot water on the ground floor :

Riser	Flow rate (gpm)	Total equivalent length (ft)	Friction (psi/100ft)	Pipe size (inch)	Velocity (fps)
Riser1	5	75	4.98	3/4"	5
Riser2	5	75	4.98	3/4"	5
Riser3	8	69	5.3	1"	5
Riser4	5	113	6.2	3/4"	5
Riser5	5	114	6.1	3/4"	5
Riser6	8	166	3.8	1"	4
Riser7	8	100	6.3	3/4"	5
Riser8	8	92	6.8	3/4"	5

Table 4-10 : The sizing pipe for hot water on the first floor :

Riser	Flow rate (gpm)	Total equivalent length (ft)	Friction (psi/100ft)	Pipe size (inch)	Velocity (fps)
Riser9	8	100	1.2	1 1/4"	3
Riser10	12	95	1.3	1 1/4"	3
Riser11	15	168	0.7	2"	3
Riser12	15	150	0.8	2"	3
Riser13	15	73	1.6	2"	3
Riser14	2	78	3.2	1/2"	3

4.2 Drainage system

The wastewater system should be designed, constructed, and maintained to guard against fouling, deposit of solids, and clogging. And the foul air in the wastewater system should be exhausted to the outside, through vent pipes.

We made our calculations using the table of drainage fixture unit values for various plumbing fixture to find the amount of drainage fixture unit (dfu). Then we use the table of horizontal fixture branch and stuck to determine the diameters of the pipes.

4.2.1 Table shows the drainage fixture unit and sizing the stack

Table 4-11 : Sizing of stack 1:

Stack 1			Horizontal branch		
Section	**Total (dfu)**	**Pip size (inch)**	**Branch (section)**	**Total (dfu)**	**Pipe size (inch)**
from ground floor to manhole drain	-----	-----	From ground floor	24	4

Table 4-12: Sizing of stack 2:

Stack 2			Horizontal branch		
Section	**Total (dfu)**	**Pip size (inch)**	**Branch (section)**	**Total (dfu)**	**Pipe size (inch)**
from ground floor to manhole drain	-----	-----	From ground floor	24	4

Table 4-13: Sizing of stack 3:

Stack 3			Horizontal branch		
Section	**Total (dfu)**	**Pip size (inch)**	**Branch (section)**	**Total (dfu)**	**Pipe size (inch)**
from ground floor to manhole drain	-----	-----	From ground floor	20	3

Table 4-14 : Sizing of stack 4:

Stack 4			Horizontal branch		
Section	**Total (dfu)**	**Pip size (inch)**	**Branch (section)**	**Total (dfu)**	**Pipe size (inch)**
from ground floor to manhole drain	-----	-----	From ground floor	6	2

Table 4-15: Sizing of stack 5:

Stack 5			Horizontal branch		
Section	**Total (dfu)**	**Pip size (inch)**	**Branch (section)**	**Total (dfu)**	**Pipe size (inch)**
from ground floor to manhole drain	-----	-----	From ground floor	30	4

Table 4-16: Sizing of stack 6:

Stack 6			Horizontal branch		
Section	**Total (dfu)**	**Pip size (inch)**	**Branch (section)**	**Total (dfu)**	**Pipe size (inch)**
from ground floor to manhole drain	-----	-----	From ground floor	30	4

Table 4-17:Sizing of stack 7:

Stack 7			Horizontal branch		
Section	**Total (dfu)**	**Pip size (inch)**	**Branch (section)**	**Total (dfu)**	**Pipe size (inch)**
from first floor to ground floor	10	4	From first floor	10	4
from ground floor to manhole drain	10	4	From ground floor	-----	-----

Table 4-18:Sizing of stack 8:

Stack 8			Horizontal branch		
Section	**Total (dfu)**	**Pip size (inch)**	**Branch (section)**	**Total (dfu)**	**Pipe size (inch)**
from first floor to ground floor	10	4	From first floor	10	4
from ground floor to manhole drain	10	4	From ground floor	-----	-----

Table 4-19:Sizing of stack 9:

Stack 9			Horizontal branch		
Section	**Total (dfu)**	**Pip size (inch)**	**Branch (section)**	**Total (dfu)**	**Pipe size (inch)**
from first floor to ground floor	10	4	From first floor	10	4
from ground floor to manhole drain	10	4	From ground floor	-----	-----

Table 4-20: Sizing of stack 10:

Stack 10			Horizontal branch		
Section	**Total (dfu)**	**Pip size (inch)**	**Branch (section)**	**Total (dfu)**	**Pipe size (inch)**
from first floor to ground floor	10	4	From first floor	10	4
from ground floor to manhole drain	10	4	From ground floor	-----	-----

Table 4-21: Sizing of stack 11:

Stack 11			Horizontal branch		
Section	**Total (dfu)**	**Pip size (inch)**	**Branch (section)**	**Total (dfu)**	**Pipe size (inch)**
from first floor to ground floor	10	4	From first floor	10	4
from ground floor to manhole drain	10	4	From ground floor	-----	-----

Table 4-22: Sizing of stack 12:

Stack 12			Horizontal branch		
Section	**Total (dfu)**	**Pip size (inch)**	**Branch (section)**	**Total (dfu)**	**Pipe size (inch)**
from first floor to ground floor	20	4	From first floor	20	4
from ground floor to manhole drain	20	4	From ground floor	-----	-----

Table 4-23: Sizing of stack 13:

Stack 6			Horizontal branch		
Section	**Total (dfu)**	**Pip size (inch)**	**Branch (section)**	**Total (dfu)**	**Pipe size (inch)**
from ground floor to manhole drain	-----	-----	From ground floor	20	4

Table 4-24: Sizing of stack 14:

Stack 12			Horizontal branch		
Section	**Total (dfu)**	**Pip size (inch)**	**Branch (section)**	**Total (dfu)**	**Pipe size (inch)**
from first floor to ground floor	20	4	From first floor	20	4
from ground floor to manhole drain	20	4	From ground floor	-----	-----

Table 4-25: Sizing of stack 15:

Stack 6			Horizontal branch		
Section	**Total (dfu)**	**Pip size (inch)**	**Branch (section)**	**Total (dfu)**	**Pipe size (inch)**
from ground floor to manhole drain	-----	-----	From ground floor	20	4

Table 4-26: Sizing of stack 16:

Stack 12			Horizontal branch		
Section	**Total (dfu)**	**Pip size (inch)**	**Branch (section)**	**Total (dfu)**	**Pipe size (inch)**
from first floor to ground floor	20	4	From first floor	20	4
from ground floor to manhole drain	20	4	From ground floor	-----	-----

Table 4-27: Sizing of stack 17:

Stack 6			Horizontal branch		
Section	Total (dfu)	Pip size (inch)	Branch (section)	Total (dfu)	Pipe size (inch)
from ground floor to manhole drain	-----	-----	From ground floor	20	4

Table 4-28: Sizing of stack 18:

Stack 12			Horizontal branch		
Section	Total (dfu)	Pip size (inch)	Branch (section)	Total (dfu)	Pipe size (inch)
from first floor to ground floor	14	4	From first floor	14	4
from ground floor to manhole drain	14	4	From ground floor	-----	-----

Table 4-29: Building drain:

Branch of building drain from stack	Total dfu value from stacks	Diameter of building drain (inch)	Slope %	Velocity ft/s
Building drain from stack 1	24	4	1 2	3.86
Building drain from stack 2	24	4	1 2	3.86
Building drain from stack 3	20	3	1 2	3.19
Building drain from stack 4	6	2	1 2	2.43
Building drain from stack 5	30	4	1 2	3.86
Building drain from stack 6	30	4	1 2	3.86
Building drain from stack 7	10	4	1 2	3.86
Building drain from stack 8	10	4	1 2	3.86
Building drain from stack 9	10	4	1 2	3.86

Building drain from stack 10	10	4	1 2	3.86
Building drain from stack 11	10	4	1 2	3.86
Building drain from stack 12	20	4	1 2	3.86
Building drain from stack 13	20	4	1 2	3.86
Building drain from stack 14	20	4	1 2	3.86
Building drain from stack 15	20	4	1 2	3.86
Building drain from stack 16	20	4	1 2	3.86
Building drain from stack 17	20	4	1 2	3.86
Building drain from stack 18	14	4	1 2	3.86

5 Chapter 5: Firefighting System

property management is entrusted with the responsibility of protecting and preserving an institution's buildings, collections, operations and occupants. Constant attention is required to minimize adverse impact due to climate, pollution, theft, vandalism, insects, mold and fire. Because of the speed and totality of the destructive forces of fire, it constitutes one of the more serious threats. An uncontrolled fire can obliterate an entire room's contents within a few minutes and completely burn out a building in a couple hours.

The first step toward halting a fire is to properly identify the incident, raise the occupant alarm, and then notify emergency response professionals. This is often the function of the fire detection and alarm system. Several system types and options are available, depending on the specific characteristics of the protected space.

Fire fighting systems and equipment vary depending on the age, size, use and type of building construction. A building may contain some or all of the following features:

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

In the following sections each feature is to be described.

5.1 Fire extinguisher

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

The following table shows the principle use for different extinguishing agent :

ID sign	Typical appearance	Extinguisher Type Cylinder contains	**Class A** Wood, paper, textiles etc, normal combustibles	**Class B** Flammable liquids, petrol, paints	**Class E** Electrical fires	**Class F** Cooking oil, animal fats & vegetable oils
		Dry Chemical Powder	YES	YES	YES	NO
		Co2 Carbon Dioxide	NO	YES	YES	NO
		Water	YES	NO	NO	NO
		Foam	YES	YES	NO	NO
		Wet Chemical	YES	NO	NO	YES

Figure 8: Fire extinguisher rating guide

Fire extinguisher locations must be clearly identified. It is the policy of the Community Safety , Department that fire extinguishers be logically grouped at exits from the building, so that occupants first go to the exit and then return to fight the fire, knowing that a safe exit behind them away from the fire. In some instances this will be at odds with the prescriptive requirements of Australian Standard AS2444 Portable fire extinguishers and fire blankets - Selection and location which simply specifies a distance of travel to a fire extinguisher rather than their location in relation to escape paths.

5.2 Fire hose reel

Fire Hose cabinet should be installed according to NPFA 14 and shown in drawings:

1-Near escape stairs

2- 30 m(100ft) length of the pipe which is the distance traveled by the pipeline passing barriers and walls until it reaches the fire place .

3- Next to the main door of the building.

4- Fire house cabinet height above the ground (90-150)cm.

Note: all Fire Hose cabinet distribution is shown on drawings..

Fire house cabinet includes two types:

a) Hose Reel :

Figure 9: Hose Reel

b) Hose Rack:

Figure10 : Hose Rack

5.3 Fire hydrant system

Located in the street and it is used in case that we couldn’t overcome the fire from inside the building .

Fire Hydrant should be installed according to NPFA 14:

-A pipe with 4’’ diameter branched into two pipes each with 2.5’’diameter with a flow of 250 gpm.

Figure 11: Fire hydrant

5.4 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 .

5.5 Smoke sensor

A smoke detector is a device that senses smoke, typically as an indicator of fire. Commercial security devices issue a signal to a fire pump to open Automatically as part of a fire alarm system.

Figure 12: Smoke sensor

5.6 Pumps room

5.6.1 Component and equipment used

In any fire fighting system we need water to be pumped until it reaches the desired fire place .

1- Gate valve

2- check valve : It prevents back flow, and allows only flow in on direction, and is installed in pump discharge line directly to prevent pumps from starting at a load or at the system pressure.

3- Suction header: It prevents vortex

4- Discharge header

5- Diesel pump: It’s a 100% stand-by pump, operates in case of power failure with the failure of pressure make up process by the electric pump, or to even with the present of power if failure of pressure make up process.

6- Jockey pump :It’s the first pump to start in case of fire, It operates as a pressure maintenance pump so in case of a leakage in the system pressure it will makes the system pressure as recommended, and A jockey pump should be sized to make up the allowable leakage rate within10 minutes or 1GPM (3.8 L/min), whichever is larger, and is used for this job instead-off starting the electric pump to protect it from starting until a serious problem occurs.

7- Electric pumps : It’s the second pump to start in case of fire; it's the 100% duty pump.

8- Pressure relief valve : A valve being set at a pressure higher than the system pressure or shut off pressure of the diesel pump to protect the system from the very high pressure generated by the diesel pump in case of sudden acceleration.

The relief valve shall be located between the pump and the pump discharge check valve and shall be so attached that it can be readily removed for repairs without disturbing the piping.

Note: - locations of all gate valves in the pump room are mainly for make ease maintenance for each component in the room and without loss water in pipes as possible as we can and for make maintenance which stops the system 100 % is very not possible as we can.

9- Flow switch It gives signal when a flow happened in a pipe.

10- Fuel tank Which is used in diesel pump

5.6.2 Shut off of the pumps

1- The Jockey pumps stops automatically when the pressure in pipes reached its rated pressure.
2- The Electric pump stops after reached the rated pressure by 10 minutes.
3- The Diesel pump stops after 30minutes after reaching its rated pressure.

5.7 Pipe size calculation

The fire hose reel system is to be used, so the pipe size for this system will be calculated as follows:

The minimum flow rate for single cabinet = 23 (l/min) .

Then:

$$\text{The total flow rate} = \text{min. flow rate} \times \text{No. of cabinet}$$

$$\text{The total flow rate} = 23 \times 6 = 138 \ \text{L/min} = 8.22 \ \text{m}^3/\text{h} = 36.16 gpm$$

Table 5-1:Pipe schedule for supply piping

Total Accumulated Flow		Total Distance of Piping from Farthest Outlet		
L/min	gpm	<15.2 m (<50 ft)	15.2–30.5 m (50–100 ft)	>30.5 m (>100 ft)
379	100	2	2½	3
382–1893	101–500	4	4	6
1896–2839	501–750	5	5	6
2843–4731	751–1250	6	6	6
4735	1251 and over	8	8	8

Note: For SI units, 3.785 L/min = 1 gpm; 0.3048 m = 1 ft.

Then the

is to be used to calculate the pipe size by follow the next procedure. First, the total flow Table rate is determined which is 138 l/min for our calculation sample. Then the total distance of piping from farthest outlet is to be chose. Finally, the intersection between the two values in

Table will give the size of pipe supply which is equal to 3".

Standpipes are classified in NFPA 14 into the following three groups on the basis of hose size and use:

- Class I: Provided with 2½-inch hose stations and intended primarily for use by fire department personnel and not by building occupants.

- Class II: Provided with 1½-inch hose stations and intended for use by building occupants as well as by fire department personnel.
- Class III: Provided with 1½-inch and 2½-inch hose stations and intended for use by building occupants as well as by fire department personnel.

Then to determine the outlet pipe size from pipe supply to hose connection the class of the building must be chose from the NFPA. For this building the class is chose to be class II. A class II referred to NFPA means: standpipe system provides (1½-in.) hose stations to supply water for use primarily by the building occupants or by the fire department during initial response. According to the NFPA 14 the pressure required for the (1½-in.) pipes is 6.9 bar.

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6 Chapter 6 : Photovoltaic System

There are tow system :

- **On-Grid system**
- **Off-Grid Solar system**

6.1 On grid solar

Definition: On-Grid Systems are solar PV systems that only generate power when the power grid is available and interface with the grid to send excess power out when you are over producing so you can bank it for later use.

Benefits: These are simplest systems and the most cost effective to install. These systems will pay for themselves by offsetting utility bills in 6-10 yrs.

Downside: These do not provide power during a grid outage.

6.2 Off grid solar

Definition: These systems allow you to store your solar power in batteries for use when the power grid goes down. Additionally, they provide power to offset the grid power whenever the sun is shining and will even send excess power to the grid to bank if for later use.

Benefits: Provides power for critical loads when they power grid is down.

Downside: Cannot be expected to provide power for all loads since the cost and volume of batteries would be prohibitive. Off-Grid systems require a lot more specialized equipment to function that is more costly and more complex to install. Specifically they require a central/string inverter, a charge controller as well as a batteries.

Sizing the solar array and the batteries required is complex. Detailed analysis of requirements will be needed to provide for minimal critical needs. You'll also need to rewire you main electrical panel to isolate the "critical loads" so that only they are provided power in an outage. This means that your well pump, refrigerator and a few lights are provided power while your air conditioners and TV and other non-essential loads are not.

This is definitely not a homeowner installable system. Installing it is both dangerous and complex. Also, batteries are expensive, require ongoing maintenance and periodic replacement.

Given the additional specialized equipment required and the fact that it required expert installation, expect a off-grid system to cost four(4) times as much to install per watt and to require ongoing maintenance outlays.

6.3 Calculation

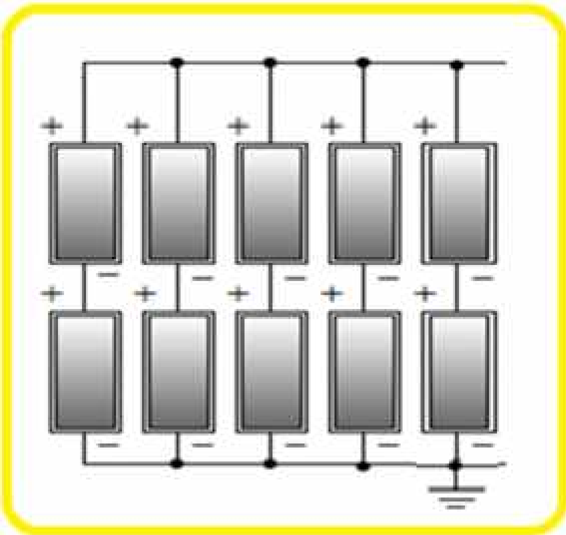


Figure 13: panel in series

$$V_{Rated} = N \times Vmpp \quad (6.1)$$

N : panel in series (shown on drawings)

Vmpp : Voltage at maximum power from data sheet.

V_{Rated} = 2 x 36.1= 72.2 volt/string.

the inverter range from data sheet is (44-85) volt so is 72.2V Acceptable.

We can use 76 panel on different surfaces of the Building.

$$\text{Area of panels} = number\ of\ panels\ X\ area\ of\ one\ panel \quad (6.2)$$

* Area of one panel from data sheet (1966mm X 1000mm X 50mm)

Area of panels = 76 X 1.966 = 149 m^2

Area Of the roof that we need = $\frac{\text{Area of panels}}{0.4} = \frac{149}{0.4} = 372.5\ m^2$

P_{DC} = 1k X µpv $X are\ of\ panel$ = 1000 X 14% X 149 = 20860m^2

module efficiency µpv $from\ data\ sheet$.

P_{AC} = µConventional X Pdc = 75% X 20860 = 15645 W

:

Data Sheet For the Inverter.

Manufacturer:	Xantrex	Xantrex	Xantrex	Sunny Boy	Sunny Boy
Model:	STXR1500	STXR2500	PV 10	SB2000	SB2500
AC power:	1500 W	18,000 W	10,000 W	2000 W	2500 W
AC voltage:	211–264 V	211–264 V	208 V, 3Φ	198–251 V	198–251 V
PV voltage range MPPT:	44–85 V	44–85 V	330–600 V	125–500 V	250–550 V
Max input voltage:	120 V	120 V	600 V	500 V	600 V
Max input current:	—	—	31.9 A	10 A	11 A
Maximum efficiency:	92%	94%	95%	96%	94%

7 Chapter 7: Bills Of Quantity

Table 7-1:Bills of quantities for pilgrims rest building :

PLUMBING, SANITARY AND MECHANICAL WORKS					
No.	**Work Description**	**Unit**	**Qut.**	**Unit Price US $**	**Total Price US $**
	Preamble. a- The contractor shall, when pricing the rates of this bill, take into consideration to include and allow for the costs and expenses of all requirements stipulated herein below, drawings and the specifications of the tender. b- The contractor should visit the site to verify the amount of work and familiarize himself with the nature of work for proper construction of the new floors. c- c-The surplus & demolished materials shall be removed out from the site to a dump site approved by the municipality through a pre-coordinated manner to ensure minimal noise and dust pollution within the vicinity and to avoid obstruction for building activities. The contractor should coordinate with the client for any possible materials or elements that need to be preserved and handed over to the client stores. The contractor is requested to equally consider the following notes when quoting his prices: 1- The price shall include all required chipping in concrete walls, cutting holes (any diameter), excavation, backfilling and cement covering as specified. 2- The Contractor is requested to read the bill of quantities in conjunction with the set specifications, drawings, addendums and contract conditions 3- (S & I) implies supply and install, including testing, adjusting,				

	balancing, ….all the way to a successful operation, including the commissioning.				
12.1	Supply and Install porcelain wall mounted W.C white color European type or E.A. Price shall include all fixation and hanging bracket, 8-LT Capacity .(concealed) cistern ,valves ,fitting, hard solid seat and 13mm stop angle valve , chrome plated 13mm hose , and accessories , side 1 m length 13mm chrome plated hand shower for W.C (heavy duty) with spring nozzle outlet and all other required materials, including connection to drainage system and water system including 3/8" angle valve (European type or E.A) and paper holder. All to be done as per drawings, specifications and the approval of the Engineers.	NO.	33	600	19800
12.2	ditto , but for handicapped toilet (creavit type),including all necessary fitting and accessories as shows on drawings and in specifications. price includes supplying and installing 40 * 60 cm mirror	NO.	2	1000	2000
12.3	Supply and install porcelain wall hung semi pedestal wash basin European type class A, size (45* 55) cm. Complete with all fittings, valves, waste pipes to nearest floor trap, taps (mixers) (Class A and approved by Palestine Standards Institution), connection to water distribution, traps, with soap holder and any other necessary parts as Specification and as directed by Eng. Price including supplying and installing 40*60cm Aluminum framed mirror.	NO.	20	500	10000
12.4	Supply and Install White Vitreous European Sink (30 cm. Deep) double bowl. (Class A and approved by Palestine Standards Institution). Complete with all necessary valves, Goose neck taps (mixer) (Class A and approved by Palestine Standards Institution), connection to water distribution, fittings, anti-chemical waste siphon, and any other necessary parts and accessories to complete works per specifications and as directed by Engineer.	NO.	1	450	450
	Total for this page				32250

PLUMBING, SANITARY AND MECHANICAL WORKS					
No.	Work Description	Unit	Qut.	Unit Price US $	Total Price US $
	FORWARDED TOTAL				32250
12.5	a. Supply and Install 4" PVC Floor Trap. "With Quality approval Tag" Price to include siphon to be fixed in reinforced concrete, (20*20) cm double Chrome plated cover one grated and one-closed, the connection with 2'' pipe) And all other fittings needed to comply with specifications and as directed by Engineer.	NO.	45	80	3600
12.7	Supply and Install (Clean Out) UPVC 4'', of Drainage Network. "With Quality approval Tags" In size and location shown in the drawings and where necessary, including all needed to complete work as specification and directed by Eng.	NO.	57	70	3390
12.8	UPVC Drainage Pipe and UPVC Fittings: Supply, installation, testing and commissioning of UPVC drainage and ventilation pipes down to manholes with all required fittings including excavation, back filling, incasing with concrete and roof vent caps, including connections as shown in drawings and in accordance to specifications.				
	a- Size 2-inch diameter. b-	MR	220	12	2640
	c- Size 4-inch diameter. d-	MR	100	19	1900
	d- Size 6-inch diameter. e-	MR	290	35	10150
	e- Size 8-inch diameter. f-	MR	350	45	15750
	Total for this page				37430
	TOTAL CARRIED TO NEXT PAGE				69680

PLUMBING, SANITARY AND MECHANICAL WORKS					
No.	**Work Description**	**Unit**	**Qut.**	**Unit Price US $**	**Total Price US $**
	FORWARDED TOTAL				69680
12.9	Roof Drains: Supply, installation and commissioning of U.P.V.C Rain water(Storm Water) roof drain (Class A and approved by Palestine Standards Institution) .	NO.	8	80	640
12.10	Rain Water pipes: - U.P.V.C rain(storm) water pipes down to a free discharge with wired mesh above ground level, with all required hanging accessories, fittings and vent caps, all as shown in drawings, specifications, and approval of supervisor engineer. U.P.V.C Pipe of 4 -inch diameter.	MR	180	15	2700
12.11	Supply Materials for , and Construct Manholes In compliance with specifications and Drawings. Price to include excavation, concrete works, block works, back filling, cement plaster, benching, Cast Iron cover of weight not less than 50 kg, and bearing capacity load for the cover not less than 8 ton. And all necessary works to comply with drawings and specifications.				
	a. Manholes Ø 50 cm clear size	NO.	19	300	5100
	a. Manholes Ø 60 cm clear size	NO.	9	350	2450
	b. Manholes Ø 80 cm clear size	NO.	14	450	4500
	d. Manholes Ø 100 cm clear size	NO.	2	600	1800
12.12	Supply Materials for , and Construct Manholes Oil separator In compliance with specifications and Drawings. Price to include excavation, concrete works, block works, back filling, cement plaster, benching, Cast Iron cover of weight not less than 50 kg, and bearing capacity load for the cover not less than 8 ton. And all necessary works to comply with drawings and specifications.				
	Manholes Ø 120 cm clear size	NO.	1	950	950
	Total for this page				18140
	TOTAL CARRIED TO NEXT PAGE				87820

PLUMBING, SANITARY AND MECHANICAL WORKS					
No.	**Work Description**	**Unit**	**Qut.**	**Unit Price US $**	**Total Price US $**
	FORWARDED TOTAL				87820
12.13	WATER METER: Supply and install Water meter inside steel box, as per specification, drawings and supervisor engineer. Price includes all galvanized steel main water pipes (Ø ¾”) or more, (Class A and approved by Palestine Standards Institution) with asphalt protection (factory covered), laid underground with all necessary fittings e.g. elbows, T’s, unions, stop valves, non-return valves, automatic air vents, of best quality (Class A and approved by Palestine Standards Institution).	L.S	1	1000	1000
12.14	Supply and install of approved quality local made solar heating unit including 2 solar plates 0.90*1.90m and 200 Lit Cylindrical double jacket galvanized steel tank with glazed lining And also it works in electric powered water heating , the price also includes automatic air vent and all required fittings and connections.	NO.	11	1600	17600
12.15	Galvanized cold & hot water supply pipes: Supply and installation of cold water distribution network of galvanized pipes of various diameters, (Seamless piping as per standard ASTM-A53schedule 40). From roof to sanitary fixture collectors and external water distribution network. Price includes all fittings, T’s, elbows, insulation, etc., and all is needed to complete the works.				
	1- 1/2’’ pipe size	MR	30	14	420
	2- 3/4’’ pipe size	MR	180	18	3240
	3- 1’’ pipe size.	MR	200	26	5200
	4- 1, 1/4’’ pipe size.	MR	90	30	2700
	5- 1, 1/2’’ pipe size.	MR	50	35	1750
	6- 2’’ pipe size	MR	150	43	6450
12.16	Water Filter. The unit price shall include, isolating valves, check valves, pressure relief valve, automatic back wash and all accessories as called for in the Specification.	NO.	1	1000	1000
	Total for this page				39360
	TOTAL CARRIED TO NEXT PAGE				127180

PLUMBING, SANITARY AND MECHANICAL WORKS					
No.	**Work Description**	**Unit**	**Qut.**	**Unit Price US $**	**Total Price US $**
	FORWARDED TOTAL				127180
12.17	Supply and install Hot and cold-water collectors with aluminum box price includes copper collectors, automatic air vent and with all necessary fittings (Italian made), all according to drawings specifications and Engineer's approval.				
	1- size 3/4'' for EYES 24	NO.	14	250	3500
12.18	Supply and install the outlets for hot and cold water feeding lines to the sanitary fixture units (Class A and approved by Palestine Standards Institution), the price includes all needed Pex. Pipes of 16mm diameter and a 2.2mm thickness (type Vesbo or equivalent), with a network connection not less than 75% and a 10 bar pressure ,and isolated by a 1'' PVC pipe for protection , and that's from collector to the sanitary outlet, and copper bent16mm*1/2'' all with its plastic box, all according to drawings specifications and Engineer's approval.	NO.	31	18	558
12.19	Solenoid valve Supply and installation of works by 220 volts natural state is closed for Solenoid valve includes installation and electric wires needed to run made by Spartan Scientific or EA.	NO.	5	50	250
12.20	Supply and install LIFFTING pump in the mechanical room of approved manufacture, including all valves, strainer, pressurized tank, electrical power supply complete with concrete base and connections to rising main, the price include all pipes from pump to roof tanks. All are according to drawings and specifications and approval of supervisor engineer. A 50m3/hr & 27m head.	NO.	2	2500	5000
12.21	Supply and Install PVC White Water Tank Two 2 Cubic meters in size for water system. Price to include well-painted steel stand, automatic float valves, valves, fittings, vents, watertight cover, lock and all necessary works to complete works as per Specifications and drawings.	NO.	13	400	5200
	Total for this page				14508
	TOTAL CARRIED TO NEXT PAGE				141688

PLUMBING, SANITARY AND MECHANICAL WORKS					
No.	**Work Description**	**Unit**	**Qut.**	**Unit Price US $**	**Total Price US $**
	FORWARDED TOTAL				141688
12.22	Supply and install a fire hose cabinet , made of galvanized steel of thickness 1.5 mm , price includes hinges lock, pipes ,valves ,extinguisher Co2 , nozzles ,1 1/2''hose reel ,1 1/2'' linen hose ,and all necessary accessories to be exist inside this fire cabinet as details on drawings and all according to specification and Engineer's approval .	NO.	6	600	3600
12.23	Supply, install, test and commission package type electric driven split case end suction multi-stage booster pump, LPC Approved, for firefighting system. The set is composed of three pumps (one is electrical pump, the second one is a diesel pump, and the third one is a jockey pump), and control panel. The price includes all fittings needed for installation, such as but not limited to, strainers, stop valves, flexible joints, OS & Y valves, non-return valves, ……. On addition to reinforced concrete bases, anti-vibration isolators, pressurized tank, pressure switches, pressure gauges, electric floating valve installed inside well, 2X8" headers at both suction and discharge ports, test line with flow switch with all related accessories, and all needed pipes and fittings inside pumps room, supplying and installing 6" chimney for diesel pump, The pumps specifications are: Electrical Pump 16m Head &138 L/min Water Flow Diesel Pump 16m Head & 138L/min Water Flow Rate Jockey Pump 16m Head &138 L/min Water Flow Rate	NO.	2	22000	44000
12.24	Expansion Tank (closed type). The unit price shall include gate valve, double check valve, safety valve, drain valve. Expansion Tank volume: 100 Gallons .	NO.	1	200	200
12.25	Supply and install Portable Fire Extinguisher each in Location as decided by the Engineer.	NO.	16	80	1280
	Total for this page				49080
	TOTAL CARRIED TO NEXT PAGE				190768

PLUMBING, SANITARY AND MECHANICAL WORKS					
No.	**Work Description**	**Unit**	**Qut.**	**Unit Price US $**	**Total Price US $**
	FORWARDED TOTAL				190768
	Supply and install a Sch-40 fire water pipes (Seamless piping as per standard ASTM-A53 schedule 40). grooved or screwed connections, including all the requested fittings and supports UL/FM approved				
	1- 3'' Sch-40 fire pipes.	MR	100	65	6500
	2- 1 1/2'' Sch-40 fire pipes.	MR	240	45	10800
12.26	a. Supply and install in-line Axial fans of approved manufacture (Vortices or equally approved). Price includes the making necessary holes in glass and fixing, electrical connections. All is according to nearest power point and disconnect switch, drawings, specifications and approval of supervisor engineer.				
	* wall mounted Exhaust fan, capacity 50 cfm	NO.	22	50	1100
	* wall mounted Exhaust fan, capacity 100 cfm	NO.	4	100	400
12.27	b.Supply and install wall-mounted kitchen hood of size 200cm*50cm*100cm. The hood should be made from 316 stainless steel sheets of gauge 14 and equipped with built-in 500 CFM exhaust fan and gravity shutter.	NO.	1	1000	1000
12.28	Supply and installation of solar cells according to the manufacturer's instructions and accounts. The price includes all the required equipment, installation and extension of electric wires and rules for solar cells.	NO.	76	300	22800
12.29	Supply and installation of inverter dc to ac according to the manufacturer's instructions and accounts. The price includes all the required equipment, installation and extension of electric wires and devices to protect network .	NO.	1	3000	3000
	Total for this page				45600
	TOTAL CARRIED TO NEXT PAGE				236368

PLUMBING, SANITARY AND MECHANICAL WORKS					
No.	**Work Description**	**Unit**	**Qut.**	**Unit Price US $**	**Total Price US $**
	FORWARDED TOTAL				236368
12.30	**VRF SYSTEM** Supply, install & commissioning for Heat pump VRF (variable refrigerant Flow) system ,of type Daikin or equivalent Korean brands . Refrigerant R410a.Complete with the outdoor and indoor units, piping & wiring network, control system and all necessary parts needed according to drawings and specifications.				
12.31	**Outdoor Units** Variable refrigerant flow outdoor unit, scroll compressor with invertors drive, refrigerant R 410 A, Outdoor design conditions 24C summer indoor temperature,36C summer outdoor temperature.				
	a- Outdoor unit size30 HP- for riser 3	No.	1	12000	12000
	b- Outdoor unit size 50 HP- for riser 1	No.	1	32000	32000
	c- Outdoor unit size 54 HP- for riser 2	No.	1	35000	35000
12.32	**Indoor Units** The around flow cassette type VRF indoor units with filter, Wall mounted thermostat including on-off, real time clock, schedule timer, fan control, Darin UPVC piping network2'' to nearest floor trap, and temperature set and display. Indoor design conditions 24 C cooling, 50%relative humidity at high speed flow. According to the following capacities:				
	a-Cooling Capacity up to 2.2 kW 60cm x60cm	No.	2	1200	2400
	b-Cooling Capacity up to 3.6 kW,60cm x60cm	No.	1	1300	1300
	e-Cooling Capacity up to 4.5 kW 60cm x60cm	No.	1	1450	1450
	c-Cooling Capacity up to 5.6 kW,60cm x60cm	No.	21	1500	31500
	d-Cooling Capacity up to7.1 kW,60cm x60cm	No.	33	1600	19800
	Total for this page				135450
	TOTAL CARRIED TO NEXT PAGE				371818

PLUMBING, SANITARY AND MECHANICAL WORKS					
No.	**Work Description**	**Unit**	**Qut.**	**Unit Price US $**	**Total Price US $**
	FORWARDED TOTAL				371818
12.33	**Centralized controller** Centralized controller for VRF system to control all indoor units set points, programmed on off operation, and alarms view, to be connected to 170 indoor units.	NO.	1	1500	1500
12.34	**copper piping network** Supply, install & commissioning for copper valves on both liquid and gas lines	NO.	120	70	8400
12.35	All joints Indoore and outdoor unit :				
	a. Refnet	NO.	6	150	900
	b. Header	NO.	8	200	1600
12.36	Supply and installation of solar cells according to the manufacturer's instructions and accounts. The price includes all the required equipment, installation and extension of electric wires and rules for solar cells.	NO.	76	300	22800
12.37	Supply and installation of inverter dc to ac according to the manufacturer's instructions and accounts. The price includes all the required equipment, installation and extension of electric wires and devices to protect network .	NO.	1	3000	3000
	Total for this page				38200
	FORWARDED TOTAL				410018

Appendix

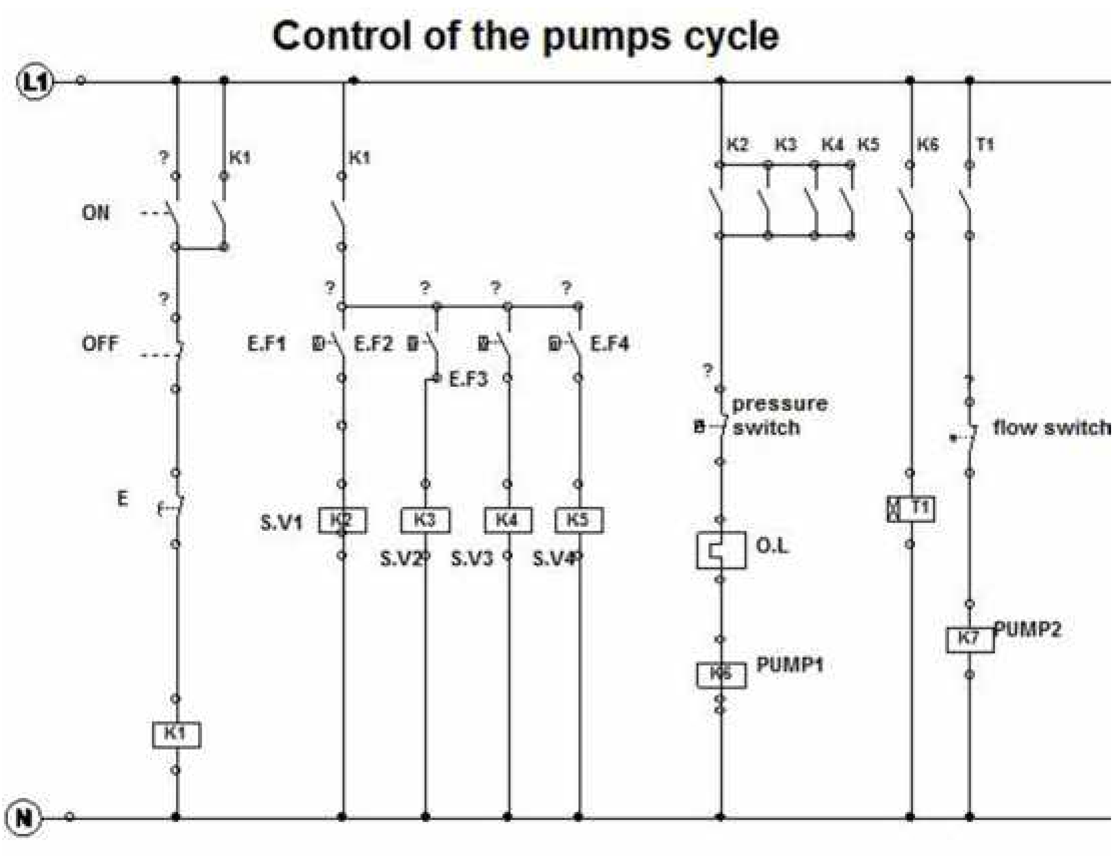

Control of the pumps cycle
L1
N
ON
OFF
E
K1
E.F1
E.F2
E.F3
E.F4
S.V1
S.V2
S.V3
S.V4
K2
K3
K4
K5
K6
T1
pressure switch
flow switch
O.L
PUMP1
K7
PUMP2

TABLE 9–1 Cooling load temperature differences (CLTD) for sunlit roofs, °C.

No.	Roof Description of Construction	U_m W/m²·°C	Solar Time, h 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	Without Suspended Ceiling																									
1	Steel sheet with 25.4 mm (or 50.8 mm) insulation	1.209 (0.704)	0	−1	−2	−2	−3	−2	3	11	19	27	34	40	43	44	43	39	33	25	17	10	7	5	3	1
2	25 mm wood with 25.4 mm insulation	0.963	3	2	0	−1	−2	−2	−1	2	8	15	22	29	35	39	41	41	39	35	29	21	15	11	8	5
3	101.6 mm L.W. concrete	1.209	5	3	1	0	−1	−2	−2	1	5	11	18	25	31	36	39	40	40	37	32	25	19	14	10	7
4	50.8 mm H.W. concrete 25.4 mm (or 50.8 mm) insulation	1.170 (0.693)	7	5	3	2	0	−1	0	2	χ6	11	17	23	28	33	36	37	37	34	30	25	20	16	12	10
5	25.4 mm wood with 50.8 insulation	0.619	2	0	−2	−3	−4	−4	−4	−2	3	9	15	22	27	32	35	36	35	32	27	20	14	10	6	3
6	152.4 mm L.W. concrete	0.897	12	10	7	5	3	2	1	0	2	4	8	13	18	24	29	33	35	36	35	32	28	24	19	16
7	63.5 mm wood with 25.4 mm insulation	0.738	16	13	11	9	7	6	4	3	4	5	8	11	15	19	23	27	29	31	31	30	27	25	22	19
8	203.4 mm L.W. concrete	0.715	20	17	14	12	10	8	6	5	4	4	5	7	11	14	18	22	25	28	30	30	29	27	25	22
9	101.6 mm H.W. concrete with 25.4 mm (or 50.8 mm) insulation	1.136 (0.681)	14	12	10	8	7	5	4	4	6	8	11	15	18	22	25	28	29	30	29	27	24	21	19	16
10	63.5 mm wood with insulation	0.528	18	15	13	11	9	8	6	5	5	5	7	10	13	17	21	24	27	28	29	29	27	25	23	20
11	Roof terrace system	0.602	19	17	15	14	12	11	9	8	7	8	8	10	12	15	18	20	22	24	25	26	25	24	22	21
12	152.4 mm H.W. concrete with 25.4 mm (or 50.8 mm) insulation	0.664	18	16	14	12	11	10	9	8	8	9	10	12	15	17	20	22	24	25	25	25	24	22	20	19
13	101.6 mm wood with 25.4 mm (or 50.8 mm) insulation	0.602 (0.443)	21	20	18	17	15	14	13	11	10	9	9	9	10	12	14	16	18	20	22	23	24	24	23	22

TABLE 9-2 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

TABLE 9–4 Cooling load temperature differences (CLTD) for various construction groups of sunlit walls, °C.

North Latitude Wall Facing	Solar Time h																								Hour of Max. CLTD	Min. CLTD	Max. CLTD	Difference CLTD
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24				
Group A Walls																												
N	8	8	8	7	7	7	7	6	6	6	6	6	6	6	6	6	6	6	7	7	7	7	8	8	2	6	8	2
NE	11	11	10	10	10	9	9	9	8	8	8	9	9	9	9	10	10	10	11	11	11	11	11	11	22	8	11	3
E	14	13	13	13	12	12	11	11	10	10	10	11	11	12	12	13	13	13	14	14	14	14	14	14	22	10	14	4
SE	13	13	13	12	12	11	11	10	10	10	10	10	10	11	11	12	12	13	13	13	13	13	13	13	22	10	13	3
S	11	11	11	11	10	10	9	9	9	8	8	8	8	8	8	8	9	9	10	10	11	11	11	11	23	8	11	3
SW	14	14	14	14	13	13	12	12	11	11	10	10	10	9	9	10	10	10	11	12	13	13	14	14	24	9	14	5
W	15	15	15	14	14	14	13	13	12	12	11	11	10	10	10	10	10	11	11	12	13	14	14	15	1	10	15	5
NW	12	12	11	11	11	11	10	10	10	9	9	8	8	8	8	8	8	8	9	9	10	11	11	11	1	8	12	4
Group B Walls																												
N	8	8	8	7	7	6	6	6	5	5	5	5	5	5	5	6	6	7	7	8	8	8	8	8	24	5	8	3
NE	11	10	10	9	9	8	7	7	7	7	8	8	9	9	10	10	11	11	11	12	12	12	11	11	21	7	12	5
E	13	13	12	11	10	10	9	8	8	9	9	10	12	13	13	14	14	15	15	15	15	15	14	14	20	8	15	7
SE	13	12	12	11	10	10	9	8	8	8	8	9	10	11	12	13	14	14	14	14	14	14	14	14	21	8	14	6
S	12	11	11	10	9	9	8	7	7	6	6	6	6	7	8	9	10	11	11	12	12	12	12	12	23	6	12	6
SW	15	15	14	13	13	12	11	10	9	9	8	8	7	7	8	9	10	11	13	14	15	15	16	16	24	7	16	9
W	16	16	15	14	14	13	12	11	10	9	9	8	8	8	8	8	9	11	12	14	15	16	16	17	24	8	17	9
NW	13	12	12	11	11	10	9	9	8	7	7	7	6	6	7	7	8	8	9	11	12	13	13	13	24	6	13	7
Group C Walls																												
N	9	8	7	7	6	5	5	4	4	4	4	4	5	5	6	6	7	8	9	9	9	10	9	9	22	4	10	6
NE	10	10	9	8	7	6	6	6	6	7	8	10	10	11	12	12	12	13	13	13	13	12	12	11	20	6	13	7
E	13	12	11	10	9	8	7	7	8	9	11	13	14	15	16	16	17	17	16	16	16	15	14	13	18	7	17	10
SE	13	12	11	10	9	8	7	6	7	7	9	10	12	14	15	16	16	16	16	16	16	15	14	13	19	6	16	10
S	12	11	10	9	8	7	6	6	5	5	5	5	6	8	9	11	12	13	14	14	14	14	13	12	20	5	14	9
SW	16	15	14	12	11	10	9	8	7	7	6	6	6	7	8	10	12	14	16	18	18	18	13	17	22	6	18	12
W	17	16	15	14	12	11	10	9	8	7	7	7	7	7	8	9	11	13	16	18	19	20	19	18	22	7	20	13

TABLE 9-5 Description of wall construction groups.

Group No.	Description Of Construction	U_{ov}, W/m^2·°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

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

TABLE 9-7 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

TABLE 9-8 Shading coefficient (SC) for glass windows without interior shading.[1]

Type of Glass	Nominal Thickness, mm	Solar Trans.	Shading Coefficient, W/m²·K $h_o = 22.7$	Shading Coefficient, W/m²·K $h_o = 17.0$
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

TABLE 9–10 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

	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
SE	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
	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
SSE	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
	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
S	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
	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
SSW	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
	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
SW	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
	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
WSW	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

TABLE 9–11 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

TABLE 9-14 Cooling load factor $(CLF)_u$, 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

TABLE 9—15 Diversity factor for selected applications.[4]

Application	Diversity Factor	
	Lights	People
Peripheral aras of offices with glazing area of 20%-50%	0.70-0.85	0.7-0.8
Core areas of offices and peripheral areas with less than 20% glazing	0.90-1.00	0.7-0.8
Apartments and hotel bedrooms	0.30-0.50	0.4-0.6
Public rooms in hotels	0.90-1.00	0.4-0.6
Department stores and supermarkets	0.90-1.00	0.8-1.0

9.9 MISCELLANEOUS HEAT GAINS

These heat gains or heat losses are considered part of the total cooling load and include the following:

(1) Supply and return duct system heat losses:
All supply and return duct systems, if they are located outside the conditioned space, must be well insulated to minimize this heat loss and to prevent moisture condensation on the duct surface.

[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.

TABLE 9-16 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	0.6
2	0.58	0.59	0.60	0.61	0.62	0.64	0.66	0.7
3	0.17	0.66	0.67	0.67	0.69	0.70	0.72	0.7
4	0.13	0.71	0.72	0.72	0.74	0.75	0.77	0.7
5	0.10	0.27	0.76	0.76	0.77	0.79	0.80	0.8
6	0.08	0.21	0.79	0.80	0.80	0.81	0.83	0.8
7	0.07	0.16	0.34	0.82	0.83	0.84	0.85	0.8
8	0.06	0.14	0.26	0.84	0.85	0.86	0.87	0.8
9	0.05	0.11	0.21	0.38	0.87	0.88	0.89	0.9
10	0.04	0.10	0.18	0.30	0.89	0.89	0.9	0.9
11	0.04	0.08	0.15	0.25	0.42	0.91	0.91	0.9
12	0.03	0.07	0.13	0.21	0.34	0.92	0.92	0.9
13	0.03	0.06	0.11	0.18	0.28	0.45	0.93	0.9
14	0.02	0.06	0.10	0.15	0.23	0.36	0.94	0.9
15	0.02	0.05	0.08	0.13	0.20	0.30	0.47	0.9
16	0.02	0.04	0.07	0.12	0.17	0.25	0.38	0.9
17	0.02	0.04	0.06	0.10	0.15	0.21	0.31	0.4
18	0.01	0.03	0.06	0.09	0.13	0.19	0.26	0.3

The recommended duct insulation thickness $\Delta x_{ins.}$, for this purpose must sa following condition:

$$R_{ins.} = (T_{s,avg.} - T_{sur,avg.})/47.3) = (\Delta x_{ins.}/k_{ins.}) \qquad (9-8)$$

where R_{ins} is the thermal resistance of the insulation, $T_{s,avg}$ is the average su temperature and $T_{sur,avg}$ is the surrounding air temperature. Thus, if the tem difference $(T_{s,avg.} - T_{sur,avg})$ and the thermal conductivity k_{ins}, of the insulating mat given or known then the required insulation material thickness can be calcula Eq. (9 - 8).

The heat loss from the duct system Q_{Loss}, is calculated by using the following e

$$Q_{Loss} = U_{ov.} A_s(T_{s,avg.} - T_{sur,avg}) \qquad (9-9)$$

where, $U_{ov.}$ is the duct overall heat transfer coefficient and A_s is the duct outsid area.

(2) Supply duct air leakage into non-conditioned space:
It occurs due to poor construction and workmanship of duct connection

(3) Heat generated by fans and blowers:
Such heat gains are added to the air stream if the fan is located on the of the cooling coil.

9.10 COOLING LOAD FORM

The calculation of various components of the cooling load of a building must b out on a room-by-room basis, as the case for heating load calculation. The coo

[5] Stoecker and Jones, 1982, "*Refrigeration and Air Conditioning*" 2nd ed. McGraw Hill.

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

Table 9.3 Water Supply Fixture Units and Fixture Branch Sizes

Fixture[a]	*Use*	*Type of Supply Control*	*Fixture Units*[b]	*Min. Size of Fixture Branch*[c] *in.*
Bathroom group[e]	Private	Flushometer	8	—
Bathroom group[e]	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:

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

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, 3/8 or 1/2 in.	4.5
Sink faucet, 3/4 in.	6.0
Bath faucet, 1/2 in.	5.0
Shower head, 1/2 in.	5.0
Laundry faucet, 1/2 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
3/4-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 (1/2 in.)	5.0

Source. Data reproduced with permission from National Standard Plumbing Code, published by the National Association of Plumbing, Heating, Cooling Contractors.

Table 9.10 Estimated Hot Water Demand

Building Type	*Hot Water* per Person, gal/day*	*Maximum Hourly Demand, Portion of Daily Use, gal*	*Duration of Peak Load, hr*	*Storage Capacity, Portion of Daily Use, gal*	*Heating Capacity Portion of Daily Use, gph*
Residences, apartments, hotels[b]	20–40	1/7	4	1/5	1/7
Office buildings	2–3	1/5	2	1/5	1/6
Factory buildings	5	1/3	1	2/5	1/8

*at 140°F.

[b]Allow additional 15 gal per dishwasher and 40 gal per domestic clothes washer.

Source. From Ramsey and Sleeper, *Architectural Graphic Standards*, 8th ed., 1989, reprinted by permission of John Wiley & Sons.

Table 10.1 Approximate Discharge Rates and Velocities* in Sloping Drains Flowing Half Full*

Actual Inside Diameter of Pipe, in.	1/16 in./ft Slope .5, .8 %		1/8 in./ft 1% Slope		1/4 in./ft 2% Slope		1/2 in./ft Slope	
	Discharge, gpm	Velocity, fps	Discharge, gpm	Velocity, fps	Discharge, gpm	Velocity, fps	Discharge, gpm	Velocity, fps
1¼							3.40	1.78
1⅜					3.13	1.34	4.44	1.90
1½					3.91	1.42	5.53	2.01
1⅝					4.81	1.50	6.80	2.12
2					8.42	1.72	11.9	2.43
2½			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	3.14	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

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

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

Table 10.5 Building Drains and Sewers[a]

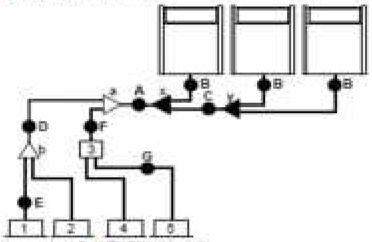
Diameter of Pipe, in.	*Maximum Number of Fixture Units That May Be Connected to Any Portion of the Building Drain or the Building Sewer*			
	Slope per Foot			
	1/16 in.	*1/8 in.* 1%	*1/4 in.* 2%	*1/2 in.*
2			21	26
2½			24	31
3			42[b]	50[b]
4		180	216	250
5		390	480	575
6		700	840	1000
8	1400	1600	1920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

Table 10.7 Size and Length of Vents

Size of Soil or Waste Stack, in.	Fixture Units Connected	*Diameter of Vent Required, in.*								
		1¼	1½	2	2½	3	4	5	6	8
		Maximum Length of Vent, ft								
1½	8	50	150							
2	12	30	75	200						
2	20	26	50	150						
2½	42		30	100	300					
3	10		30	100	100	600				
3	30			60	200	500				
3	60			50	80	400				
4	100			35	100	260	1000			
4	200			30	90	250	900			
4	500			20	70	180	700			
5	200				35	80	350	1000		
5	500				30	70	300	900		
5	1100				20	50	200	700		
6	350				25	50	200	400	1300	
6	[illegible]				15	30	125	[illegible]	1100	
6	960					24	100	250	1000	
6	1900					20	70	200	700	
8	600						50	150	500	1300
8	1400						40	100	400	1200
8	2200						30	80	350	1100
8	3600						25	60	250	800
10	1000							75	125	1000
10	2500							50	100	500
10	3800							30	80	350
10	5600							25	60	250

4.1.2 To select the piping size

Determine the proper size referring to following tables and reference figure (only for indication).



1,2 VRV DX indoor unit
3 BP box
4,5 RA DX indoor unit
a,b Indoor branch kit
x,y Outdoor multi connection kit

A, B, C: Piping between outdoor unit and (first) refrigerant branch kit

Choose from the following table in accordance with the outdoor unit total capacity type, connected downstream.

Outdoor unit capacity type (HP)	Piping outer diameter size (mm)	
	Gas pipe	Liquid pipe
8	19.1	9.5
10	22.2	9.5
12~16	28.6	12.7
18~22	28.6	15.9
24	34.9	15.9
26~34	34.9	19.1
36~54	41.3	19.1

D: Piping between refrigerant branch kits

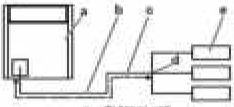
Choose from the following table in accordance with the indoor unit total capacity type, connected downstream. Do not let the connection piping exceed the refrigerant piping size chosen by the general system model name.

E: Piping between refrigerant branch kit and indoor unit

Pipe size for direct connection to indoor unit must be the same as the connection size of the indoor unit (in case indoor unit is VRV DX indoor or Hydrobox).

Indoor unit capacity index	Piping outer diameter size (mm)	
	Gas pipe	Liquid pipe
15~50	12.7	6.4
63~125	15.9	9.5
200	19.1	
250	22.2	

- When the equivalent pipe length between outdoor and indoor units is 90 m or more, the size of the main pipes (both gas side and liquid side) must be increased. Depending on the length of the piping, the capacity may drop, but even in such a case it is possible to increase the size of the main pipes.



a Outdoor unit
b Main pipes
c Increase
d First refrigerant branch kit
e Indoor unit

Size up		
HP class	Piping outer diameter size (mm)	
	Gas pipe	Liquid pipe
8	19.1 → 22.2	9.5 → 12.7
10	22.2 → 25.4(a)	
12+14	28.6(b)	12.7 → 15.9
16	28.6 → 31.8(a)	
18~22		15.9 → 19.1
24	34.9(b)	
26~34	34.9 → 38.1(a)	19.1 → 22.2
36~54	41.3(b)	

(a) If size is NOT available, increase is NOT allowed.
(b) Increase is NOT allowed.

VRV TABLES

Choose from the following table in accordance with the outdoor unit total capacity type, connected downstream.

Outdoor unit capacity type (HP)	Piping outer diameter size (mm)	
	Gas pipe	Liquid pipe
8	19.1	9.5
10	22.2	9.5
12~16	28.6	12.7
18~22	28.6	15.9
24	34.9	15.9
26~34	34.9	19.1
36~54	41.3	19.1

D: Piping between refrigerant branch kits

Choose from the following table in accordance with the indoor unit total capacity type, connected downstream. Do not let the connection piping exceed the refrigerant piping size chosen by the general system model name.

Indoor unit capacity index	Piping outer diameter size (mm)	
	Gas pipe	Liquid pipe
<150	15.9	9.5
150≤x<200	19.1	
200≤x<290	22.2	
290≤x<420	28.6	12.7
420≤x<640		15.9
640≤x<920	34.9	19.1
≥920	41.3	

Example:

- Downstream capacity for E=capacity index of unit 1
- Downstream capacity for D=capacity index of unit 1+capacity index of unit 2

b Main pipes
c Increase
d First refrigerant branch kit
e Indoor unit

Size up		
HP class	Piping outer diameter size (mm)	
	Gas pipe	Liquid pipe
8	19.1 → 22.2	9.5 → 12.7
10	22.2 → 25.4(a)	
12+14	28.6(b)	12.7 → 15.9
16	28.6 → 31.8(a)	
18~22		15.9 → 19.1
24	34.9(b)	
26~34	34.9 → 38.1(a)	19.1 → 22.2
36~54	41.3(b)	

(a) If size is NOT available, increase is NOT allowed.
(b) Increase is NOT allowed.

- The pipe thickness of the refrigerant piping shall comply with the applicable legislation. The minimal pipe thickness for R410A piping must be in accordance with the table below.

Pipe Ø (mm)	Minimal thickness t (mm)
6.4/9.5/12.7	0.80
15.9	0.99
19.1/22.2	0.80
28.6	0.99
34.9	1.21
41.3	1.43

- In case the required pipe sizes (inch sizes) are not available, it is also allowed to use other diameters (mm sizes), taken the following into account:
  - Select the pipe size nearest to the required size.
  - Use the suitable adapters for the change-over from inch to mm pipes (field supply).
  - The additional refrigerant calculation has to be adjusted as mentioned in "5.6.3 To determine the additional refrigerant amount" on page 16.

F: Piping between refrigerant branch kit and BP unit

Pipe size for direct connection on BP unit must be based on the total capacity of the connected indoor units (only in case RA DX indoor units are connected).

Total capacity index of connected indoor units	Piping outer diameter size (mm)	
	Gas pipe	Liquid pipe
20~62	12.7	6.4
63~140	15.9	9.5
150~208	19.1	

Example:

Downstream capacity for F=capacity index of unit 4+capacity index of unit 5

G: Piping between BP unit and RA DX indoor unit

Only in case RA DX indoor units are connected.

Indoor unit capacity index	Piping outer diameter size (mm)	
	Gas pipe	Liquid pipe
20, 25, 30	9.5	6.4
50	12.7	
60		9.5
71	15.9	

4.1.3 To select refrigerant branch kits

Refrigerant refnets

For piping example, refer to "4.1.2 To select the piping size" on page 7.

- When using refnet joints at the first branch counted from the outdoor unit side, choose from the following table in accordance with the capacity of the outdoor unit (example: refnet joint a).

Outdoor unit capacity type (HP)	2 pipes
8~10	KHRQ22M29T9
12~22	KHRQ22M64T
24~54	KHRQ22M75T

- For refnets joints other than the first branch (example refnet joint b), select the proper branch kit model based on the total capacity

INFORMATION

Maximum 8 branches can be connected to a header.

- How to choose an outdoor multi connection piping kit. Choose from the following table in accordance with the number of outdoor units.

Number of outdoor units	Branch kit name
2	BHFQ22P1007
3	BHFQ22P1517

The RYYQ22~54 models, consisting of two or three RYMQ modules, require a 3-pipe system. There is an additional equalising pipe for such modules (in addition to the conventional gas and liquid piping). This equalising pipe does not exist for RYYQ8~20 or RXYQ8~54 units.

The equalising pipe connections for the different RYMQ modules are mentioned in below table.

RYMQ	Equalising pipe Ø (mm)
8	19.1
10~16	22.2
18~20	28.6

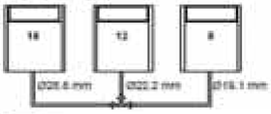
Deciding the equalising pipe diameter:

- In case of 3 multi units: the connection diameter of outdoor to T-joint has to be kept.
- In case of 2 multi units: the connection pipe has to have the largest diameter.

There is never a connection of the equalising pipe with the indoor units.

Example: (free multi combination)

RYMQ8+RYMQ12+RYMQ18. Largest connection is Ø28.6 (RYMQ18); Ø22.2 (RYMQ12) and Ø19.1 (RYMQ8). In figure below only equalising pipe is shown.



INFORMATION

Reducers or T-joints are field supplied.

VRV TABLES

4.1.3 To select refrigerant branch kits

Refrigerant refnets

For piping example, refer to "4.1.2 To select the piping size" on page 7.

- When using refnet joints at the first branch counted from the outdoor unit side, choose from the following table in accordance with the capacity of the outdoor unit (example: refnet joint a).

Outdoor unit capacity type (HP)	2 pipes
8~10	KHRQ22M29T9
12~22	KHRQ22M64T
24~54	KHRQ22M75T

- For refnets joints other than the first branch (example refnet joint b), select the proper branch kit model based on the total capacity index of all indoor units connected after the refrigerant branch.

Indoor unit capacity index	2 pipes
<200	KHRQ22M20T
200≤x<290	KHRQ22M29T9
290≤x<640	KHRQ22M64T
≥640	KHRQ22M75T

- Concerning refnet headers, choose from the following table in accordance with the total capacity of all the indoor units connected below the refnet header.

Indoor unit capacity index	2 pipes
<200	KHRQ22M29H
200≤x<290	
290≤x<640	KHRQ22M64H(a)
≥640	KHRQ22M75H

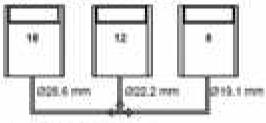
(a) If the pipe size above the refnet header is Ø34.9 or more, KHRQ22M75H is required.

largest diameter.

There is never a connection of the equalising pipe with the indoor units.

Example: (free multi combination)

RYMQ8+RYMQ12+RYMQ18. Largest connection is Ø28.6 (RYMQ18); Ø22.2 (RYMQ12) and Ø19.1 (RYMQ8). In figure below only equalising pipe is shown.



INFORMATION

Reducers or T-joints are field supplied.

NOTICE

Refrigerant branch kits can only be used with R410A.

References

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

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

[3] M. A. A. M. A.Hammad, *Heating and Air Conditioning for Residantial Buildings*, National Library Department, Jordan, 2007.

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

Cataloge

SF260 | Poly x-tra

Hanwha Solar

Five Key Features

1. Guaranteed quality: 12 year product warranty, 25 year linear performance warranty *
2. Predictable output: Positive power sorting of 0 to + 5 W
3. Innovative solutions: Anti-reflecting coating for high sunlight absorption
4. Robust design: Module certified to withstand high snow loads, up to 5.4 kN/m^2 **
5. Long term responsibility: Free module recycling in PV Cycle member countries

* Please refer to Hanwha Solar Product Warranty for details.
** Please refer to Hanwha Solar Module Installation Guide.

Quality and Environmental Certificates

- ISO 9001 quality standards and ISO 14001 environmental standards
- OHSAS 18001 occupational health and safety standards
- IEC 61215 and IEC 61730 Class A certifications
- Conformity to CE

About Hanwha Solar

Hanwha Solar is a vertically integrated manufacturer of photovoltaic modules designed to meet the needs of the global energy consumer.

- High reliability, guaranteed quality, and excellent cost-efficiency due to vertically integrated production and control of the supply chain
- Optimization of product performance and manufacturing processes through a strong commitment to research and development
- Global presence throughout Europe, North America, and Asia, offering regional technical and sales support

Hanwha Solar

SF260 | Poly x-tra

Electrical Characteristics

Electrical Characteristics at Standard Test Conditions (STC)

Power Class	275 W	280 W	285 W	290 W	295 W	300W
Maximum Power (P_{max})	275 W	280 W	285 W	290 W	295 W	300W
Open Circuit Voltage (V_{oc})	44.1 V	44.3 V	44.5 V	44.7 V	44.9 V	45.0V
Short Circuit Current (I_{sc})	8.35 A	8.40 A	8.45 A	8.50 A	8.55 A	8.60A
Voltage at Maximum Power (V_{mpp})	36.1 V	36.1 V	36.2 V	36.3 V	36.4 V	36.5V
Current at Maximum Power (I_{mpp})	7.62 A	7.76 A	7.87 A	7.99 A	8.11 A	8.22A
Module Efficiency (%)	14.0 %	14.3 %	14.5 %	14.7 %	15.0 %	15.2%
Cell Efficiency (%)	15.8 %	16.0 %	16.2 %	16.5 %	16.8 %	17.1%

P_{max}, V_{oc}, I_{sc}, V_{mpp} and I_{mpp} tested at STC defined as irradiance of 1000 W/m² at AM 1.5 solar spectrum and temperature 25 ± 2 °C.
Electrical Characteristics: measurement tolerance of ± 3 %.

Electrical Characteristics at Normal Operating Cell Temperature (NOCT)

Power Class	275 W	280 W	285 W	290 W	295 W	300W
Maximum Power (P_{max})	200 W	204 W	208 W	211 W	215 W	219W
Open Circuit Voltage (V_{oc})	40.6 V	40.8 V	40.9 V	41.1 V	41.3 V	41.4V
Short Circuit Current (I_{sc})	6.76 A	6.80 A	6.84 A	6.88 A	6.92 A	6.96A
Voltage at Maximum Power (V_{mpp})	32.8 V	32.9 V	33.0 V	33.1 V	33.2 V	33.3V
Current at Maximum Power (I_{mpp})	6.10 A	6.21 A	6.30 A	6.39 A	6.49 A	6.58A
Module Efficiency (%)	12.7 %	13.0 %	13.2 %	13.4 %	13.7 %	13.9%

P_{max}, V_{oc}, I_{sc}, V_{mpp} and I_{mpp} tested at NOCT defined as irradiance of 800 W/m², wind speed 1 m/s.
Electrical Characteristics: measurement tolerance of ± 3 %.

Temperature Characteristics

Normal Operating Cell Temperature (NOCT)	45 °C ± 3 °C
Temperature Coefficient of P	− 0.45 %/°C
Temperature Coefficient of V	− 0.32 %/°C
Temperature Coefficient of I	+ 0.04 %/°C

Maximum Ratings

Maximum System Voltage	1000 V (IEC)
Series Fuse Rating	15 A
Maximum Reverse Current	Series fuse rating multiplied by 1.35

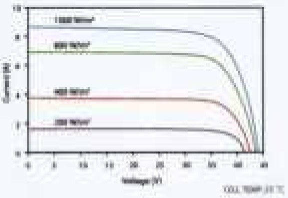
Nomenclature

Full product name:
SF260-36-1PxxxL
xxx represents the power class

Performance at Low Irradiance:

The typical relative change in module efficiency at an irradiance of 200 W/m² in relation to 1000 W/m² (both at 25 °C and AM 1.5 spectrum) is less than 5 %.

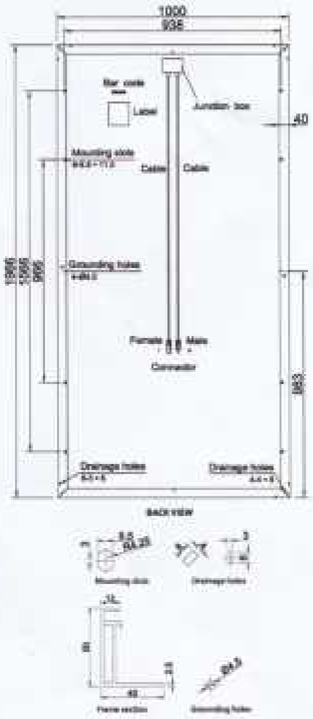
Various Irradiance Levels



Mechanical Characteristics

Dimensions	1966 mm × 1000 mm × 50 mm
Weight	26 kg
Frame	Aluminum alloy
Front	Tempered glass
Encapsulant	EVA
Back Cover	Composite sheet
Cell Technology	Polycrystalline
Cell Size	156 mm × 156 mm
Number of Cells (Pieces)	72 (6 × 12)
Junction Box	Protection class IP67 with bypass-diode
Output Cables	Solar cable: 4 mm²; length 1200 mm
Connector	Linyang LY0706-2

Basic Design



System Design

Operating Temperature	− 40 °C to 85 °C
Hail Safety Impact Velocity	25 mm at 23 m/s
Fire Safety Classification (IEC 61730)	Class C
Static Load Wind / Snow	2400 Pa / 5400 Pa

Packaging and Storage

Storage Temperature	− 40 °C to 85 °C
Packaging Configuration	20 pieces per pallet
Loading Capacity (40 ft. HQ Container)	440 pieces

Hanwha Solar

OUTDOOR SYSTEM		RYYQ22T	RXYQ22T	RYYQ24T	RXYQ24T	RYYQ26T	RXYQ26T	RYYQ28T	RXYQ28T	RYYQ30T	RXYQ30T	RYYQ32T	RXYQ32T	RYYQ34T	RXYQ34T	RYYQ36T	RXYQ36T
System - Outdoor unit module 1		RYMQ10T	RXYQ10T	RYMQ8T	RXYQ8T	RYMQ12T	RXYQ12T	RYMQ12T	RXYQ12T	RYMQ12T	RXYQ12T	RYMQ16T	RXYQ16T	RYMQ16T	RXYQ16T	RYMQ16T	RXYQ16T
System - Outdoor unit module 2		RYMQ12T	RXYQ12T	RYMQ16T	RXYQ16T	RYMQ14T	RXYQ14T	RYMQ16T	RXYQ16T	RYMQ18T	RXYQ18T	RYMQ16T	RXYQ16T	RYMQ18T	RXYQ18T	RYMQ20T	RXYQ20T
Capacity range	HP	22		24		26		28		30		32		34		36	
Cooling capacity - Nom.	kW	61.5		67.4		73.5		78.5		83.5		90.0		95.0		101.0	
Heating capacity - Nom.	kW	69.0		75.0		82.5		87.5		93.5		100.0		106.0		113.0	
Power input - 50Hz - Cooling - Nom.	kW	16.3		18.2		20.0		22.0		23.7		26.0		27.7		31.5	
Power input - 50Hz - Heating - Nom.	kW	16.5		18.3		20.3		21.9		23.5		25.6		27.2		29.8	
EER		3.77		3.70		3.68		3.57		3.52		3.46		3.43		3.21	
ESEER		7.07 [1]		6.81 [1]		6.89 [1]		6.69 [1]		6.60 [1]		6.50 [1]		6.44 [1]		6.02 [1]	
COP		4.18		4.10		4.06		4.00		3.98		3.91		3.90		3.79	
Maximum number of connectable indoor units		64 [2]															
Piping connections - Liquid - OD	mm	15.9				19.1											
Piping connections - Gas - OD	mm	28.6		34.9												41.3	
Piping connections - Piping length - OU - IU - Max.	m	165 [3]															
Piping connections - Total piping length - System - Actual	m	1,000 [3]															
Piping connections - Level difference - OU - IU	m	90 [3] Outdoor unit in highest position / 90 [3] Indoor unit in highest position															
Current - 50Hz - Maximum fuse amps (MFA)	A	63								80							

(1) The AUTOMATIC ESEER value corresponds with normal VRV IV Heat Pump operation, taking into account advanced energy saving operation functionality (variable refrigerant temperature control operation) (2) Actual number of connectable indoor units depends on the indoor unit type (VRV indoor, Hydrobox, RA indoor, etc.) and the connection ratio restriction for the system (50% <= CR <= 130%) (3) Refer to technical specifications for more detail

OUTDOOR SYSTEM		RYYQ38T	RXYQ38T	RYYQ40T	RXYQ40T	RYYQ42T	RXYQ42T	RYYQ44T	RXYQ44T	RYYQ46T	RXYQ46T	RYYQ48T	RXYQ48T	RYYQ50T	RXYQ50T	RYYQ52T	RXYQ52T	RYYQ54T	RXYQ54T
System - Outdoor unit module 1		RYMQ8T	RXYQ8T	RYMQ10T	RXYQ10T	RYMQ10T	RXYQ12T	RYMQ12T	RXYQ12T	RYMQ14T	RXYQ14T	RYMQ16T	RXYQ16T	RYMQ16T	RXYQ16T	RYMQ16T	RXYQ16T	RYMQ18T	RXYQ18T
System - Outdoor unit module 2		RYMQ10T	RXYQ10T	RYMQ12T	RXYQ12T	RYMQ16T	RXYQ16T	RYMQ16T	RXYQ16T	RYMQ16T	RXYQ16T	RYMQ16T	RXYQ16T	RYMQ16T	RXYQ16T	RYMQ18T	RXYQ18T	RYMQ18T	RXYQ18T
System - Outdoor unit module 3		RYMQ20T	RXYQ20T	RYMQ18T	RXYQ18T	RYMQ16T	RXYQ16T	RYMQ16T	RXYQ16T	RYMQ16T	RXYQ16T	RYMQ16T	RXYQ16T	RYMQ18T	RXYQ18T	RYMQ18T	RXYQ18T	RYMQ18T	RXYQ18T
Capacity range	HP	38		40		42		44		46		48		50		52		54	
Cooling capacity - Nom.	kW	106.0		112.0		118.0		124.0		130.0		135.0		140.0		145.0		150.0	
Heating capacity - Nom.	kW	120.0		125.0		132.0		138.0		145.0		150.0		156.0		162.0		168.0	
Power input - 50Hz - Cooling - Nom.	kW	31.0				33.3		35.0		37.0		39.0		40.7		42.4		44.1	
Power input - 50Hz - Heating - Nom.	kW	29.9		30.9		33.0		34.7		36.8		38.4		40.0		41.6		43.2	
EER		3.42		3.61		3.54				3.51		3.46		3.44		3.42		3.40	
ESEER		6.36 [1]		6.74 [1]		6.65 [1]		6.62 [1]		6.60 [1]		6.50 [1]		6.46 [1]		6.42 [1]		6.38 [1]	
COP		4.01		4.05		4.00		3.98		3.94		3.91		3.90		3.89		3.89	
Maximum number of connectable indoor units		64 [2]																	
Piping connections - Liquid - OD	mm	19.1																	
Piping connections - Gas - OD	mm	41.3																	
Piping connections - Piping length - OU - IU - Max.	m	165 [3]																	
Piping connections - Total piping length - System - Actual	m	1,000 [3]																	
Piping connections - Level difference - OU - IU	m	90 [3] Outdoor unit in highest position / 90 [3] Indoor unit in highest position																	
Current - 50Hz - Maximum fuse amps (MFA)	A	100										125							

FXFQ-A

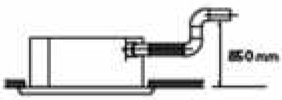
Round flow cassette

FXFQ 20-63A

BRC1E52A/B   BRC7FA532F

ROUND FLOW

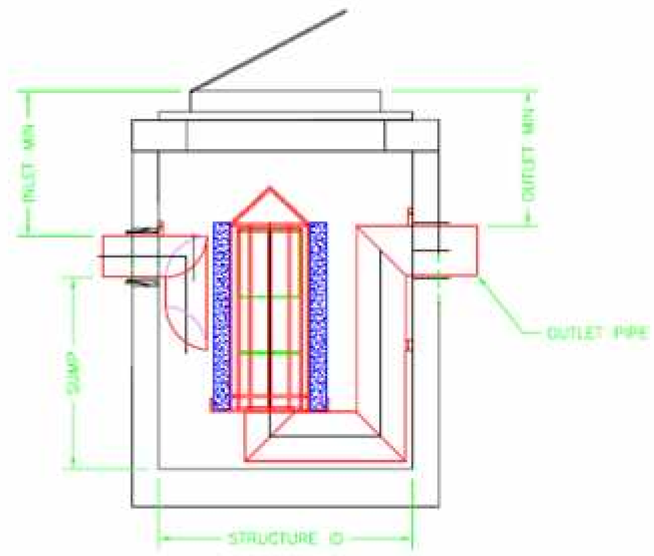
- The round flow cassette provides a more comfortable environment and offers greater savings in energy consumption to shop, office and restaurant owners
- 360° air discharge ensures uniform air flow and temperature distribution
- Modern style decoration panel is available in 3 different variations: pure white (RAL9010) auto cleaning panel, pure white (RAL9010) standard panel with grey louvers and pure white (RAL9010) standard panel with white louvers
- Daikin introduces first auto cleaning cassette to European market.
- Higher efficiency and comfort thanks to daily auto cleaning of the filter
- Lower maintenance costs thanks to auto cleaning function.
- Easy dust removal with vacuum cleaner without opening the unit.
- The presence sensor (optional) adjusts the set point with standard 1°C if no one is detected in the room, it is possible to adjust the set point with 2, 3 or 4°C (optional). It also automatically directs air flow away from any person to avoid draught.
- The floor sensor (optional) detects the average floor temperature and ensures even temperature distribution between ceiling and floor. Cold feet will become history.
- Individual flap control: one or more flaps can be easily closed via the wired remote controller (BRC1E52) in case you would refurbish or rearrange your interior
- Low energy consumption thanks to specially developed small tube heat exchanger, DC fan motor and drain pump
- Fresh air intake: up to 20%
- Low installation height: 214mm for class 20-63
- Standard drain pump with 850mm lift



INDOOR UNIT				FXFQ20A	FXFQ25A	FXFQ32A	FXFQ40A	FXFQ50A	FXFQ63A	FXFQ80A	FXFQ100A	FXFQ125A
Cooling capacity	Nom.		kW	2.2	2.8	3.6	4.5	5.6	7.1	9.0	11.2	14.0
Heating capacity	Nom.		kW	2.5	3.2	4.0	5.0	6.3	8.0	10.0	12.5	16.0
Power input - 50Hz	Cooling	Nom.	kW	0.038				0.053	0.061	0.092	0.115	0.186
	Heating	Nom.	kW	0.038				0.053	0.061	0.092	0.115	0.186
Dimensions	Unit	HeightxWidthxDepth	mm	204x840x840						246x840x840		288x840x840
Weight	Unit		kg	19			20	21		24		26
Decoration panel	Model			BYCQ140D7W1								
	Colour			Pure White (RAL 9010)								
	Dimensions	HeightxWidthxDepth	mm	60x950x950								
	Weight		kg	5.4								
Decoration panel 2	Model			BYCQ140D7W1W								
	Colour			Pure White (RAL 9010)								
	Dimensions	HeightxWidthxDepth	mm	60x950x950								
	Weight		kg	5.4								
Decoration panel 3	Model			BYCQ140D7GW1								
	Colour			Pure White (RAL 9010)								
	Dimensions	HeightxWidthxDepth	mm	145x950x950								
	Weight		kg	10.3								
Fan-Air flow rate - 50Hz	Cooling	High/Nom./Low	m³/min	12.5/10.6/8.8			13.6/11.6/9.5	15.0/12.8/10.5	16.5/13.5/10.5	22.8/17.6/12.4	26.5/19.5/12.4	33.0/26.5/19.9
	Heating	High/Nom./Low	m³/min	12.5/10.6/8.8			15.6/11.6/9.5	15.0/12.8/10.5	16.5/13.5/10.5	22.8/17.6/12.4	26.5/19.5/12.4	33.0/26.5/19.9
Sound power level	Cooling	High/Nom.	dBA	49/-			51/-		53/-	55/-	60/-	61/-
Sound pressure level	Cooling	High/Nom./Low	dBA	31/29/28			33/31/29		35/33/30	38/34/30	43/37/30	45/41/36
	Heating	High/Nom./Low	dBA	31/29/28			33/31/29		35/33/30	38/34/30	43/37/30	45/41/36
Refrigerant	Type			R-410A								
Piping connections	Liquid OD/Gas OD/Drain		mm	6.35/12.7/VP25 (O.D. 32/I.D. 25)					9.52/15.9/VP25 (O.D. 32/I.D. 25)			
Power supply	Phase/Frequency/Voltage		Hz/V	1~/50/60/220-240/220								
Current - 50Hz	Maximum fuse amps (MFA)		A	16								

BYCQ140D7W1 = pure white panel with grey louvers, BYCQ140D7W1W = pure white standard panel with white louvers, BYCQ140D7GW1 = Pure white auto cleaning panel
The BYCQ140D7W1W has white insulation. Be informed that formation of dirt on white insulation is visibly stronger & that it is consequently not advised to install the decoration panel in environments exposed to concentrations of dirt.

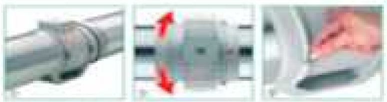
ESK Koala Oil/Water Separator



ESK Model	Max. Flow (gpm)	Structure ID (in)	Sump Depth(in)	Inlet Min Cover Depth(in)	Outlet Min Cover Depth(in)	Outlet Pipe OD Dia(in)	Total Volume(gal)	Oil Storage Volume(Gal)
1.5	24	48	32	19	20	6	251	72
3	48	48	32	19	20	6	251	72
6	95	48	32	19	20	6	251	72
10	159	48	32	19	20	6	251	72
15	238	48	38	24	25	8	298	133
20	317	48	38	24	25	8	298	133
30	476	60	48	26	27	12	588	269
40	634	60	48	26	27	12	588	269
50	793	72	68	25	26	12	1199	426
65	1030	72	68	25	26	12	1199	426
80	1268	72	68	25	26	12	1199	426
100	1585	96	68	25	26	12	2131	758
110	1744	96	78	36	37	16	2444	988
120	1902	96	78	36	37	16	2444	988
130	2061	96	78	36	37	16	2444	988
140	2219	96	78	36	37	16	2444	988
150	2378	96	78	36	37	16	2444	988
160	2536	96	78	36	37	16	2444	988
170	2695	96	78	36	37	16	2444	988
180	2853	96	78	36	37	16	2444	988
190	3012	96	78	36	37	16	2444	988
200	3170	96	78	36	37	16	2444	988
225	3566	120	88	37	38	20	4308	2144
250	3963	120	88	37	38	20	4308	2144
275	4359	120	88	37	38	20	4308	2144
300	4755	120	88	37	38	20	4308	2144

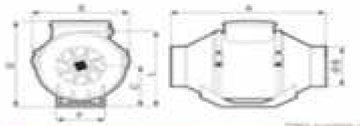
VORTICE® LINEO

LONG LIFE 30.000 h



- **Lineo series extractors have certified air flow, pressure (to UNI 10531:1995, corresponding to ISO 5801) and noise levels (UNI EN ISO 3741). Certification of these parameters guarantees that our products will always meet the your requirements and expectations.**

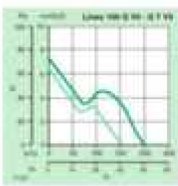
Dimensions (mm)

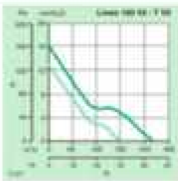


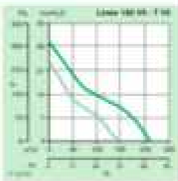
AND WITHOUT TIMERS. SAFETY AND ACOUSTIC PERFORMANCES CERTIFIED NEW

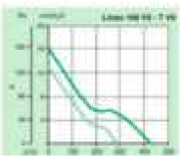
SAFETY GUARANTEED AND CERTIFIED

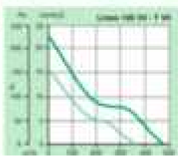
PERFORMANCE AND SILENCE GUARANTEED AND CERTIFIED BY IMQ PERFORMANCE











KINGIANT

INDUSTRY CENTRIFUGAL PUMP

Model

CMI Series

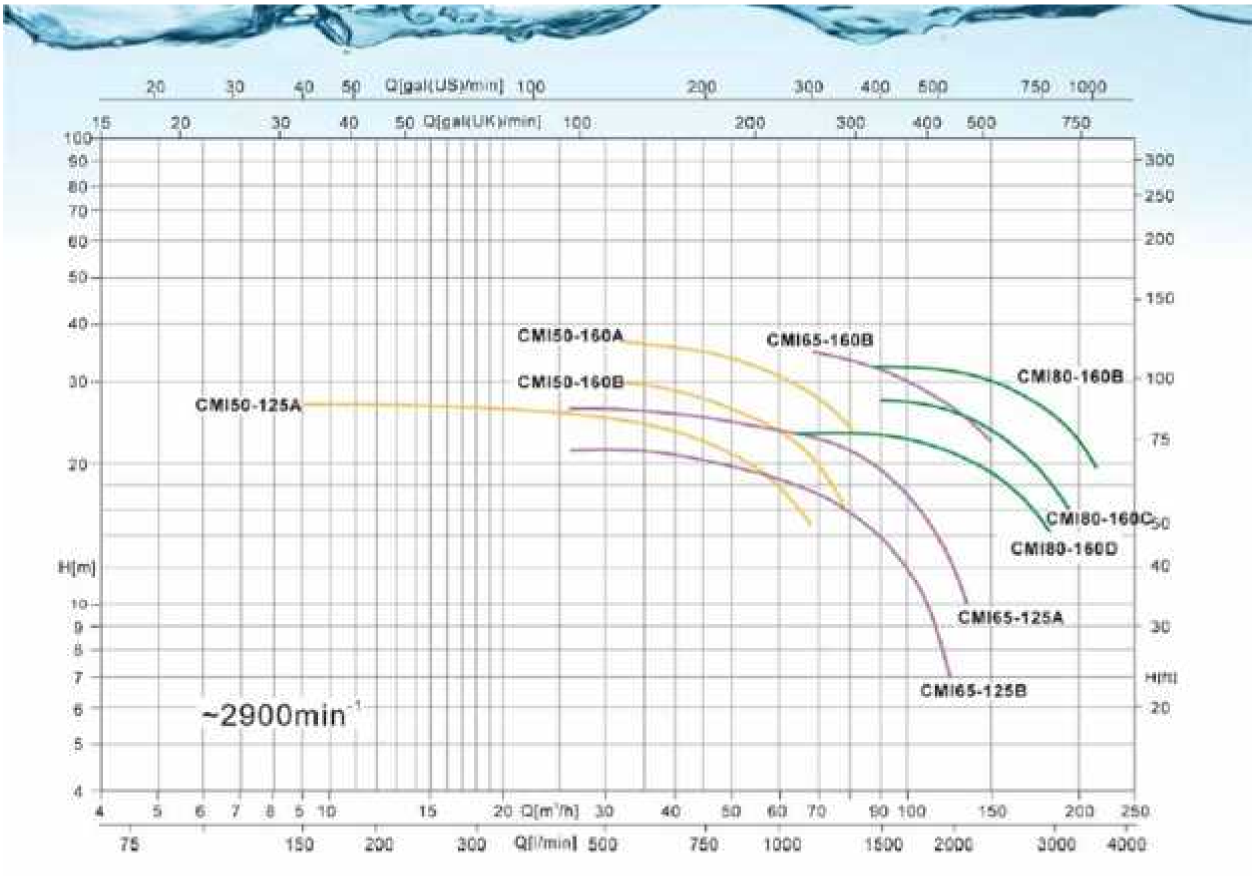
CMI

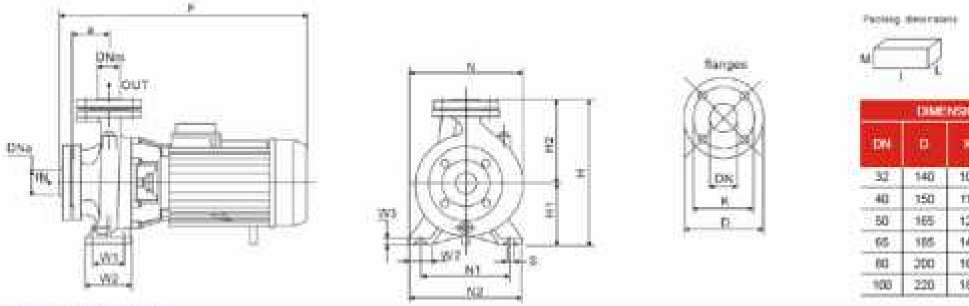
CONSTRUCTION:

PUMP Centrifugal - Big Capacity
Pump Body: Cast Iron
Impeller: Brass / Cast Iron
Mechanical Seal: Carbon / Ceramic / Stainless steel

MOTOR Single Phase Heavy Duty Continuous Work
Motor Housing: Aluminium
Shaft: Carbon Steel / Stainless Steel
Insulation: Class B / Class F
Protection: IP44 / IP54
Cooling: External ventilation

USES - Monobloc horizontal centrifugal pumps, constructed to EN 733 standards; widely used in water supplies, pressurisation and fire-fighting systems, standard supply with counter-flange.
Main application: household water pumping, circulation and domestic power boosting.
High building water supplying boostering.
Industry water suppling circulating boostering.





DIMENSIONS (mm)				
DN	D	K	holes n°	holes Ø
32	140	100	4	18
40	150	110	4	18
50	165	125	4	18
65	185	145	4	18
80	200	160	4	18
100	220	180	8	18

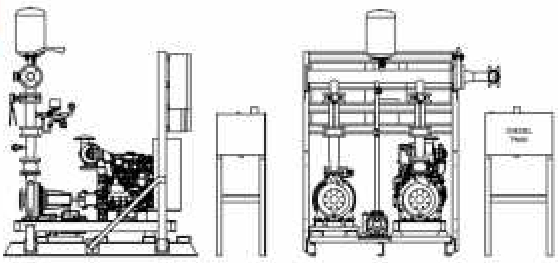
INSTALLATION DIMENSION

TYPE	DIMENSIONS (mm)														Packing			Kg
	DNM	DNA	A	F	H	H1	H2	N	N1	N2	W	W1	W2	W3	S	I	L	M	
CMI 50-125 A	50	65	100	525	292	132	160	250	190	240	100	70	50	12	14	520	260	355	50
CMI 50-160 B	50	65	100	590	340	150	180	270	212	265	100	70	50	12	14	615	310	460	65
CMI 50-160 A	50	65	100	590	340	150	180	270	212	265	100	70	50	12	14	615	310	460	71
CMI 65-125 B	65	80	100	605	340	160	180	280	212	280	125	95	65	14	14	615	310	460	64
CMI 65-125 A	65	80	100	605	340	160	180	280	212	280	125	95	65	14	14	615	310	460	70
CMI 65-160 B	65	80	100	635	360	160	200	290	212	280	125	95	65	14	14	665	335	535	90
CMI 80-160 D	80	100	125	665	405	180	225	330	250	320	125	95	65	14	14	665	335	535	98,5
CMI 80-160 C	80	100	125	735	405	180	225	330	250	320	125	95	65	14	14	735	355	535	129
CMI 80-160 B	80	100	125	790	405	180	225	330	250	320	125	95	65	14	14	815	355	535	143

Fire fighting units with horizontal pumps back pull-out type, made according to standard EN 12845

1 Electric main pump + 1 Diesel main motorpump + 1 jockey pump

"EDP" Series

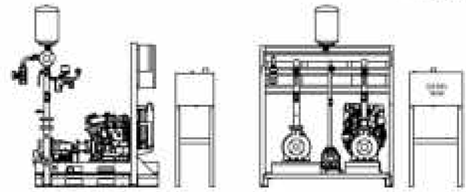


Fire fighting unit according to standard EN 12845 consists of 1 electric main pump + 1 diesel main motorpump + 1 jockey pump

Fire fighting units with horizontal pumps back pull-out type, made according to standard EN 12845

1 Electric main pump + 1 Diesel main motorpump + 1 jockey pump

"EDP" Series



Units with capacity from m3/h [illegible] up to m3/h [illegible]

Code	Model	Electric Power (kW)	Q CAPACITY OF EACH SERVICE PUMP																		
			m3/h	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			l/min	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
			H TDH [illegible]																		
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SPLASHPROOF AXIAL EXTRACT FANS USED TO EXTRACT AIR EITHER DIRECTLY TO THE OUTSIDE OR INTO DUCTING UP TO 4m LONG

VORTICE® PUNTO RANGE

1 Installation showing extract directly to the outside.
2 Ceiling installation on up to 4m duct.
3 Through the wall installation with wall sleeve and grille.
4 Window installation with standard window kit.

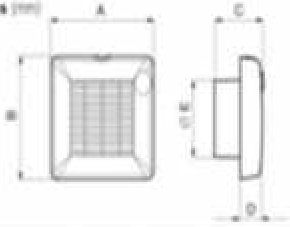
- **For intermittent or continuous ventilation of bathrooms, toilets, kitchens or utility rooms in domestic or commercial properties.**
- 82 models available with or without the option of automatic shutters, timer, pull cord, humidistat, electronic microprocessor and Passive infrared.
- Motor with shielded poles, either with bronze or ball bearings, and with thermal cut-out.
- The standard models can be speed regulated.
- Data and performances IMQ Performance certified.
- High airflow rate, low operating noise level and low power consumption due to the wing profile blades and motor support.
- IPX4 splashproof protection on all models.
- Motor support and grille made of anti-UV ABS.
- Available in three outlet sizes Ø 100, 120 and 150 mm.
- Conforms to the following standards: CEI EN 60335-2-80 (Part 2: Particular requirements for fans), CEI EN 60529 (Code IP) and CEI 107-63/1986.

Design: F. Trabucco & Associates

Accessories
(description and data on page 25)

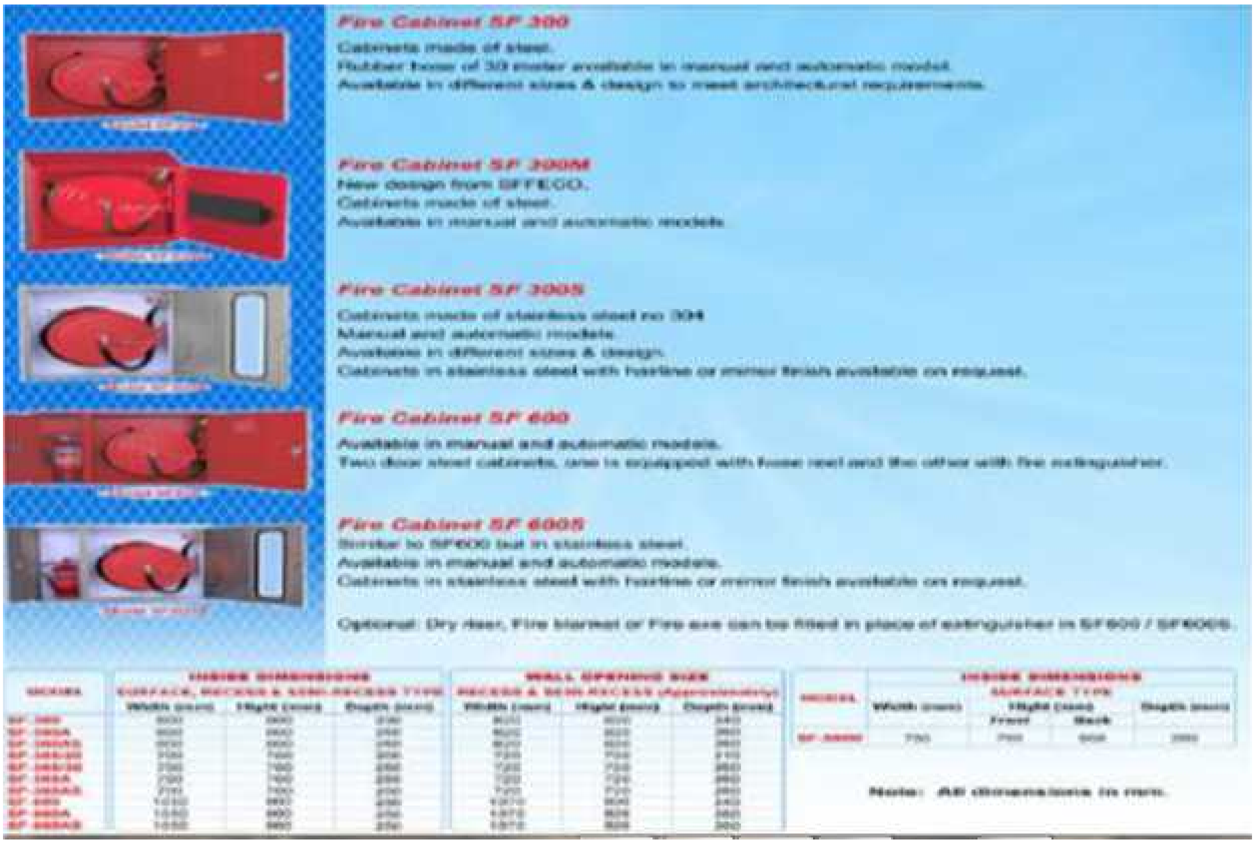
Wiring diagrams shown on page XXVI

Dimensions (mm)



	A	B	C	D	Ø E
M 100/4"	158	160	100	47	99
M 120/5"	179	181	110	47	119
M 150/6"	214	215	117	47	158

Product	V ~ 50 Hz	W	A	Rpm	Delivery m³/h	Delivery l/s	P max mm H₂O	P max Pa	Lp dB(A) 3 m	Approvals	kg	Insulation	IP	°C max
M 100/4"	230-240	18	0.1	2300	90	25	3	29	37.5		0.6	□	X4	50
M 120/5"	230-240	20	0.12	2150	175	48.6	4.5	44	39.5		0.8	□	X4	50
M 150/6"	230-240	30	0.15	2150	335	93.1	6	59	46		1.1	□	X4	50



Fire Cabinet SF 300
Cabinets made of steel.
Rubber hose of 30 meter available in manual and automatic model.
Available in different sizes & design to meet architectural requirements.
Fire Cabinet SF 300M
New design from SFFECO.
Cabinets made of steel.
Available in manual and automatic models.
Fire Cabinet SF 300S
Cabinets made of stainless steel no 304
Manual and automatic models.
Available in different sizes & design.
Cabinets in stainless steel with hairline or mirror finish available on request.
Fire Cabinet SF 600
Available in manual and automatic models.
Two door steel cabinets, one is equipped with hose reel and the other with fire extinguisher.
Fire Cabinet SF 600S
Similar to SF600 but in stainless steel.
Available in manual and automatic models.
Cabinets in stainless steel with hairline or mirror finish available on request.
Optional: Dry riser, Fire blanket or Fire axe can be fitted in place of extinguisher in SF600 / SF600S.
INSIDE DIMENSIONS
WALL OPENING SIZE
Note: All dimensions in mm.