جامعة بوليتكنك فلسطين

College Of Engineering & Technology

Mechanical Engineering Department

Refrigeration & Air Conditioning Engineering

Graduation Project

Mechanical Systems Design for a Green Tower

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Abstract

المشروع هو عبارة عن برج تجاري بيئي يتضمن العديد من الأنشطة التجارية والإدارية والفندقية بالإضافة إلى عنصر الترفيه. حيث يتكون البرج من 19 طابق بمساحة إجمالية تبلغ 20000 م^2. ويعتمد تصميمه وتشغيله على الطاقة البديلة والمتجددة لتوفير استهلاك الطاقة.

ويقوم المشروع على عمل الخدمات الميكانيكية وشبكات المياه والصرف الصحي ونظام تكييف الهواء. ويشمل أيضا على تصميم نظام إخماد الحريق. والري بواسطة المياه الرمادية بعد فصلها ومعالجتها.

The project is an Environmental commercial tower includes many of the commercial, administrative and hotel activities in addition to the entertainment element. The tower consists of 19 floors with a total area of 20000m^2, and depends on its design and run on alternative and renewable energy to provide energy consumption. Includes work in the design of mechanical services of water and sewage networks and air conditioning system provider of energy and the project includes design of fire fighting system, and irrigation system by gray water after separated and processed.

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CHAPTER ONE:

INTRODUCTION

1.1 Project outline:

Chapter one:

Includes an overview about project, project benefits and objectives.

Chapter two:

Includes an overview about green building design standard.

Chapter three:

Includes an overview about solar energy.

Chapter four:

Includes an overview about the cooling and heating systems, and how to calculate cooling load from all sources, and variable refrigerant volume system (VRV).

Chapter five:

Includes an overview about plumping systems, water distribution system (cold and hot water), separation and treatment of gray water.

Chapter six:

Includes overview about irrigation system.

Chapter seven:

Includes overview about firefighting system.

Chapter eight:

Includes overview about building management system.

1.2 Scope of project:

The scope of the project is the design of mechanical systems and environmental design for a green tower located at Bethlehem city including these main topics:

1. Overview about the natural energy using.
2. Solar energy, design and overview.
3. Design of air conditioning system.
4. Design and overview about plumping system.

5. Design and overview about gray water system.

6. Design irrigation system.

7. Programming the Irrigation system, and gray water treatment plant by programmable logic controller (PLC).

1.3 Project objectives:

The main objective of the project is to develop mechanical services design in green tower, and the aim objectives are:

1. Design the solar energy.

2. Design the air conditioning system for all floors.

3. Design the domestic water system and design grid of pipes to sewage and drainage system.

4. Design the gray water system.

5. Design the fire fighting system for tower.

6. Programming the irrigation system and gray water plant by programmable logic controller (PLC).

7. Design irrigation system.

1.4 Project benefits:

1- The main benefit is to fulfill the graduation requirements of Palestine Polytechnic University,

and be familiar with all mechanical design of system installed in tower to be ready in working in this field after graduation.

2- To be familiar with all mechanical calculation and design of system installed in residential building.

3- To be familiar with the different mechanical drawings.

4- To be familiar with solar cells design.

1.5 Tower description:

The tower consists of nineteen stories, and the total area of the tower is 20,000 m^2. it consists of the following departments:

1. Barking.
2. Games hall for children.
3. Bowling and billiard hall.
4. Restaurant and offices.
5. Learning halls and theaters.

1.6 Time table:

Table (1-1) Time table for the first semester.

Objective	Week #															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Estimate goals of project	■	■	■	■												
Planning, setting project concepts and goals				■	■	■										
Establishing scientific background and visit engineers						■	■	■	■	■	■	■	■			
Studying mechanical services books									■	■	■	■	■	■		
Analyzing data											■	■	■	■	■	
HVAC calculations													■	■	■	
Studying solar cells concept														■	■	
Writing report									■	■	■	■	■	■	■	
Presentation																■

Table (1-2) Time table for second semester.

Objective	Week #															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Set and review goals of project	■	■														
Design plumbing system		■	■	■												
Design gray water system				■	■	■	■									
Design irrigation system						■	■	■								
Design fire fighting system							■	■	■							
Design HVAC system									■	■	■	■	■	■		
Design solar cells system										■	■	■	■	■	■	
Writing documentation			■	■	■	■	■	■	■	■	■	■	■	■	■	
Printing documentation out																■

CHAPTER TWO
Green building design standards

2.1: Introduction:

Green building refers to both a structure and the using of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle: from sitting to design, construction, operation, maintenance, renovation, and demolition. In other words, green building design involves finding the balance between homebuilding and the sustainable environment. This requires close cooperation of the design team ,the engineers, and the client at all project stages. The Green Building practice expands and complements the classical building design concerns of economy, utility, durability, and comfort.

Leadership in Energy and Environmental Design (LEED) is a set of rating systems for the design, construction, operation, and maintenance of green buildings which was Developed by the U.S. Green Building Council. Currently world green building council is doing research on how green buildings affect health and productivity of their users.

Although new technologies are constantly being developed to complement current practices in creating greener structures, the common objective is that green buildings are designed to reduce the overall impact of the built environment on human health and the natural environment by:

- Efficiently using energy, water, and other resources
- Protecting occupant health and improving employee productivity
- Reducing waste, pollution and environmental degradation

A similar concept is natural building, which is usually on a smaller scale and tends to focus on the use of natural materials that are available locally. Other related topics include sustainable design and green architecture. Sustainability may be defined as meeting the needs of present generations without compromising the ability of future generations to meet their needs. Although some green building programs don't address the issue of the retrofitting existing homes, others do, especially through public schemes for energy efficient refurbishment. Green construction principles can easily be applied to retrofit work as well as new construction.

A 2009 report by the U.S. General Services Administration found 12 sustainably designed buildings cost less to operate and have excellent energy performance. In addition, occupants were more satisfied with the overall building than those in typical commercial buildings. These are eco friendly buildings.

2.2: Goals of green building:

Figure (2.1)Benefits of green building.

Green building brings together a vast array of practices, techniques, and skills to reduce and ultimately eliminate the impacts of buildings on the environment and human health. It often emphasizes taking advantage of renewable resources, e.g., using sunlight through passive solar, active solar, and photovoltaic equipment, and using plants and trees through green roofs, rain gardens, and reduction of rainwater run-off. Many other techniques are used, such as using low-impact building materials or using packed gravel or permeable concrete instead of conventional concrete or asphalt to enhance replenishment of ground water.

While the practices or technologies employed in green building are constantly evolving and may differ from region to region, fundamental principles persist from which the method is derived:

1- Sitting.

2- Structure design efficiency.

3- Energy efficiency.

4- Water efficiency.

5- Materials efficiency.

6- Indoor environmental quality enhancement.

7- Operations and maintenance optimization.

8- Waste and toxics reduction.

The essence of green building is an optimization of one or more of these principles. Also, with the proper synergistic design, individual green building technologies may work together to produce a greater cumulative effect.

On the aesthetic side of green architecture or sustainable design is the philosophy of designing a building that is in harmony with the natural features and resources surrounding the site. There are several key steps in designing sustainable buildings: specify 'green' building materials from local sources, reduce loads, optimize systems, and generate on-site renewable energy.

2.3: Energy efficiency:

Green buildings often include measures for:

1- Reduce energy consumption

2- Reduce the embodied energy required to extract ,process, transport

3- Make less install building materials and operating energy to provide services such as heating and power for equipment.

As high-performance buildings use less operating energy, embodied energy has assumed much greater importance and may make up as much as 30% of the overall life cycle energy consumption.

To reduce operating energy use, designers use details that reduce air leakage through the building envelope (the barrier between conditioned and unconditioned space). They also specify high-performance windows and extra insulation in walls, ceilings, and floors. Another strategy, passive solar building design, is often implemented in low energy homes. Designers orient windows and walls and place awnings, porches, and trees to shade windows and roofs during the summer while maximizing solar gain in the winter. In addition, effective window placement ,day lighting, can provide more natural light and lessen the need for electric lighting during the day. Solar water heating further reduces energy costs.

Onsite generation of renewable energy through solar power, wind power, hydro power, or biomass can significantly reduce the environmental impact of the building.

2.4: Water efficiency:

Reducing water consumption and protecting water quality are key objectives in green building. One critical issue of water consumption is that in many areas, the demands on the supplying aquifer exceed its ability to replenish itself. To the maximum extent feasible, facilities should increase their dependence on water that is collected, used, purified, and reused on-site. The protection and conservation of water throughout the life of a building may be accomplished by designing for dual plumbing that recycles water in toilet flushing or by using water for washing of the cars (Gray water reuse specification and details in chapter 5). Waste-water may be minimized by utilizing water conserving fixtures such as ultra-low flush toilets and low-flow shower heads. Bidets help eliminate the use of toilet paper, reducing sewer traffic and increasing possibilities of re-using water on-site. Point of use water treatment and heating improves both water quality and energy efficiency while reducing the amount of water in circulation. The use of non-sewage and gray water for on-site use such as site-irrigation will minimize demands on the local aquifer. Large commercial buildings with water and energy efficiency can qualify for an LEED certification.

2.5: Regulation and operation:

As a result of the increased interest in green building concepts and practices, a number of organizations have developed standards, codes and rating systems that let government regulators, building professionals and consumers embrace green building with confidence. In some cases, codes are written so local governments can adopt them as bylaws to reduce the local environmental impact of buildings.

Green building rating systems:

1- LEED, United States and Canada.

2- BREEAM, United Kingdom.

3- DGNB, Germany.

4- CASBEE, Japan.

5- VERDE, Spain.

That rating systems help consumers determine a structure's level of environmental performance. They award credits for optional building features that support green design in categories such as location and maintenance of building site, conservation of water, energy, and building materials, and occupant comfort and health.

Green building codes and standards, such as the International Code Council's draft International Green Construction Code (IGCC), are sets of rules created by standards development organizations that establish minimum requirements for elements of green building such as materials or heating and cooling.

Using simulation software's, and 3D programs to put the project under controlling and to be sure the calculations. Autodesk Ecotect 2011 is program used to put the building under true and actual conditions refer to weather data for the location of building, we get some information to be sure about the contents of the walls and ceiling and ventilation quantities and another data.

Very important thing in green buildings is the direction of this building, especially building which based on electricity generate using cells that generate electricity from sun.

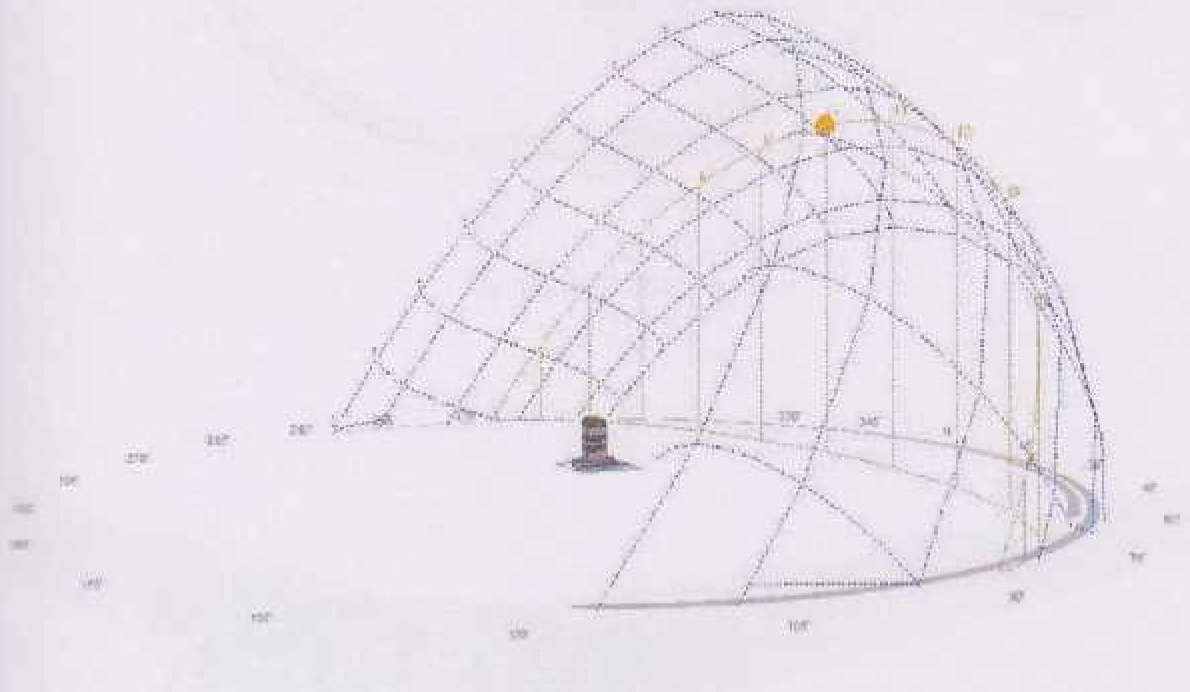

Figure (2.2): Sun path throughout the year

Another tool in Ecotect software is the lighting time and shadow of buildings that used in the project to be useful for loads calculation and for electrical engineers to put them calculations as best as to be power saver, as shown in figure below the shadow range over all the year

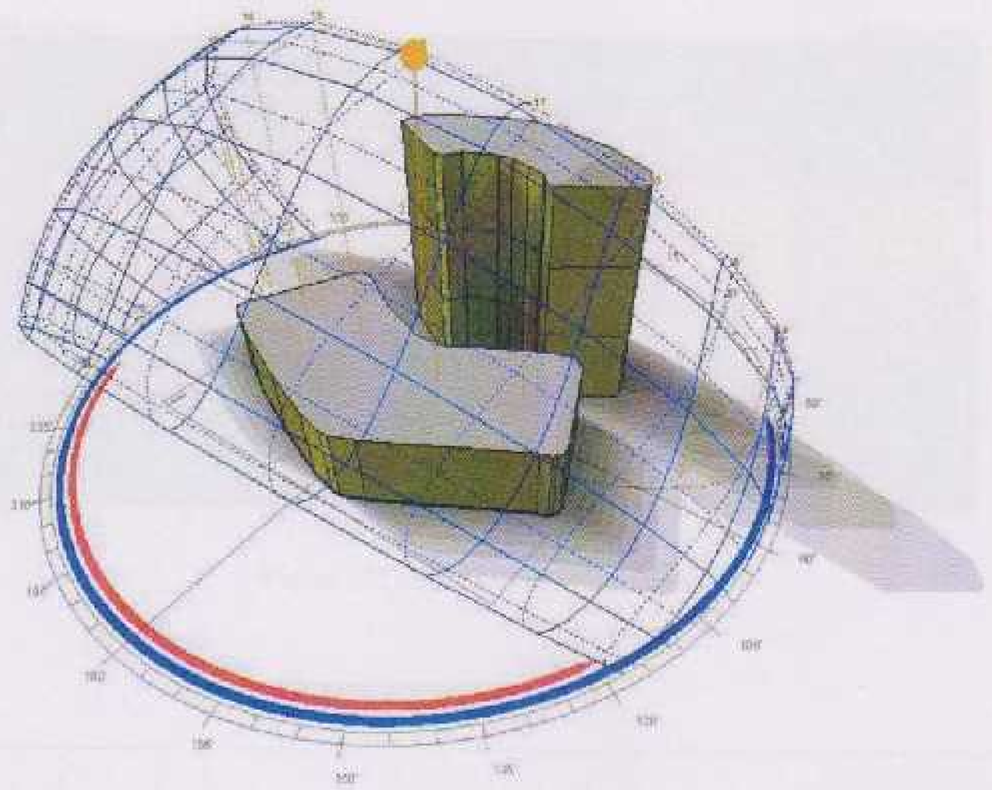

Figure (2.3): Shadow range

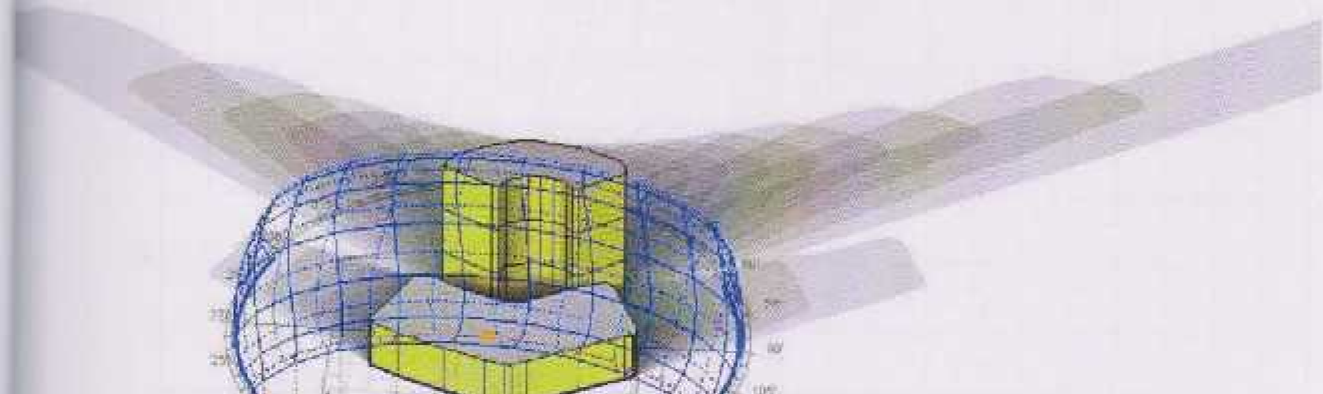

Figure (2.4): Shadow range

Heat transfer from outside walls and due to solar radiation that used in heating and cooling loads calculation is very important, figure exported from Ecotect software represent total monthly solar radiation

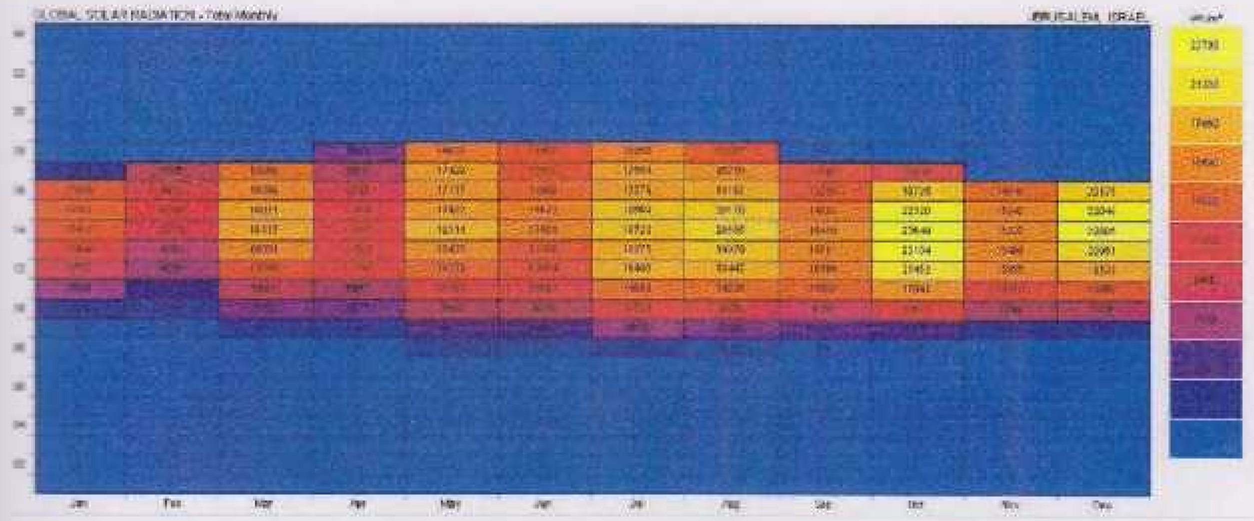

Figure (25): Monthly solar radiation

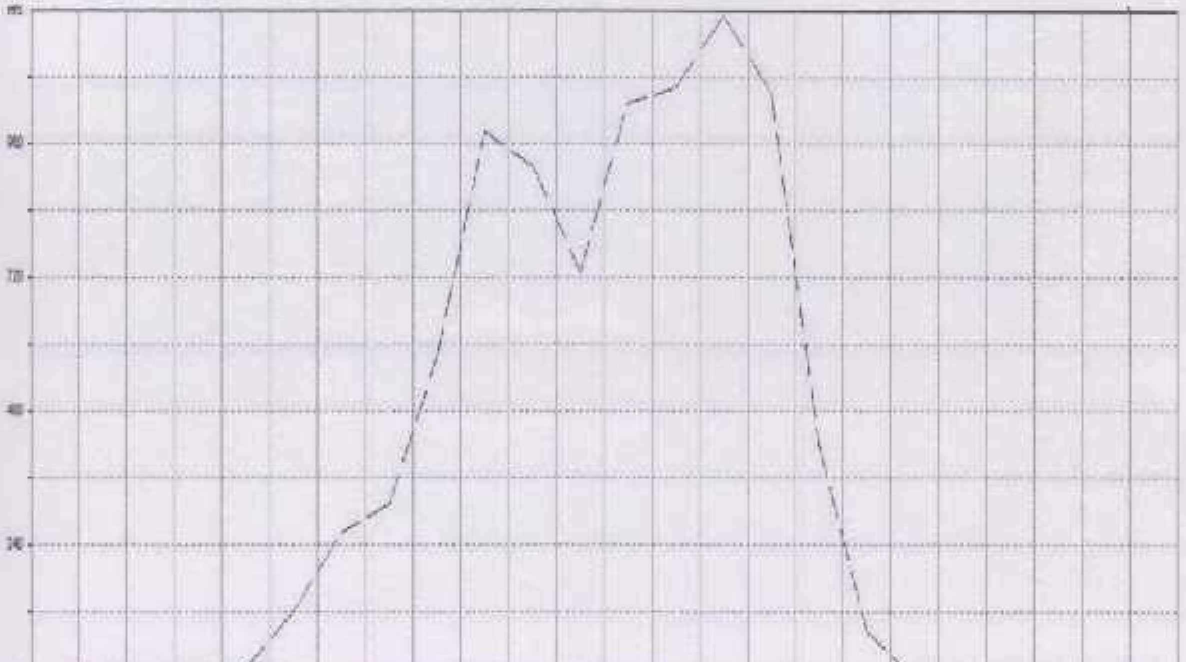

Figure (2.6): Temperature distribution overall year

CHAPTER THREE:

SOLAR ENERGY

3.1 Introduction:

Solar energy is one of the largest sources of light and heat on the face of the earth. This energy is distributed on the ground parts by its proximity to the equator, and this line is the area that has the largest share of that energy, Thermal energy generated by the sun's rays utilized by turning them into (electrical energy) by using photovoltaic panels.

3.2 Solar energy use:

1- Electricity generation.

2- Thermal uses (Heating water).

3.2.1 Electricity generation.

There are two ways to generate electricity by solar energy:

- PV cells.

- Thermal conversion of solar radiation.

Note: In the project the way chose is the method of electricity generation via PV cells was adopted .

3.2.1.1 Parts of PV cells system:

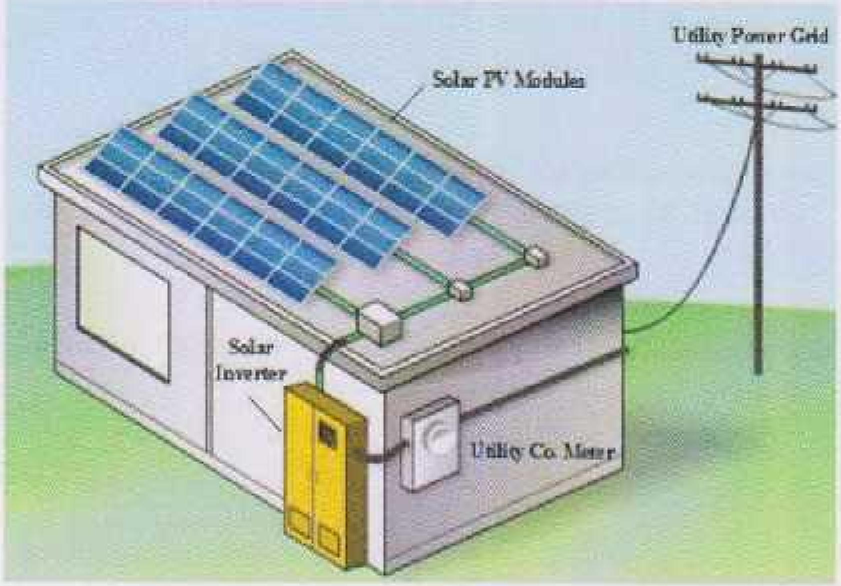

Figure (3.1) Parts of PV cells system.

1-Solar panels:

The solar panels (photovoltaic or PV modules) convert daylight to electricity. A number of modules are connected together to increase the electrical power that can be generated.

PV cells have important advantages:

1-Solar cells are characterized as one piece with no moving parts.

2- Don't consume any energy.

3- Don't pollute the air.

4- It has a long life.

5- Little maintenance.

Selected PVcells for the system:

HSL 60 POLY (Hanwha Solar). Appendix B- C 46, 47, 48-

2- Solar inverter:

A solar inverter, or PV inverter, or Solar converter, converts the variable direct current (DC) output of a photovoltaic (PV)solar panel into a utility frequency alternating current (AC) that can be fed into a commercial electrical grid or used by a local, off electrical network.

Selected inverter: SUNNY BOY 1600TL.

Appendix B- C49-

3-DC Isolator:

The DC isolator provides a safe means of disconnecting the solar array from the inverter, for example for periodic maintenance. Some inverters have integrated DC isolators.

Selected DC Isolator:

Telergon DC Isolators for Photovoltaic applications, from IPD industrial product.

Model # S518004PS0.

Appendix B- C43,42-

4-Generation meter:

The generation meter accurately counts the number of units of electricity created by the PV system. This is important for the measurement of the Feed-In Tariff revenue.

Selected generation meter: DIN rail mounted electricity meters.

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3.2.1.2Calculations of the system:

The Rate effective sun hours in Palestine = 5.4 h.

The proposed area of the cells on the southern facade of the tower = $514m^2$

Figure (3.2) The southern facade of the tower.

- Every 1 kWp gives 1600 kWh.

-kWp: kilowatt-peak, a measure of the peak output of photovoltaic system.

-Every 1 kWp needs $10m^2$ (this area includes the spaces between the cells).

-The production of electricity in the system per year = 51.4 kWp = 82240 kWh.

-The price of electricity produced every year = 50988.8 NIS = 14568.2S.

The cost of the system:

Every 1 kWp equivalent to 1450$

The total cost of the system in the project = 74530$

The time required to recover costs= total cost / price of electricity every year

= 5.1 years

3.2.2 Thermal uses (Heating water).

Solar water heating systems use free heat from the sun to warm domestic hot water.

3.2.2.1 Benefits of solar water heating

- Hot water throughout the year. The system works all year round, though it is necessary to heat the water further with a boiler or immersion heater during the winter months.
- Reduced energy bills. Sunlight is free, so once you've paid for the initial installation your hot water costs will be reduced.
- Lower carbon footprint. Solar hot water is a green, renewable heating system and can reduce your carbon dioxide emissions.

3.2.2.2 How does solar water heating systems works?

Solar water heating systems use solar panels, called collectors, fitted to your roof. These collect heat from the sun and use it to heat up water which is stored in a hot water cylinder. A boiler or immersion heater can be used as a back-up to heat the water further to reach the desired temperature. There are two types of solar water heating panels:

1- Evacuated tubes.
2- Flat plate collectors, which can be fixed on the roof tiles or integrated into the roof.

3.2.2.3The solar water heating system in the tower:

Solary system: is a forced-circulation, closed-loop system, designed primarily for climates that experience annual and persistent hard-freeze conditions.

The parts of system:

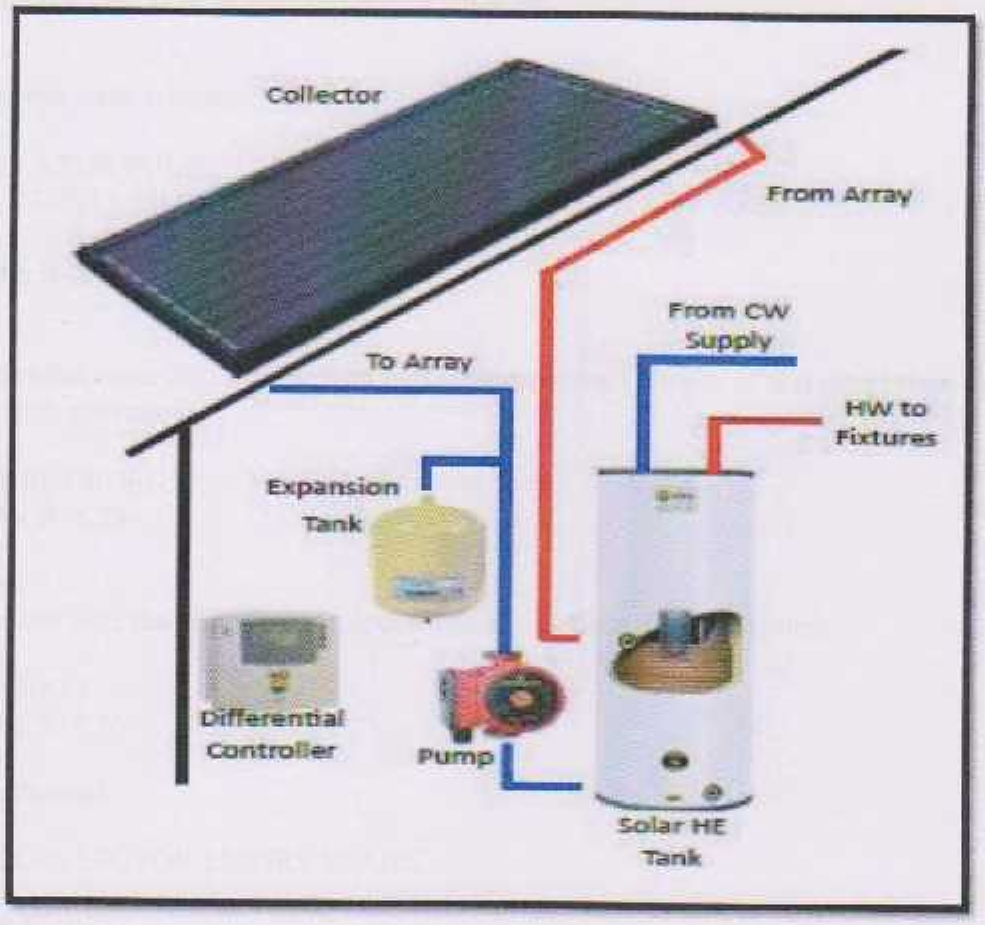

Figure (3.3) The parts of system:

1-Solar heater tank: Two tanks where selected:

- Model# SU80-1.
- Capacity 80 GAL.
- Hight 58.750 in.
- Diameter 24.500 in.

Appendix B- C40-

2-ExpansionTank: Its used to absorb the increased volume of heated fluids and keeps the system pressure below setting on relief valves.

- Model # SET-16.
- Capacity 4.8-9.2 gpm.

Appendix B- C30-

3-Pumps: Are used in a solar system to circulate heat transfer fluid throughout the system allowing solar heat to be transferred and/or collected.

- Two pumps were selected:

- CIRCULATOR PUMP.
- Model # UPS15-58FCLC.

Appendix B- C30-

4- Differential controller: Includes an LCD that provides a variety of real time information about system operations.

-Model # SETR0301U.

Appendix B- C29-

5- Valves:

Have various uses that complete the operations and design of a solar system.

-Model #50613.

Appendix B- C30-

6- Solar Panels:

-Select 8 COLLECTOR EMPIRE SERIES.

-Model # **PS/BS21.**

Appendix B- C41-

CHAPTER FOUR
AIR CONDITIONING SYSTEM

4.1 Introduction:

The main objective of air conditioning is to maintain the environment in enclosed spaces at conditions that induce the feeling of comfort to all occupants of the spaces. This feeling of comfort is influenced by a number of air related parameter which are the temperature inside the conditioned space, humidity, air motion and its speed and the air purity.

The purity of air and its quality include the absence of odors, toxic, and suspended particles, such as dust and dirt.

In selecting a suitable air conditioning system for a particular application, consideration should also be known as following:

- System constraints: cooling load, zoning requirements, heating and ventilation.
- Architectural constraints : size and appearance of terminal devices, acceptable noise level, space available to house equipment and its location relative to the conditioned space , acceptability of components obtruding into the conditioned space.
- Financial constraints: capital cost, operating cost, maintenance cost.

4.2 Heating and cooling load:

Heating load: it is in winter and it is the rate at which heat must be added to the space in order to maintain the desired conditions in the space.

Cooling load: it is in summer and it is the rate at which heat must be removed from space in order to maintain the desired conditions in the space.

4.3 Cooling load sources:

The cooling loads for a given space consist of the following heat gains:

1- Heat gains that transmitted through building structures such as walls, floors and ceiling that are adjacent to unconditioned spaces. The heat transmitted is caused by temperature difference that exists on both sides of structures.

2- Heat gain due to solar effect which includes:

a- Solar radiation transmitted through the glass and absorbed by inside surfaces and furniture.

b- Solar radiation absorbed by walls, glass windows, glass doors and roofs that are exposed to solar radiation.

3- Sensible and latent heat gains brought in to the space.

4- Sensible heat produced in space by lights, appliances, motor and other miscellaneous heat gains.

5-latent heat produced from cooking, hot baths.

6- Sensible and latent heat produced by occupants.

The heating load sources that affect the air conditioning system design can be made-up of many components, including the follow:

1) Heat loss through the exposed areas which consist of the walls, the roofs, windows, doors, and walls between the space and unheated spaces.
2) Heat required to warm air infiltrated through cracks of windows and doors, and by opening and closing of doors and windows or to warm mechanical ventilation air to the temperature of the space.
3) Domestic hot water load.
4) Miscellaneous heat load such as emergency heating loads and safety factor heating load

4.3.1 Solar radiation:

Solar radiation received at the earth's surface on a plane perpendicular to the sun rays may reach at hourly value $900 W/m^2$

On a clear day. This value of solar radiation intensity occurs when the sun is directly over head. Solar radiation intensity decreases as the suns angle of altitude decreases. The altitude angle is the angle that the sun rays make with horizontal line in a vertical plane.

Time of day and altitude of the location are also factors that affect the direct radiation.

4.3.2 Heat gain through sunlit walls and roofs:

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

The calculation of this type of heat gain can be obtained by using the following relation for the heat transmission through the walls.

$$U=\frac{1}{\sum Rth} \quad \dots (4.1)$$

→Where R_{th} are the thermal resistances of the various materials $(m^2.°C/W)$.

The transmitted heating load can be calculated from the relation:

$$Q= U*A*\Delta T \quad \dots (4.2)$$

→ Where:

Q: Heat flow through the walls, ceiling, floor, by conduction (W).

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

A: is the effective area that heat transmitted through it (m^2).

ΔT: The total equivalent temperature difference which take in consideration the increase of wall temperature due to absorption of solar radiation.

The value of CLTD extracted from table A-1 (appendix) needs to be corrected, so that the actual value is found for different cases, and hence it will be called corrected CLTD and can be calculated from the following equation:

$$(CLTD)corr = (CLTD+LM)K + (25.5-T_i) + (T_{o,m} - 29.4)f \text{ .... (3.3)}$$

Where:→

- **LM**: latitude correction factor which can obtain from table A-2 (appendix) from reference for horizontal and vertical surfaces.
- **K**: Color adjustment factor such that K=1.0 for dark colored roof, and K=0.5 for permanently light colored roofs.
- **(25.5-Ti)** : a correction factor for indoor design temperature where Ti is the room design temperature °C.
- **($T_{o,m}$ −29.4)**: A correction factor for outdoor mean temperature .

It is related to the outdoor design temperature to, according to the relation

$T_{o,m}$= To-DR/2

- **DR**: The daily temperature range which equal to the difference between the average maximum and average minimum temperature for the hottest month of the summer season.
- **F**: Roof fan factor such that f=1.0 if there is no attic or roof fan & f=1 if there is not an attic or roof fan.

Over all heat transfer coefficient depends on the layers which the building is consist of and the indoor and outdoor convection heat transfer coefficient.

So over all heat transfer coefficient can be calculated by the following equation:

$$U = \frac{1}{\frac{1}{h_{f\,in}} + \sum \frac{\Delta x}{k_m} + \frac{1}{h_{f\,out}}} \quad \dots (4.4)$$

→Where:

U: over all heat transfer coefficient (W/m^2. K).

K: conduction heat transfer coefficient (W/m. K).

X: layer thickness (m).Δ

: Indoor convection heat transfer coefficient (W/m^2. K).$h_{f\,in}$

: Outdoor convection heat transfer coefficient (W/m^2. K).$h_{f\,out}$

4.3.2 Heat transfer through glass:

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

1- Transmitted component:

It represents the largest component, which is transmitted directly into the interior of the building or the space. This component represents about 42 to 87% of incident solar radiation, depending on the glass transmissibility value.

2-Absorbed component:

This component is absorbed by the glass itself and raises its temperature. About 5 to 50% of solar radiation is absorbed by the glass depending on the absorptive value of glass.

3-Reflected component:

This component is reflected by glass to the outside of the building. About 8% of the solar energy is reflected back by the glass.

The amount of solar radiation that can be transmitted through glass depends upon the following factor:

1-Type of glass. (Single, double or insulation glass).

2-Availability of shading (such as drapes, venetian blinds, construction overhang, wing wall, etc).

3-Time of the day.

4-Orientation of glass area (north, northeast, east orientation, etc).

5-Solar radiation intensity and incident angle.

6-Latitude angle of the location.

4.3.2.1 Transmission heat gain:

The transmitted cooling load can be calculated from the relation:

$$Qtr = A(SHG)(SC)(CLF) \quad .... (4.5)$$

→Where is:

a) Solar heat factor(**SHG**):

Is a factor represents the amount of solar energy from table A-3 (appendix).

b) Shading coefficient(**SC**):

This factor accounts for different shading effects of the glass wall or widow and can be extracted from special tables for single and double glass without inside shading or for single and double glass as well as for insulating glass with internal shading form table A-4-2 (appendix).

c)Cooling load factor (**CLF**):

Represent effect of the internal walls, floor, and furniture on the instantaneous cooling load, we find it from table A-5-1(appendix) for glass, and from table (A-6-1), (A-6-2) (appendix) for lights and occupants respectively .

4.3.2.1 Convection heat gain:

The value of the convection heat gain by the glass can be calculated from the equation:

$$Qconv. = U*A*(CLTD)corr \quad ....(4.6)$$

→Where: **CLTD** is the temperature difference for the glass and can be extracted from table A-7 (appendix) Its designed for inside room temperature of 25.5°C and outside mean temperature of 29.4°C.If Ti and To.m are different from 25.5°C and 29.4°C , then a correction must be added to the value of CLTD.

4.3.3 Heating gain due to equipment:

Sensible and latent heat loads arising from various equipment and appliances that are installed in a conditioned space. The indicated heat dissipation rates from such equipments and appliances should be inclined when the cooling load is estimated. Care must be taken when considering such dissipation rates all sensible or latent or partly sensible and partly latent.

4.3.4 Heating gain due to lights:

Heat gains due to lights are sensible loads. Such loads must be carefully analyzed specially for supermarkets, department stores and other commercial applications that are usually brightly illuminated. The peak lighting heat gains for some applications such as hospitals, restaurants and office will not occur simultaneously with the peak heat gain from other source. This fact should be considered when calculating the peak load for certain application.

The heat gain due to fluorescent lamps is obtained by multiplying the rated voltage of lamp by 1.2 while that for ordinary lamp is obtained from its rated voltage directly.

Lighting intensity differs from one application to another. It ranges from 10 to 30 W/m^2 of floor area for apartments, hospitals, hotels etc. and from 30 to 60 W/m^2 for class rooms, offices, barbershop and similar application.

These lighting intensities can be used to estimate the heat gain from lights if the exact lighting power is not known.

The heat gain from lights it is not an instantaneous load on the air conditioning equipment. The radiant energy from lights is first observed by walls, floor and furniture of the space causing there temperature to increase with time. As time passes, heat is converted from these surfaces.

This result in a time delay between turning the light on and the energy from the light to have an effect on the cooling load. To accommodate for this fact, the following equation can be used to calculate the heat gain due to the lights.

$$Q_{Lt} = P_{Lt} * A * (F_u * F_b) (CLF)_{Lt} \quad ....(4.7)$$

→ Where:.

P_{Lt}: The lamp rated power in watts per $m^2 (60W/m^2)$.

A: Area of zone.

F_u: The fraction of lamps that are in use (F_u=1) .

F_b: The ballast factor that equals to 1.2 for fluorescent lamps and equals to 1.0 for ordinary lamps, (F_b=1.2).

(CLF)$_{Lt}$: The light cooling load factor from table A-6-1(appendix) 10 hours turned on and 10 hours of operation, CLF=0.85.

4.4 Heat and human comfort

The indoor design requirement are chosen to meet human body needs, so human body feeling with relax under known condition of temperature and relative humidity, in order to know these conditions of comfort it is very essential to understand the principle of heat transfer and body temperature.

The normal body temperature is 37.2°C which is mostly higher than ambient temperature thus heat is transferred from the human body to ambient air by the difference in temperature. For reaching equilibrium the human body must generate heat equal to the heat loss by the body, the following equation describes the heat balance:

$$M-P = E+R+C+S \quad .... (4.8)$$

Where:

M: metabolic rate.

P: mechanical work done by the body.

E: rate of total evaporation loss.

R: is the rate of heat dissipated by radiation from the body.

C: is the rate of heat dissipated by convection from the body.

S: rate of heat storage of human body.

The amount of heat generated by the body depends on the type of personals activity, this heat is produced by metabolizing the food we eat, the process is known as metabolism, 1met = seated quiet person (100 W if body surface area is $1.7m^2$).

4.5 Cooling load calculations:

4.5.1 Over all heat transfer coefficient for various sections in the tower:

1) Calculation of overall heat transfer coefficient for outside walls:

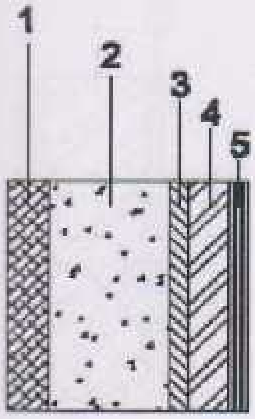

Figure (4.1) Construction of outside wall.

Table (4.1) The thermal resistance & thickness (Δx) for the outside walls.

Layer#	material	ΔX(m)	Rth(m^2.°C/W)
	Inside air film		0.12
1	Stone	0.07	0.041
2	Concrete	0.2	0.141
3	Polypropylene	0.03	0.75
4	Cement brick	0.07	0.078
5	plaster	0.03	0.025
	outside air film		0.06
	U=0.402W/m^2.C		

$$U = \frac{1}{\frac{1}{h_{f\,in}} + \sum \frac{\Delta x}{k_m} + \frac{1}{h_{f\,out}}} =$$

$$\frac{1}{0.12+0.041+1.41+0.75+0.078+0.025+0.06} = 0.402\text{W/m}^2.^{\circ}\text{C}$$

2) Calculation of overall heat transfer coefficient for inside walls:

Figure (4.2) Construction of inside wall.

Table (4.2) The thermal resistance & thickness (Δx) for the inside walls.

Layer#	material	ΔX(m)	Rth(m^2.°C/W)
	Inside air film		0.12
1	plaster	0.03	0.025
2	block	0.1	0.192
3	plaster	0.03	0.025
	inside air film		0.12
	U=2.07W/m^2.°C		

3) Calculation of overall heat transfer coefficient for ceiling between two floors:

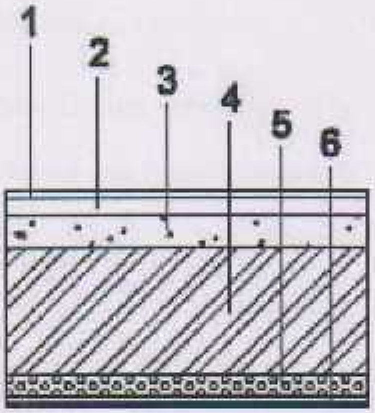

Figure (4.3) Construction of ceiling between two floors.

Table (4.3) The thermal resistance & thickness (Δx) for the ceiling between two floors.

Layer#	material	ΔX(m)	Rth(m^2.°C/W)
	Inside air film		0.12
1	tiles	0.01	0.0083
2	sand	0.1	0.33
3	concert	0.25	0.029
4	block	0.2	0.21
5	polypropylene	0.03	0.75
6	plaster	0.03	0.025
	outside air film		0.12
	U=0.63W/m^2.°C		

4.5.2. Sample calculation for Floor No. 12:

Inside Design Condition: T_i =20°C ,φ =50%

Outside Design Condition: T_o=30°C , φ =53 %

Table A-9 and figure1 (appendix).

Cooling load:

Table (4.4) Cooling load for floor No.12.

	Area (m^2)	U ($W/m^2.C$)	($T_i - T_o$) C	Q_{Loss} (kW)
Walls				
S-Wall	102.6	0.402	10	0.485
E-Wall	46.5	0.402	10	0.187
W-Wall	46.5	0.402	10	0.187
N-Wall	39.2	0.402	10	0.157
	11.6	0.402	12	0.056
	175.6	0.402	6.667	0.422
	27.6	0.402	8	0.089
	63.6	0.402	2	0.051
Ceiling				
Ceiling	494.5	0.63	0	0
Floor				
O-Floor	153.7	0.63	10	0.968
I-Floor	340.8	0.63	0	0
Windows				
S	20.34	3.2	10	0.651
E	27.9	3.2	10	0.893
W	27.9	3.2	10	0.893
N	8.4	3.2	12	0.323
	16	3.2	10	0.512
Doors				
North	4	3	2	0.024
	8	1.468	10	0.117
	3.6	1.468	6.667	0.035
			Q_{total} =	3.05

4.5.2.1 Calculation of the value of (CLTD) corrected:

Table (4.5) the value of (CLTD) corrected.

Surface	U ($W/m^2.°C$).	Area (m^2)	CLTD (C)	LM	CLTD $_{corr.}$ (c)	Q (kW)
E-wall	0.402	74.4	18	0	18.25	0.546
W-wall	0.402	74.4	23	0	23.25	0.695
N-wall	0.402	59.87	11	0.5	11.75	0.283
S-wall	0.402	114.75	16	-1.6	14.65	0.676
E-Glass	3.2	27.9	2	0	2.25	0.201
W-Glass	3.2	27.9	2	0	2.25	0.201
N-Glass	3.2	10.98	2	0.5	2.75	0.097
S-Glass	3.2	17.64	2	-1.6	0.65	0.037
					Total =	2.73

4.5.2.2 Calculation of transmitted heat gains:

Table (4.6) transmitted heat gains.

Surface	Area (m^2)	SHG	SC	CLF	Q $_{Loss}$ (kW)
N-Glass	16	126	0.57	0.18	0.207
S-Glass	15.84	227	0.57	0.57	1.168
E-Glass	27.9	678	0.57	0.24	2.588
W-Glass	27.9	678	0.57	0.1	1.078
				Total=	5.041

4.5.2.3 Cooling load from occupancy:

There is latent heat & sensible heat from people:

For each person:

From table (A-8). (appendix)

Q_s per person = 70 W/person.

Q_L per person = 44 W/person

Sensible heat gain:

Q_S = No. of person * Qs per person * CLF_{occ} [W] …. (3.9)

CLF_{occ}: Cooling factor for occupants from Table A-6-2(appendix).

CLF_{occ}= 0.87

Q_S = 128*70*0.87=7795.2 W

Latent heat gain:

Q_L = No. of person * Q_L per person …. (4.10)

Q_L = 100*44 = 4400 W

total heat gain from people (latent heat & sensible heat):

$Q_t = Q_S + Q_L$…. (4.11)

=7795.2 + 4400 = 12195.2 W

4.5.2.4 Cooling load from ventilation:

$$Q = \frac{N\times V\times \Delta h}{3600\times v_o} \quad \text{…. (4.12)}$$

- 100 persons in the floor

N: number of room air change per hour.

V: volume of room.

v_o: Specific volume for outside air.

T_o = 30 °C $\quad$ T_i = 20 °C

φ_o = 53.7% $\quad$ φ_i = 50%

Table A-10 and Figure1 (appendix).

From psychometric chart:

h_{in} = 39 kJ/kg dry air.

h_{out} = 67.7 kJ/kg dry air.

= 0.84 m^3/kg dry airv_{in}

= 0.878 m^3/kg dry airv_o

$$Q = \frac{1.5\times 2.75\times 494.5\times(67.7-39)}{3600\times 0.878}\times 1000 = 18.52 \text{ kW}$$

4.5.2.5 Cooling load from infiltration:

The air is leaking because of passing air through walls and around the doors and it has sensible heat, in large buildings that use central air-conditioning system usually use the amount of air required for ventilation instead of leak air in infiltration as treated in this project.

About infiltration calculations is given by [just equations explain]:

$Q = \dot{m} * \Delta H$

$\dot{m} = \frac{V}{v}$

V = (number of air change/hour)*volume

$h = h_i - h_o \Delta$

Where:

$\dot{m}_v$: Is the mass flow rate of air due to ventilation.

$\dot{V}_v$: is the volumetric flow rate of air due to ventilation.

v_o : Is the specific volume at outside condition.

4.5.2.5 Total cooling load calculation for the tower:

Table (4.7) Total cooling load calculation for the tower.

# Floor	Cooling Load in [kW]
-2	0
-1	0
GF	255.75
1	260.27
2	77.33
3	54.94
4	54.94
5	54.94
6	37.83
7	37.83
8	54.94
9	54.27
10	37.94
11	37.86
12	54.94
13	54.94
14	54.94
15	41.35
16	31.75
17	0
Q_{Total}	**1256.76**

4.6 Heating load calculations:

Inside Design Condition: $T_i = 20^{\circ}C$, $\varphi = 50\%$

Outside Design Condition: $T_o = 4.7^{\circ}C$, $\varphi = 71.1\%$

Table (A-9), (A-10) and figure1 (appendix).

Table (4.8) heating load for floor No.12.

	Area (m^2)	U ($W/m^2.C$)	($T_i - T_o$) C	Q_{Loss} (kW)
Walls				
S-Wall	102.6	0.402	15.3	0.631
E-Wall	46.5	0.402	15.3	0.286
W-Wall	46.5	0.402	15.3	0.286
N-Wall	39.2	0.402	15.3	0.241
	11.6	0.402	12	0.065
	175.6	0.402	6.667	0.471
	27.6	0.402	8	0.089
	63.6	0.402	2	0.051
Ceiling				
Ceiling	494.5	0.63	0	0
Floor				
O-Floor	153.7	0.63	15.3	1.482
I-Floor	340.8	0.63	0	0
Windows				
S	20.34	3.2	15.3	0.996
E	27.9	3.2	15.3	1.366
W	27.9	3.2	15.3	1.366
N	8.4	3.2	15.3	0.411
	16	3.2	15.3	0.783
Doors				
Door	4	3	2	0.024
North	8	1.468	15.3	0.180
	3.6	1.468	6.667	0.035
Ventilation	-	-	-	18.52
			Q_{total} =	27.274

4.7 Variable refrigerant volume system (VRV).

4.7.1 Introduction about VRV:

VRV is variable control of capacity by inverter, refrigerant volume can be controlled or modulating by electronic expansion valve, VRV system can control each zone alone with regard to other spaces, a variation of this system, often referred to as a multi split, includes multiple indoor units connected to a single condensing unit.

This system also ductless which means heat is transferred to or from the space directly by circulating refrigerant to evaporators located near or within the conditioned space. In contrast, conventional systems transfer heat from the space to the refrigerant by circulating air (in ducted systems) or water (in chillers) throughout the building.

4.7.2 VRV benefits

VRV systems have several key benefits, including:

- Installation advantages. Chillers often require cranes for installation, but VRF systems are light weight and modular. Each module can be transported easily and fits into a standard elevator. Multiples of these modules can be used to achieve cooling capacities of hundreds of tons. Each module (or set of two) is an independent refrigerant loop, but they are controlled by a common control system.
  An additional installation advantage is that the piping connections between outdoor and indoor unit have total length of (1000 m), which is make the system applicable in large and higher buildings, and the number of indoor unit that connected to one outdoor unit reaches to (64).

  Maintenance and commissioning
  VRV system with their standardized configurations and sophisticated electronic controls are aiming toward near plug-and-play commissioning.
  Because they are DX systems, maintenance costs for a VRV should be lower than for water-cooled, chillers, so water treatment issues are avoided. Normal maintenance for a VRV, similar to that of any DX system, consists mainly of changing filters and cleaning coils.

  Comfort. Many zones are possible, each with individual set point control. Because VRF systems use variable speed compressors with wide capacity modulations capability, they can maintain precise temperature control, generally within ± 1 °F
  (+ 0.06 °C), according to manufactures' literature.

  Energy efficiency. the energy efficiency of VRV systems derives from several factors. The VRV essentially eliminates duct losses, which are often estimated to be between 10% to 20% of total airflow on a ducted system. VRV systems typically include two to three compressors, one of each is variable speed, in each condensing unit, enabling wide capacity modulation. This approach yields high part-load efficiency, which translates into high seasonal energy efficiency, because, because HVAC systems typically spend most of their operating hours in the range of 40% to 80% of maximum capacity, so through using inverter technology and control of each zone separately the operating cost be lower with using modulating valve that control the amount of flowing refrigerant with changing load.

4.7.3 Applications

VRV systems are generally best suited to buildings with diverse, multiple zones requiring individual control, such as office building, hospitals, or hotels a VRV system does not compete well with roof top systems in a large low-rise building such as a big box retail store. Although VRF heat pumps operate at ambient temperatures as low as 0 °F (-18 °C), as in all heat pumps, their efficiency drops off considerably at low temperatures, so they are less cost effective compared to gas heating in very cold climates.

4.7.4 Sample calculation:

For floor 12, cooling capacity 54.93 kW.

Table(4.9) Sample calculation for floor 12.

Unit type	No. of model	No. of units	Cooling capacity (kW)	Total cooling capacity (kW)
Wall mounted unit	FXAQ25P	2	2.8	5.6
Wall mounted unit	FXAQ20P	8	2.2	17.6
Wall mounted unit	FXAQ50P	1	5.6	5.6
Round flow cassette	FXFQ63A	2	7.1	14.2
Round flow cassette	FXFQ32A	3	3.6	10.8

- Appendix B – C.14, C.19
- Refnet header (branch kit), model number KHRP26M33H. appendix B-C.17
- Refnet joint (branch kit), model number KHRP25M33T. appendix B-C.18
- MAX-Fan, fan model 10" MAX, flow 920 cfm, length 8 1/2". appendix B - C.7, C.6
- grill 15×22.5 cm. appendix B-C.12, C.13
- Fixable duct . appendix B-C.11

CHAPTER FIVE

PLUMBING SYSTEM

5.1 Plumbing system:

Plumbing: is the art of installing in buildings the pipes, fixtures and other apparatus for bringing in the water supply and removing liquid and water-carried wastes.

Plumbing fixture: are receptacles intended to receive and discharge water, liquid or water carried wastes into a drainage system with which they are connected.

Minimum plumbing facilities:

All code state the minimum plumbing facilities that are required in each building types.

Hydraulics: hydraulics is study of the physical principals that govern behavior of liquid at rest and motion there are two separate and distinct types of liquid flows with which were concerned:

-Flow in closed pressurized system: a system that is now here open to the atmosphere and operates above atmospheric pressure. This is the type of flow that occurs in domestic water systems:

1- Cold water system.

2- Hot water system.

-Flow occurs in all drainage systems (gravity flow)

1- Sanitary drainage system.

2- Storm drainage system.

This type of flow (gravity flow) is caused simply by the slope of pipe containing the liquid These systems are open to the atmospheric the pipes containing the liquid in gravity flow almost always run only partially full (as compared to completely full in pressurized systems).

Static pressure:

Static pressure is caused by the weight of water above any point the system.

$P=F/A = W/A$.

W: weight.

A: area.

5.1.1 Plumbing materials:

The knowledge of plumbing materials is necessary for the proper design of efficient safe, reliable and economical plumbing systems.

All materials used in plumbing systems should meet the requirements of at least one of the standard related to this topic.

Piping materials and standard fittings:

1- Ferrous metal pipe (iron steel).
2- Nonferrous metallic pipe (copper, brass).
3- Plastic pipe:
   ABS (acrylonitrile butadiene system)
   PE (poly ethylene)
   PVC (polyvinyl chloride)
   CPVC (chlorinated polyvinyl chloride)
4- Nonmetallic pipe other than plastic.
   Vitrified clay (term cotta)
   Asbestos cement
   Concrete pipe
5- Joints between dissimilar.

Thermal expansion:

For hot water and stream piping, the problem of thermal expansion is important especially in high rise building or in structures with long horizontal runs due to temperature difference, the length of pipe expands depends on the pipe type, expansion joints and loops are installed every soft depending on pipe size lusts the expansion coefficients and typical expansions for common piping materials.

5.2 Water supply, distribution:

There are two basic types of water distribution systems for building:

1- Up feed distribution system.
2- Down feed distribution system.

- Up feed distribution system:

There are two methods commonly used for up feed distribution system:

1- The supply of water for the building is received from a public street main (usually 35 psi for residential structures, and about 50 psi for other buildings)
2- Private water supply enters into a pneumatic tank (pressurized tank) and is pressurized from approximately 35 to 60 psi.

- Hydro-Pneumatic tank sizing and selection:

Sizing:

Step1:

1- Pump delivery rate: 130.13 gpm

2- Desired minimum pump run time: 2 minutes

3- Number of gallons = 130.13×2 = 260.26 gallon

Step 2:

1- Maximum drawdown required = 260.26

Minimum system pressure (pump cut in) = 57.85 psi

Maximum system pressure (pump cut out) = 65.1 psi

Air pre-charge pressure = 59 psi

2- From table # in appendix drawdown factor = 0.01

3- The minimum total volume required:

V = 260.26/0.01 = 2602.6 gallon

Selection:

ASME bladder type hydro-pneumatic tank

Model number JOPR-22-024

Tank volume = 2640 gallon

Diameter = 72 in

Over head = 164 in

System connection = 2 1/2"

Weight = 2211 kg

Appendix B-C.49.

- Down feed distribution system:

  The water from the gravity tank on the roof serves the floors below by down feed distribution (gravity) system.
  Minimum press required on the top floor is usually is 15 psi (for flues valve), and max press on the lowest floor should not exceed 50 psi, otherwise pressure-reading values are used to reduce the pressure.

Zoning multistory building:

In a multistory building it is logical and economical to limit the height of the water zone to 15 stories each, for example a 45 story building can be divided into three zones.

Flow pressure: the pressure available at the fixtures when the outlet is wide open it must be equal or exceed the minimum fixture pressure.

In adequate pressure: the pressure is the said to be inadequate when the city main pressure is insufficient to provide the required minimum flow pressure. In this case a pressurized (pneumatic) tank or and over roof tank (gravity tank) is to used.

For the flow condition

Main pressure = static head + friction head + flow pressure.

5.2.1 Water service sizing:

Wsfu: water supply fixture unit (wsfu) it is used to calculate the probable maximum water demand (max requirement of water for building).

This wsfu technique is used and becomes more accurate as the number of fixture increase because the system is based on diversity between fixture in use.

water supply fixture unit: technique should never be applied installations with only a few fixture, because in such installations, the additional use of single fixture can drastically change the total usage pattern.

In this case, i.e. for small installation such as residences and small stores use the unite of bathroom groups and converted to gpm plus individual fixture flow rates (in gpm).

5.2.2 Water pipe sizing:

1- By friction head loss.
2- By velocity limitation.

Water pipe sizing by friction head loss:

The procedure is as follows:

-Step 1: draw rise (plumbing section). On this riser show:

- Floor to floor heights.
- Run out distance to farthest fixture on each floor.
- Lengths of piping from service point to the floor take off points.

-Step 2: show the wsfu for each fixture and fixture unit total on each pipe run out. Use separate fixture units for hot and cold water where applicable.

-Step 3: total fixture units in each branch of the system, show both hot and cold water fixture units. (It is understood that hot water pipe sizing will require a separate diagram and calculation), add the continuous water loads.

-Step 4: show source pressure (minimum) and the minimum flow pressure requires of the most remote outlets.

-Step 5: determine the pressure available for friction head loss from the service point to the final outlet.

-Step 6: determine the required pipe size in each section using the friction head loss data calculated in step 5 and friction head charts. Section is normally based on uniform friction head loss per foot throughout and maximum water velocity – usually 8fps, except that branches feeding quick closing devices such as flush values should be limited about 4 fps to avoid water hammer.

5.2.3 Water pipe sizing by velocity limitation:

As said before the water velocity in the piping system in building is not preferred to exceed 8fps. Outside building it may exceed 8 fps.

Velocity of water for sudden open (flush values, etc…)<4 fps for building where available water pressure is more than adequate to supply all the fixture, where exists a simplified pipe sizing method based on water velocity considerations.

This method is normally applicable to all private residences, multiple residences and commercial and industrial building up to three stories in height.

To determine the method applicability, a rapid pressure calculation is made. If this calculation shows that pressure is adequate, use the following procedure:

-Step 1: prepare a building riser diagram show all fixture loads in wsfu and gpm in each pipe section include all continuous loads in gpm figures.

-Step 2: identify all branch piping that feeds quick-closing devices such as flush values, solenoid values (as in clothes washers) and self-closing faucets, the velocity in these branch pipes must be limited to 4 fps to avoid water hammer.

-Step 3: size all individual fixture branches according to the code minimum requirements.

-Step 4: size all other parts of the piping system in accordance with water velocity limitation for the type of piping selected.

5.3 Domestic hot water:

Almost all plumbing fixture except flush-type unit (closet bowls and urinals) require hot water as well as cold.

The usual point of use temperatures are:

Lavatories, showers and tubes: (35-40 °C)

Residential dishwashing and laundry: (50-60 °C).

Commercial and institutional kitchens: (60 °C).

Commercial and institutional laundries: (80 °C).

Sanitizing use

Note:

That these are fixture water temperatures depending on the design and length of the supply piping from the hot water heater, the water heater outlet temperature will be 5 to 20 F higher than fixture temperature to compensate for temperature loss in the supply piping.

Note:

Water heating system is designed to provide hot water at the minimum required temperature because:

1- Lower the heat loss in piping.
2- Slower scale formation in piping.
3- Avoidance.

5.3.1 Types of hot water heaters:

1- Instantaneous water heater:
   a. Atmore
   b. Gas boiler

2- Tank type water heater
3-

Instantaneous water heater:
When hot water faucet opens or other fixture demands hot water they are referred to as tank less heaters because they do not use any sort of storage tank, should be large enough to provide maximum hot water demand immediately at required temperature.
Tank type water heaters: are the most common used units, their advantages are they makes or provide large quantity of heated water available up on demand.
Circulating system are usually provided when the piping run is about 100 ft long.

1- Thermos phone circulation system (the taller the building the better the thermo siphon).
2- Forced circulation system (low and long building).
3-

5.3.2 Sizing of hot water boiler:

Sample calculation for boiler capacity (**3rd floor**):

Number of person = 50 person.

Daly consumption = number of persons * hot water per person

= 50*2 gal/day = 100 gal/day.

Storage capacity= daily consumption * storage capacity portion of daily use

= 100 * 1/5 = 20 gal.

= 90.9 L.

5.4 Plumbing calculation:

Table (5.1) Estimating demand fixture unit:

From table (P-2), estimate fixture unit quantity for each fixture

Floor	Fixtures	FU		
		CW	HW	
-2	0	0	-	Up feed system
-1	6 WC 6 LAV	60 21	-	
GF	10 WC 10 LAV 1 KS	100 20 4	-	
1	4 WC 9 LAV	40 18	-	
2	4 WC 9 LAV 2 KS	40 18 8	-	
3	4 WC 9 LAV	40 18	-	
4	4 WC 9 LAV	40 18	-	
5	4 WC 9 LAV	40 18	-	
6	2 WC 6 LAV 4 SH	40 12 16	-	
7	2 WC 6 LAV 4 SH	40 12 16	-	
8	4 WC 9 LAV	40 13.5	0 13.5	Down feed system
9	4 WC 9 LAV	40 13.5	0 13.5	
10	4 WC 8 LAV 2 KS	40 12 6	0 12 6	

Floor	Fixtures	FU		
		CW	HW	
11	4 WC 9 LAV	40 13.5	0 13.5	Down feed system
12	4 WC 9 LAV 1 KS	40 13.5 3	0 13.5 3	
13	4 WC 9 LAV 1 KS	40 13.5 4	0 13.5 3	
14	4 WC 9 LAV 1 KS	40 13.5 3	0 13.5 3	
15	4 WC 9 LAV 1 KS	40 13.5 3	0 13.5 3	
16	2 WC 4 LAV 2 KS	40 6 6	0 6 6	
17	0	0	0	
	Total	1186.25	372	

-The maximum instantaneous cold water demand is = 1186.25 FU, from table (P-1) by interpolation: 1186.25 = 234.39 gpm.

-The maximum instantaneous hot water demand is = 372 FU, from table (P-1) by interpolation: 372 = 120.8 gpm.

Where:

WC: water closet

LAV: lavatory

KS: kitchen sink

Table (5.2) Pipe sizing for black and gray water.

From table (P-3), estimate pipes sizes for horizontal pipes and vertical pipes (stacks)

	Black water			Gray water		
Floor No.	FU	Horizontal pipe diameter	Vertical pipe diameter	FU	Horizontal pipe diameter	Vertical pipe diameter
16	20	4"	4"	20	4"	4"
15	40	4"	4"	31	4"	4"
14	40	4"	4"	31	4"	4"
13	40	4"	4"	31	4"	4"
12	40	4"	4"	27	4"	4"
11	40	4"	4"	32	4"	4"
10	40	4"	4"	27	4"	4"
9	40	4"	4"	27	4"	4"
8	40	4"	4"	39	4"	4"
7	40	4"	4"	39	4"	4"
6	40	4"	4"	27	4"	4"
5	40	4"	4"	27	4"	4"
4	40	4"	4"	27	4"	4"
3	40	4"	4"	27	4"	4"
2	40	4"	6"	27	4"	4"
1	40	4"	6"	27	4"	4"
GF	120	4"	6"	96	4"	4"
			6"			6"

5.5 Manhole calculation:

Sample calculation - gray water manholes calculations:

-type of cover manhole: cast iron, 8 ton.

The depth of the first manhole (60 cm) and the calculation of the second manhole according to it and so on.

For manhole 1:

Top level = 0.0 m

Depth = 0.6m

Outlet level = top level – depth = 0.0 – 0.6 = -0.6m

For manhole 2:

The distance between manhole 1 and manhole 2 is 5.5m, depth of manhole 2 is:

Depth = (distance*slope) + depth of manhole + 5 cm

Depth = 73 cm

Outlet of manhole 2 = top level – depth of manhole 2 = 0.0 – 73 = -73 cm

Invert level of manhole 2 = outlet of manhole 2 + 5 cm = -6 cm

Table (5.3) Gray water manholes table:

Manhole NO.	Top level (m)	Invert level (m)	Outlet level (m)	Depth (m)	Diameter (m)
1	0.0	-0.55	-0.6	0.60	0.60
2	0.0	-0.60	-0.75	0.75	0.60
3	0.0	-0.90	-0.95	0.95	0.60
4	0.0	-0.55	-0.6	0.60	0.60
5	0.0	-1.10	-1.15	1.15	0.80
6	-2	-3.45	-3.5	1.30	0.80

Table (5.4) Black water manholes table:

Manhole NO.	Top level (m)	Invert level (m)	Outlet level (m)	Depth (m)	Diameter (m)
1	0.0	-0.55	-0.60	0.60	0.60
2	0.0	-0.75	-0.80	0.80	0.60
3	0.0	-0.95	-1.00	1.00	0.60
4	0.0	-1.15	-1.20	1.20	0.80
5	0.0	-1.35	-1.40	1.30	0.80
6	0.0	-1.55	-1.60	1.40	0.80
7	0.0	-1.75	-1.80	1.60	1.00
8	0.0	-1.95	-2.00	1.80	1.00
9	0.0	-2.15	-2.20	2.00	1.00

5.6 Flood water drainage system:

System consists of drainage network on the floors below the zero level, System works on water drainage, especially the Floodwaters.

5.6.1 Parts of the system:

Figure 5.1Channel drain.

1- Channel drain:
Type: 12" Pro Series Channel™ Drains.
appendix B-c20-

2-Pumps:

A-Two submersible pumps.
-Type: WILO.
-Model: FA15.52-260E.
appendix B-c21-
B-Two submersible pumps.
-Type: WILO.
-Model: MTS40E26.15/15.
appendix B-c21-
3- Pipes:
-U.P.V.C (4", 6")

5.7 Gray water:

Grey water is all wastewater that is discharged from a house, excluding black water (toilet water). This includes water from showers, bathtubs, sinks, kitchen, dishwashers, laundry tubs, and washing machines (Figure 1). It commonly contains soap, shampoo, toothpaste, food scraps, cooking oils, detergents and hair. Grey water makes up the largest proportion of the total wastewater flow from households in terms of volume. Typically, 50-80% of the household wastewater is grey water. If a composting toilet is also used, then 100% of the household wastewater is grey water.

Not all grey water is equally "grey". Kitchen sink water laden with food solids and laundry water that has been used to wash diapers are more heavily contaminated than grey water from showers and bathroom sinks. Therefore, different grey water flows may require different treatment methods that would render the water suitable for reuse.

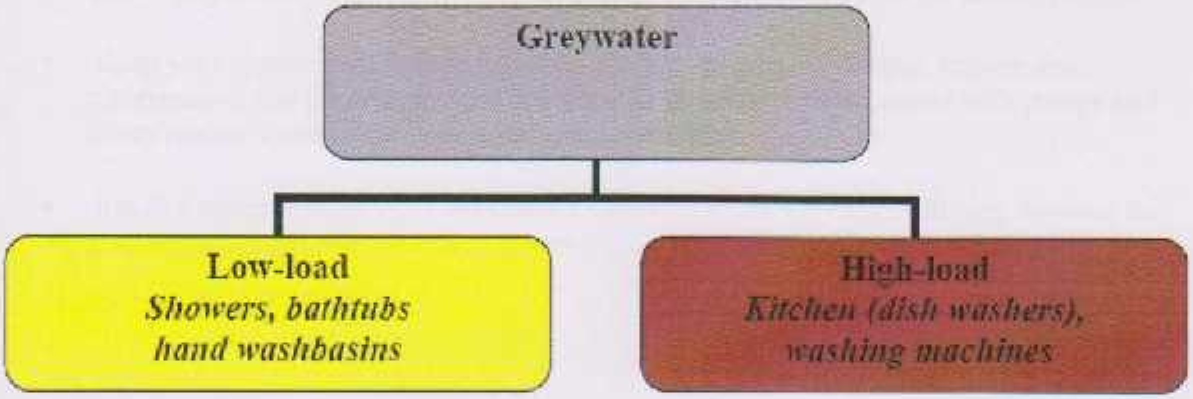

Figure (5.2)Major gray water sources.

5.7.1 Benefits of Gray water:

Reusing gray water is an important component of sustainable water practices. There are many benefits of using gray water instead of potable water for irrigation.

- Decrease potable water use by 16 to 40 percent, depending on the site.
- Decrease water and wastewater utility bills.
- Diversify the City's water portfolio and provide an alternate source of Irrigation water, reserving treated potable water for high-quality water Needs.
- Reduce the energy (approximately 2 watt-hours per gallon of water) and Chemicals needed to treat wastewater.

Another benefit of using gray water is that it connects us to our water supply, helping us understand where our water comes from and where it goes. Becoming conscious of our water supply encourages healthier product choices and engagement with our landscape. By reusing household gray water, we preserve water resources for other living things. In concert with water-wise landscaping, rainwater harvesting, and conservation, using gray water as a resource helps reduce dependency on imported water and protects watersheds.

5.7.2 Gray water Basics:

Gray water is a unique source of water and must be used differently from potable water and rainwater. These are some basic guidelines for residential gray water systems:

- Do not store gray water more than 24 hours. If you store gray water, the nutrients in it start to break down and create bad odors.
- Minimize contact with gray water. Gray water can contain pathogens. All systems must be designed so that water soaks into the ground and is not accessible to contact by people or animals.
- Infiltrate gray water into the ground; do not allow it to pool or run off. You'll need to know how fast water soaks into your soil to properly design your system. Pooling gray water can provide opportunities for mosquitoes to breed, as well as for human contact.
- Keep your system as simple as possible. Simple systems last longer, require less maintenance, use less energy, and cost less. Keep in mind that systems with pumps and filters require more commitment and regular maintenance.
- Install a diverter valve at a convenient location to allow for easy switching between the gray water system and the sewer system.

5.7.3 Pumped Systems:

In pumped systems, gray water is directed to a holding tank for temporary storage before being pumped to the landscape. If the system is to be used for drip irrigation, the gray water must be filtered before it reaches the drip emitters.

5.7.3.1 Pumps used in the system:

1- Pumps used in the case of treatment:

- Selected pump A: VersaFlo® TP100.appendix B-c26-

- Selected pump D :(CR, CRN64). appendix B-c27-

2- Pump used in the black flush system:

- Selected pump B: VersaFlo® TP100. appendix B-c26-

3- Pump used to drain gray water to manholes:

- Selected pump C :(CR, CRN64). appendix B-c27-

4-Water distributions pump on irrigation networks:

- Selected pump C :(CR, CRN64). appendix B-c27-

5.7.4 Sand Filter:

5.7.4.1Basic of operation filters:

1-Normal working conditions are obtained when headloss is less than 0.3 bar (5 psi) with clean filter.

2-If headloss exceeds 0.3 bar (5 psi) - filter is either partially clogged or operating under an excessive flow rate.

3-Backflush the filter at the beginning and at the end of irrigation. Chlorinate before end of irrigation, as necessary.

4- Backflush filter when headloss increases by 0.3 - 0.5 bar (4.5 - 7.5 psi) above headloss of clean filter, or every 3 hours, whichever comes first.

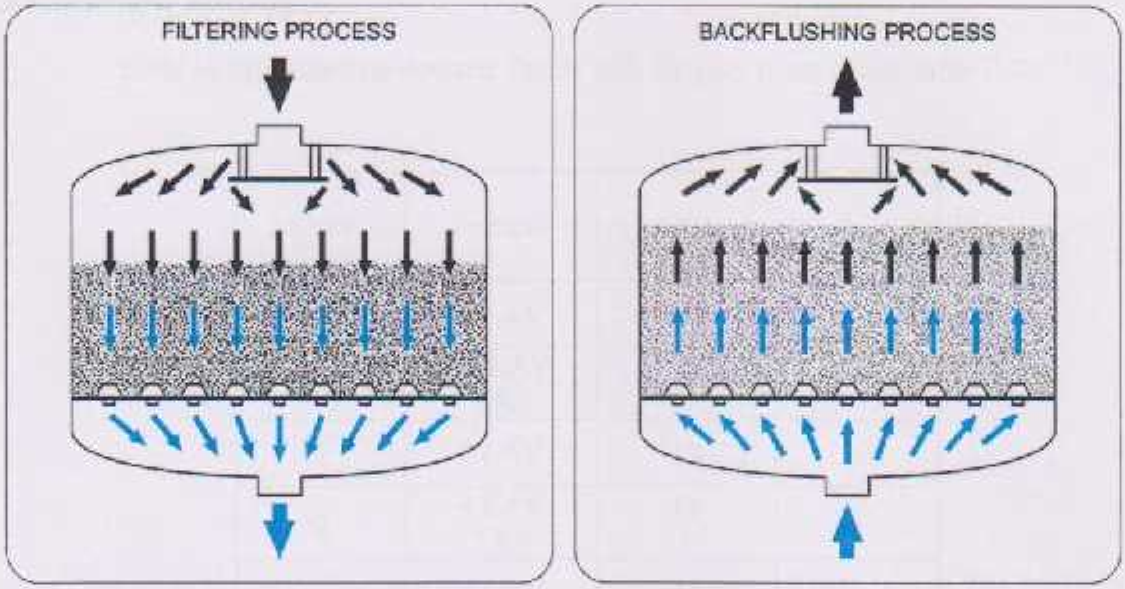

Figure (5.3) sand filter process.

Selection of sand filters from ODIS (Irrigation equipment LTD) company:

-Sand filter number 1 with type model 4363. appendix B-c24,25-

-Sand filter number 2 with type model4303. appendix B-c26,25-

5.8 Gray water calculation.

Table (4.3) Estimating demand fixture unit for gray water (From table P-2):

Floor	Fixtures	FU	
		CW	HW
-1	6 LAV	12	-
GF	10 LAV 1 KS	20 4	-
1	9 LAV	18	-
2	9 LAV 2 KS	18 8	-
3	9 LAV	18	-
4	9 LAV	18	-
5	9 LAV	18	-
6	6 LAV 4 SH	12 16	-
7	6 LAV 4 SH	12 16	-
8	9 LAV	13.5	13.5
9	9 LAV	13.5	13.5
10	9 LAV 1 KS	13.5 3	13.5 3
11	9 LAV 1 KS	18 3	18 3
12	9 LAV 1 KS	13.5 3	13.5 3
13	9 LAV 1 KS	13.5 3	13.5 3
14	9 LAV 1 KS	13.5 3	13.5 3
15	9 LAV 1 KS	13.5 3	13.5 3
16	4 LAV 2 KS	13.5 6	13.5 6
	Total	516	

From table (P-1), by interpolation 516 FU = 142.2 gpm

Where:

LAV: bath faucet.

KS: kitchen sink.

SH: shower head.

CHAPTER SIX
Irrigation System Design

6.1: Introduction:

Irrigation is the artificial application of water to the land or soil. It is used to assist in the growing of agricultural crops, maintenance of landscapes, and revegetation of disturbed soils in dry areas and during periods of inadequate rainfall. Additionally, irrigation also has a few other uses in crop production, which include protecting plants against frost, suppressing weed growth in grain fields and preventing soil consolidation. In contrast, agriculture that relies only on direct rainfall is referred to as rain-fed or dryland farming.

Irrigation systems are also used for dust suppression, disposal of sewage, and in mining. Irrigation is often studied together with drainage, which is the natural or artificial removal of surface and sub-surface water from a given area.

Irrigation has been a central feature of agriculture for over 5.000 years and is the product of many cultures.

6.2: Types of irrigation:

1- Surface irrigation.

2- Localized irrigation.

3- Subsurface textile irrigation.

4- Drip irrigation.

5- Irrigation using sprinkler systems, which we used in the project.

6- Irrigation using Center pivot.

7- Irrigation by Lateral move.

6.3: Water resources

Irrigation water can come from groundwater, from surface water or from nonconventional sources like treated wastewater, desalinated water or drainage water. Around 90% of wastewater produced globally remains untreated, causing widespread water pollution, especially in low-income countries. Increasingly, agriculture uses untreated wastewater as a source of irrigation water. Cities provide lucrative markets for fresh produce, so are attractive to farmers. However, because agriculture has to compete for increasingly scarce water resources with industry and municipal, there is often no alternative for farmers but to use water polluted with urban waste, including sewage, directly to water their crops. Significant health hazards can result from using water loaded with pathogens in this way, especially if people eat raw vegetables that have been irrigated with the polluted water, so that gray water treatment is very important in this field.

6.4: Irrigation using sprinkler systems.

Irrigation sprinklers are sprinklers providing irrigation to vegetation, or for recreation, as a cooling system, or for the control of airborne dust. The sprinkler system irrigates the field and thus it is widely used in areas as it checks the wastage of water through seepage and evaporation.

Sprinkler irrigation is a method of applying irrigation water which is similar to natural rainfall. Water is distributed through a system of pipes usually by pumping. It is then sprayed into the air through sprinklers so that it breaks up into small water drops which fall to the ground.

The pump supply system, sprinklers and operating conditions must be designed to enable a uniform application of water.

The main advantages of sprinkler irrigation - reasons for choosing the system:

1- Expansive land leveling is not required.
2- Water saving irrigation intensity can be changed in accordance with the infiltration capacity of soil.
3- High efficiency due to uniform water distribution.
4- No special skills trained personal can operate the system reasonably well.
5- Ease and uniform application of fertilizers and pesticides through irrigation system.
6- Possibility of applying minute quantity of water for germination and other irrigation systems.
7- Frequent and light irrigation possible giving better response from the crops.
8- Increase in yield and quality, early ripening, water conservation and alternative value of specific period saving of labor, machinery, fertilizer and pesticides.
9- Soil moisture is maintained at optimum level by sprinkler irrigation and 20 higher yields are obtained of crops and the quality of other crops is also good.
10- Providing irrigation to vegetation as a cooling system.
11- Using for the control of airborne dust.

Sprinkler irrigation system components:

1 - Pumping Unit (Pumps)
2 - The main pipes (Main lines)
3 - Sub-pipe (lateral lines)
4 - Sprayers (Nozzles)

Types of Sprays:

1 - Which operates low pressure (0.7 to 2 Kg / 2 cm), "low pressure sprinklers" a few coverage area and has high rate of spray.

2 - Average operating pressure (2-5 Kg / 2 cm), "sprinklers medium pressure" consistency desirable good efficiency, little impact on soil.

3 -High operating pressure (5-10 Kg / 2 cm), "high-pressure sprinklers" large size of water drops, large droplets fall rate

Also in the system should install a rain sensor, which saves water by shutting the irrigation system temporarily when it rains without erasing the program.

Figure (6.1): rain sensor

- Irrigation sketches from M304 to plan M311, plot to scale.
- Details on plots.

6.5: System design and selection:

6.5.1: Sprinkler system:

Selection:

Model number 570™ series

Table (6.1) Spray head, 15' series at 30 PSI, number of heads on each feed line:

570™ series sprayheads (@ 30 PSI)		Gallons per minute (GPM)			
		5 GPM	8 GPM	12 GPM	15 GPM
15' quarter circle (90°)		5	9	14	17
15' half circle (90°)		3	4	7	9
15' full circle (90°)		1	2	3	4

Table (6.2): Nozzle, 15' series with 27° trajectory (black):

Pattern		Pressure [PSI]	Flow [GPM]	Radius [Feet]
90°		30	0.85	15'
180°		30	1.65	15'
360°		30	3.6	15'
0-360°		30	3.82	13'

6.5.2: Control system:

6.5.2.1: System controlled using PLC programming and timers, which connected with BMS System,

1- Siemens PLC controller

2- Valve wire connections

3- Grease cap/ wire connectors

4- Anti-Siphon valve

5- Sprinkler

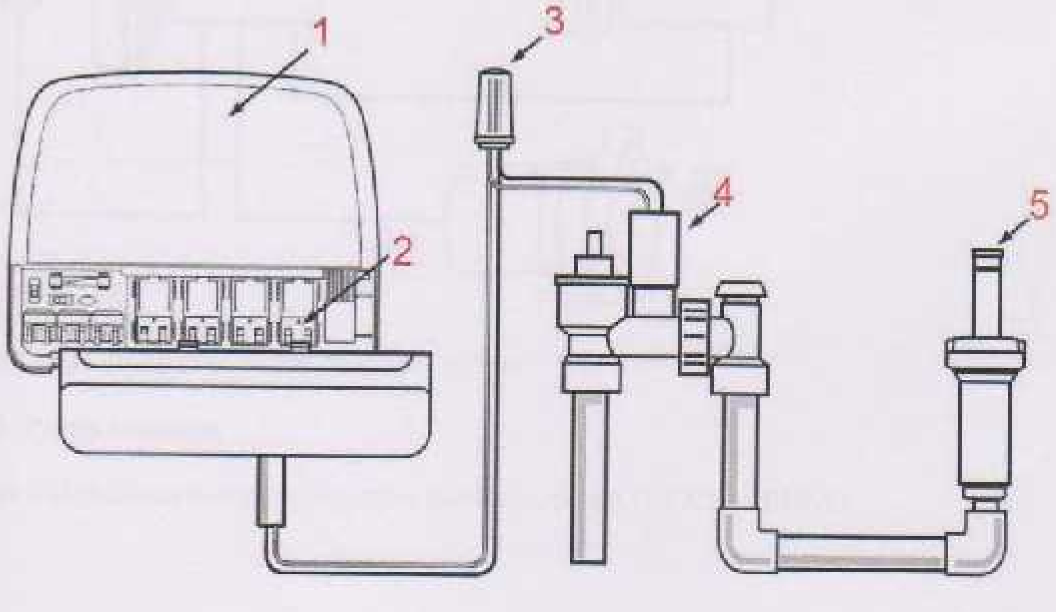

Figure (6.2) Control system for irrigation.

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6.5.2.1: Pump control and protection:

1- Power supply

2- Pump start relay

3- Minimum spacing 5'

4- Siemens PLC controller

5- Pump

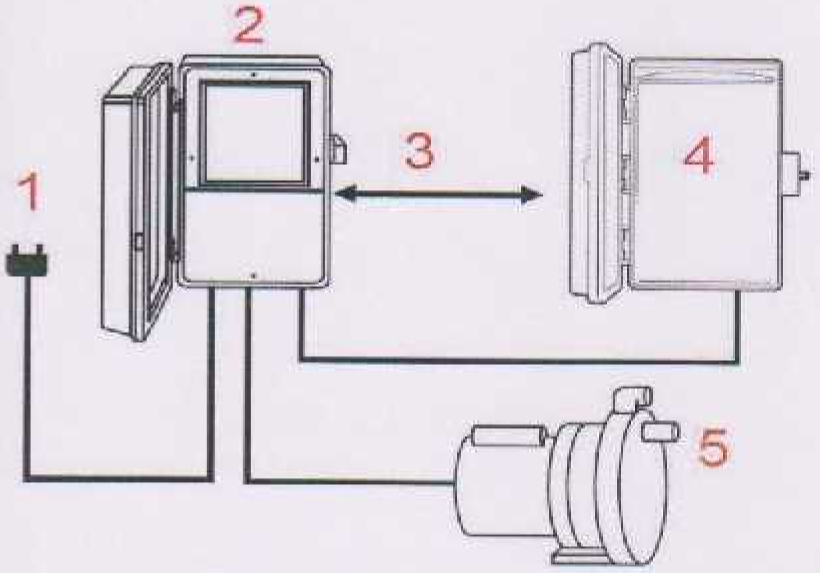


Figure (6.3) Pump control for irrigation system.

6.5.3: Pump selection

Water distributions pump on irrigation networks, pump C :(CR, CRN64).

CHAPTER SEVEN

FIRE FIGHTING SYSTEM

7.1The Fire Triangle:

There are three components required for combustion to occur:

Fuel – to vaporize and burn

Oxygen – to combine with fuel vapor

Heat – to raise the temperature of the fuel vapor to its ignition temperature

The following is the typical "fire triangle", which illustrates the relationship between these three components:

Fighter (7.1):The Fire Triangle.

7.2Classifications of Fire:

Fires are classified into five groups as follows:

Class A: Class A fires involve common combustibles such as wood, paper, cloth, rubber, trash and plastics. They are common in typical commercial and home settings, but can occur anywhere these types of materials are found.

Class B: Class B fires involve flammable liquids' gases, solvents, oil, gasoline, paint, lacquers, tars and other synthetic or oil-based products. Class B fires often spread rapidly and, unless properly secured, can reflash after the flames are extinguished.

Class C: Class C fires involve energized electrical equipment, such as wiring, controls, motors, data processing panels or appliances. They can be caused by a spark, power surge or short circuit and typically occur in locations that are difficult to reach and see.

Class D: Class D fires involve combustible metals such as magnesium and sodium. Combustible metal fires are unique industrial hazards which require special dry powder agents.

Class K: Class K fires involve combustible cooking media such as oils and grease commonly found in commercial kitchens. The new cooking media formulations used form commercial food preparation require a special wet chemical extinguishing agent that is especially suited for extinguishing and suppressing these extremely hot fires that have the ability to reflash.

A	Common Combustibles	Wood, Paper, Cloth, Etc.
B	Flammable Liquids & Gases	Gasoline, Propane other Solvents
C	Live Electrical Equipment	Computers, Fax Machines, Etc.
D	Combustible Metals	Magnesium, Lithium, Titanium
K	Cooking Media	Oils, Lards, Fats

Figure (7. 2) fire clasification.

Fire Signatures:

fire signatures any fire effect (smoke, heat, light, etc.) that can be sensed by fire detector The amount of heat released by fire varies in accordance with the type of combustible, arrangement of the combustible ,availability of oxygen ,and numerous other factors.

7.3 Types of Firefighting Systems:

Fire systems are classified as follows:

Portable fire extinguishers can contain a wide variety of extinguishing agents; the portable fire extinguishers enable an individual with minimal training to extinguish an incipient fire. A portable fire extinguisher should not be considered as the sole solution to fire protection analysis of a building but, rather only one of many components of a total fire protection plan.

7.3.1 Firefighting Extinguishers:

Types of Portable Firefighting Extinguishers:

1-Foam: fire extinguishers extinguish the fire by taking away the heat element of the fire triangle. Foam agents also separate the oxygen element from the other elements, and we use it in the tower.

Water extinguishers are for Class A fires only - they should not be used on Class B or C fires. The discharge stream could spread the flammable liquid in a Class B fire or could create a shock hazard on a class C fire.

Foam extinguishers can be used on Class A & B fires only. They are not for use on Class C fires due to the shock hazard.

2-Carbon Dioxide: Carbon dioxide fire extinguishers extinguish the fire by taking away the oxygen element of the fire triangle and also by removing the heat with a very cold discharge. Carbon dioxide can be used on Class B & C fires. They are usually ineffective on Class A fires.

3-Clean agent extinguishers: Halogenated or Clean Agent extinguishers include the halon agents as well as the newer and less ozone depleting halocarbon agents. They extinguish the fire by interrupting the chemical reaction of the fire triangle.

4-Dry chemical extinguishers hand and wheeled: fire extinguishers extinguish the fire primarily by interrupting the chemical reaction of the fire triangle

5-Wet chemical extinguishers: Wet Chemical is a new agent that extinguishes the fire by removing the heat of the fire triangle and prevents reigniting by creating a barrier between the oxygen and fuel elements and use in kitchen.

6-Dry Powder: extinguishers are similar to dry chemical except that they extinguish the fire by separating the fuel from the oxygen element or by removing the heat element of the fire triangle. .

7.3.2 Fire hose cabinet.

A fire hose is a high-pressure hose that carries water or other fire retardant (such as foam to a fire to extinguish it. Outdoors, it attaches either to a fire engine or a fire hydrant.

Indoors, it can permanently attach to building's standpipe or plumbing system. Hero invented it and based it on double action piston pump.

Consist of tow type:

- Hose reel a pipe which consists of rubber rolled on pulley having an arm witch use by regular people.

- Hose rack: a pipe which consists of Cloth-reinforced which usually use by Civil Defense Company.

7.3.2.1 Fire hose calculation:

Table (8.1) Fire hose calculation

Zone	Floor	Main riser	Branch	Branch to the hose
1	-2,-1,0	6"	4"	2"
2	1to 6	6"	4"	2"
3	7 to17	6"	4"	2"

Sample calculation for zone 1:

P.pump = Pr. + P.fr. + P.e   1.

Pr: the pressure at the hose cabinet.

P fr: pressure lose due to friction pipes.

Pele. : pressure lose due to elevation(head).

Number of cabinets = 28 unit.

Flow for cabinets, Q = 28 × 6 =168 L/s.

Q = 2217.3gpm.

Pr 4.5 bar.

Pel. = 6.8 m = 0.66 bar.

Pfr. = Leq. × F.L

Leq = 96.8 × 1.5 = 104.7 m

Leq = 515 ft

Pfr = Leq × F.L

=104.7 × 0.01 = 1.57 bar

P.pump = Pr. + P.fr. + P.el.

P pump = 4.5 + 1.57 + 0.66 = 6.73 bar

Pipe friction = pump P – pressure head – minimum flow pressure

= 97.6 – 9.5 – 65.2

= 22.9 psi

Main riser pipe size selection = 6"

Branch =4"

Branch to hose cabinet= 2"

Pumps selected:

One electrical main pump, one diesel main motor pump, one jockey pump

For riser 1:

Code: 700.444

Model: EDP-C80-250/255-89.8

For riser 2:

Code: 700.441

Model: EDP-C80-200/205-65.3

For riser 3:

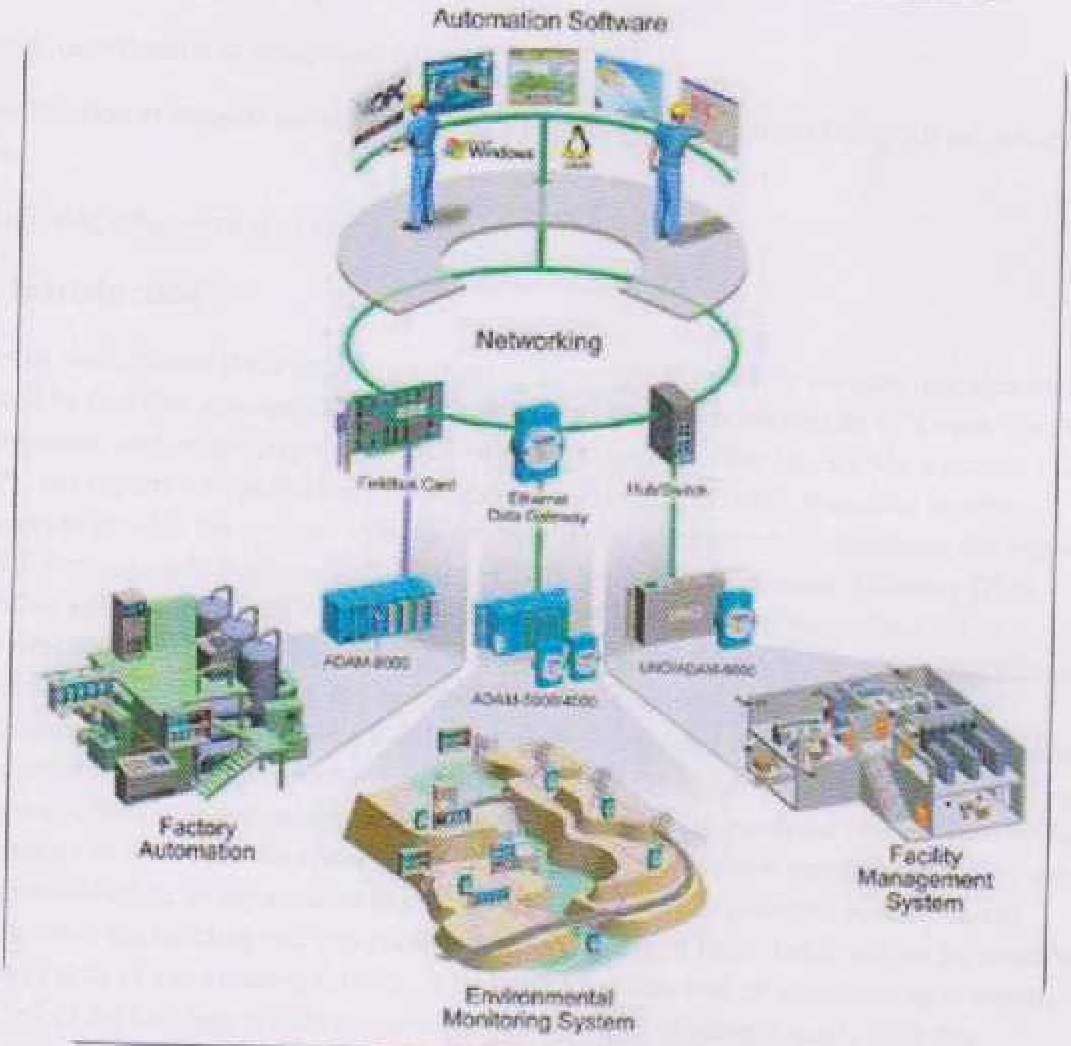
Code: 700.447

Model: EDP-S80-315R/302-177.5

Appendix B -c2,4-

CHAPTER EIGHT

Building Management System



8.1: Summary

A well designed and managed Building Management System (BMS) provides great opportunities for improvements in energy efficiency by:

• Enabling building managers to provide an optimal working environment consistent with maintaining a building's energy efficiency rating..

• Early identification of equipment failure.

• Identification of unusual patterns of energy usage, such as equipment being left on out of office hours.

• Monitoring effectiveness of Energy Management Plans.

8.2: Introduction

Effective well utilized Building Management Systems (BMS) provide the core management tool required by building managers to ensure compliance with, and achievement of, Green Lease requirements, such as the target NABERS rating, monitoring of the Energy Management Plan (EMP), and reports for the Building Management Committee (BMC). It enables building managers to provide the optimal working environment consistent with maintaining the required NABERS rating while minimizing the costs to both landlords and tenants. Effective BMS utilization allows for optimal building performance by extending the operational life of equipment and systems through reducing loads and operating hours. Maintenance and capital costs are therefore reduced and less embedded energy is consumed through equipment replacement and upgrades. When a building has been completed the impact of its structure on its energy consumption performance is normally fixed until refurbishment occurs. Base building and tenant light and power energy consumption can however be increased or decreased by the performance of both building systems and tenants. A BMS will show increases in energy use due to equipment failure or adjustments to operating parameters. For example, heating valves opening when the building requires cooling or whole floors of lights being left on for extended periods of time due to cleaning activity. A BMS also indicate that air conditioning is starting up hours before the building is fully occupied due to activities of security staff. With this information in hand, the building manager may be able to rectify such issues through consultation or engineering solutions. In the absence of a BMS, the impact of such events can be disguised by seasonal variations, changes in occupancy levels or technology upgrades. A correctly configured BMS with an adequate number of correctly located monitoring points is the only way a building manager can be quickly alerted to problems which could otherwise remain undetected until annual inspections or external audits are undertaken. A BMS is also a primary tool for identifying energy intensity improvement opportunities, for example refining the size and number of lighting time blocks, providing meaningful reports to the Building Management Committee on issues and opportunities, and enabling identification of faults, maintenance planning, and energy saving upgrades.

8.3: BMS data.

For a BMS to function effectively it needs to reside on a computer that has adequate capacity and speed to support BMS function. BMS related data storage of one year is required for all active control points. Computers and data storage hardware will normally require replacement at least once during an average tenancy. The BMS data collection network should have capacity to provide data to the BMS at required frequency, via an industry open protocol such as a fully compliant BACNET.

Figure(8.1) BMS data.

8.4: Integration of BMS with other tools.

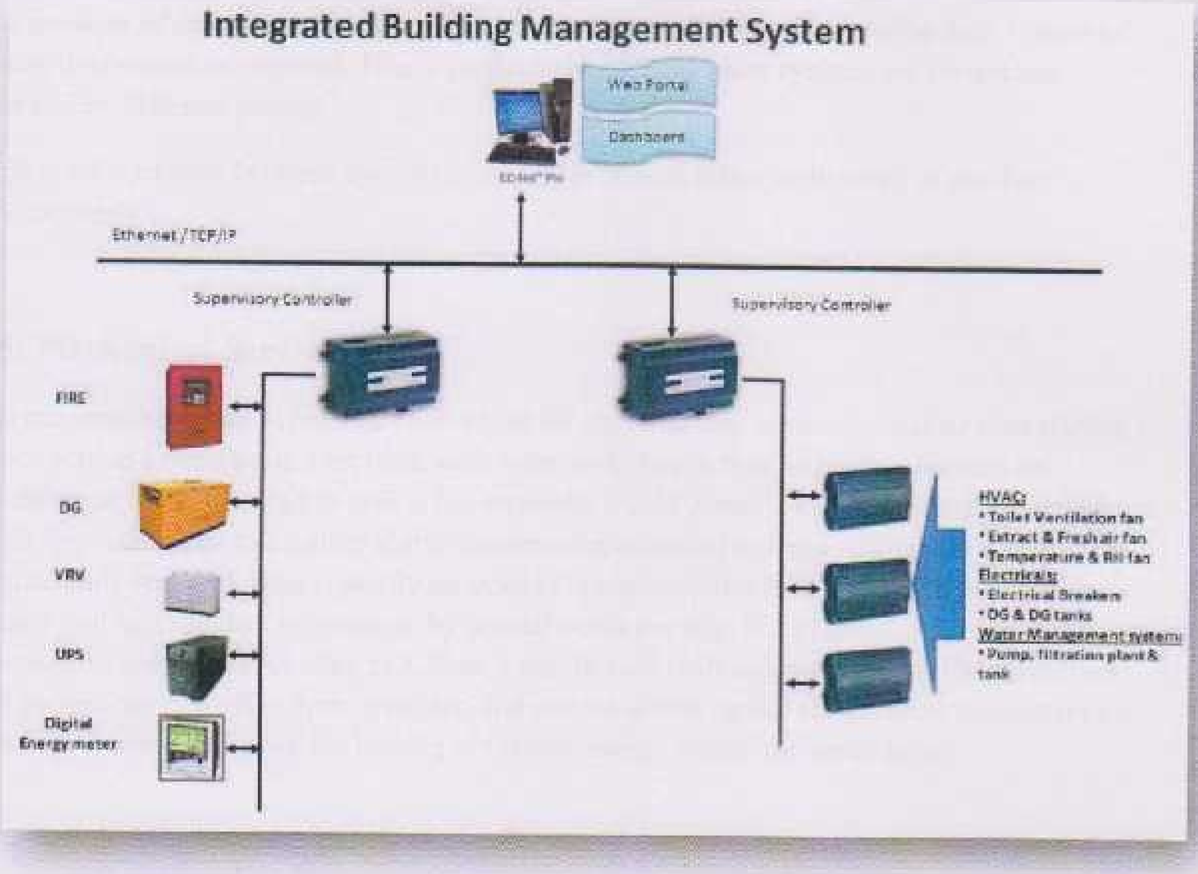


Figure (8.2) Integration of BMS.

Integration between a BMS and a business management system such as SAP requires a detailed configuration study. A high level interface between such systems can be implemented if care is given to the following.

Control of data consistency in a BMS is a live system continuously updating second by second. Business management systems typically batch by day, week, month or year.

Business management systems require data to be presented in very specific formats. Interfaces between two such systems often fall over when one or the other is upgraded.

From a business perspective the BMS is often collating the data required to allocate costs to tenant business units, or to charge sub tenants for services. It makes sound economic sense, and reduces the probability of error for data to be migrated from one system to another, provided the costs of maintaining the interface are commensurate with the benefits.

A satisfactory alternative to a high level interface given the normal batching needs of business systems is for the BMS to download its readings of hours run, energy used etc, into a spreadsheet format at agreed times. The business system can normally be easily programmed to populate its data fields by interrogating the spreadsheet at agreed times.

The manager of each system is then responsible when modifying or upgrading their system to ensure data moves as required. This is particularly relevant when systems are owned and operated by different parties.

High level interfaces between systems will seldom be cost effective in small or medium environments.

8.5: Mechanical Services.

It is recommended that software be optimized for start and stop schedules. Rather than starting to pre-condition a building at a set time, each zone starts just in time to reach minimum set condition as occupants start to arrive. For example, a cold winter's night may need an extra hour of air flow compared to a milder night. Tenant complaints led to fixed settings for earlier starts than actually required. This typically means that energy requirements for heating and cooling greater will be extended, on average, by several hours per day. For example, many buildings provide full heating and cooling to 5.30 or 6 pm. In well built and insulated buildings, chillers and boilers can turn off at 4pm or earlier, and remain within agreed temperature parameters for two hours or more utilizing the heating or cooling energy within the water loops.

Other mechanical service considerations include:

• Automated seasonal temperature adjustment, lowering set point temperature at low temperatures and gradually raising through the seasons, giving immediate savings.

• Scheduling calendar to be highly sophisticated so as to be able to check and adjust for daylight saving, Easter and other events which can be adjusted without programming skills. For example, shutting down unoccupied zones or temporarily varying working hours.

• High turndown capability utilizing VSD's for reduced airflow in low occupancy periods. This generally should go to 20 per cent or less of full flow.

• Use of CO2 sensors in car parks and return air ducts to sense when air requirements are reduced. For example, in many car parks it may be sufficient for fans to run for one to two hours per day rather than 12 or 24 hours.

• Occupancy sensors, many areas have minimal occupancy at any time or highly variable loads such as conference rooms. In such cases it may be appropriate to provide minimal conditioned air during normal hours, and ramp up only when space is fully occupied. Ramp up can sometimes be most effectively provided by standalone units to avoid over sizing the central plant to respond to low frequency situation.

• Utilize enthalpy control in low humidity environments. This can improve air quality and lower energy consumption as air cools when moisture is added.

• Economy cycle to fully utilize free cooling. In many environments the outside air temperature is lower than return air temperature when cooling is required. Even when this is the case, the energy intensity of many buildings is such that during spring and autumn they may need cool air to maintain required conditions. If the fresh air intakes can provide more than minimum fresh air requirements then "free" 12 cooling is available from the atmosphere.

• Night Purge. In many hot climatic zones several hours of low overnight temperatures occur. If fans are run in this period this cold air can pre cool the internal structure reducing the day time cooling load at minimal cost during off peak tariff periods.

.

• Calibrate sensors. While many modern sensors do not suffer accuracy drift over time, a base line error of up to one degree can occur. It is essential that offset to correct occurs at the zone or at the BMS so that control strategies utilize a true reading at all times.

• Calling after hours air conditioning. The ability to call must be limited to genuine operational needs in small areas, and turn off after a limited period or as soon as no occupation is detected. Many systems lack the turn down capacity to service small areas, so entire floors or wings are turned on for the comfort of one or two people. Consider providing airflow only and activate heating or cooling when two-four out of hours calls are made.

• Ideally no or minimal heating should be called by the system in summer, and similarly in winter minimum or no cooling should be required.

8.6: Hydraulics in BMS:

•Meters to report to BMS (number must enable excess consumption to system or zone). Temperature optimization control of boilers, by control strategy.

• Flow meters to alarm on abnormal consumption.

• Boiler temperature reset optimization, to match actual and predicted loads.

• Automated shut down valves in critical areas to avoid waste and damage from major failure, with BMS over ride function.

8.7: Building maintenance services BMS - green clean.

"Specified for green buildings"

BMS Green Clean is a commercial cleaning program that is designed to increase the health and indoor air quality of our buildings for the benefit of our employees, tenants and the environment.

BMS is committed to developing and maintaining an environment that enhances human health and fosters a transition toward sustainability. The BMS Green Clean program is a commercial cleaning program that is designed to increase the health and quality of our buildings for the benefit of our employees, tenants and the environment. BMS is committed to continuous improvement in:

- Demonstrating institutional practices that promote sustainability, including measures to increase efficiency and use of renewable resources, and to decrease production of waste and hazardous materials, both in BMS's own operations and in those of its suppliers.
- Promoting health, productivity and safety of the BMS community through design and maintenance of the built environment.
- Enhancing the health of our building's ecosystems.
- Developing planning tools to enable comparative analysis of sustainability implications and to support long-term economic, environmental and socially responsible decision-making.
- Encouraging environmental inquiry and institutional learning throughout the company.
- Establishing indicators for sustainability that will enable monitoring reporting and continuous improvement.

Green Seal org and BMS have worked closely through the standards development committee to create a uniform set of guidelines and approved products for cleaning service providers. For more detailed information on products and standards that are used BMS should go to the principles and policies for the program.

8.8 Aspects that have been applied from BMS in green tower [for this project]:

8.8.1 Design automatic system for recycling station.

There are three cases of the system:

-Filtration process.
-Backflush process.
-Overflow process.
-Drainage process.

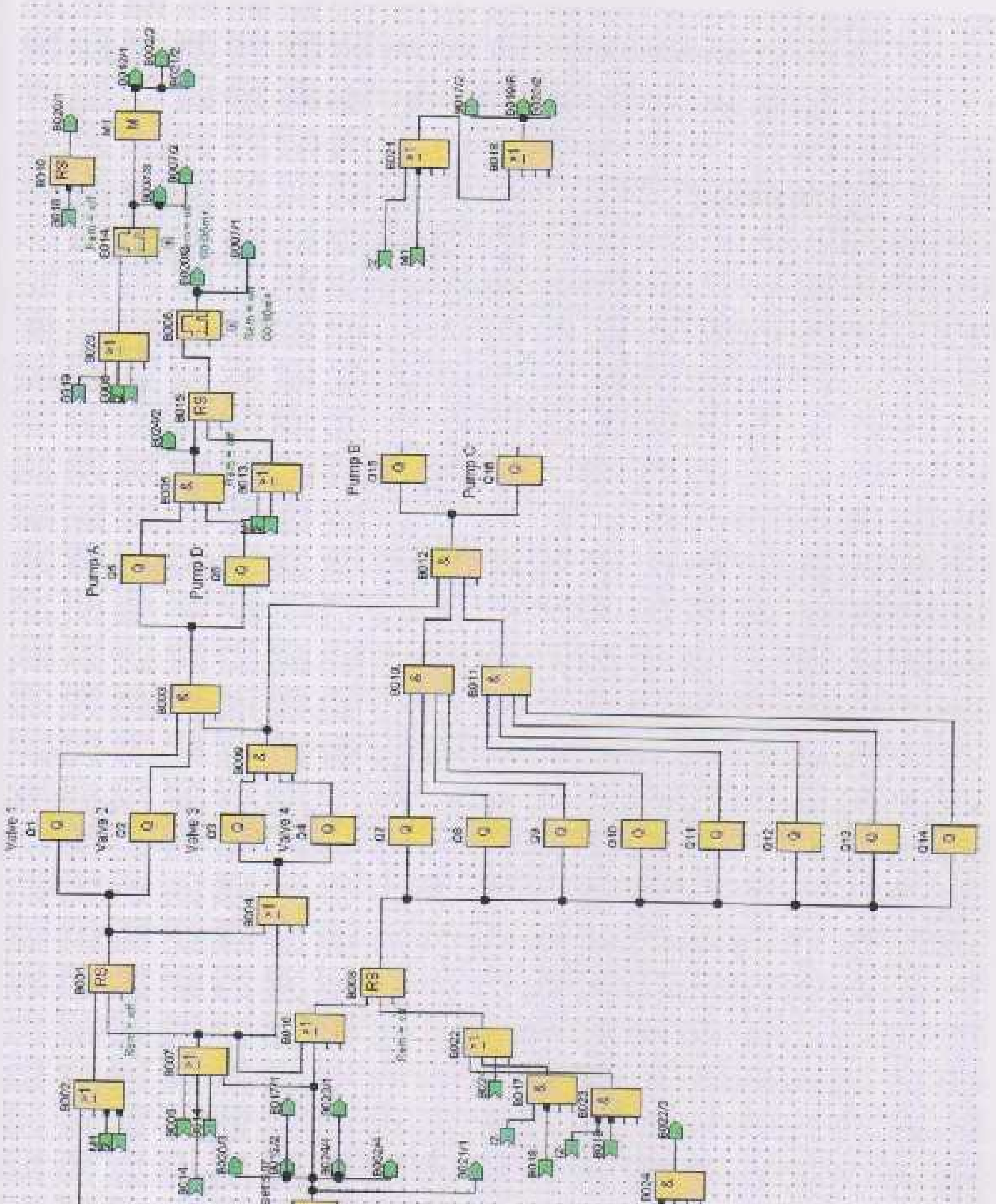
We are design a control system to control of all parts in the system (pumps, valves, level sensor, and pressure sensor).
And by using the PLC program we are design the control system.

Table (8.1) Allocation table of plc process for gray water system.

Process	Part on (open)	Part off (close)
Filtration process	Pump(A,C) Valves(1,2,3,4,5,10,11)	Pump(B,D) Valves(6,7,8,9,12,13,14,15) Level sensor
Back flush process	Pump(B,C) Valves(6,7,8,3,4,9,12,13)	Pump(A,D) Valves(1,2,5,10,11,14,15) Level sensor
Over flow process	Pump C Valves(12,13,14) Level sensor	Pump(A,B,D) Valves(6,7,8,9,12,13, 14,15)
Drain process	Pump C Valves(12,13,14,15)	Pump(A,B,D) Valves(6,7,8,9,12,13, 14,15)

Filtering control circuit (using LOGO software) :

-Full program simulation attached in CD.



8.8.2 Automatic system design of the irrigation system

A control system to control of all parts in the irrigation system (pumps, valves, level sensor).

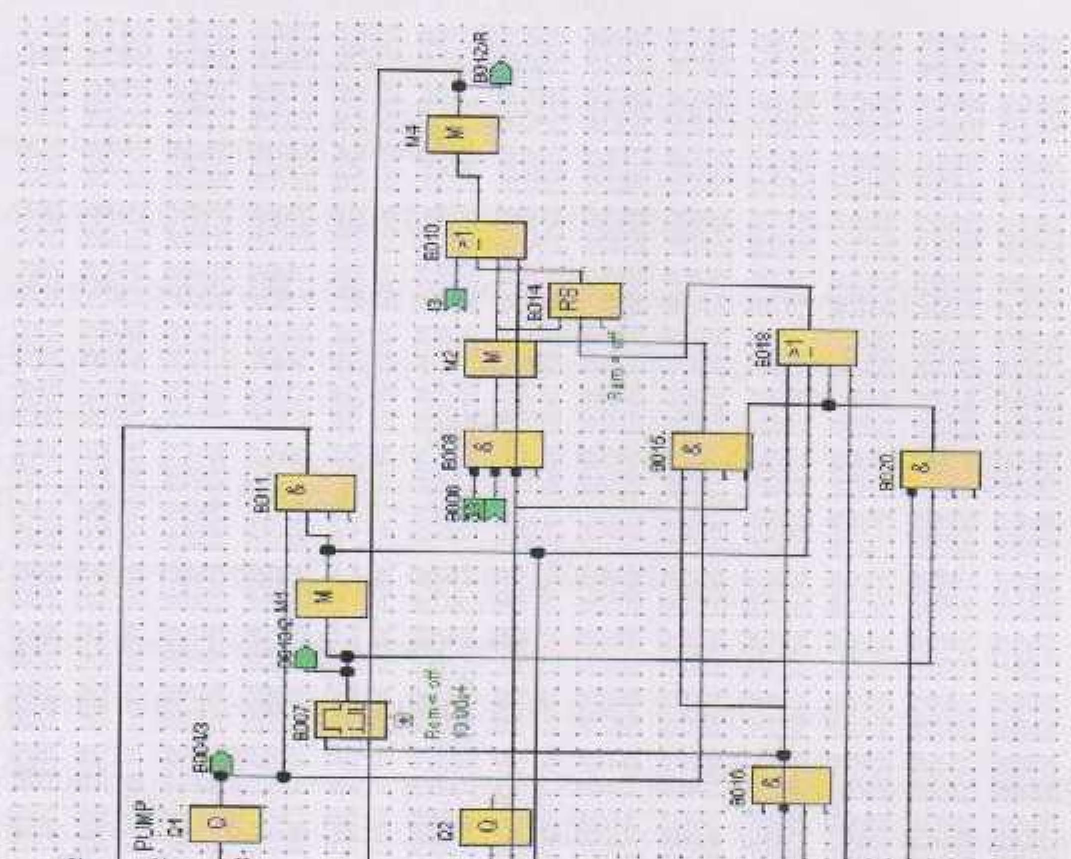
And by using the PLC program we design the following control system:

Table (8.2) allocation table of plc process for irrigation system .

Process	Part on (open)	Part off (close)
Irrigation time process	Pump (E) or (F) Valve (16) Level sensor LS2	————
Stop time process	————	Pump (E) or (F) Valve (16)

Irrigation control circuit (using LOGO software) :

Full program simulation attached in CD.



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Appendix

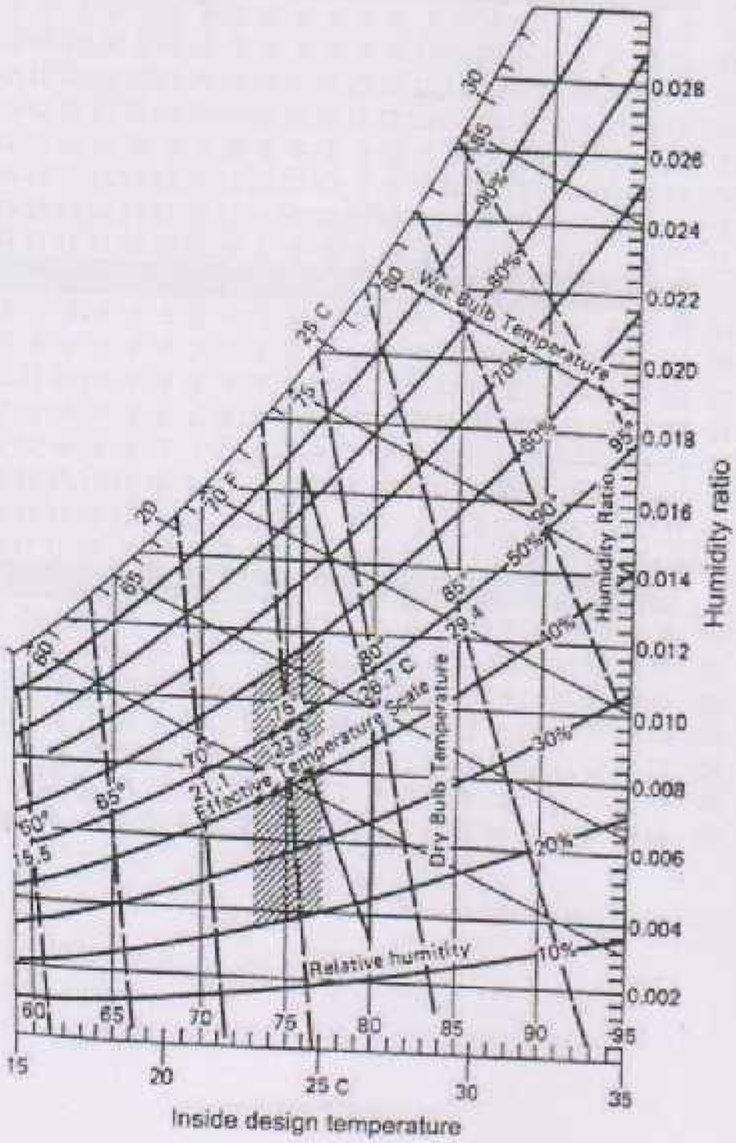

Figure-1: AHSREA Comfort chart

Table (A-1) 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

Continued Table (A-1)

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				
NW	14	13	12	11	10	9	8	7	6	6	5	5	6	6	6	7	9	10	12	14	15	15	15	15	22	5	15	10
	Group D Walls																											
N	8	7	7	6	5	4	3	3	3	3	4	4	5	6	6	7	8	9	10	11	11	10	10	9	21	3	11	8
NE	9	8	7	6	5	5	4	4	6	8	10	11	12	13	13	13	14	14	14	13	13	12	11	10	19	4	14	10
E	11	10	8	7	6	5	5	5	7	10	13	15	17	18	18	18	18	18	17	17	16	15	13	12	16	5	18	13
SE	11	10	9	7	6	5	5	5	5	7	10	12	14	16	17	18	18	18	17	17	16	15	14	12	17	5	18	13
S	11	10	8	7	6	5	4	4	3	3	4	5	7	9	11	13	15	16	16	16	15	14	13	12	19	3	16	13
SW	15	14	12	10	9	8	6	5	5	4	4	5	5	7	9	12	15	18	20	21	21	20	19	17	21	4	21	17
W	17	15	13	12	10	9	7	6	5	5	5	5	6	6	8	10	13	17	20	22	23	22	21	19	21	5	23	18
NW	14	12	11	9	8	7	6	5	4	4	4	4	5	6	7	8	10	12	15	17	18	17	16	15	22	4	18	14
	Group E Walls																											
N	7	6	5	4	3	2	2	2	3	3	4	5	6	7	8	10	10	11	12	12	11	10	9	8	20	2	12	10
NE	7	6	5	4	3	2	3	5	8	11	13	14	14	14	14	14	15	14	14	13	12	11	9	8	16	2	15	13
E	8	7	6	5	4	3	3	6	10	15	18	20	21	21	20	19	18	18	17	15	14	12	11	9	13	3	21	18
SE	8	7	6	5	4	3	3	4	7	10	14	17	19	20	20	20	19	18	17	16	14	13	11	10	15	3	20	17
S	8	7	6	5	4	3	2	2	2	3	5	7	10	14	16	18	19	18	17	16	14	13	11	10	17	2	19	17
SW	12	10	8	7	6	4	4	3	3	3	4	5	7	10	14	18	21	24	25	24	22	19	17	14	19	3	25	22
W	14	12	10	8	6	5	4	3	3	4	4	5	6	8	11	15	20	24	27	27	25	22	19	16	20	3	27	24
NW	11	9	8	6	5	4	3	3	3	3	4	5	6	7	9	11	14	18	21	21	20	18	15	13	20	3	21	18
	Group F Walls																											
N	5	4	3	2	1	1	1	2	3	4	5	6	8	9	11	12	12	13	13	13	11	9	7	6	19	1	13	12
NE	5	4	3	2	1	1	3	8	13	16	17	16	16	15	15	15	15	14	13	12	10	9	7	6	11	1	17	16
E	5	4	3	2	2	1	4	9	16	21	24	25	24	22	20	19	18	17	15	13	11	10	8	7	12	1	25	24
SE	5	4	3	2	2	1	2	6	10	15	20	23	24	23	22	20	19	17	16	14	12	10	8	7	13	1	24	23
S	5	4	3	2	2	1	1	1	2	4	7	11	15	19	21	22	21	19	17	15	12	10	8	7	16	1	22	21
SW	8	6	5	4	3	2	1	1	2	3	4	6	10	14	20	24	28	30	29	25	30	16	11	10	18	1	30	29
W	9	7	5	4	3	2	2	2	2	3	4	6	8	11	16	22	27	32	33	30	24	19	15	12	19	2	33	31
NW	8	6	4	3	2	2	1	1	2	3	4	6	7	9	12	15	19	24	26	24	20	16	12	10	19	1	26	25
	Group G Walls																											
N	2	1	0	0	0	1	4	5	5	7	8	10	12	13	13	14	14	15	12	8	6	5	4	3	18	0	15	15
NE	2	1	1	0	0	5	15	20	22	20	16	15	15	15	15	15	14	12	10	8	6	5	4	3	9	0	22	22
E	2	1	1	0	0	6	17	26	30	31	28	22	19	17	17	16	15	13	11	8	7	5	4	3	10	0	31	31
SE	2	1	1	0	0	3	10	18	24	27	28	27	23	20	18	16	15	13	11	8	7	6	4	3	11	0	28	28
S	2	1	1	0	0	0	1	3	7	12	17	22	25	26	24	21	17	14	11	8	7	5	4	3	14	0	26	26
SW	3	2	2	1	0	0	1	3	4	6	9	14	21	28	33	35	34	29	20	13	10	7	6	4	16	0	35	35
W	4	3	2	1	1	1	1	3	5	6	8	10	15	23	31	37	40	37	21	16	11	8	6	5	17	1	40	39
NW	3	2	1	1	0	0	1	3	4	6	8	10	12	15	20	26	31	31	23	14	10	7	5	4	18	0	31	31

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

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

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

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

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

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

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

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

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

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

Continued Table (A-5-1)

Glass Facing	Building Construction	Solar Time, h																
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
W	M	0.15	0.13	0.11	0.10	0.09	0.09	0.09	0.10	0.11	0.12	0.13	0.14	0.19	0.29	0.40	0.50	0.56
	H	0.14	0.13	0.12	0.11	0.10	0.11	0.12	0.13	0.14	0.14	0.15	0.16	0.21	0.30	0.40	0.49	0.54
	L	0.12	0.10	0.08	0.06	0.05	0.06	0.07	0.09	0.10	0.12	0.13	0.15	0.17	0.26	0.40	0.53	0.63
WNW	M	0.15	0.13	0.11	0.10	0.09	0.09	0.10	0.11	0.12	0.11	0.14	0.15	0.17	0.24	0.35	0.47	0.55
	H	0.14	0.13	0.12	0.11	0.10	0.11	0.12	0.13	0.14	0.15	0.16	0.17	0.18	0.25	0.36	0.46	0.53
	L	0.11	0.09	0.08	0.06	0.05	0.06	0.08	0.10	0.12	0.14	0.16	0.17	0.19	0.23	0.33	0.47	0.59
NW	M	0.14	0.12	0.11	0.09	0.08	0.09	0.10	0.11	0.13	0.14	0.16	0.17	0.18	0.21	0.30	0.42	0.51
	H	0.14	0.12	0.11	0.10	0.10	0.10	0.12	0.13	0.15	0.16	0.18	0.18	0.19	0.22	0.30	0.41	0.50
	L	0.12	0.09	0.08	0.06	0.05	0.07	0.11	0.14	0.18	0.22	0.25	0.27	0.29	0.30	0.33	0.44	0.57
NNW	M	0.15	0.13	0.11	0.10	0.09	0.10	0.12	0.15	0.18	0.21	0.23	0.26	0.27	0.28	0.31	0.39	0.51
	H	0.14	0.13	0.12	0.11	0.10	0.12	0.15	0.17	0.20	0.23	0.25	0.26	0.28	0.28	0.31	0.38	0.49
	L	0.11	0.09	0.07	0.06	0.05	0.07	0.14	0.24	0.16	0.48	0.58	0.66	0.72	0.74	0.73	0.67	0.59
HORIZ.	M	0.16	0.14	0.12	0.11	0.11	0.11	0.16	0.24	0.13	0.43	0.52	0.59	0.64	0.67	0.66	0.62	0.56
	H	0.17	0.16	0.15	0.14	0.13	0.15	0.20	0.28	0.16	0.45	0.52	0.59	0.62	0.64	0.62	0.58	0.51

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

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

Table (A-6-1) Cooling load factor $(CLF)_{Lt}$, for lights [3]

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

[3] Adapted from Stoecker and Jones, 1982, "*Refrigeration and Air Conditioning*", 2[nd] ed., MacGraw Hill. (Fixture X = not vented recessed lights and Fixture Y = vented or free-hanging light.)
[4] Adapted from Jones, 1979 "*Air Conditioning applications and Design*", Edward Arnold.

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

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

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

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

Table (A-8) 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 (A-9)

درجات حرارة المنطقة الرابعة(س°)

12	11	10	9	8	7	6	5	4	3	2	1	الشهر
10.6	16	20.1	22.3	24	23.6	21.7	19.9	17.4	9.5	8.2	8.3	المتوسط الشهري
13.7	19.3	21.2	27.4	30	29.3	27.5	25.3	20.8	13.6	11.8	11.2	المتوسط الشهري للدرجة القصوى
7.9	12.6	15.9	17	18	17.9	15.8	14.5	13.9	5.4	4.7	5.3	المتوسط الشهري للدرجة الدنيا
5.8	6.7	8.3	10.4	12	11.4	11.7	10.8	6.9	8.3	7.2	5.9	المدى
25.3	28.6	32.9	36.1	36.1	35.8	33.2	33.2	34.1	19.7	19.7	14.3	الدرجة القصوى
6.6	11.9	14	14.7	13.7	13.8	10.9	7	4.4	-1.3	1.2	-2	الدرجة الدنيا

درجة الحرارة التصميمية للمنطقة الرابعة.
صيفاً: 30 س°
شتاءً: 4.7 س°

Table (A-10)

قيم الرطوبة النسبية التصميمية (بالمائة)

شتاءً		صيفاً		
اقصى	ادنى	اقصى	ادنى	
69.3	65.7	49	44	المنطقة الاولى
69.3	65.7	49	44	المنطقة الثانية
69.7	68	61.9	55.5	المنطقة الثالثة
71.7	68	53.7	49.7	المنطقة الرابعة
73.7	65.9	65.2	61.5	المنطقة الخامسة
69	62	77	75	المنطقة السادسة - غزة
69.7	68	61.9	55.5	المنطقة السابعة- غزة

Table (P-1): 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
10000	790	10000	790

Table (P-2): Water supply fixture units and fixture branch sizes

Fixture[a]	*Use*	*Type of Supply Control*	*Fixture Units*[b]	*Min. Size of Fixture Branch*[d] *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	3/8
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	3/8
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[c]
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 (P-3) Horizontal Fixture Branches and Stacks

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

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

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

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

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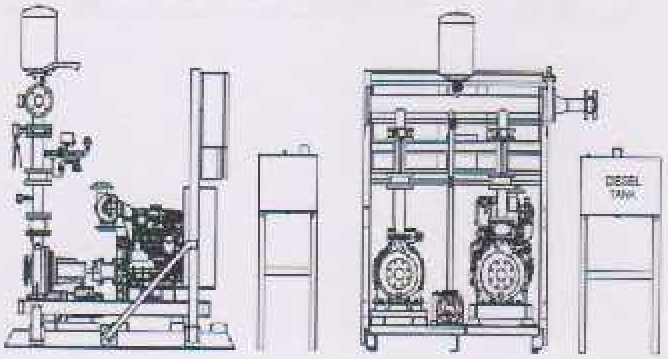
Appendix B:

C.1: Water tank

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

<u>1 Electric main pump + 1 Diesel main motorpump + 1 jockey pump</u>

"EDP" Series

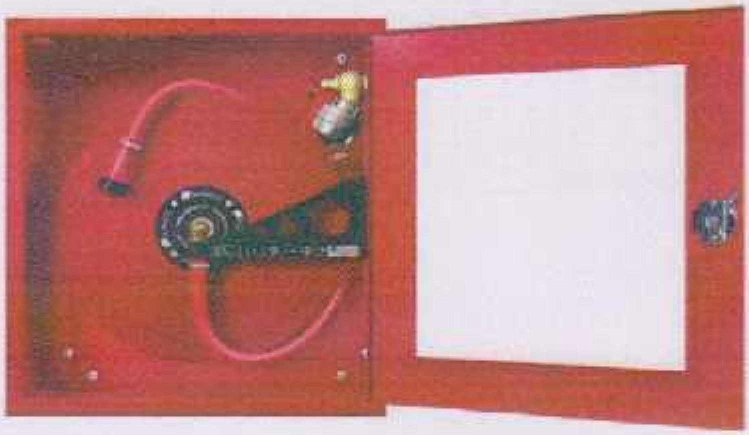


C.2:

C.3:

Model S2 is a recessed installation type cabinet with a separate compartment for the accommodation of portable extinguisher or similar equipments. Reel has been fastened on a 180° hanged support and installed on the right side of the cabinet. This model complies with DIN 14461 standard.

Designed and manufacture in accordance with EN 671-1



MODEL	HOSE		SIZE (mm) W x H x D	ORDER CODE
	Diameter (mm)	Length (m)		
S2	25	20	740 x 840 x 250	S2 - 20
S2	25	20	740 x 840 x 200	S2 - 20 - 20
S2	25	30	740 x 840 x 250	S2 - 30

C.4: Fire Fighting pump selection:

Code	Model	Electric Power (kW)	Q= CAPACITY OF EACH SERVICE PUMP													
			m³/h Q	48	72	96	108	120	138	180	210	240	270	300	330	360
			Usg. Q	1100	1200	1500	1800	2000	2300	3000	3500	4000	4500	5000	5500	6000
			H= Total head (m.c.a.)													
700.422	EDP-L65-200/187-24	15+1.1	60	49	40	40*	34	24								
700.423	EDP-A65-200/193-30	22+1.1	58	50	46	40*	40	40	30	17						
700.424	EDP-L65-200/198-27	18.3+1.1	53	51	51	48	45*	42								
700.425	EDP-L65-200/210-30	22+1.1	59	58	56	55	52*	50								
700.426	EDP-S65-200/215-42.6	30+2.2	65	64	64	61	57*	55	48	34						
700.427	EDP-L65-250/241-43.6	30+2.2	75	74	73	69	64*	61								
700.428	EDP-L65-250/238-50	37+2.2	80	87	85	83	77*	74								
700.429	EDP-S65-250/232-42.6	30+2.2	75	74	73	65	60	55	[illegible]							
700.430	EDP-S65-250/243-63.3	45+2.2	83	82	82	78	75	71	58							
700.431	EDP-S65-250/255-63.3	45+2.2	92	92	91	89	85	83	74	55						
700.432	EDP-S65-250/269-63.3	55+2.2	95	94	94	92	93	92*	77	64						
700.433	EDP-S65-315/273-69.8	55+2.2	101	100	99	98	97*	95	84							
700.434	EDP-S65-315/[illegible]	75+3	112	111	110	110	108*	103	95	77						
700.435	EDP-L80-200/188-30	22+1.1	48				45	41	38*	32						
700.436	EDP-L80-200/207-42.5	30+1.1	58				55	54	52*	48	40					
700.437	EDP-L80-250/225-50	37+2.2	71				67	65	59*	52						
700.438	EDP-L80-250/238-63.3	45+2.2	80				79	78	70*	60						
700.439	EDP-L80-250/256-69.8	55+2.2	92				91	90	86	79*	69					
700.440	EDP-L80X-250/270-123.4	75+3	117				109	108	101	94*	82					
700.441	EDP-C80-250/205-63.3	45+1.1	59					56	45	53	45	42				
700.442	EDP-C80-250/216-63.3	55+1.5	84					52	50	51	52*	48				
700.443	EDP-C80-250/225-69.3	55+2.2	75					70	68	64*	57	44	36			
700.444	EDP-C80-250/255-[illegible]	75+2.2	88					88	84	80	77*	70	66	38		
700.445	EDP-C80-250/264-103.4	75+2.2	100					90	93	87	83*	74	69	57		
700.446	EDP-S80-255/285-177.5	110+2.2	102					107	108	101	98	92*	83	85	83	77
700.447	EDP-S80-315/303-177.5	110+3	117					115	113	112	108*	102	92			

Spray Foam fire extinguishers provide a fast, powerful means of tackling 'A' and 'B' class fires. Highly effective against petrol and volatile liquids, forming a flame smothering seal over the surface and preventing re-ignition. Ideal for multi-risk usage. Fire ratings provide a means of measuring the effectiveness of a fire extinguisher in terms of the maximum size of fire that can be extinguished

Certified to BS-EN3

C.5:

C.6:

FAN MODEL	RPM	MAX WATTS	MAX AMPS	0"	.125"	.25"	.375"	.5"	.75"	1.0"	1.25"	1.5"	MAX in wg	DUCT DIA
8" MAX 667 CFM	3250	179	1.5	667	650	630	610	585	520	420	150	100	1.64	8"
12" MAX 1708 CFM	3374	489	4.1	1708	1680	1655	1630	1595	1530	1460	1380	1300	3.34	12"

C.7:

Max-Fan™ PRO SERIES PERFORMANCE AT PRESSURE

Free Air: 0" — Fan Attached to Filter: .5"

FAN MODEL	SPEED	RPM	VOLTS	MAX WATTS	MAX AMPS	0" (Free Air)	.125"	.25"	.375"	.5" (Fan Attached to Filter)	.75"	1.0"	1.25"	MAX in. wg	DUCT DIA.
6" PRO SERIES	High	3322	120	69	0.62	420	405	386	364	338	273	96	39	1.377	6
	Med./High	3077	120	60	0.54	379	356	332	306	275	177	65	N/A	1.225	
	Medium	2637	120	52	0.49	291	253	220	194	165	65	N/A	N/A	0.911	
8" PRO SERIES	High	3288	120	186	1.58	863	838	812	785	755	604	532	335	2.052	8
	Med./High	2836	120	165	1.42	726	680	630	580	538	470	388	220	1.69	
	Medium	2276	120	127	1.15	530	468	407	368	333	193	58	N/A	1.128	
14" PRO SERIES	High	1715	120	378	3.17	2270	2200	2120	2040	1960	1755	1480	500	1.594	14
	Med./High	1644	120	330	2.77	2171	2080	2000	1905	1805	1570	1260	445	1.506	
	Medium	1571	120	314	2.72	2083	1970	1860	1735	1600	1350	600	140	1.421	
16" PRO SERIES	High	1712	120	350	2.91	2343	2275	2205	2120	2030	1835	1540	485	1.586	16
	Med./High	1629	120	319	2.74	2250	2150	2045	1950	1850	1590	1265	365	1.486	
	Medium	1547	120	321	2.91	2149	2040	1905	1745	1560	1280	595	230	1.401	

C.8:

TDI Performance Data :

Model Number	Motor HP	Fan RPM	Max BHP	* $L_{wi}A$	** dBA	Static Pressure in Inches WG / CFM								
						0.000 CFM	0.125 CFM	0.250 CFM	0.375 CFM	0.500 CFM	0.625 CFM	0.750 CFM	0.875 CFM	1.000 CFM
24-0624	1/4	860	0.29	78	67	5439	4712	3741						
24-0335	1/4	860	0.29	77	66	5682	4376							
24-0630	1/3	860	0.39	77	66	6215	5391	4313						
24-0609	1/4	1140	0.27	83	72	4337	3930	3430	2679					
24-0412	1/4	1140	0.25	81	70	5058	4452							
24-0612	1/3	1140	0.35	83	72	5104	4685	4166	3480					
24-0417	1/3	1140	0.34	82	71	5708	5085	4304	3333					
24-0426	1/2	1140	0.58	85	74	7123	6441	5598	4481					
24-0621	1/2	1140	0.59	85	74	6734	6250	5670	4983	4116				
24-0435	1/2	1140	0.87	87	76	8181	7391							
24-0630	3/4	1140	0.80	88	77	8239	7654	6981	6188	5261				
24-0635	1	1140	1.15	89	78	9028	8398	7867	6762					
24-0604	1/2	1725	0.60	94	83	4902	4829	4358	4054	3697	3278			
24-0407	1/2	1725	0.56	93	82	5760	5391	4977	4531	3971	3282			
24-0609	1	1725	0.93	97	86	6563	6309	6033	5736	5407	5001	4521	3958	
24-0316	1	1725	0.91	93	82	7960	7484	6045	6375	5758	5026			
24-0612	1.5	1725	1.22	95	84	7724	7444	7147	6834	6510	6147	5740	5170	4306
24-0417	1	1725	1.20	95	84	8638	8255	7830	7349	6833	6281	5657	4776	
24-0321	1.5	1725	1.23	95	84	9059	8585	8035	7464	6632	6093	5130		
24-0618	1.5	1725	1.70	97	86	9237	8960	8660	8344	7981	7578	7162	6679	
24-0423	1.5	1725	1.65	97	86	9994	9561	9103	8592	8060	7469	6806	6065	
24-0328	1.5	1725	1.70	96	85	10293	9805	9263	8828	7858	7041			

C.9: NC

NECK VELOCITY(FPM)	SOUND LEVEL- NC
300-600	Less than 20
700-600	Less than 30
900-700	Less than 35
1100-900	Less than 40
1600-1100	Less than 40

C.10: Grill

	1-Way		2-Way		3-Way		4-Way	
Neck Size (in.)	NC-Level	CFM Range	NC-Level	CFM Range	NC-Level	CFM Range	NC-Level	CFM Range
6 x 6	25-35	45-140	25-35	45-140	25-35	50-160	25-35	50-160
9 x 9	25-35	95-275	25-35	95-275	25-35	110-315	25-35	110-315
12 x 12	25-35	175-480	25-35	175-480	25-35	200-560	25-35	200-560
15 x 15	25-35	275-660	25-35	275-775	25-35	310-875	25-35	310-875
18 x 18	25-35	390-1090	25-35	390-1090	25-35	450-1260	25-35	450-1260
21 x 21	25-35	540-1515	25-35	540-1515	25-35	615-1725	25-35	615-1725
24 x 24	25-35	705-1690	25-35	705-1690	25-35	800-1925	25-35	800-1925

C.11:

Listed size	CFM range
6" dia.	60-315
8" dia.	105-560
10" dia.	165-870
12" dia.	225-1255
14" dia.	320-1710
16" dia.	420-2240
18" dia.	530-2830
20" dia.	660-3500
24" dia.	940-4950

C.12:

4-way TYPE 4

Listed Size Outlet Area			V_K Outlet Velocity, FPM 500	600	700	800	900	1000	1200	1400	1600	1800	2000
			P_T Total Pressure, Inches H_2O .02	.02	.03	.04	.05	.06	.09	.12	.16	.20	.25
6 x 6 A_K .10	CFM		50	60	70	80	90	100	120	140	160	180	200
	T	X	2-3	2-3	2-4	2-4	3-5	3-5	4-6	4-8	5-8	5-8	6-11
		Y	2-3	2-3	2-4	2-4	3-5	3-5	4-6	4-8	5-8	5-9	6-11
	NC		25	25	25	25	25	30	30	30	35	40	40
9 x 9 A_K .22	CFM		110	135	155	180	205	225	270	315	360	410	450
	T	X	2-4	2-4	3-5	3-5	4-6	5-8	5-9	5-11	6-12	7-13	8-14
		Y	2-4	2-4	3-5	3-5	4-6	5-8	5-9	5-11	6-12	7-13	8-14
	NC		25	25	25	25	25	30	30	35	40	40	40
12 x 12 A_K .40	CFM		200	240	280	320	360	400	480	560	640	725	800
	T	X	3-5	4-6	4-6	5-8	5-9	6-11	6-12	7-13	8-15	9-17	10-19
		Y	3-5	4-6	4-6	5-6	5-9	6-11	6-12	7-13	8-15	9-17	10-19
	NC		25	25	25	25	25	30	30	35	40	40	40
15 x 15 A_K .62	CFM		310	375	440	500	565	625	750	875	1000	1125	1250
	T	X	4-6	4-8	5-9	6-11	6-11	6-12	8-15	10-18	10-19	12-21	13-23
		Y	4-6	4-8	5-9	6-11	6-11	6-12	8-15	10-18	10-19	12-21	13-23
	NC		25	25	25	25	25	30	30	35	40	40	40
18 x 18 A_K .90	CFM		450	540	630	720	810	900	1080	1260	1440	1620	1800
	T	X	4-8	5-9	5-11	6-12	7-13	8-15	10-17	11-20	13-23	15-27	16-30
		Y	4-8	5-9	5-11	6-12	7-13	8-15	10-17	11-20	13-23	15-27	16-30
	NC		25	25	25	25	25	30	30	35	40	40	40

C.13:

1-way TYPE 1L

Listed Size Outlet Area			V_K Outlet Velocity, FPM										
			500	600	700	800	900	1000	1200	1400	1600	1800	2000
			P_T Total Pressure, Inches H_2O										
			.02	.02	.03	.04	.05	.06	.09	.12	.16	.20	.25
9 x 6	CFM		65	80	95	105	120	130	160	185	210	240	260
	T	X	5-8	6-9	7-11	8-12	9-13	10-15	12-18	15-21	16-24	19-28	21-32
A_K .13		Y	-	-	-	-	-	-	-	-	-	-	-
	NC		20	20	20	20	20	30	30	30	35	40	40
12 x 6	CFM		90	105	120	140	160	175	210	245	280	315	350
	T	X	5-8	6-9	9-13	9-14	10-15	12-18	14-20	17-25	18-27	20-30	23-35
A_K .17		Y	-	-	-	-	-	-	-	-	-	-	-
	NC		20	20	20	20	20	30	30	35	40	40	40
15 x 6	CFM		110	130	155	175	200	220	265	310	360	395	440
	T	X	5-8	7-10	9-13	10-15	12-18	14-20	16-24	18-27	21-31	24-36	28-41
A_K .22		Y	-	-	-	-	-	-	-	-	-	-	
	NC		20	20	20	20	30	30	30	35	40	40	40
12 x 9	CFM		130	155	180	210	235	260	310	365	415	470	520
	T	X	7-10	6-12	10-14	11-17	12-18	14-20	17-25	19-29	22-23	25-37	32-45
A_K .26		Y	-	-	-	-	-	-	-	-	-	-	-
	NC		20	20	20	20	30	30	30	35	40	40	40
16 x 9	CFM		165	195	230	260	295	325	390	460	525	590	650
	T	X	9-13	10-14	11-17	12-18	15-23	17-25	20-30	22-33	25-37	29-42	36-48
A_K .32		Y	-	-	-	-	-	-	-	-	-	-	-
	NC		20	20	20	20	30	30	30	35	40	40	40
18 x 9	CFM		195	235	275	310	350	390	470	545	625	700	780
	T	X	9-13	10-15	12-18	14-20	16-24	15-26	20-30	25-37	27-40	31-44	39-54
A_K .39		Y	-	-	-	-	-	-	-	-	-	-	-
	NC		20	20	20	20	30	30	30	35	40	40	40
15 x 12	CFM		220	260	305	350	390	435	525	610	700	785	870
	T	X	10-14	11-17	13-19	15-23	18-26	19-29	22-32	26-39	30-43	35-48	42-64
A_K .43		Y	-	-	-	-	-	-	-	-	-	-	-
	NC		20	20	20	20	30	30	30	35	40	40	40

C.14:

Indoor unit				FXAQ15P	FXAQ20P	FXAQ25P	FXAQ32P	FXAQ40P	FXAQ50P	FXAQ63P
Cooling capacity	Nom.		kW	1.7	2.2	2.8	3.6	4.5	5.6	7.1
Heating capacity	Nom.		kW	1.9	2.5	3.2	4.0	5.0	6.3	8.0
Power input - 50Hz	Cooling	Nom.	kW	0.017	0.019	0.028	0.030	0.020	0.033	0.050
	Heating	Nom.	kW	0.025	0.029	0.034	0.035	0.020	0.039	0.060
Casing Colour				White (3.0Y8.5/0.5)White (3.0Y8.5/0.5)						
Dimensions	Unit	H x W x D	mm	290x795x238				290x1,050x238		
Weight	Unit		kg	11				14		
Fan-Air flow rate - 50Hz	Cooling	High/Low	m³/min	7.0/4.5	7.5/4.5	8/5	8.5/5.5	12/9	15/12	19/14
Sound power level	Cooling	Nom.	dBA	-						
Sound pressure level	Cooling	High/Low	dBA	34.0/29.0	35.0/29.0	36.0/29.0	37.5/29.0	39.0/34.0	42.0/36.0	47.0/39.0
Refrigerant	Type			R-410A						
Piping connections	Liquid/OD/Gas/OD/Drain		mm	6.35/12.7/VP13 (I.D. 13/O.D. 18)						9.52/15.9/VP13 (I.D. 13/O.D. 18)
Power supply	Phase/Frequency/Voltage		Hz/V	1~/50/220-240						
Current - 50Hz	Maximum fuse amps (MFA)		A	16						

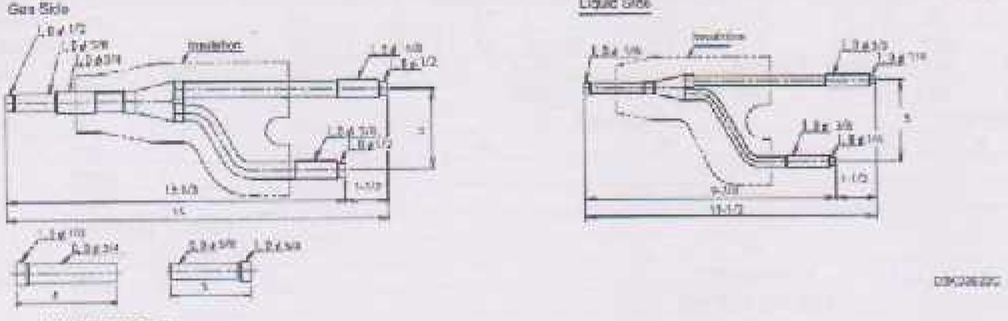
C.15:

Outdoor Units			RYYQ44T			RYYQ46T			RYYQ48T		
			RYMQ12T	RYMQ14T	RYMQ18T	RYMQ14T	RYMQ16T	RYMQ16T	RYMQ16T	RYMQ16T	RYMQ16T
Capacity	Nominal Cooling	kW		124.00			130.00			135.00	
	Nominal Heating	kW		138.00			145.00			150.00	
EER				3.54			3.51			3.46	
ESEER				6.62*			6.6*			6.5*	
COP				3.58			3.94			3.91	
Dimensions	Height	mm	1685	1685	1685	1685	1685	1685	1685	1685	1685
	Width	mm	930	1240	1240	1240	1240	1240	1240	1240	1240
	Depth	mm	765	765	765	765	765	765	765	765	765
Weight		kg	155	309	309	309	309	309	309	309	309
Air Flow Rate		m³/sec	3.08	4.33	4.33	3.72	4.33	4.33	4.33	4.33	4.33
External Static Pressure	High	Pa	78	78	78	78	78	78	78	78	78
Electrical Details	Power Supply	Phase /Hz / V					3ph / 50 Hz / 380~415V				
	Running Current	amps	12.7	18.0	18.0	15.4	18.0	18.0	18.0	18.0	18.0
	Starting Current	amps		databook			databook			databook	
	Fuse Rating	amps	32	40	40	32	40	40	40	40	40
Refrigerant Circuit	Refrigerant Type						R410a				
	Refrigerant Charge	kg	6.3	10.4	10.4	10.3	10.4	10.4	10.4	10.4	10.4
	Additional Charge	kg					data book				
Sound Pressure		dBA	61	64	64	61	64	64	64	64	64
Sound Power		dBA	81	86	86	81	86	86	86	86	86
Piping Limits	Maximum Length	m					165				
	Maximum Vertical Rise	m					data book				
Piping Connections	Liquid	inches		3/4			3/4			3/4	
	Gas	inches		1 5/8			1 5/8			1 5/8	
Capacity Index Limit				550~1430			575~1495			600~1500	
Maximum Number of Connected Indoor Units				64			64			64	

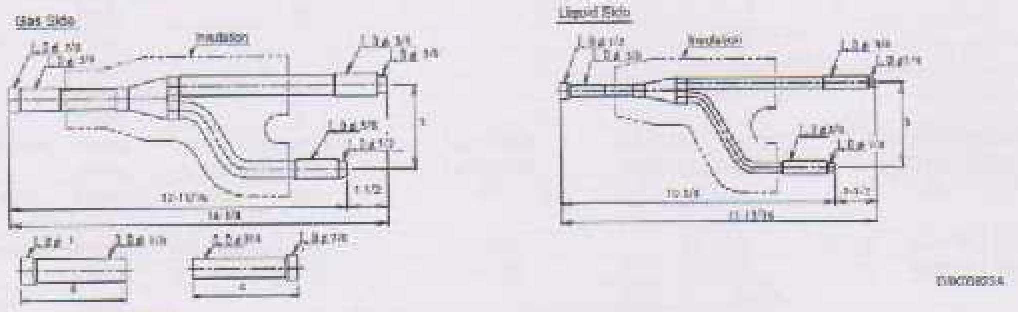
C.16:

Outdoor Units			RYYQ50T			RYYQ52T			RYYQ54T		
			RYMQ16T	RYMQ16T	RYMQ18T	RYMQ16T	RYMQ18T	RYMQ18T	RYMQ18T	RYMQ18T	RYMQ18T
Capacity	Nominal Cooling	kW		140.00			145.00			150.00	
	Nominal Heating	kW		156.00			162.00			168.00	
EER				3.44			3.47			3.40	
ESEER				6.46*			6.42*			6.38*	
COP				3.88			3.89			3.89	
Dimensions	Height	mm	1685	1685	1685	1685	1685	1685	1685	1685	1685
	Width	mm	1240	1240	1240	1240	1240	1240	1240	1240	1240
	Depth	mm	765	765	765	765	765	765	765	765	765
Weight		kg	309	309	319	309	319	319	319	319	319
Air Flow Rate		m³/sec	4.33	4.33	4.18	4.33	4.18	4.18	4.18	4.18	4.18
External Static Pressure	High	Pa	78	78	78	78	78	78	78	78	78
Electrical Details	Power Supply	Phase					3ph / 50Hz / 380~415V				
	Running Current	amps	18.0	18.0	20.8	18.0	20.8	20.8	20.8	20.8	20.8
	Starting Current	amps		databook			databook			databook	
	Fuse Rating	amps	40	40	40	40	40	40	40	40	40
Refrigerant Circuit	Refrigerant Type						R410a				
	Refrigerant Charge	kg	10.4	10.4	11.7	10.4	11.7	11.7	11.7	11.7	11.7
	Additional Charge	kg					data book				
Sound Pressure		dBA	64	64	65	64	65	65	65	65	65
Sound Power		dBA	86	86	86	86	86	86	86	86	86
Piping Limits	Maximum Length	m					165				
	Maximum Vertical Rise	m					data book				
Piping Connections	Liquid	inches		3/4			3/4			3/4	
	Gas	inches		1 5/8			1 5/8			1 5/8	
Capacity Index Limit				625~1625			650~1690			675~1755	
Maximum Number of Connected Indoor Units				64			64			64	

C.17:



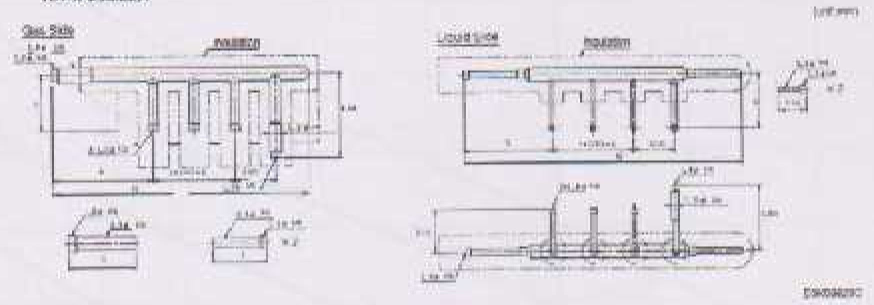
KHRP26M33T



KHRP26M72TU

C.18:

KHRP26M22H



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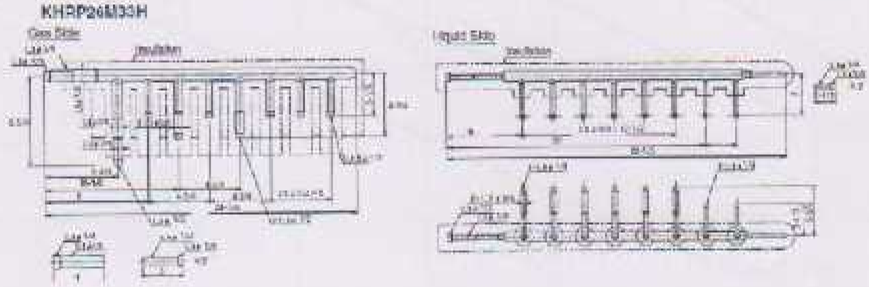


C.19:

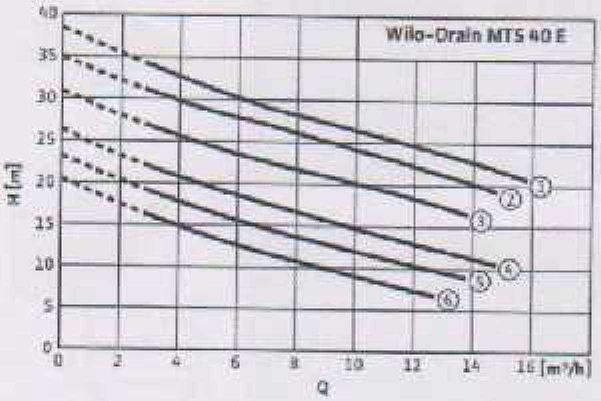
Indoor unit				FXFQ20A	FXFQ25A	FXFQ32A	FXFQ40A	FXFQ50A	FXFQ63A	FXFQ80A	FXFQ100A	FXFQ125A
Cooling capacity	Nom.		kW	2.2	2.8	3.6	4.5	5.6	7.1	9.0	11.2	14.0
Heating capacity	Nom.		kW	2.5	3.2	4.0	5.0	6.3	8.0	10.0	12.5	16.0
Power input -50Hz	Cooling	Nom.	kW	0.038				0.053	0.061	0.092	0.115	0.186
	Heating	Nom.	kW	0.038				0.053	0.061	0.092	0.115	0.186
Dimensions	Unit	HxWxD	mm	204x840x840						246x840x840		288x840x840
Weight	Unit		kg	19			20	21		24		26
Decoration panel	Model			BYCQ140D7W1								
	Colour			Pure White (RAL 9010)								
	Dimensions	HxWxD	mm	60x950x950								
	Weight		kg	5.4								
Decoration panel 2	Model			BYCQ140D7W1W								
	Colour			Pure White (RAL 9010)								
	Dimensions	HxWxD	mm	60x950x950								
	Weight		kg	5.4								
Decoration panel 3	Model			BYCQ140D7GW1								
	Colour			Pure White (RAL 9010)								
	Dimensions	HxWxD	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			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
Sound power level	Cooling	High/Nom.	dBA	48/-			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								

C.20:

C.21:

Wilo-Drain MTS 40 E

2-pole, 50 Hz



1 = MTS 40 E 39.16/25
2 = MTS 40 E 35.15/23
3 = MTS 40 E 31.14/21
4 = MTS 40 E 26.15/15
5 = MTS 40 E 23.14/12
6 = MTS 40 E 20.13/11

All shown pump curves are valid for a density of ρ = 1 kg/dm³

Terminal diagram

Wilo-Drain ...	Connection	Cable type	Clamp connections					
			U	V	W	PE	T1/WSK	T2/WSK
MTS 40/... 1~	1~230 V	3 x 1.5 mm² 2)	1 (L1)	2 (N)	–	green/yellow	–	–
MTS 40/... 3~	3~400 V	6 x 1.0 mm²	1	2	3	green/yellow	4	5
MTS 40 E ... 3~	3~400 V	7 x 1.5 mm² 2)	1	2	3	green/yellow	4	5

1) Connection of mains cable with shock-proof plug to capacitor box
2) Strand 7 not used

C.22:

12" Pro Series Channel™ Drains

Part No.	Description	Color	Pkg. Qty.	Wt. Ea. (lbs.)	Product Class	Specifications
847	12" x 20" Light Traffic Channel Grate*	Gray	1	4.64	25N	12" wide UV-protected high-impact PVC Light Traffic Channel Grate. Open surface area 46.77 square inches/foot. 149.13 GPM per foot.
	*Produced under license [illegible]					
	[illegible]					

Part No.	Description	Color	Pkg. Qty.	Wt. Ea. (lbs.)	Product Class	Specifications
846	12" x 20" Cast Iron Heavy Traffic Channel Grate	Black	1	28.08	25N	12" Wide Cast Iron Heavy Traffic Channel Grate. Open surface area 46.70 square inches per foot. 142.86 GPM per foot.
	[illegible]					

C.23:

Part No.	Description	Color	Pkg. Qty.	Wt. Ea. (lbs.)	Product Class	Specifications
849	Grate Security Clip*	Gray	10	0.40	25IN	
	For use with 845 and 847 grates and 840 or 843 channels only (2 per grate). Mounts inside channel drain and secures grate. Screw and nut included. *Produced under license of First Plast S.R.L. - Italy					

Part No.	Description	Color	Pkg. Qty.	Wt. Ea. (lbs.)	Product Class	Specifications
840	12" x 20" Shallow Profile Channel Drain	Light Gray	1	4.00	25IN	12" wide Shallow Profile UV-protected high-impact PVC Channel Drain with mechanical interlocking joints.
	Grate should be recessed 1/8" below finish grade in non-traffic applications. Grate should be recessed 1/4" in traffic applications.					

Part No.	Description	Color	Pkg. Qty.	Wt. Ea. (lbs.)	Product Class	Specifications
841	12" Shallow Profile End Cap/3" & 4" S&D SPT Knockout End Outlet	Light Gray	1	1.00	25IN	12" wide Shallow Profile high-impact PVC End Cap/3" & 4" Corrugated S&D Pipe.

Part No.	Description	Color	Pkg. Qty.	Wt. Ea. (lbs.)	Product Class	Specifications
843	12" x 20" Deep Profile Channel Drain*	Light Gray	1	6.00	25IN	12" wide Deep Profile UV-protected high-impact PVC Channel Drain with mechanical interlocking joints.
	Grate should be recessed 1/8" below finish grade in non-traffic applications. Grate should be recessed 1/4" in traffic applications. *Produced under license of First Plast S.R.L. - Italy					

Part No.	Description	Color	Pkg. Qty.	Wt. Ea. (lbs.)	Product Class	Specifications
844	12" Deep Profile End Cap/3" & 4" S&D SPT Knockout End Outlet*	Light Gray	1	1.50	25IN	12" wide Deep Profile high-impact PVC End Cap/3" & 4" Corrugated S&D Pipe.
	*Produced under license of First Plast S.R.L. - Italy					

C.24: Gray water

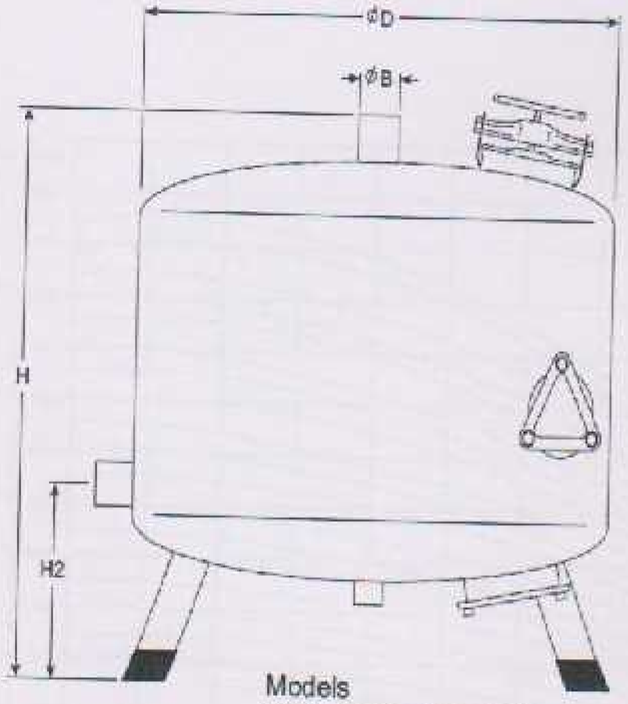
Dimensions & Weight

Metric Units

Model	B		D	H	H1	H2	Weight
	mm	inch	inch	mm	mm	mm	kg
4121	25	1"	12"	1150	775	120	42
4162 *	40	2"	16"	1250	870	180	50
4202	50	2"	20"	1250	870	180	70
4203	80	3"	20"	1400	1040	180	75
4242	50	2"	24"	1350	950	260	90
4243	80	3"	24"	1350	950	260	90
4303	80	3"	30"	1080	-	270	135
4363	80	3"	36"	1100	-	270	185
4484	100	4"	48"	1100	-	270	310
4604	100	4"	60"	1330	-	400	430
4363U	80	3"	36"	1325	-	390	200
4484U	100	4"	48"	1435	-	455	330
4604U	100	4"	60"	1890	-	650	460

* Available with 1½" Inlet Outlet (Model 41615).

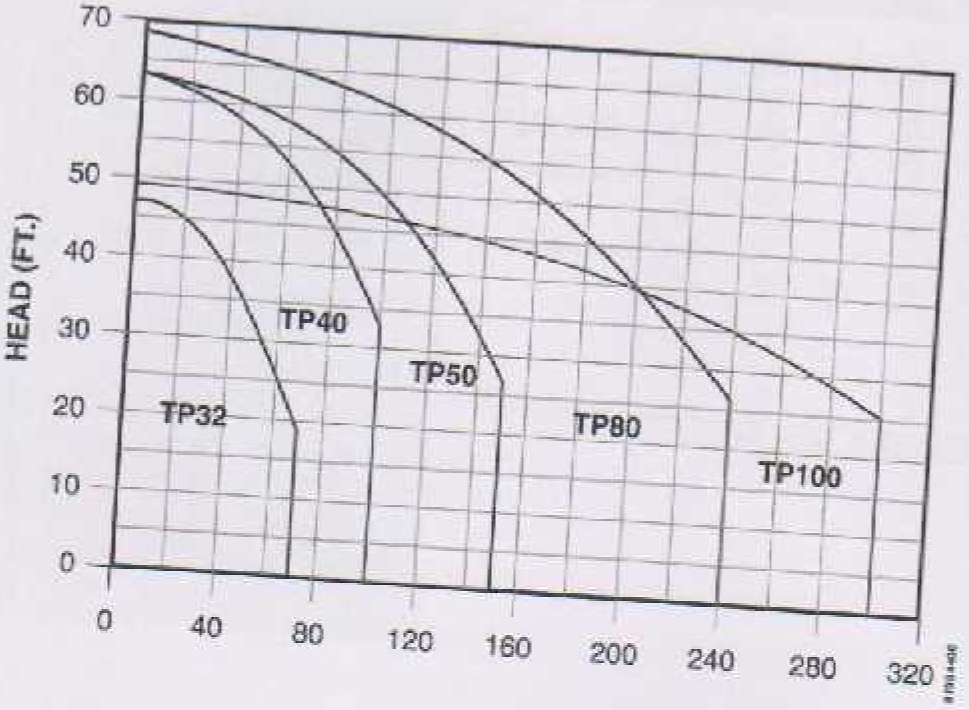
C.25:



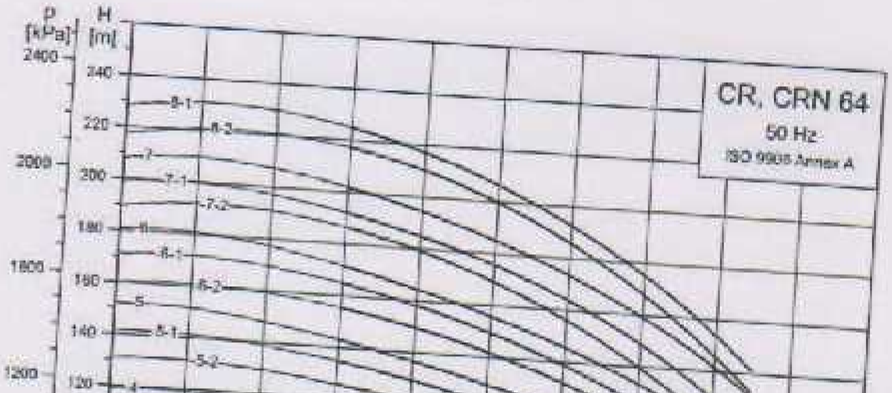
Models
4303, 4363, 4484,4604

C.26:

Performance range, TP



C.27:



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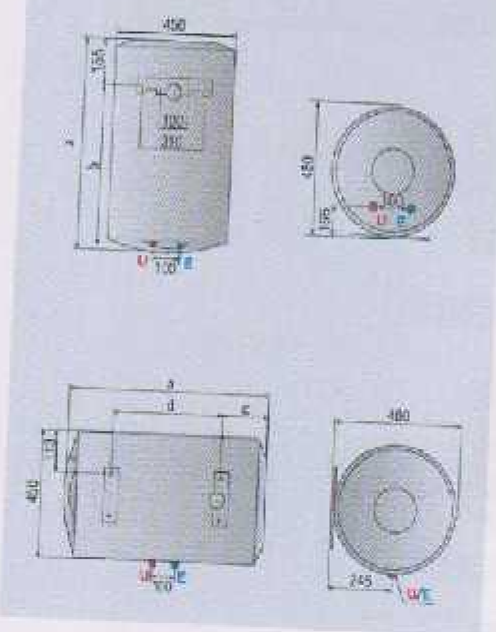


TECHNICAL DATA		PRO R 50 V	PRO R 80 V	PRO R 100 V	PRO R 50 H	PRO R 80 H	PRO R 100 H
Capacity	l	50	80	100	50	80	100
Installation		V	V	V	H	H	H
Size		Regular	Regular	Regular	Regular	Regular	Regular
Power	kW	1.5	1.5	1.8	1.2	1.5	1.8
Voltage	V	230	230	230	230	230	230
Heating time (ΔT=45°C)	h/min	150'	256'	340'	2.0'	2.56'	3.40'
Heat dispersion at 65°C	kWh/24h	0.96	1.22	1.39	1.02	1.48	1.65
Max working pressure	bar	8	8	8	8	8	8
Max working temperature	°C	75	75	75	75	75	75
Weight	kg	16.5	22	25.5	16.5	22	25.5
Class	IP	IPX3	IPX3	IPX3	IPX1	IPX1	IPX1
OVERALL DIMENSIONS							
a	mm	550	758	913	550	750	913
b	mm	388	502	758	-	-	-
c	mm	-	-	-	185	174	177
d	mm	-	-	-	190	135	487
CODE		3200423	3200424	3200425	3200426	3200427	3200428

C.29:

MODEL #	SETR0501U	SETR0502U	SETR0503MCU
DISPLAY	Animated LCD	Animated LCD	Animated LCD
OPERATING VOLTAGE	120 VAC/60 Hz	120 VAC/60 Hz optional 240 VAC /60 Hz	120 VAC/60 Hz optional 240 VAC /60 Hz
LINE CORD	7', 18 AWG rated at 221 °F	7', 18 awg rated at 221 °F	7', 18 awg rated at 221 °F
AMBIENT TEMP OPERATING RANGE	32 °F - 113 °F 0 °C - 45 °C	32 °F - 113 °F 0 °C - 45 °C	32 °F - 113 °F 0 °C - 45 °C
INPUTS	3 for Temp Sensors, Varistor Protected PT1000-PROBE PT1000-PLUG	4 Temp Recording, 1 Temp Recording Pulse, 1 Direct Sensor (TEMP/FLOW RATE)	5 Temp Recording, 1 Temp Recording Pulse, 1 Direct Sensor (TEMP/FLOW RATE)
OUTPUTS	1 for Circulating Pump, Fuse Protected MAX LOAD 0.5 HP (120 V~) LITTELFUSE 215.004 1 for Circulating Pump, FUSE PROTECTED	1 Relay Switched Output MAX LOAD 0.5 HP (120 V~) 1 Triac Output: SPEED CONTROL MAX LOAD 1.5 HP (120 V~)	1 Relay Switched Output MAX LOAD 0.5 HP (120 V~) 2 Triac Output: SPEED CONTROL MAX LOAD 1.5 HP (120 V~)

C.30

COMPONENTS

SET-16

UPS15-58FC LC

519601

50613
24124
40643

T-174

C.40:

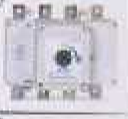
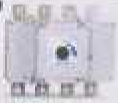
SOLAR TANK **SPECIFICATIONS**

MODEL #	SU80-1	SU80TC-1	SU80HE-1	SU120-1	SU120TC-1	SU120HE-1
GALLON CAPACITY	80.000 GAL	80.000 GAL	80.000 GAL	119.900 GAL	119.900 GAL	119.900 GAL
CONNECTION	SIDE	TOP	SIDE	SIDE	TOP	SIDE
ELEMENT WATTAGE UPPER	4500 W	4500 W	4500 W	4500 W	4500 W	4500 W
HEIGHT	58.750 IN	58.750 IN	58.750 IN	62.000 IN	62.000 IN	62.000 IN
DIAMETER	24.500 IN	24.500 IN	24.500 IN	28.250 IN	28.250 IN	28.250 IN
APPROX SHIP WT.	198.000 LBS	192.000 LBS	222.000 LBS	338.000 LBS	335.000 LBS	380.000 LBS
APPROX R-FACTOR	R-17.3	R-17.3	R-17.3	R-16.7	R-16.7	R-17.3

C.41:

MODEL #	PS/BS21	PS/BS24	PS/BS32	PS/BS40	PS/BS40-1.5
GROSS AREA	19.700 FT²	24.810 FT²	32.790 FT²	40.810 FT²	40.810 FT²
DRY WEIGHT	16.000 LBS	20.000 LBS	26.000 LBS	33.000 LBS	36.000 LBS
FLUID CAPACITY	0.780 GAL	0.780 GAL	1.000 GAL	1.200 GAL	1.610 GAL
DESIGN FLOW RATE	0.540 GPM	0.620 GPM	0.830 GPM	1.040 GPM	1.040 GPM
PRESSURE DROP AT DFR	0.015 PSIG	0.017 PSIG	0.018 PSIG	0.020 PSIG	0.020 PSIG
MAX FLOW RATE	12.000 GPM	12.000 GPM	12.000 GPM	12.000 GPM	12.000 GPM
MAX OPERATING PRESS	160.000 PSIG	160.000 PSIG	160.000 PSIG	160.000 PSIG	160.000 PSIG
STD. HEADER WIDTH	43.875 IN	38.750 IN	61.375 IN	51.375 IN	51.375 IN
HEADER, CENTER TO CENTER	71.500 IN	93.625 IN	115.93.625 IN	115.625 IN	115.625 IN

C.42:

SS03154PR0 	315A	315A	315A	200A	200A	250A	-	-
SS08004PC0 	800A	700A	700A	630A	550A	500A	-	-
SS12504PC0 	1250A	1250A	1250A	1000A	870A	850A	-	-
SS18004PS0 	1800A	1800A	1800A	1500A	1350A	1250A	-	-

C.43:

Electrical data (according to IEC 60947-3)

Thermal current Ith (40 °C)		1800A
Rated insulation voltage Ui (V)		1000
Rated impulse withstand voltage Uimp (kV)		12

DC Rated operational current Ie (A)

Voltage (DC)	Category of operation	Ie
400 V	DC21B	1800
600 V	DC21B	1800
800 V	DC21B	1500
900 V	DC21B	1350
1000 V	DC21B	1250

Standards. IEC 60947-1&3

Short-circuit behaviour

Short-circuit making capacity (peak value)	Icm	100kA
Short-time withstand current (1 sec) (rms)	Icw	50kA

Quality Telergon, S.A.U.

ISO 9001 & 14001	TÜVRheinland®

Connection capacity

Bar (Thickness * Width) (mm)	2*[illegible]
Rigid cable (mm²)	-
Max. Connecting copper bar (mm)	-
Tightening torque (N·m)	55

Testing as per IEC 60947-3

Arsenal Research	arsenal research

C.44:

Number of phases	Three phases					Single phase			
Meter type	A43	B23	C13	A44	B24	A41	B21	C11	A42
Connection	Direct connected			Transformer connected		Direct connected			Transformer connected
Nominal voltage	3 x 230/400 V AC			3 x 230/400 V AC		230 V AC			230 V AC
Frequency	50 or 60 Hz			50 or 60 Hz		50 or 60 Hz			50 or 60 Hz
Voltage (V AC) phase to neutral phase to phase	3 x 57,7 - 288 3 x 100 - 500	3 x 220 - 240 3 x 380 - 415		3 x 57,7 - 288 3 x 100 - 500	3 x 220 - 240 3 x 380 - 415	57,7-288	220-240	230	57,7-288
Accurcy class (active energy)	Class 1 (B)			Class 1 (B) or Class 0,5 S (C)		Class 1 (B)			Class 1 (B) or Class 0,5 S (C)
Maximum current	80 A	65 A	40 A	6 A		80 A	65 A	40 A	6 A
Reference current	5 A			1 A		5 A			1 A
DIN modules	7	4	3	7	4	4	2	1	4
Meter type	A43	B23	C13	A44	B24	A41	B21	C11	A42
Pulse output	Steel			Steel		Steel			Steel
Alarm									

C.45:

Feature	A43	B23	C13	A44	B24	A41	B21	C11	A42
Pulse output	Steel			Steel		Steel			Steel
Alarm									
Reactive energy	Bronze			Bronze		Bronze			Bronze
Four quadrant measurements									
Resettable registar	Silver			Silver		Silver			Silver
2 inputs and 2 outputs									
Up to 4 tariffs - controlled by externa signal or communi cation									
Up to 4 tariffs - controlled by internal clock	Gold	No		Gold	No	Gold	No		Gold
Basic clock functions									
Advanced clock functions	Platinum			Platinum		Platinum			Platinum
Harmonics and THD									
Configurable I/O									
In-built communication M-Bus	Option			Option		Option			Option
In-built communication RS-485 (Modbus RTU or EQ bus)	Option			Option		Option			Option
KNX module via IR port	Available	2014*		Available	2014*	Available	2014*		Available
Meter type	A43	B23	C13	A44	B24	A41	B21	C11	A42

C.46:

System design	
Static load wind/snow	4000 Pa/5400 Pa
Hail safety impact velocity	25 mm at 23 m/s
Operating and storage temperature	−40° C to 85° C
Normal operating cell temperature (NOCT)	45 ± 3° C
Maximum system voltage	1000 V (IEC)
Series fuse rating	13 A
Maximum reverse current	Series fuse rating multiplied by 1.35
Fire safety classification (IEC 61730)	Class C
Safety class	II

Caution: Please read the installation Guide before using the product.

Mechanical characteristics/packaging	
Cell technology	4 busbar polycrystalline
Cell configuration	60 cells (6 x 10), 156 mm x 156 mm (6 in x 6 in)
Dimensions	1670 mm x 1000 mm x 32 mm
Weight	18.5±0.5 kg
Frame	Aluminum-alloy, anodized
Front	3 mm tempered anti-reflection glass
Backsheet	Multi-layer composite sheet
Junction box	Protection class IP 67; 3 sets of diodes
Output cables	Solar cable: 4 mm²; length 1000 mm
Connector	Amphenol H4
Packaging configuration	32 pieces per pallet, 832 pieces/container (40 ft. HQ)

C.47:

HSL 60 S POLY

Electrical characteristics at standard test conditions (STC)					
Module type	HSL60P6-PC-1-xxx (xxx = power class)				
Power class	250 W	255 W	260 W	265 W	270 W
Maximum power (P_{max})	250 W	255 W	260 W	265 W	270 W
Open circuit voltage (V_{oc})	37.6 V	37.8 V	38.1 V	38.3 V	38.5 V
Short circuit current (I_{sc})	8.72 A	8.86 A	8.98 A	9.12 A	9.22 A
Voltage at maximum power (V_{mpp})	30.5 V	30.7 V	30.9 V	31.1 V	31.2 V
Current at maximum power (I_{mpp})	8.20 A	8.31 A	8.42 A	8.53 A	8.66 A
Module efficiency (%)	15.0%	15.3%	15.6%	15.9%	16.2%

STC: Irradiance at 1000 W/m² – Air mass 1.5 – Cell temperature at 25 ± 2° C. Measurement tolerance P_{mpp}: ±3%.
Positive power sorting of module power class: 0 to +5 W. Efficiency at 200 W/m² in relation to 1000 W/m² is at least 97% of STC efficiency.

C.48:

Electrical characteristics at nominal operating cell temperature (NOCT)

Power class	250 W	255 W	260 W	265 W	270 W
Maximum power (P_{max})	183 W	187 W	191 W	196 W	199 W
Open circuit voltage (V_{oc})	35.1 V	35.4 V	35.7 V	35.9 V	36.1 V
Short circuit current (I_{sc})	7.05 A	7.16 A	7.26 A	7.37 A	7.45 A
Voltage at maximum power (V_{mpp})	28.0 V	28.2 V	28.4 V	28.6 V	28.7 V
Current at maximum power (I_{mpp})	6.54 A	6.64 A	6.73 A	6.84 A	6.92 A

NOCT: Irradiance at 800 W/m² – Ambient temperature of 20° C – Wind speed at 1 m/s. Measurement tolerance P_{mpp}: ±3%.

Temperature characteristics

Temperature coefficients of P	-0.41%/° C
Temperature coefficients of V	-0.31%/° C
Temperature coefficients of I	+0.055%/° C

System design

Static load wind/snow	4000 Pa/5400 Pa
Hail safety impact velocity	25 mm at 23 m/s
Operating and storage temperature	-40° C to 85° C
Normal operating cell temperature (NOCT)	45±3° C
Maximum system voltage	1000 V (IEC)
Series fuse rating	15 A
Maximum reverse current	Series fuse rating multiplied by 1.35
Fire safety classification (IEC 61730)	Class C
Safety class	II

C.49:

Technical Data	Sunny Boy 1300TL	Sunny Boy 1600TL	Sunny Boy 2100TL
Input (DC)			
Max. DC power (@cos φ = 1)	1400 W	1700 W	2200 W
Max. input voltage	600 V	600 V	600 V
MPP voltage range	115 V[1] – 480 V	155 V to 480 V	200 V to 480 V
Rated input voltage	400 V	400 V	400 V
Min. input voltage / initial input voltage	100 V[1] / 120 V[1]	125 V / 150 V	125 V / 150 V
Max. input current / max. input current per string	15 A[1] / 12 A[1]	12 A[1] / 12 A[1]	12 A[1] / 12 A[1]
Max. DC short-circuit current	18 A	18 A	18 A
Number of independent MPP inputs / strings per MPP input	1 / 1	1 / 1	1 / 2
Output (AC)			
Rated power (at 230 V, 50 Hz)	1300 W	1600 W	1950 W
Max. apparent AC power	1300 VA	1600 VA	2100 VA
Nominal AC voltage	220 V / 230 V / 240 V	220 V / 230 V / 240 V	220 V / 230 V / 240 V
Nominal AC voltage range	180 V to 260 V	180 V to 260 V	180 V to 260 V
AC power frequency / range	50 Hz, 60 Hz[1] / -6 Hz ... +5 Hz	50 Hz, 60 Hz[1] / -6 Hz ... +5 Hz	50 Hz, 60 Hz[1] / -6 Hz ... +5 Hz
Rated power frequency / rated grid voltage	50 Hz / 230 V	50 Hz / 230 V	50 Hz / 230 V
Max. output current	7.2 A	8.9 A	11 A
Power factor at rated power	1	1	1
Feed-in phases / connection phases	1 / 1	1 / 1	1 / 1
Efficiency			
Max. efficiency / European weighted efficiency	96.0 % / 94,3 %	96.0 % / 95.0 %	96.0 % / 95.2 %
Protective Devices			
Input side disconnection point	○	○	○
Ground fault monitoring / grid monitoring	● / ●	● / ●	● / ●
DC reverse polarity protection / AC short-circuit current capability / galvanically isolated	● / ● / –	● / ● / –	● / ● / –
All-pole sensitive residual-current monitoring unit	●	●	●
Protection class (according to IEC 62103) / overvoltage category (according to IEC 60664-1)	I / III	I / III	I / III

MODEL NUMBER	MAWP	TANK VOLUME		DIAMETER		OVERHEADS		SYS CONN	LEG CLEARANCE		SHIPPING WEIGHT	
	PSIG	GAL	L	IN	MM	IN	MM	INCH (NPT)	IN	MM	LBS	KG
JOPR-22-080	125	80	300	20	508	62¾	1597	2	14	356	230	104
JOPR-22-105	125	105	400	24	610	56	1422	2	14	356	325	147
JOPR-22-009	125	120	450	24	610	66	1676	2	14	356	335	152
JOPR-22-135	125	135	500	24	610	71½	1816	2	14	356	340	154
JOPR-22-011	125	158	600	30	762	58	1473	2	14	356	435	197
JOPR-22-012	125	211	800	30	762	76	1930	2	14	356	515	234
JOPR-22-013	125	264	1000	36	914	67	1702	2	14	356	715	324
JOPR-22-014	125	317	1200	36	914	78½	1994	2	14	356	815	370
JOPR-22-015	125	370	1400	36	914	91	2311	2	14	356	935	424
JOPR-22-016	125	422	1600	48	1219	63½	1613	2	14	356	1075	488
JOPR-22-017	125	528	2000	48	1219	77¾	1965	2	14	356	1235	560
JOPR-22-018	125	660	2500	48	1219	94	2388	2	14	356	1435	651
JOPR-22-019	125	793	3000	48	1219	122¾	3121	2	14	356	1900	862
JOPR-22-020	125	1056	4000	54	1372	132	3429	2½	14	356	2400	1089
JOPR-22-021	125	1320	5000	54	1372	151	3835	2½	14	356	2700	1225
JOPR-22-022	125	1600	6050	72	1829	107	2718	2½	14	356	3425	1554
JOPR-22-023	125	2000	7600	72	1829	130	3302	2½	14	356	4000	1814
JOPR-22-024	125	2640	10000	72	1829	164	4166	2½	14	356	4875	2211
JOPR-22-028	125	2800	10600	72	1829	174	4420	3	14	356	5300	2404
JOPR-22-030	125	3000	11400	72	1829	186	4724	3	14	356	5700	2585
JOPR-22-039	125	3963	15000	72	1829	230	5842	3	14	356	7100	3220

C.50:

MAXIMUM OPERATING PRESSURE PSIG	MINIMUM OPERATING PRESSURE AT TANK LOCATION (PSIG)										
	5	10	12	15	20	30	40	50	60	70	80
27	0.527	0.408	0.360	0.288	0.168						
30	0.560	0.447	0.403	0.336	0.224						
35	0.604	0.503	0.463	0.403	0.302	0.101					
40	0.640	0.548	0.512	0.457	0.366	0.183					
45	0.670	0.586	0.553	0.503	0.419	0.251	0.084				
50	0.696	0.618	0.587	0.541	0.464	0.309	0.155				
55	0.717	0.646	0.617	0.574	0.502	0.359	0.215	0.072			
60	0.736	0.669	0.643	0.602	0.536	0.402	0.268	0.134			
65	0.753	0.690	0.665	0.627	0.565	0.439	0.314	0.188	0.062		
70	0.767	0.708	0.685	0.649	0.590	0.472	0.354	0.236	0.118		
75	0.780	0.725	0.702	0.669	0.613	0.502	0.390	0.279	0.167	0.056	
80	0.792	0.739	0.718	0.686	0.634	0.528	0.422	0.317	0.211	0.106	
90	0.812	0.764	0.745	0.716	0.669	0.573	0.478	0.382	0.287	0.191	0.095
100	0.828	0.785	0.767	0.741	0.698	0.610	0.523	0.436	0.347	0.261	0.174
110	0.842	0.802	0.786	0.762	0.723	0.642	0.561	0.481	0.401	0.321	0.241

C.51: irrigation

Pipe Size	Maximum Available GPM (Maximum Safe GPM)				
	Steel Pipe	Copper Pipe	PVC Pipe	PE (poly) Tube	PEX (CTS) Tube
1/2"	6 GPM(7 ft/sec)	6 GPM(7 ft/sec)	6 GPM(7 ft/sec)	6 GPM(7 ft/sec)	3 GPM(7 ft/sec*)
3/4"	11 GPM(7 ft/sec)	11 GPM(7 ft/sec)	11 GPM(7 ft/sec)	11 GPM(7 ft/sec)	7 GPM(7 ft/sec*)
1"	18 GPM(7 ft/sec)	18 GPM(7 ft/sec)	18 GPM(7 ft/sec)	18 GPM(7 ft/sec)	12 GPM(7 ft/sec*)
1 1/4"	23 GPM(5 ft/sec)	23 GPM(5 ft/sec)	23 GPM(5 ft/sec)	23 GPM(5 ft/sec)	–
1 1/2"	32 GPM(5 ft/sec)	32 GPM(5 ft/sec)	32 GPM(5 ft/sec)	32 GPM(5 ft/sec)	–
2"	52 GPM(5 ft/sec)	52 GPM(5 ft/sec)	52 GPM(5 ft/sec)	52 GPM(5 ft/sec)	–

C.52:

1 570™ SERIES FIXED-SPRAY SPRINKLERS

Radius: 5′-17′

Toro 570™ Series fixed-spray sprinklers produce a precise, uniform fan of water that's ideal for small lawn, shrub and ground cover areas. Pop-up models disappear when not in use. Shrub sprays mount above foliage to water ground cover and shrubs. True matched precipitation rates and color coding by radius are just two of the valuable features of 570™ sprinklers and nozzles. Toro has more than 35 different interchangeable nozzles to choose from to give you maximum flexibility and precision.

Perfect for smaller lawn and garden areas.

C.53:

15′ SERIES WITH 27° TRAJECTORY (BLACK)

PATTERN	PSI	GPM	RADIUS
90°	30	0.85	15′
180°	30	1.65	15′
360°	30	3.60	15′
0-360°	30	3.82	13′

C.54:

570™ Series Nozzles

5′ SERIES WITH 0° TRAJECTORY (RED)

PATTERN	PSI	GPM	RADIUS
90°	30	0.09	5′
180°	30	0.19	5′
360°	30	0.38	5′

C.55:

For the exact flow by sprinkler type, refer to the Sprinkler Performance Chart on the right.

HOW MANY SPRINKLERS CAN I USE?				
	Gallons Per Minute (GPM)			
	5 GPM	8 GPM	12 GPM	15 GPM
570 Series Sprayheads (@ 30 PSI)				
15′ Quarter Circle (90°)	5	9	14	17
15′ Half Circle (180°)	3	4	7	9
15′ Full Circle (360°)	1	2	3	4
Single Stream & SimpleSet Rotors (@ 45 PSI)				
30° to 120° (1.5 Nozzle)	3	5	8	10
121° to 240° (3.0 Nozzle)	1	2	4	5
241° to 360° (6.0 Nozzle)	0	1	2	2
MultiStream Rotors (@ 35 PSI)				
90°	3	5	8	10
135°	2	3	5	6
180°	1	2	3	4
270°	1	1	2	3
360°	0	1	1	2
Universal Impact Rotors (@ 30 PSI)				
90° (Orange Nozzle)	3	5	8	10
120° (Red Nozzle)	2	4	6	7
180° (Black Nozzle)	1	2	4	5
270° (Blue Nozzle)	1	2	3	3
360° (Green Nozzle)	0	1	2	2

* pressures are based on working pressure at the head
* all measurements based on Class 200 PVC for all lateral pipes