College of Engineering and Technology

Mechanical Engineering Department

Management of mechanical systems using building management system (BMS) and Internet of thing (IoT)

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Jun 2021

ACKNOWLEDGEMENTS

First, we would like to express our sincere thanks to Dr. Hussein Amro for guiding us throughout this experience. With continuous support, encouragement, motivation and valuable suggestions, the project was realized.

Second, we would like to thank all staff members in the College of engineering who helped and advised us throughout our study. Special thanks to our Parents, brothers, sisters, family, friends and partners who have helped with their valuable suggestion and guidance has been helpful in various phases of the completion of the project. We know the thanks are not enough. We believe you deserve more and more.

Abstract

This research presents building management system (BMS), which is the key module in order to perform the controlling and automation of a specific building or a room. the main areas of BMS are also focused on switching and controlling power input/output. Modern building services systems are an integration of mechanical, electrical and control components. In the world of today, various subsystems in a large building have been traditionally operated separately, each with their own Information Technology (IT) structure. These Conventional systems have put a strain on energy and time. This research Design and Implement Building Management System, using the Internet of Things (IoT), that controls and monitors several subsystems: HVAC, security, fire alarm, lighting, and pumping systems. Using The SmartX AS-B controller to help reduce energy costs, ease operation and remote control. Concluding that implementing a robust BMS structure, gives a continuous support for all systems, to provide maximum performance, helps any future expansion to incorporate new facilities, making it the optimum solution for all rising problems.

الملخص

يقدم هذا البحث نظام ادارة المباني، وهو الوحدة الرئيسية لأداء التحكم والتشغيل الالي لمبنى او غرفة معينة يرتكز نظام ادارة المباني على التشغيل والتحكم في المدخلات والمخرجات للطاقة. أنظمة خدمات البناء الحديثة عبارة عن تكامل بين المكونات الميكانيكية والكهربائية والتحكمية. في الوقت الحاضر تم بشكل تقليدي تشغيل العديد من الأنظمة الفرعية في المباني الكبيرة بشكل منفصل، ولكل منها هيكل تكنولوجيا معلومات خاص بها، وضعت هذه الأنظمة ضغطا على الوقت والجهد، يقوم هذا البحث بتصميم وتنفيذ نظام أدارة المباني باستخدام انترنت الاشياء، الذي يتحكم ويراقب أنظمة فرعية متعددة، مثل: أنظمة التدفئة والتهوية وتكييف الهواء، والأمن، والإنذار، والإضاءة، وأنظمة السباكة. باستخدام جهاز التحكم، للمساعدة في تقليل تكلفة تشغيل الطاقة، التشغيل والتحكم عنن بعد، تتطلب الأنظمة في المباني صيانة دورية لإعطاء الأداء الأمثل والمستمر بالإضافة الى تعديل وتوسيع النظام لدمج المباني الجديدة وتوفير الصيانة المستمرة لنظام ادارة المباني، واستخدام أنظمة التحكم لضمان السيطرة على المبنى والتأكد من استمرار عمله بأمثل وأسلس الطرق, تنفيذ وتطبيق نظام ادارة المباني يعطي دعما لهيكلية المبنى ويسعد في المراقبة والتحكم بجميع الانظمة الموجودة بالمبنى وترشيد استهلاك الطاقة مما يجعله الحل الأمثل لجميع المشاكل المتزايدة وتسهيل نظام المباني الذكية.

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Chapter 1

1 Introduction

1.1 Introduction

In the last few years, vertical habitation especially High-Rise Buildings (HRB) is a trend, driven by urbanization, and overpopulated. Hence this type of building and the fourth industrial revolution, especially the Internet of Things (IoT), the number of systems that are employed in a building has increased significantly, such as Lighting, HVAC, Ventilation systems, Fire Alarm Panels, Fire Fighting Panels, Water Tank Monitoring, Elevator Operations, CCTV, Access Control, Security, Generators, and many more of the subsystems.

This issue makes it difficult to maintain and control the safety, security, and management of buildings optimally by humans only, so the implementation of a Building Management System (BMS), can be defined as centralized control and monitoring system for the building, using computers. BMS will be able to effectively maintain buildings, monitor and control all public facilities, and help to rationalize electrical consumption. In this project, a BMS system will be designed for a hotel, in Bethlehem – bet sahour, which is still a proposed building, and it will be due for a makeover, so the Internet of Things (IoT) technologies will be used to optimize the management, energy-savings, and efficient maintenance without incurring outrageous costs.

The rapid acceleration in the prevalence of IoT is much large in recent years, the rise of universal sensors, smart devices, and the capacity of wired or wireless network has enabled many more networks to work together in harmony, which makes decisions and physical feedback to change in a real-time manner. [1]

The number of IoT devices maximized, started to be used for personal benefits in homes or publicly buildings, to take advantage of the highly intelligent future and present of devices, while being resource-constrained, it's smart to use the IoT services and applications to make use of many things created by the IoT communications and transform this data into useful information, and real-time knowledge discovery and decision making.[2]

1.2 Problem Definition

subsystems in a building have traditionally been operated separately, each with their own IT structure. However, as the number of subsystems increased the case for integrated solutions also grew. In particular, the addition of fluctuating renewable energy generation and energy storage capacity added a new level of complexity, one which demanded a new form of management in buildings, in order to reduce rising overall costs. Conventional systems suffer from inefficient use of energy and time under used facility.

In this project, a modern control system with a management level named Building management system (BMS), is designed to save energy, cost, time and enables human comfort conditions to be easily monitored and controlled.

1.3 Recognition Of Need

According to our project, a suitable solution is to design a building management system connected to IoT, to control subsystems to save energy, cost, and time.

1.4 Project Aim And Methodology

The main aim is to design and implement a Building Management system using the Internet of Things. Designing a system that controls these systems HVAC, plumbing, firefighting, electrical system, and employing the IoT principle in this system. **The detailed objectives include:**

Send data about the connected system state to the user's gadget employing IoT. Enabling the user to control the system's capacities distantly, energy saving by restricting unnecessary use of energy. Develop, work, and present modern systems.

Research methodology phases are:

1. Design mechanical schemes that include: HVAC, plumbing, firefighting, and electrical system.
2. The proposed control circuit for the planning system.
3. Controlling and monitoring systems: HVAC, water pumping systems, firefighting alarm system, lighting and security system.
4. Peruse the new performance and contrast it and old performance for energy saving cost and time Building management system, brings the user absolute control of a building’s space, lighting, security, assets, internal environment, and utility monitoring. While connected to a cloud-based building management system, IoT devices make real-time actions, creating BMS by having the HVAC system connected to IoT, HVAC system designed by the rivet, shows a 9 story Hotel with the proper implementation of services, by constructing BMS and IoT connection physical devices with a virtual universal information cloud, we get readings and data from all types of implemented sensors, then data is gathered by the system, then immediately moved to the cloud, which provides many

services such as daily weather feed and air quality reports, this enables devices to make smart decisions while being completely secure.

Conceptual Design

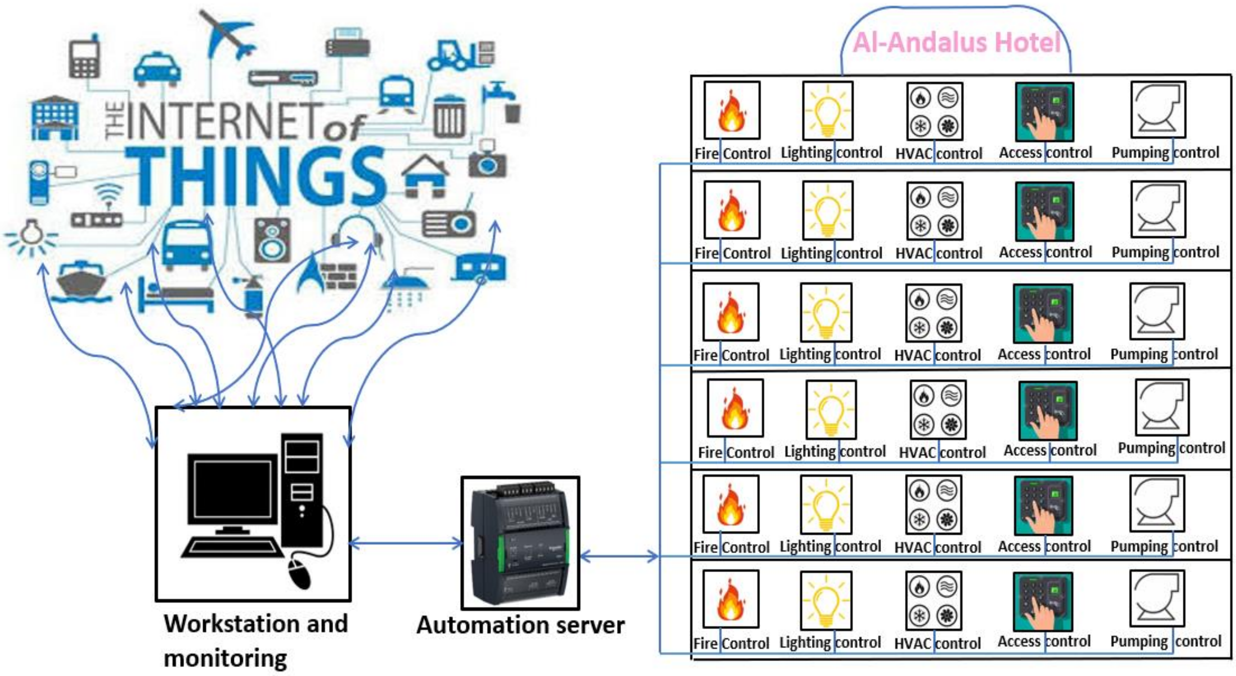


Figure 1-1: Conceptual Design

Figure (1-1) shows an example of a hotel that contains different systems (firefighting systems, air conditioning systems, lighting, monitoring and security, and ventilation systems). The project will focus on managing these systems, and the BMS controller SmartX AS-B will be used to control these systems.

1.5 Related Work

Wang, S., & Xie, Experiments show that the embedded Web server provides an easy means for developing the programs to access control network, the combination of the embedded Web server and PC Web server is also simple for application while providing more functions and capacity, the method integrating PC Web server and BMS database is much more efficient and powerful. [3]

Yu, J., Kim, M., Bang, H.-C., Bae, S.-Ha, smart building on IoT and cloud-based technology that can perform collaboration and efficient operation with various sensing devices in building and facilities, the cloud server forecasts the energy consumption of buildings based on sensor data from the IoT system with diverse sensors in buildings.[4]

Akkaya, K., Guvenc, I., Aygun, R., Pala, N., & Kadri, future smart buildings have a great potential to save energy by employing smart control strategies on HVAC through the help of data collected via IoT, the data collected on the IoT cloud is analyzed and saved, then fetched when needed .[5]

Png, E., Srinivasan, S., Bekiroglu, K., Chaoyang, J., Su, R., & Poolla, scalable and economical IoT upgrade for HVAC control, by using personal computer as central scheduler controlling an embedded raspberry pi with a various number of sensors, interfaced with BACnet then attached to the IOT cloud .[4]

Minoli, D., Sohraby, K. and Occhiogrosso, this article focuses on the relationship between the Internet of Things and smart building connections. Smart buildings based on the Internet of Things concept are expected to develop rapidly in the next five years. The integration of the Internet of Things is expected to improve the function, performance, energy efficiency and cost-effectiveness of buildings, which is aimed at commercial buildings due to high energy consumption .[7]

Mataloto, B., Ferreira, J. C., & Cruz, N., IOT for building and energy management, a unique way to control and save environments with the use of microcontrollers like raspberry pi that represent the core of the system, using IOT to connect buildings with the world servers, by creating IOT platform consisting of sensor layer, communication layer and application layer, saving a lot of time, expenses, and effort. [8]

Daniel Minoli, Kazem Sohraby, and Benedict Occhiogrosso. performed a real-world trial, an optimized HVAC control system, taking results of data collected in 51 days, showing an average of 19% reduction (0.46 GJ/day) in HVAC energy consumption. Within the first 10 days of the experiment a substantial 32% decrease in thermal energy. approving that good communication with the building system will increase the volume of comfort. [14]

These papers and researches, were great resources for information and data, starting from identifying several terms, and explaining the processes needed to implement a BMS, in general manners, their results were used as a guide, showing that the executing is applicable and successful.

1.6 Conclusion Of The Chapter

Building management system, brings the user absolute control of a building's space, lighting, security, assets, internal environment, and utility monitoring. When IoT devices are connected to a cloud-based building management system, they can operate in real time, while the IoT-oriented BMS is an open platform that combines all individual data into a database to ensure functionality and comfort, and has high Productivity and energy saving features.

Creating BMS to control systems while connected to IoT, HVAC system designed by the rivet, shows a 9 story Hotel with the proper implementation of services, by constructing BMS and IoT connection, linking physical devices with a virtual cloud, we get readings and data from all types of implemented sensors, And then immediately moved to the cloud, which provides many services, such as daily weather forecasts and air quality reports, this enables the devices to make informed decisions while being completely secure.

1.7 Time Table

Table 1-1: Time table

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Project idea selection	■	■														
Data collection			■	■	■	■	■									
Conceptual design						■	■									
Mechanical plan drawing						■	■	■	■	■	■	■	■			
Controllers' selection												■	■			
Week	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
Component selection	■	■	■													
BMS plans Drawing				■	■	■	■	■	■	■	■	■	■	■		
conclusion													■	■	■	

1.8 Content Of Table

Table 1-2: cost table

Quantity	Description	Unit price (USD)	Total Price (USD)
1	Smart AS-B Server	2000$	2000$
3	Extension I/O module SXWI116XX10001	212$	636$
		total	2636$
	Accesses System		
1	EcoStruxure™ Security Expert_SP-C	1500$	1500$
58	Junction Box	10$	580$
58	Simple Fingerprint&RFID Card Access Control Teminal	277$	16066$
58	ZKTeco -EX-802 exit button	4$	232$
58	magnetic door lock	30$	1680$
58	DOOR SENSOR	7$	406$
		Total	20464$
	HVAC System		
1	VRF Touch Centralized Controller DMS 2.5	600$	600$
58	Room Wired Controller MWR-WG00UN	130$	7540$
24	Temperature outdoor sensor ST060	70$	1680$
58	Humidity/Temperature Sensors HIH6100	54$	3132$
58	CO2 sensor CRIR M1	60$	3480$
		Total	16432$
	Fire Alarm System		
1	Fire alarm control panel ESSER	700$	700$
82	Smoke detector A9030T	13$	1066$
18	Heat detector A9020T	7$	126$
20	Sounder fire alarm A9097B	5$	100$

18	Manual call pint A9060T	4$	72$
18	CO2 detector CozIR®-A	25$	375$
		Total	2439$
Lighting system			
6	Lighting controller SpaceLogic C-Bus DALI-2 Gateway	1500$	9000$
24	Light driver HED6030-A 24 V DALI LED	14$	336$
36	Ballast 320W 24VDC Non-dimmable CV LED Driver	7$	252$
48	on/off push button HYTRONIK HDS2400 DALI SWITCH	130$	6340$
24	PUSH-BUTTON DALI DT CONTROLER SR2422-NK-4DIM-G2 DIMMING	6$	144$
6	KNX/Dali gateway	550$	3300$
		Total	19372$
		Total cost	61343 $

Chapter 2

Heating And Cooling Load

2.1 Introduction

Over the years, human has tried to develop from his living conditions to become comfortable, easy, and healthy, more suitable for humans and adapt to them throughout the year and changing seasons. to design HVAC system, the first step is to calculate the cooling and heating loads, plus the sizing of HVAC system, choosing the proper equipment's, sorting the air distribution to follow the required cooling and heating values, with the right perspective to cooling and heating loads in a closed space.

2.2 Human Comfort

Human thermal comfort is defined as a state of mind, which expresses satisfaction with the surrounding environment. High temperatures and humidity give discomfort sensations. Also, discomfort and heat stress reduce worker production and may increase medical issues. So, we need an HVAC system to make people feel comfortable in different regions and different temperatures in all seasons.

By Ashrae the comfort zone is:

ASHRAE Standard: Thermal Environmental Conditions for Human Occupancy is an American National Standard published by ASHRAE that establishes the ranges of indoor environmental conditions to achieve acceptable thermal comfort for occupants of buildings.

humans can live comfortably in a temperature range of (22 to 27)˚ c, and in a moderate humidity of range (40% to 60%), we propose to obtain a temperature of 24°c and a humidity of 50%.

Comfort zone in Psychometric chart:

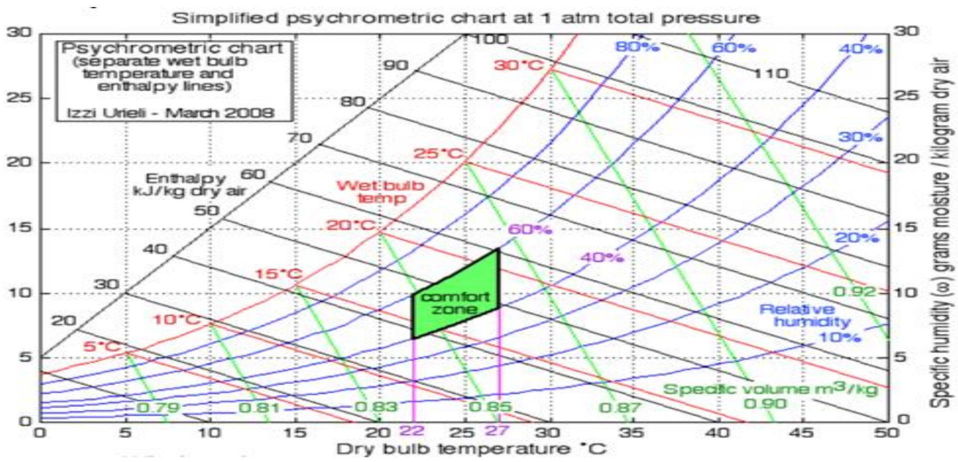


Figure 2-1: Comfort zone in Psychometric chart

2.3 Building Description

The hotel includes nine floors, two floors' basements, ground floor for reception and six floors for hotel guests, located in Bethlehem – bet sahour.

The horizontal area of the building=250 m^2

The total area of the building =2250 m^2

The following table 2-1 shows the details of each floor in the building:

Table 2-1: building description

Floor	Description
-2 Basement	For general services like: electrical room, store and necessary equipment.
-1 Basement	Car parking
Ground floor	Reception and office
First floor	Three room for guests and restaurant
Second floor	Hotel rooms of various sizes.
Third floor	Hotel rooms of various sizes.
Fourth floor	Hotel rooms of various sizes.
Fifth floor	Hotel rooms of various sizes.
Sixth floor	Roof floor

2.4 Heating And Cooling Load

2.4.1 Introduction

The heating load is the measure of thermal energy that must be added to a space to keep the temperature inside a satisfactory reach. The cooling load is the amount of thermal energy that must be removed from a space(cooling) to keep the temperature within an acceptable range.

The heating and cooling load calculation are the first steps of the HVAC plan HVAC design includes more than the load estimate calculation. Sizing of one HVAC system, selecting HVAC equipment, and planning the air distribution system to meet the exact predicted heating and cooling loads start with an accurate comprehension of the heating and cooling loads on a space.

2.4.2 Outside And Inside Design Conditions:

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

The following table 2-2 shows the outside and inside design condition:

Table 2-2: outside and inside design condition

Property	Inside design condition		Outside design condition	
	summer	winter	summer	winter
Temperature (˚C)	24	24	30	4.7
Relative humidity (%)	50	50	51.3	70
Wind speed(m/s)	-	-	1.4	1.4

2.4.3 Calculation Of Overall Heat Transfer Coefficient (U):

To calculate the heat gain from walls, ceiling, ground and doors, one need to calculate the value of overall heat transfer coefficient (U) for each one of them. The value of U is depending in the kind of material that content in walls, ceiling…etc. The amount of load either heating or cooling (from walls, doors…etc.) is directly proportional with the value of the U.

U_{out} = Overall heat transfer coefficient for the outside walls of the rooms.

U_{in} = Overall heat transfer coefficient for the internal walls of the rooms.

$U_{ceiling}$ = Overall heat transfer coefficient for the ceiling of the rooms.

U_{floor} = Overall heat transfer coefficient for the ground of the rooms.

U_{doors} = Overall heat transfer coefficient for the doors of the rooms.

U_{glass} = Overall heat transfer coefficient for the glass of the rooms.

$$U = \frac{1}{R_{th}} = \frac{1}{\frac{1}{h_i}+\frac{\Delta x_1}{k_1}+\frac{\Delta x_2}{k_2}+\cdots+1/h_0} \quad \text{(Eqn 2.1)}$$

Where:

Δx: the thickness of the wall [m].

k: Thermal conduction of the material (W/mK)

$\boldsymbol{h_i}$: Convection coefficient of inside wall, floor, or ceiling (W/m^2.K).

$\boldsymbol{h_0}$: Convection coefficient of outside wall, floor, or roof (W/m^2.K).

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

1. <u>For external wall</u>

The following table 2-3 shows the construction of external wall

Table 2-3: the construction of external wall

	Material	Thickness of the wall(m)	Heat transfer coefficient the wall (W/ m^2.K)
1	plaster	0.02	1.2
2	Cement break	0.07	0.95
3	Polystyrene	0.03	0.03
4	Concrete	0.13	1.75
5	Stone	0.07	1.7

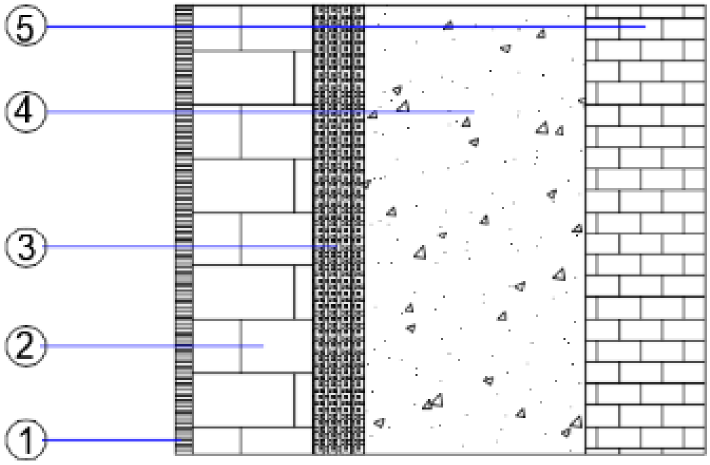


Figure 2-2: external wall construction

Rin and Rout for the external walls as 0.12 and 0.03(m^2.°K /W), respectively from table (A-27).

$$U_{wall} = \frac{1}{R_{in}+\frac{\Delta x_{st.}}{k_{st.}}+\frac{\Delta x_{con.}}{k_{con.}}+\frac{\Delta x_{poly.}}{k_{poly.}}+\frac{\Delta x_{Brick}}{k_{Brick}}+\frac{\Delta x_{plaster}}{k_{plaster}}+R_{out}}$$

$$U = \frac{1}{0.12+\frac{0.07}{1.7}+\frac{0.13}{1.75}+\frac{0.03}{0.03}+\frac{0.07}{0.95}+\frac{0.02}{1.2}+0.06} = 0.738\ (W/m^2.°K)$$

2. For internal wall:

The following table 2-4 shows the construction of internal wall:

Table 2-4: construction of internal wall

	Material	Thickness of the wall(m)	Heat transfer coefficient the wall (W/ m^2.K)
1	plaster	0.025	1.2
2	Cement break	0.05	0.95
3	plaster	0.025	1.2

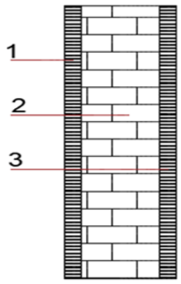


Figure 2-3: The construction of internal wall

$$U = \frac{1}{R_{in} + \frac{\Delta x_{(cem).}}{k_{cem.}} + \frac{\Delta x_{plaster}}{k_{plaster}} + \frac{\Delta x_{(cem).}}{k_{cem.}} + R_{out}}$$

$$U = \frac{1}{0.12 + \frac{0.025}{1.2} + \frac{0.05}{0.95} + \frac{0.025}{1.2} + 0.12} = 2.99\ (W/m^2.\ °K)$$

3. For ceiling and Roof

The following table shows the construction for ceiling and roof:

Table 2-5: construction of celling.

	Material	Thickness of the wall(m)	Heat transfer coefficient the wall (W/ m^2.K)
1	Asphalt	0.02	0.8
2	Concrete	0.05	1.75
3	Polystyrene	0.05	0.03
4	Concrete	0.06	1.75
5	Brick	0.14	0.95
6	plaster	0.02	1.2

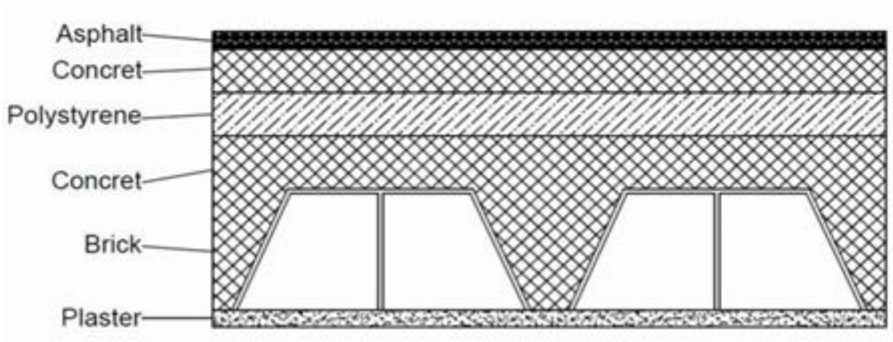


Figure 2-4: celling construction

Because of its construction, the ceiling is divided into two overall heat transfer coefficient one with brick and the other without. R_{in} and R_{out} for the ceiling are 0.1 and 0.02($W/m^2.°C$), respectively from table (A-27).

$$U_1 = \frac{1}{R_{in}+\frac{\Delta x_{asph.}}{k_{asph.}}+\frac{\Delta x_{conc.}}{k_{conc.}}+\frac{\Delta x_{poly.}}{k_{poly.}}+\frac{\Delta x_{conc.}}{k_{conc.}}+\frac{\Delta x_{Brick}}{k_{Brick}}+\frac{\Delta x_{Plaster}}{k_{Plaster}}+R_{out}}$$

$$U_1 = \frac{1}{0.1+\frac{0.02}{0.8}+\frac{0.05}{1.75}+\frac{0.05}{0.03}++\frac{0.06}{1.75}+\frac{0.14}{0.95}+\frac{0.02}{1.2}+0.04} = 0.49\ (W/m^2.°K)$$

$$U_2 = \frac{1}{R_{in}+\frac{\Delta x_{asph.}}{k_{asph.}}+\frac{\Delta x_{conc.}}{k_{conc.}}+\frac{\Delta x_{poly.}}{k_{poly.}}+\frac{\Delta x_{conc.}}{k_{conc.}}+\frac{\Delta x_{Plaster}}{k_{Plaster}}+R_{out}}$$

$$U_2 = \frac{1}{0.1+\frac{0.02}{0.8}+\frac{0.05}{1.75}+\frac{0.05}{0.03}++\frac{0.2}{1.75}+\frac{0.02}{1.2}+0.04} = 0.51\ (W/m^2.°K)$$

4. **For glass,** from table (A-28), U_g = 3.2 $W/m^2.°K$, for double glass aluminum frame.
5. **For door,** from table (A-29), Ud = 3.6 $W/m^2.°K$, for wood door type.

2.4.4 Heating And Load Calculations:

heating load is the amount of heat energy supplied to a space to preserve a specific temperature range; the heating loads components are:

1) Heat loss through all exposed walls, ceiling, floor, windows, doors, and walls between a heated space and an unheated space (partition walls).
2) Heat load required to warm outside cold air infiltrated to heated space through cracks (clearances) of windows and doors, and outside cold air infiltrated due to opening and closing of doors.
3) domestic hot water load.
4) Miscellaneous loads such as emergency heating loads and safety factor heating load.
5) Occupancy.

Heat loss calculation:

The factors that cause heat loss in a space are the walls, floor, ceilings, doors, Windows, and the infiltration. To calculate each value, we use the following equations:

$$Q = A \times U \times \Delta T \qquad \text{(Eqn 2-2)}$$

Where:

Q: is the heat transfer rate [kW].

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

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

U: Is the overall heat transfer coefficient. [W/m^2. K].

3.4.5 Total Heat Load Calculation:

Total heat load calculations for the sample room which is located in the third floor south east of the building at the wall, windows, door … etc. Shown in figure 2-5.

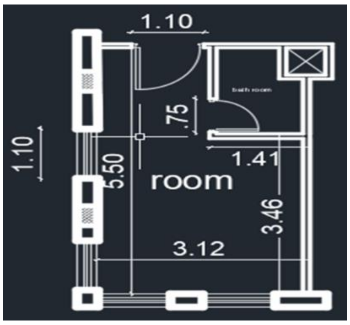


Figure 2-5: the sample of room.

Calculation the heat loss from the bedroom in the fourth floor as a sample:
The height of the room = 3m.
The height of the door = 2m.
The height of the window = 2m.

Heat loss through ceiling (Qc):

No heat loss through ceiling because

$$(Tin - Tout) = 0$$

Heat loss through floor (Qf):

No heat loss through floor because;

$$(Tin - Tout) = 0$$

Heat loss through walls (Qw):

Area for the Window

$$A = 1.10 * 2 = 2.2 \, m2$$

Area for the door

$$A = 2 \times 1.10 = 2.2\ m2$$

We have four windows in external wall

The external wall area ($A_{ex.\ wall}$) is

$A_{ex.\ wall}$ = ((5.50+3.12) *3-(4*2.2))
=17.06 m^2

The heat loss from external wall ($Q_{w.\ ex}$) is

$Q_{w.\ ex} = U_{w.} A_{w.\ ex} (T_{in} - T_{out})$ (Eqn 2-3)
=0.738 (17.06) (24-4.7)
= 0.2429 kW

The unconditioned temperature (T_{un}) is 20 C.
The heat loss from Internal wall is:

$A_{w\ un}$= (3*3 -2.2) =6.8 m^2

$Q_{w\ in} = U_{in} A_{w\ in} (T_{in} - T_{un})$ (Eqn 2-4)
=2.99 * 6.8*(24-20)
=0.081 kW.

Now, the total heat loss from walls ($Q_{w.\ tot}$) is:

$Q_{w.\ tot} = Q_{w.\ ex} + Q_{w.\ in}$ (Eqn 2-5)
=0.2429+0.081
=0.3239 kW

Heat loss through windows (Q_g):

$Q_g = U_g A_g (T_i - T_o)$ (Eqn 2-6)
=3.2 (2.2*4) 19.3
=0.594 kW

Heat loss through external door (Q_d):

$Q_d = U_d A_d (T_i - T_{un})$ (Eqn 2-7)
=3.6 *2.2 *4
=0.0316 kW

Heat loss through infiltration (Q_{inf}):

infiltration is the unwanted flow of air through cracks and gaps along the windows and doors, the volume of infiltration depends on the firmness of the windows and doors on velocity of the wind facing the outside area, or the pressure contrast between indoors and outdoors the total heat load due to infiltration (Q_{inf}) is given by the equation:

$$Q_{inf} = \frac{V_{f.}}{v_o} \times (h_{in} - h_{out})$$ (Eqn 2-8)

Where:

h_{in}: inside enthalpy temperature (kJ/kg).

h_{out}: outside enthalpy temperature (kJ/kg)

V_f: The volumetric flow rate of infiltrated air in (m^3/h)

v_o: specific volume out (m^3/kg)

$\dot{V}_f = K * L\ [0.613(S_1*S_2*V_0)^2]^{2/3}$ (Eqn 2-9)

Where:

K: the infiltration air coefficient.

L: the crack length in meter.

S_1: factor that depends on the topography of the location of the building

S_2: coefficient that depends on the height of the building.

V_0: measured wind speed (m/s).

- The value of K, S_1 and S_2:

K=0.43 from table (A-13)

S_1=0.9 from table (A-19)

S_2=0.75 from table (A-20)

V0=1.4 (m/s) from Palestinian code

And the window is sliding, then:

L = 4[(1.10+2) *2]

=24.8 m

$Vf = 0.43\times24.8\ [0.613(0.9\times0.75\times1.4)2]^{2/3}$

$=7.13\ m^3/h$

$=1.98\times10^{-3}\ m^3/s$

From the psychometric chart one can obtain the following moist air properties that correspond to the given inside and outside design condition:

v_o = 0.79 m^3/kg

h_i = 48 kJ/kg

h_o = 14 kJ/kg

$\rho_o = \frac{1}{V_o}$= 1.282 kg / m^3

The total heat loss due to infiltration is calculated by equation (2-8) as follows:

Through window

$Q_{inf,g}$=0.086 kW

Through door

L =2(1.10+2)

=6.2 m

$V_f = 0.43\times6.2\ [0.613(0.9\times0.75\times1.4)^2]^{2/3}$

$=1.78\ m^3/h$

$= 4.95\times10^{-4} m^3/s$

$Q_{inf,\ d}$=0.0216 kW

$Q_{inf} = Q_{inf,\ d} + Q_{inf,\ w}$

=0.0216+0.086

=0.1076 kW.

Heat gains due to ventilation:

ventilation main focus is to sustain a healthy indoor air, by bringing in fresh air from outdoors, the heat gain required is calculated by these equations:

$Q_{ventilation} = m_{ventilation} \times (h_{out} - h_{in})$ (Eqn 2-10)

$m_f = \frac{V_{f.}}{v_o}$

V_f = Room volume $\times$ No. of times the air changes in the hour (Eqn 2-11)

$m_f = \frac{V_{f.}}{v_o} = \frac{(5.5*3.12*3)m^3 *(2*2/3)}{0.79(3600)}$ =0.0364 kg /s

$Q_{ventilation} = 0.0244 \times 1000 \times (48 - 14)$

$Q_{ventilation} = 0.831\text{kW}$

The total heat loss from the bedroom is:

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

=0.081 +0.2429+0.594+0.0316+0.1076

=1.0571 kW.

Take a safety factor of 10 % for each space of the residence to cover the miscellaneous and emergency heating loads then:

Q_{tot} = 1057.1× 1.10= 1162.8 W.

= 1.1628 kW.

2.4.6 Total Heating Load For All Spaces:

The following table shows the heating load for each room**:**

Table 2-1: heating load for each room

[redacted]	Type of room	Area (m^2)	Q (W)
Ground floor	Office	17	598
	Reception	120	4745
Mezzanine floor	Kitchen	15	278
	Washroom	10	500
	Restaurant	28	246
	Meeting room	84	1594
1st floor	Bedroom 7	14	1069
	Bedroom 8	14	825
	Bedroom 9	21	1369
	Bedroom 10	14	1178
	Bedroom 11	14	735
	Bedroom 12	11	595
	Bedroom 13	11	533
	Bedroom 14	14	573

	Bedroom 15	14	1155
2nd floor	Bedroom 16	14	1369
	Bedroom 17	14	825
	Bedroom 18	21	1078
	Bedroom 19	14	1155
	Bedroom 20	14	628
	Bedroom 21	11	595
	Bedroom 22	11	533
	Bedroom 23	14	573
	Bedroom 24	14	1178
3rd floor	Bedroom 25	14	1048
	Bedroom 26	14	825
	Bedroom 27	21	1369
	Bedroom 28	14	1202
	Bedroom 29	14	737
	Bedroom 30	11	590
	Bedroom 31	11	533
	Bedroom 32	14	573
	Bedroom 33	14	1178
4th floor	Bedroom 34	14	1048
	Bedroom 35	14	825
	Bedroom 36	21	1369
	Bedroom 37	14	1155
	Bedroom 38	14	572
	Bedroom 39	11	534
	Bedroom 40	11	533
	Bedroom 41	14	579
	Bedroom 42	14	1178
Roof	Bedroom 43	14	948
	Bedroom 44	14	726
	Bedroom 45	21	1337

	Bedroom 46	13	1055
	Bedroom 47	14	1111

2.5 Cooling Load:

cooling load is the amount of heat energy depleted from a space to maintain an indoor specific temperature range, to accomplish the human comfort conditions a set of calculations is done in order to help selecting proper equipment's, the total cooling load of a structure involves:

1. Sensible heat gain through walls, floors and roof.
2. Sensible heat gain through windows.
3. Sensible heat and latent heat gain from ventilation.
4. Sensible and latent heat due occupancy.
5. Sensible heat gain from the equipment.
6. Direct solar ray.

3.5.1 Cooling Load Calculations:

Total cooling load calculations for the sample room which is located at the wall, Windows, door…etc.

solar radiation directed at the walls and roofs raise the surface temperature, the rate of absorbed radiation depends on the solar exposure throughout the day, building direction, walls material and shading element, the heat gained by walls and roofs is calculated by this equation:

$Q= UA\ (CLTD)_{corr.}$ (Eqn 2-12)

Where:

$(CLTD)_{corr.}$: corrected cooling load temperature difference, ˚C

$(CLTD)_{corr.} = (CLTD + LM)\ k + (25.5 - T_{in}) + (T_{hom} - 29.4)\ f$ (Eqn 2-13)

Where:

CLTD: cooling load temperature difference, ˚C, from Table (A-3) and from Table (A-2).

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

k: colour adjustment factor.

T_{in}: inside comfort design temperature, ˚C

f: attic or roof fan factor.

$T_{o,m}$: outdoor mean temperature, ˚C

$T_{o,\ m}$ = (T max + T min) /2 (Eqn 2-14)

Where:

T_{max}: maximum average daily temperature, ˚C

T_{min}: minimum average daily temperature, ˚C

T_{max} = 30 ˚C and T min = 18 ˚C are obtained from Palestinian code.

Applying these values in equation (2.18) to obtain the outdoor mean temperature

$T_{o,\ m}$ = 24 ˚C.

3.5.2 Sample Calculation:

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

Heat gain through sunlit roof (Q_{Roof}):

CLTD = 3˚C

LM = 5

k = 0.83 for permanently light colour roofs.

f = 1 there is no attic or roof fan.

$(CLTD)_{corr.}$ = (3+ 5) (0.83) + (25.5 - 24) + (24- 29.4) (1)

= 2.74˚C

$Q_{Roof} = (U_1 A_1 + U_2 A_2) (CLTD)_{corr.}$ (Eqn 2-15)

Q_{Roof} = (0.49 ×12.68 + 0.51 ×3.17) (2.74)

Heat gain through sunlit walls (Q_{wall}):

$Q^{\cdot}_{W}$ = zero

$Q^{\cdot}_{s}=UA(T_o-T_i)$

=0.738*4.9576(30-24)

$Q^{\cdot}_{s} = Q_{wall}$=21.476W.

= 21.454 W

Heat gain through unconditioned walls ($Q_{un.}$):

From the wall around bathroom:

$Q_{un} = U\ A\ \Delta T$

$\Delta T = 2/3(T_0 - T_{i)}$

$Q_{un =}$ 2.99×9.0792× 4

= 108.587W

From North wall

$Q_{un.,N.}$= U A ΔT

$\Delta T = 2/3(T_0 - T_i)$

$Q_{un., N.}$= 2.99 ×3.2832 × 4

= 39.27W

$Q_{wall\ un}$ = 108.587+ 39.27

= 147.857 W

Heat gains due to glass (Q_{Glass}):

The maximum cooling load due to the glass window Q_{Glass}, consists of transmitted ($Q_{tr.}$) And convicted ($Q_{conv.}$) cooling loads as follows:

$Q_{Glass} = Q_{tr.} + Q_{conv.}$ (Eqn 2-16)

Where:

$Q_{tr.}$: transmission heat gain, W

$Q_{conv.}$: convection heat gain, W

The transmitted cooling load is calculated as follows:

$Q_{tr.}$ = A (SHG) (SC) (CLF) (Eqn 2-17)

Where:

The transmitted cooling load is calculated as follows:

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

For wall in south direction:

A = 4.4 m^2

SHG = 227 W/m^2

SC = 0.57 (with interior shading)

CLF = 0.68 at 14:00 clock

$Q_{tr.\ s}$= 4.4× 227 × 0.57 × 0.68

= 387.135 W

For wall in west direction:

A = 4.4 m^2

SHG = 678 W/m^2

SC = 0.57 (with interior shading)

CLF = 0.53 at 14:00 clock …

$Q_{tr.\ w}$= 4.4× 678 × 0.57 × 0.53

= 901.224W.

Q conv. = UA (CLTD) corr.
(Eqn 2-16)

Where:

- ✓ U: Over all heat transfer coefficient of glass ($W/m^2.\ K$).
- ✓ A: Out windows Area of heat conduction. (m^2).
- ✓ $CLTD)_{corr.}$: Is calculated as the same of walls and roofs and the CLTD value for glass is obtained from Table (A-7)

CLTD = 7 ˚C at 14:00, clock

k = 1 for glass

f = 1 for glass

$(CLTD)_{corr.}$ = (7 + 5) 1 + (25.5 - 24) + (24 - 29.4) 1

= 8.1˚C

Q conv. = U× A×$(CLTD)_{corr.}$

= 3.2×8.8×8.1

=228.1 W

$Q_{tr.}$= $Q_{tr.s}$ + $Q_{tr.w}$ = 387.135 + 901.224 = 1288.36 W

Q_{Glass} = $Q_{tr.}$ + $Q_{conv.}$

=1288.36+228.1

=1516.46 W

Heat gains due to lights ($Q_{Lt.}$):

heat gained by lights, are sensible loads, calculated by this equation:

$Q^{\cdot}_{Lt.}$ = light intensity × A × $(CLF)_{Lt.}$
(eqn 2-17)

Where**:**

light intensity = 10-30 W/ m² for apartment, so we will take 25W/ m²

A: floor area = 15.85m²

$(CLF)_{Lt.}$: cooling load factor for lights.

$(CLF)_{Lt.}$ = 0.82 from Table (A-5)

$Q_{Lt.}$ = 25 × 15.85 × 0.82= 324.9W.

Heat gains due to infiltration (Q_f):

As the same way in heating load.

Where**:**

h_{in}: inside enthalpy temperature (kJ/kg).

h_{out}: outside enthalpy temperature (kJ/kg).

V_f: The volumetric flow rate of infiltrated air in (m^3 /h).

V_o: specific volume (m^3/kg).

v_o = 0.877 (outside the room)

h_{in} = 47.8 kJ/kg

h_{out} = 65 kJ/kg

V_o = 1.4 (m/s) from Palestinian code

V_f =2 [m^3/h/m]

L= (2W + 2H) (4) for window (double sliding window)

= (2*1.1+2*2) (4)

L_w = 24.8 m

Therefore;

$V_{inf, w}$ = 2(24.8)

= 0.014 m^3/s.

$Q_{Total, w}$= ($V_{inf, w}$/ v_o) (h_{out}- h_{in}) (Eqn 2-18)

= (0.014/0.877) (1000) (65-47.8)

=270.2W.

Q_{inf} =$Q_{inf,\ w}$ = 270.2W.

Heat gains due to occupants ($Q_{oc.}$):

sensible and latent heat gained by residents must be eliminated from conditioned space, the heat gain by occupancy is the following:

$Q_{oc.} = Q_{sensible} + Q_{latent}$
$Q_{sensible}$ = heat gain sensible × No. of people × $(CLF)_{oc.}$ (Eqn 2-19)

Where:

$(CLF)_{oc.}$: cooling load factor due to occupants.

heat gain sensible = 70W very light work from table(A-21)

No. of people = 2

$(CLF)_{oc.}$ = 0.84 at 8 hours after each entry into space is obtained from Table (A-6)

Q sensible = 70 × 2× 0.84

= 117.6 W.

Q latent = heat gain latent × No. of people
Heat gains latent = 44W… very light work from Table (A-21)

Q_{latent} = 44 × 2

= 88W.

Q oc. = 117.6 + 88

= 205.6 W.

Heat gains due to ventilation (Q_{vent}):

in places of pollution, mechanical ventilation is mandatory, especially in areas of working factories, restaurants, closed parking areas, the outdoor fresh air is recommended for mechanical ventilation, the sensible and total cooling loads to cool the air to indoors is given by this equation:

Ventilation air requirements for this room = 7.5 L/s/m^2 from table (A-26)

the rate of ventilation = (Ventilation air requirements) (area) (Eqn 2-22)

$= (0.0075)\ (15.85)$

$= 0.1188\ m^3/s$

Mass flow rate of ventilation air = $\frac{\text{rate of ventilation}}{v\ o}$ (Eqn 2-23)

$= \frac{0.1188}{0.877} = 0.1355 kg/s.$

$Q_{vent} = (m^0)\ (h_{out} - h_{in})$ (Eqn 2-24)

$= (0.1355)\ (1000)\ (65-47.8) = 2331.4 W.$

$Q_{Tot} = Q_{Roof} + Q_{wall\ un} + Q_{wall} + Q_{Glass} + Q_{Lt} + Q_{inf.} + Q_{oc.} + Q_{vent}$

$= 21.454 + 147.857 + 21.476 + 1516.46 + 324.9 + 270.2 + 205.6 + 2331.4$

$= 4840 W = 4.840\ KW.$

Take a safety factor of 10 % for each space of the residence to cover the miscellaneous and emergency cooling loads then:

$Q_{tot} = 4.840 KW \times 1.10$

$= 5.324 KW.$

2.5.3 total cooling load:

The following table 2-7 shows the total cooling load for all space by use rivet software:

Table 2-2: the total cooling load for each room (W)

	Type of room	Area (m^2)	Q (W)
Ground floor	Office	17	1303
	Reception	120	17244
Mezzanine floor	Kitchen	15	1141
	Washroom	10	1174
	Restaurant	28	4039
	Meeting room	84	10092
1st floor	Bedroom 7	14	3322
	Bedroom 8	14	848
	Bedroom 9	21	1439

	Bedroom 10	14	5368
	Bedroom 11	14	1561
	Bedroom 12	11	1634
	Bedroom 13	11	1523
	Bedroom 14	14	2841
	Bedroom 15	14	3413
2nd floor	Bedroom 16	14	3344
	Bedroom 17	14	848
	Bedroom 18	21	1439
	Bedroom 19	14	5368
	Bedroom 20	14	1565
	Bedroom 21	11	1607
	Bedroom 22	11	1527
	Bedroom 23	14	1667
	Bedroom 24	14	3413
3rd floor	Bedroom 25	14	3344
	Bedroom 26	14	848
	Bedroom 27	21	1439
	Bedroom 28	14	5321
	Bedroom 29	14	2757
	Bedroom 30	11	1603
	Bedroom 31	11	1527
	Bedroom 32	14	1667
	Bedroom 33	14	3413
4th floor	Bedroom 34	14	3344
	Bedroom 35	14	848
	Bedroom 36	21	1439
	Bedroom 37	14	5368
	Bedroom 38	14	1560

	Bedroom 39	11	1636
	Bedroom 40	11	1527
	Bedroom 41	14	1667
	Bedroom 42	14	3413
Roof	Bedroom 43	14	3225
	Bedroom 44	14	1730
	Bedroom 45	21	1470
	Bedroom 46	13	2932
	Bedroom 47	14	3269

Sample Room Using Revit:

table (2.8) shows the summary data for sample room:

Space Summary - 28 Room28

Back to summary of spaces

Inputs	
Area (m²)	14
Volume (m³)	42.30
Wall Area (m²)	44
Roof Area (m²)	16
Door Area (m²)	3
Partition Area (m²)	0
Window Area (m²)	10
Skylight Area (m²)	0
Lighting Load (W)	50
Power Load (W)	50
Number of People	2
Sensible Heat Gain / Person (W)	73
Latent Heat Gain / Person (W)	45
Infiltration Airflow (L/s)	4.2
Space Type	Dormitory Bedroom
Calculated Results	
Peak Cooling Load (W)	**5,321**
Peak Cooling Sensible Load (W)	5,406
Peak Cooling Latent Load (W)	-85
Peak Cooling Airflow (L/s)	323.7
Peak Heating Load (W)	**1,202**
Peak Heating Airflow (L/s)	92.6

2.6 Variable Refrigerant Flow System

2.6.1 Introduction

Variable refrigerant flow (VRF) systems vary the flow of refrigerant to indoor units based on demand. This ability to control the amount of refrigerant that is provided to fan coil units located throughout a building makes the VRF technology ideal for applications with varying loads or where zoning is required. VRF systems are available either as heat pump systems or as heat recovery systems for those applications where simultaneous heating and cooling is required.

In a VRF system, multiple indoor fan coil units may be connected to one outdoor unit. The outdoor unit
has one or more compressors that are inverter driven, so their speed can be varied by changing the frequency of the power supply to the compressor. As the compressor speed changes, so does the amount of refrigerant deliver by the compressor. Each indoor fan coil unit has its own metering device that is controlled by the indoor unit itself, or by the outdoor unit. As each indoor unit sends a demand to the outdoor unit, the outdoor unit delivers the amount of refrigerant needed to meet the individual requirements of each indoor unit. These features make the VRF system ideally suited for all applications that have part load requirements based on usage or building orientation, as well as applications that require zoning.

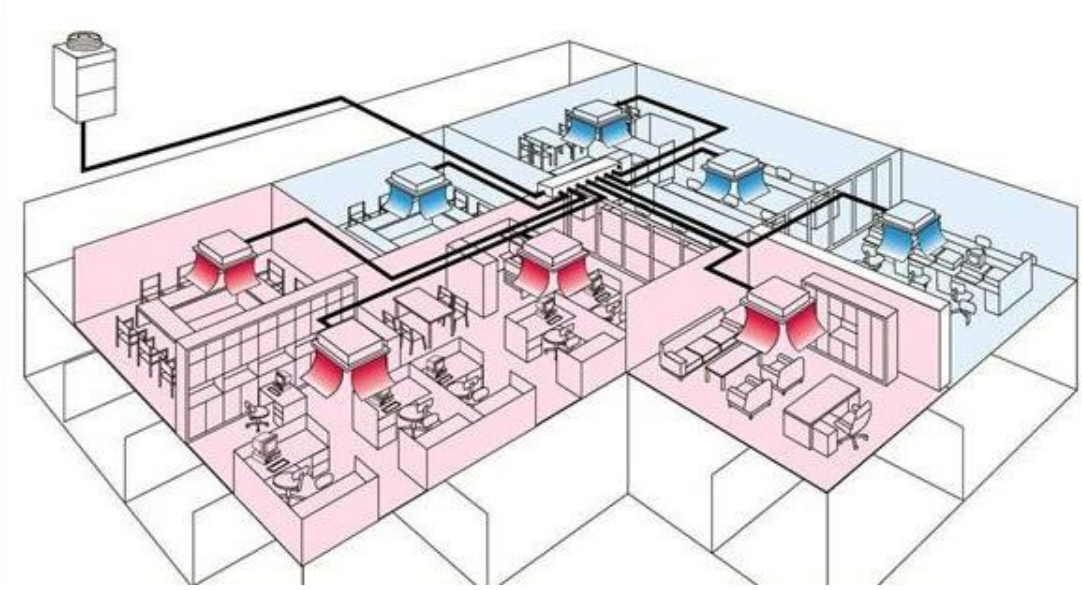


Figure 2-6: Variable refrigerant flow system

2.6.2 Advantages And Disadvantages Of A VRF System
2.6.2.1 Advantages Of A VRF System:

VRF systems use inverters, variable speed compressors, and these systems adjust the flow rate of refrigerants according to the need, because they are known for better energy consumption**,** Precise and quick room temperature control. Another advantage of VRF systems is individualized convenience. With controls on indoor units, occupants may change the temperature to their taste, which is why VRF in dormitories and hotels, for example, is such a common option, Adaptive design: VRF systems are lightweight in contrast to traditional HVAC systems. There is smaller refrigerant piping, for example, which fits better for buildings with tight requirements for space. Not to mention, because of the adaptive interface, VRF allows for simple installs and is also a good option for retrofits.

2.6.2.2 Advantages Of A VRF System:

A VRF device with a refrigerant leak is a major problem that can pose a threat to room occupants' health and safety**,** Notably, the high-volume design of VRF systems can pose a challenge to facility managers and maintenance person, A VRF system cost will definitely be higher than split ACs**.**

2.6.3 Unit Selection

Outdoor and indoor units are selected according to the thermal load of the building. depending on the “Samsung VRF catalogue”.

Indoor Unit:

In this project two types of indoor units were selected which is 4-way cassette s and Ceiling mounted.

- **Ceiling units model number** (AM056FNCDEH) will only be used for bedrooms.
- **4 Way Ceiling Cassette** model number (AM128FN4DEH) will be used for restaurants, reception hall, meeting room and the rest of the facilities that are characterized by large areas.

Outdoor unit

selected of outdoor unit depends on:

- The total actual cooling load and the capacity ratio**.** The capacity ratio is a ratio between the total capacity of the indoor and outdoor capacity and its ranged between (70% – 130 %)**.**

The outdoor unit model:

- (AM120FXVA) 12 horsepower.
- (AM140FXVA) 14 horsepower.
- (AM220FXVA) 22 horsepower.

2.6.4 Selecting Refrigerant Piping

Choose a copper pipe to connect the outdoor unit and the indoor unit. Copper pipes can better resist oxidation and corrosion, thereby extending the service life of the air conditioner. Due to the lower specific heat mass of the copper tube, the cooling rate is much faster.

The following table 2-9 shows the required load for each outdoor unit and shows the required pipe diameters:

Table 2-9: Outdoor unit and pipe size

Outdoor unit	Pipe size	
HP	Liquid(mm)	Gas(mm)
12	12.7	28.58

14	12.7	28.58
22	15.88	28.58

The following table 2-10 shows the required load for each indoor unit and shows the required pipe diameters:

Table 2-10: Size of pipe between the branch joint and indoor unit

Indoor unit type	Indoor unit model	Pipe size(mm)	
		liquid	gas
4-way cassette	AM128FN4DEH	6.35	12.70
Ceiling	AM056FNCDEH	9.52	15.88

2.7 Ventilation

Ventilation moves outdoor air into a building or a room and distributes the air in the building or room. The general purpose of ventilation in buildings is to provide healthy air for breathing by both diluting the pollutants originating in the building and removing the pollutants from it Air infiltration and exfiltration: In addition to intentional ventilation, air inevitably enters a building by the process of 'air infiltration'. This incident was caused by accidental or accidental gaps and cracks in the building envelope, which caused uncontrolled airflow into space. The corresponding loss of air from an enclosed space 'exfiltration'.

Designing of mechanical ventilation

✓ Using Air changes per hour

The required CFM is given as:

$$CFM= \frac{\text{Volume of the room} \times \text{Air Changes per Hour}}{60\ minutes} \qquad \text{(Eqn 2-25)}$$

✓ Sample calculation

$$\text{Volume} = \text{length} \times \text{width} \times \text{height} \qquad \text{(Eqn 2-26)}$$

$$= 2.2 \times 1.82 \times 3 = 12\ m^3$$

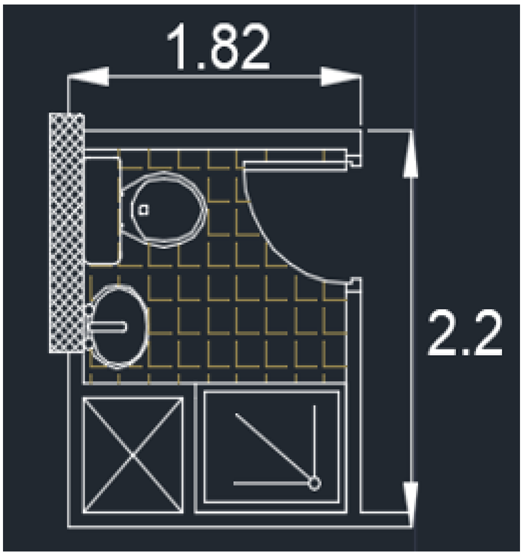


Figure 2-7:sample calculation for bathroom

Number Air Changes per Hour = 3

Required CFM=12*3*35.3147/60

Required ventilation rate = 21.21 CFM.

Required ventilation rate in =10 liters/sec.

For kitchen

Volume = Length* Width * Height

Volume=4.6*3.7*3

Volume=51.06 m^3

Number Air Changes per Hour=2

Required ventilation rate CFM =51.06*2*35.3147/60

Required ventilation rate = 60.1 CFM.

Required ventilation rate =28.34 liters/sec.

For restaurant

Ventilation air requirements for dining and cafeteria 10 L/s/Person.

Ventilation rate=10*58

Required ventilation rate 580liters/sec.

Required ventilation rate =1231 CFM

Garage for car parking

Ventilation air requirements for Garage floors 7.5 L/s/m2.

Ventilation rate=297*7.5

Required ventilation rate 2227.5 liters/sec.

Required ventilation rate =4719 CFM.

2.8 Conclusion Of The Chapter:

The VRF HVAC system is designed to provide both cooling and heating to different areas in a home. The system is so efficient that it reuses the heat generated from the cooling process to warm up a part of the home, it also allows simultaneous heating and cooling on a single system.

Chapter 3

3 Firefighting System

3.1 Introduction

Control of smoking materials and open blazes. Store combustible and ignitable fluids securely. Utilize electrical hardware effectively. Perform general housekeeping errands consistently. Purchase fire-safe furnishings, embellishments, and inside completions. Keep up business kitchen exhaust frameworks.

The flaring phase of fire will begin with a fast ascent in warmth levels, at first along the room's roof, and afterward all through the whole space. During the initial few minutes, roof temperatures can arrive at 1,000°C (1,800°F). Throughout the following couple of moments, these temperatures will spread all through the room as the roof's layer of hot gases moves. At last, this gas layer acts like a stove's oven, superheating and touching off all combustibles in the room. By then, the room and all inside it are crushed.

The fire would then be able to spread through open entryways and divider infiltrations, or through the disguised divider and roof holes to different spaces in the structure. At last, if not smothered, the fire can prompt a complete loss of the structure and its substance, also the deficiency of lives.

3.2 Fire Safety In Building

fire safety Building is divided into two parts:

1. Passive fire protection.
2. Active fire protection

Passive fire protection

Many construction materials have some natural resistance to fire and as such already have built-in fire protection. An example of such a material would be clay bricks, which, when constructed to form a wall is fire-resisting in its own right. Other materials e.g., the timber used in the construction of a timber floor may have little such built-in fire protection and may need additional protection e.g., in the form of fire-resisting boards fixed to the underside of the ceiling below.

The nature of fire insurance also varies from region to region. In some areas, construction and fire departments keep their safety regulations up-to-date and stick to them and tirelessly. Yet, code progression and implementation are not uniform around the U. S. if these codes are not kept up to date with the latest regulations and are maintained by well-equipped faculty, the nature of fire safety can tolerate extraordinary arrangement.

The new hotel will have what we believe is first-class fire protection, that is, the fire sprinklers in each visitor's room, as framework recognition and caution. More seasoned inns may only have smoke cautions in visitor rooms, in case they have that.

- **Fire sprinklers**

Fire sprinklers are central to inn fire safety. For your health, should stay in a small hotel that is completely sprinkled. inn for your wellbeing. We have an important measure to maintain the fire situation-a sprinkler frame with sprinklers in each room, which follows the generally accepted specifications and is subsequently maintained by qualified professionals. Sprinklers are intended to stop a fire when it is little, and they have an unrivaled history in saving lives and property. Yet, although it is a low-likelihood occasion, it is a high-outcome occasion. The flames in the private environment will develop at an alarming rate. Truth be told, a great many people belittle how rapidly they can turn out to be dangerous.

- **Smoke recognition and cautions.**

An arrangement of interconnected smoke alarms ought to be introduced, with units in each room including basic zones and all non-visitor rooms. In the event that they are introduced in consistence with broadly perceived principles, the caution framework will alarm visitors who are in danger. Some caution frameworks are associated straightforwardly to the local group of fire-fighters, which is better.

Active fire protection

There is a danger of fire everywhere in cafes and hotels. From huge parking lots to open flames in similar areas, cooking oil, electrical associations and paper products, a small spark can drive people crazy and guarantee lives like rebounds.
Fires in restaurants actually represent a normal loss of 246 million US dollars. In harms. More than that, 57% of flames that in eatery kitchens are followed back to electric breakdowns in cooking gear, so the human mistake isn't the solitary motivation of flames which is the frightening part. Regardless of whether the staff of the foundation has an ideal history, there is still the possibility of fire caused by equipment errors.

- **Gas identifiers**

For restaurants and hotel kitchens, there must be a gas leak detector to distinguish LPG, PNG and CNG leaks in the company foundation. This is the most widely known fire in large kitchens and can cause great harm. However, distinguishing gas in time can save a lot of difficulty. For the chilly stockpiling, you need a refrigerant gas spill indicator that will sound of caution in case of a gas spill. For inns and bigger eateries, the parking garages consistently have higher carbon monoxide levels as a matter of course, being a shut space with various vehicles that give out discharges. The carbon monoxide gas leak identifier is absolutely necessary for parking areas.

- **Smoke/Fire Alarm Systems**

The smoke/fire alarm system should be placed in every room of the accommodation or restaurant if a fire is detected. No one can tell what can cause a fire, from cigarettes to electronic malfunctions and accidental flames. The smoke identification framework will help the Foundation stop the problem from developing.

3.3 Alarm System In Firefighting

3.3.1 Introduction

Buildings must have a specific fireside safety and to insure not being risked by heat or smoke, the objective is to reduce any deaths or injury incidents in the building and provide a secure system for the fire and rescue services, also to protect as many possible parts of the building to make sure it's not out of service while dealing with any potential fires, making sure any damaged part gets repaired easily and considering environmental pollutions. The main concern is the construction fabric and its content. The materials must be combustible or combustible, and the construction also contains fiery materials such as textiles, furniture and plastics.

3.3.2 Input Device

detectors and manual call points
Detectors can be classified based on resettable capability

1. resettable: It is a device that does not damage the sensing element during operation; the recovery can be manual or automatic.
2. Non-resettable: A device in which the sensing element is designed to be destroyed in the process of operation, the sprinkler head is a good example.

3.3.2.1 Types Of Detectors

1. Smoke detectors
   devices that can detect fire or smoke and alarm residents of a building to evacuate its surroundings. The smoke alarm detected the fire from the beginning. This issue gives everybody a large period to leave the building. Installing smoke alarms can help reduce injuries and ensure safety to a large extent. All smoke detectors consist of two parts: a sensor to sense the smoke, and an electronic horn to alarm people. Smoke detectors can run on a 9-volt battery or 120-volt house
2. Heat detectors
   They detect an abnormal temperature rise or rate of temperature rise.

3.3.2.2 Type Of Alarm System

1. Electric current alarm system: is the elementary monitoring tool, monitoring entry points in houses like doors and windows, easy to operate.
2. Wired alarm system: it relies on landline phone connection to transmit data to monitoring center, this system is ineffective because of physical threats like wires being cut.
3. Wireless home alarm system: system: security system without wires is installed to transmit data by using multiple sensors connected to a frequency transmitter. When triggered, a sign will be displayed on the panel to activate an alarm. Remote management via mobile phone.
4. Unmonitored alarm system:” local” alarm meaning that anybody near affected area contacting the authority, this system isn’t costly compared to other options, but not as protecting as others.
5. Monitored home alarm system: This system is highly trusted by professionals and is always in a monitoring state, which can be protected throughout the year.

3.4 Firefighting System

Fire professionals, consultants and contractors mainly adopt NFPA (National Fire Protection Association) standards in life safety design, building structure, fire protection, fire protection, fire alarm and smoke ventilation systems. This article will analyze two different fire extinguishing systems depending on the medium used to extinguish the fire. Wet sprinkler system.
classification of firefighting in hotel Ordinary 1, Ordinary Hazard,

3.4.1 Fire Extinguishers

A fire extinguisher is a storage container used to store fire extinguishing agents such as water or chemicals. It is used to extinguish small fires. Fire extinguishers are classified according to the fire material, whether it is fired from wood or cloth, flammable liquid, electricity or metal sources. Using the wrong type of fire extinguisher may cause more serious complications.

- **Type of fire extinguishers**
  1. Water extinguishers.
  2. Foam extinguishers.
  3. Dry powder extinguishers.
  4. Carbon dioxide extinguishers.
  5. Halon extinguishers.

3.4.1 Ordinary Hazard Occupancies

Ordinary hazards are divided into two groups: Group one: occupancies with combustibility are low and moderate quantity its stockpile doesn't exceed (2.4 m), moderate fires with heat release are expected. Group 2: Moderate to high flammability and quantity, stockpiles, the most stock (3.7 m), is expected to catch fire and release heat.

3.4.2 Fire Hose Cabinet Classes

Class 2 has been selected for the project Class 2:2:
standpipe the standpipe system supplies water to the 38 mm hose station, which is mainly supplied by the building owner or the fire department. System restrictions are the pressure reaches 4.5 bar, the flow is 100 gpm, the travel distance is 30m, and it is located near the corridor and elevator. The following specifications are installed according to code NFPA 14 for class 2 F.H. C:

- The maximum pressure at any point in the system at any time mustn't exceed 24.1 bar (350 psi).
- Maximum Residual Pressure for (1½-in.) , F.H.C=6.9 Bar.
- Hydraulically designed standpipe systems shall be designed to provide the water flow rate required at a minimum residual pressure of 4.5 bar (65 psi) at the outlet of the hydraulically most remote 38-mm (1½-in.) hose station.
- Standpipe's size must be at least 100 mm (4 in.) (Main riser).

3.5 Automatic Systems

3.5.1 Fire Sprinkler System:

A fire sprinkler system is a fire safety measure, consisting of a water supply system, providing due pressure and flow rate of a water piping system, connected to fire sprinklers. For most fires, water is the ideal choice for putting out fires. Fire sprinklers use water by directly spraying the flames. This issue stops the flames from spreading. The components in the system are sprinklers, piping, and a water source. Also Alarms and system control valves may also be required to further reduce efficiency. The sprinkler is a spray nozzle, which that dispenses water onto a fire-effected area. A typical sprinkler head consists of a frame, a thermal control link, a cover, an orifice, and a deflector.

3.5.2 Types Of An Automatic Fire Sprinkler System

a. <u>Wet sprinkler systems:</u>

The sprinkler system uses an automatic sprinkler, which is connected to a pipe system filled with water and connected to the water supply system, so the water is immediately drained from the sprinkler that is opened due to heating, Wet-pipe systems as shown in figure (3-1)

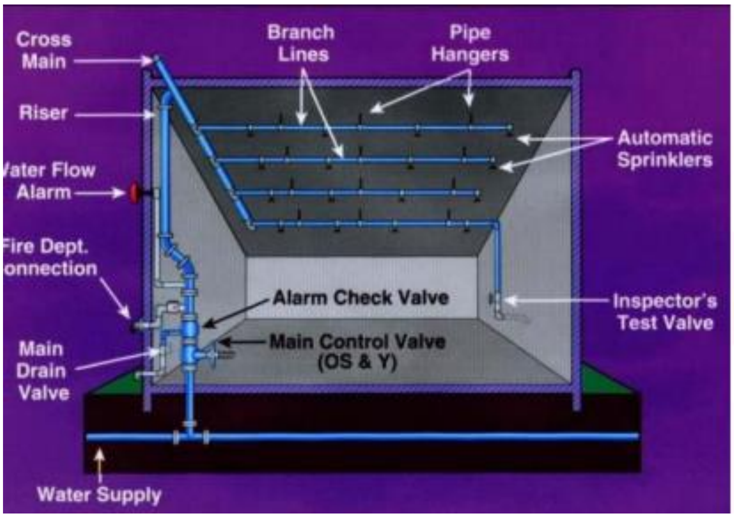


Figure3-1: Wet-pipe systems

b. <u>Dry sprinkler systems:</u>

The dry pipe system (below 40 F degrees) is usually used when there is freezing. Because the dry system responds slowly, it is converted to a wet tube system when there is enough heat. If the parts do not have heat, it is recommended to combine the two piping systems. Dry-pipe system shown in figure (3-2)

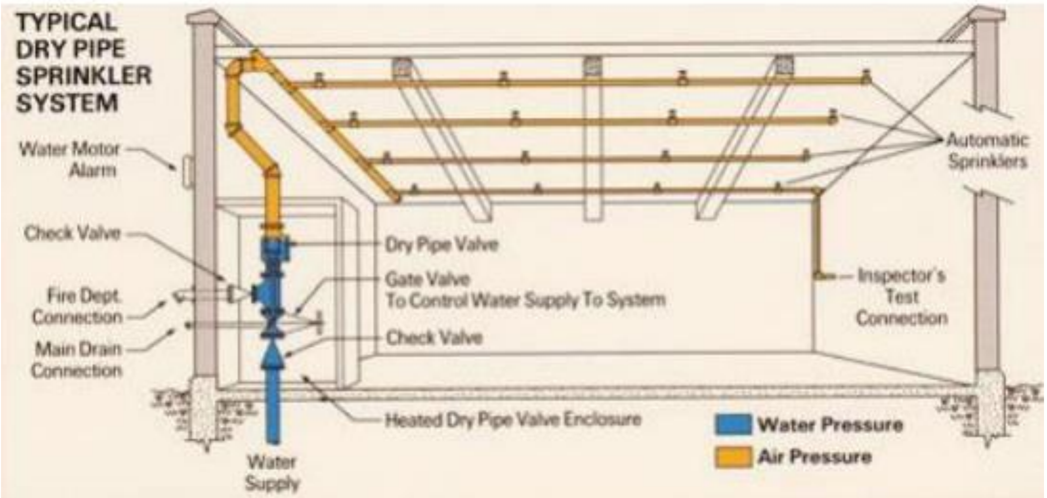


Figure 1: dry-pipe system

c. <u>Deluge sprinkler systems:</u>

The purpose of the deluge system is to wet the entire affected area to prevent the fire from spreading. They are commonly used in facilities that contain flammable materials such as flammable liquids, chemicals, and explosives. Other risks will include conditions, flammable gas tanks, oil storage tanks, oil pipelines, power plants, and sometimes rain shower systems in high-ceiling rooms because it is difficult to draw water from such a distance.

d. <u>Pre-action Sprinkler Systems:</u>

The fire sprinkler system before the operation is a dry sprinkler system. There is no water in the pipeline, but the pre-action valve prevents water from entering. A fire is detected and the pre-action valve is opened to allow water to flow into the spray pipe. At this point, the sprinkler system is now a wet pipe sprinkler system.

3.5.3 Fire Hydrant System

A fire hydrant system was installed in the building to help firefighters quickly put out the fire. Essentially, a fire hydrant system is a water network system used to transport water to limit the number of hoses that firefighters must lay. Thereby speeding up the fire extinguishing process. Fire hydrant as shown in figure (3-3)

Figure 3-3: fire hydrant

3.5 Firefighting Pump

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

1. Electrical firefighting pump.
2. Spare diesel fire pump. (No need if an extra electric pump is connected to an electric generator). Diesel pump works if:
   - The electric pump is out of service, or if there is a lack of electricity.
   - The electric pump is working but can't satisfy system water requirements.

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

Select the pump to meet the system requirements according to the following three key points Its rated flow and rated pressure; The size of most fire pumps exceeds their operating point requirements.

3.6 Flow Rate Calculations

The flow rate was calculated using Jordanian code and (Elite Fire Fighting) program software, 8 gpm from cabinet and 250 gpm for fire hydrant and 22.6 gpm for sprinkler, and the total flow rate for the system (for sprinklers) is 157 gpm.

3.6.1 Head Estimation

H pump = $H_R + H_S + H_F$ (Eqn 3-1)

H_{PUMP}: is the head of pump.
H_R : is the residual pressure.
H s: is the static pressure.
H: is the friction pressure.

- Static pressure **H_s**:

for 10.3 m ⟶ 1 bar
32.2m ⟶ X

The Static pressure **H_s** =3.12 bar for the total height.

✓ by Elite Fire Fighting program for the calculation of the head and flow rate for the pumps. Through this program, we input the input (the length and diameter of the pipeline, the number of tees and other accessories in each pipeline, and the hazard description), and the output is the required lift and flow rate of the pump.

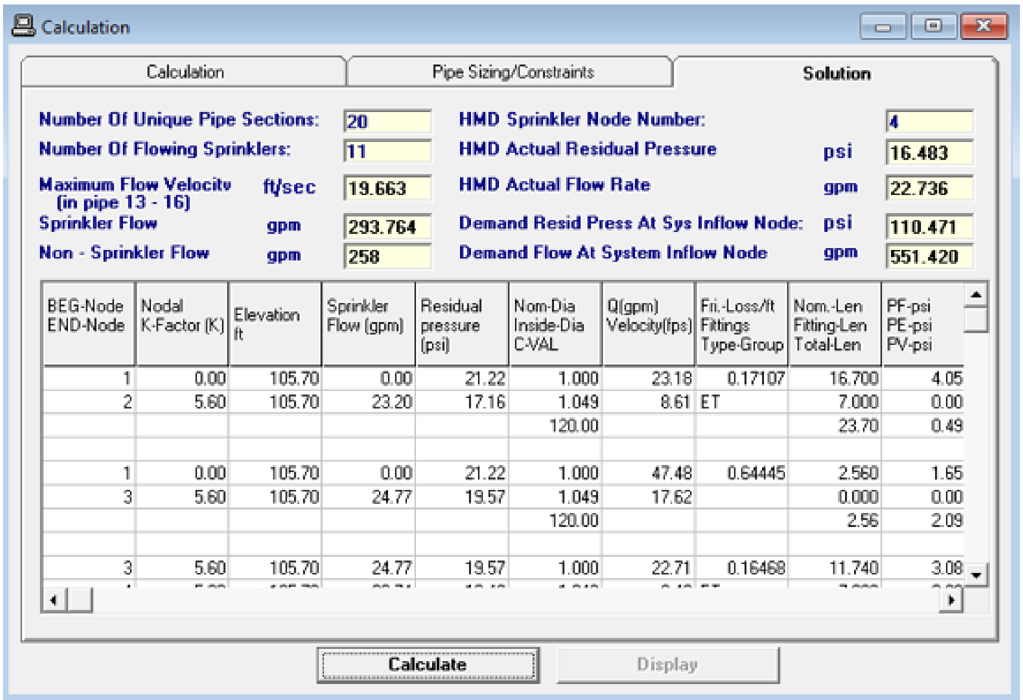


Figure**3-4**: Elite Fire Fighting program calculations

$$\mathbf{H_{pump} = H_R + H_s + H_f} = 110.471 \text{ psi}$$

3.6.2 Water tank sizing

Water tank is the main source of water that provides the firefighting network and other systems in the project, size of water tank can be calculated with referring to the NFPA 13 code, which mainly depends on the hazard classification and the expectation duration work for the system.

To calculate the size of the tank, the size should be based on the degree of risk of the type of threat we have:

Volume = Total flow rate x Duration x (3.786/1000) (Eqn 3-2)

= 551.42 (gal./min.) x 30min x [3.786 (lt/gal) x 1/1000 (m^3/lt)] = 62.63 m^3

= 63 m^3 is added to the water well.

Chapter 4

Plumbing System

4.1 Introduction

infrastructure, like plumbing and sanitary system is the essential to every building, plumbing design is critical due to its importance to take care of hygiene, pipes are installed in buildings to properly distribute drinkable water and discharge wastes, like sewage systems in a group of buildings or a city**.**

4.2 Water Supply System:

4.2.1 Introduction

The system that will be used in the hotel is up fed system and the method that used for up feed distribution system: private water supply enters into a pneumatic tank pressurized, and the main pressure that provides in this building is pump pressure.

4.2.2 Calculation Of Cold And Hot Water Supply System

The total amount of water required for the building is calculated by using the water supply fixture unit technique (WSFU). The following table 4-1 shows the total number of fixture units:

Table 4-1: Number of fixture units for first riser

Floor/fixture type	Water Closet general	Water closets private	Lavatory general	Lavatory private	Shower head	Clothes washer	Kitchen Sink
Ground floor	0	0	0	0	0	0	0
Basement floor	0	2	4	3	0	4	0
First floor	0	5	0	5	5	0	0
Second floor	0	5	0	5	5	0	0
Third floor	0	5	0	5	5	0	0
Fourth floor	0	5	0	5	5	0	0
Roof	0	3	0	3	3	0	1
Total	0	23	4	26	23	4	1

Table 4-2: Fixture units load for first riser

Floor/fixture type	NO. FU	WSFU	Total WSFU	Cold WSFU	Hot WSFU	Total Cold	Total Hot
Water closets general	0	5	0	-	-	0	0
Water closets private	23	3	69	-	-	69	0
Lavatory general	4	2	8	2*3/4	2*3/4	6	6
Lavatory private	26	1	26	1*3/4	1*3/4	19.5	19.5
Shower head	23	2	46	2*3/4	2*3/4	34.5	34.5
Clothes washer	4	4	16	4*3/4	4*3/4	12	12
Kitchen sink	1	4	4	4*3/4	4*3/4	3	3
Total	81	-	169	-	-	144	75

For estimating demand to calculate the required amount of water table(B-1):

140 WSFU = 53gpm (from table (B-5)

144 WSFU = X gpm

160 WSFU = 57 gpm

∴ X=37.5 gpm, for hot water first riser.

The following table shows the total number of fixture units and the total water supply fixture unit (WSFU) for the second riser:

Table 4-3: number of fixture units for second riser

Floor/fixture type	Water Closet general	Water closets private	Lavatory general	Lavatory private	Shower head	Clothes washer	Kitchen Sink
Ground floor	2	1	2	1	0	0	0
Basement floor	0	0	0	0	0	0	2
First floor	0	4	0	4	4	0	0
Second floor	0	4	0	4	4	0	0
Third floor	0	4	0	4	4	0	0
Fourth floor	0	4	0	4	4	0	0
Roof	0	2	0	2	2	0	1
Total	2	19	2	19	18	0	3

Table 4-5: Fixture units load for second riser.

Floor/fixture type	NO. FU	WSFU	Total WSFU	Cold WSFU	Hot WSFU	Total Cold	Total Hot
Water closets general	2	5	10	-	-	10	0
Water closets private	19	3	57	-	-	57	0
Lavatory general	2	2	4	2*3/4	2*3/4	3	3
Lavatory private	19	1	19	1*3/4	1*3/4	14.25	14.25
Shower head	18	2	36	2*3/4	2*3/4	27	27
Kitchen sink	3	4	12	4*3/4	4*3/4	9	9
Total	63	-	138	-	-	120.25	53.5

for estimating demand to calculate the required amount of water: table(B-1)

120 WSFU = 49 gpm (from table (B-5)

120.25 WSFU = X gpm

140 WSFU = 53 gpm

X= 49.05 gpm, For Cold water second riser

50 WSFU =29 gpm (from table (B-5)

53.25 WSFU = X gpm

60 WSFU = 33 gpm

X= 30.3 gpm, For Hot water second riser.

Table 4-6: Total WSFU and gpm for risers

Riser	Total WSFU CW	Total gpm CW	Total WSFU HW	Total gpm HW
First riser	144	53.8	75	37.5
Second riser	120.25	49.05	53.25	30.3
Total	264.25	77.85	128.25	50.65

4.2.2 Pipe Sizing Calculation:

Using up feed distribution system where the water serves the building by the pump, in this system the pump pressure will be the main pressure and the equation of the flow will be as following:

Pump pressure = Static head + Friction head (loss) + Flow pressure (Eqn 4-1)

- Static pressure:

the building consists of nine floors, floor to floor height is 3.84 meters, and the total vertical length from the pump source to the critical fixture is 30.4 m.

$$\text{Static pressure} = 30.4 \times \frac{0.433}{0.3048} = 43.19\text{psi} \quad \text{(Eqn 4-2)}$$

- Friction head:

pipe friction = Main pressure (pump pressure) – Static head – Flow pressure (Eqn 4-3)

=60-43.19-8 = 10.52 psi

Available friction head= 8.81 psi

Available friction head= 8.81 psi

- Total equivalent length:

We will calculate the equivalent length from the well to the farthest outlet (water closet) at the roof floor at farthest collector.

Since water pipes are using up feed system, we will need the following equation:
Pump head pressure =Friction head + static pressure + minimum flow pressure

- For cold water system:

  Total length = 69.9 m.

  Total equivalent length=69.9×1.5×3.28= 344 ft

- For hot water system:

Total length =69.9 m

Total equivalent length= 69.9×1.5×3.28 = 344 ft.

Uniform friction loss for cold= friction/100ft = available friction head/ total equivalent length.

Friction/100ft =8.81 psi/ (344/100 ft.) = 2.6 (psi/100ft).

Uniform friction loss for hot = friction/100ft =available friction head/ total equivalent length.

The following table shows the pipe sizing for cold water riser:

Table 4-7: pipe sizing for cold water riser.

Section number	Flow (gpm)	Equivalent length(ft)	Pipe sizing(in)	Velocity (fps)
1st riser part #1 (From tap off to ground floor)	5.5	2"	60.73	53.8
1st riser part #2 (first floor)	5	2"	18.9	48.4
1st riser part #3(second floor)	6.5	1.5"	18.9	41.9
1st riser part #4 (third floor)	5.5	1.5"	18.9	34.6
1st riser part #5 (fourth floor)	5.5	1.25"	18.9	24.5
1st riser part #6 (fifth floor)	4.1	1"	22.13	13.3
2st riser part #1 (from tap off to car parking)	5	2"	44.7	49
2st riser part #2(ground floor)	6.6	1.5"	18.9	44.9
2st riser part #3 (first floor)	6.3	1.5"	18.9	43.4
2st riser part #4 (second floor)	6	1.5"	18.9	38
2st riser part #5 (third floor)	5.2	1.5"	18.9	31.2
2st riser part #6(fourth floor)	5	1.25"	18.9	22.3
2st riser part #7(fifth floor)	4	1"	58.7	10.1
Main	5.5	2.5"	78.6	77.9

The following table shows pipe sizing for hot water riser:

Table 4-8: pipe sizing for hot water riser.

Section number	Flow (gpm)	Equivalent length(ft)	Pipe sizing(in)	Velocity (fps)
1st riser part #1 (From tap off to ground floor)	5.8	1.5"	61.1	37.5
1st riser part #2 (first floor)	5.2	1.5"	18.9	31
1st riser part #3(second floor)	5.5	1.25"	18.9	26.5
1st riser part #4 (third floor)	5	1.25"	18.9	21.1
1st riser part #5 (fourth floor)	5	1"	18.9	14.6
1st riser part #6 (fifth floor)	4.2	0.75"	22.1	7.8
2st riser part #1 (from tap off to car parking)	5.2	1.5"	36.3	30.3
2st riser part #2(ground floor)	5	1.5"	18.9	28.8
2st riser part #3 (first floor)	4.8	1.5"	18.9	26.4
2st riser part #4 (second floor)	5.2	1.25"	18.9	22.3
2st riser part #5 (third floor)	4.2	1.25"	18.9	17.3
2st riser part #6(fourth floor)	4.7	1"	18.9	11.9
2st riser part #7(fifth floor)	4	0.75"	60	6.1
Main	5.2	2"	86.8	50.7

4.3 Water Tank Volume

Calculation for the water well volume needed for the hotel:

The amount of water needed = 60gpm taken from American society for plumbing engineers code (ASPE).

The hotel contains 46 rooms, So:

60gpm = 272.76 L/min

(272.76l/1000) $m^3 \times 46 = 10.44\ m^3$ per day

For 7 days:

∴ $7 \times 10.44 = 73.1 m^3$

Add 63 m^3 for firefighting.

- The pump selected with main pressure provides 60 psi and that already choses in residential building that mean 4.2 bar.

4.5 Pump Selection

4.5.1 Introduction

Before you can select a pump that will fit your needs in the building, have to know the total head or pressure against which it must operate, the desired flow rate, the suction lift, and the characteristics of the fluid.in this project for pump selected was used up pumps software and filling required data.

Pump selection by software:

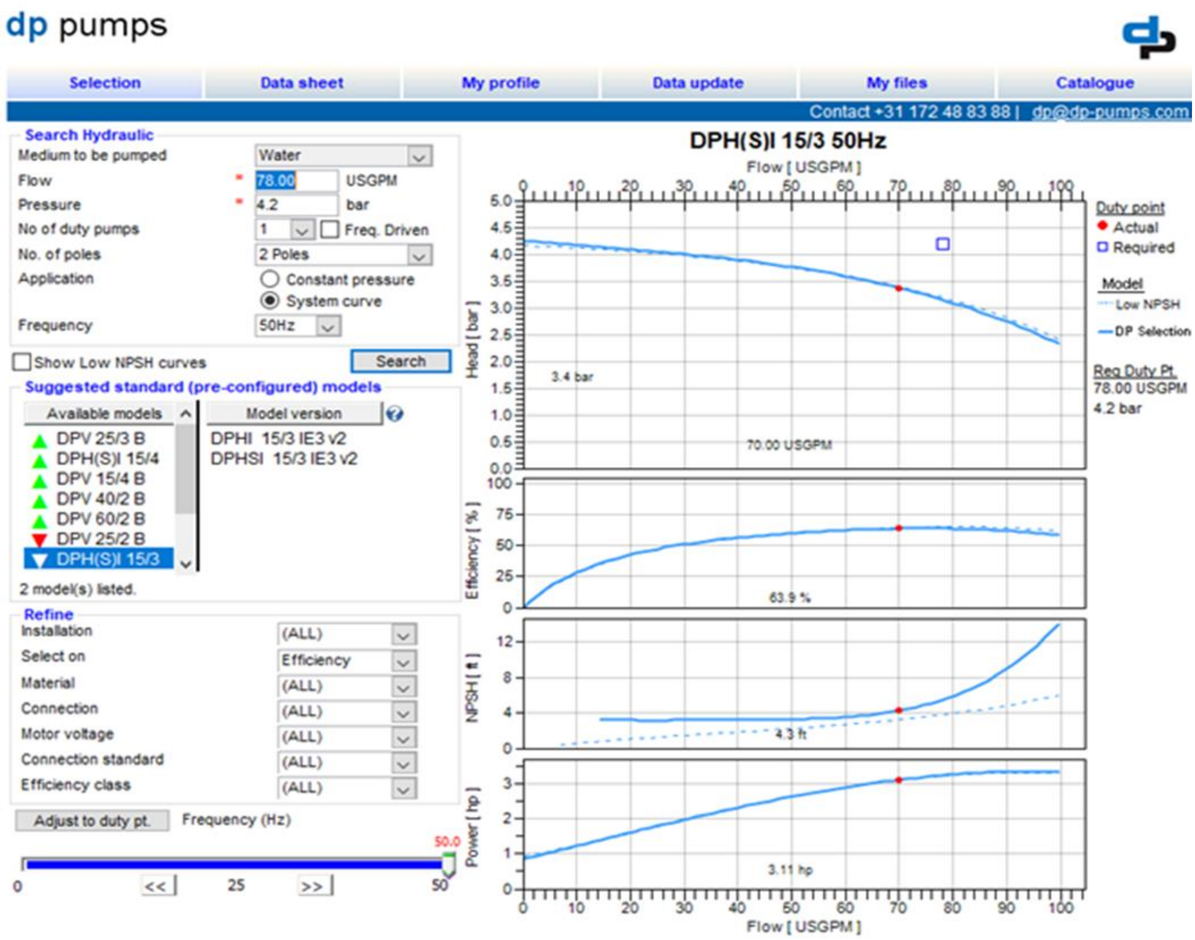


Figure 4-1: Pump data for cold water first and second riser

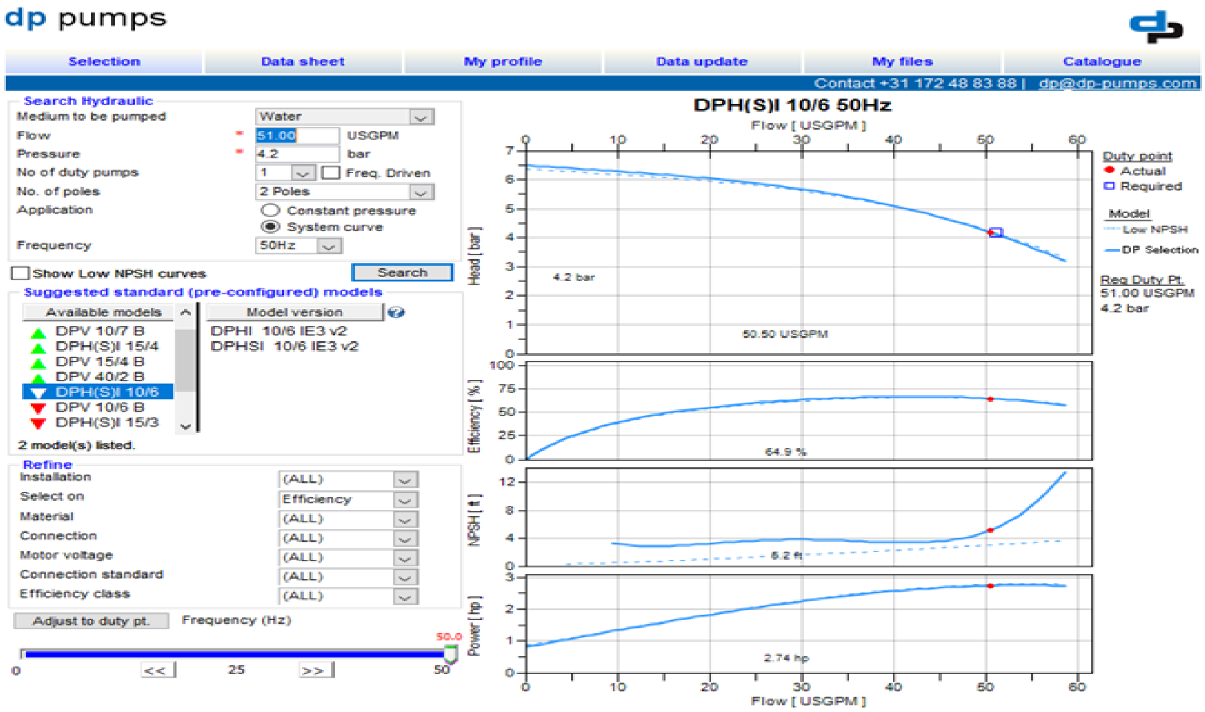


Figure 4-2: Pump data for hot water first and second riser.

4.5.2 Pneumatic Tanks

Pneumatic tanks provide pressurized water when needed, so pumps are not so important in use. In deep water well applications, water is pumped when a certain pressure point is reached, which allows the pump to work when it is ready. When a small amount of water is needed, water can be supplied to the pneumatic tank without starting the pump, so that the system is more efficient and sufficient. In addition, these tanks can also be used with booster pumps to carry water when the system is shut down. Shutdown. Pneumatic The air tank is supported by a cushion to prevent the jockey pump from circulating for a short time.

Figure 4-3: pneumatic tanks

- Selection for main pneumatic water tank

The total needed for water become pneumatic is 25% of total demand for every mechanical room and the volume of the tank be calculated from Wessel Company

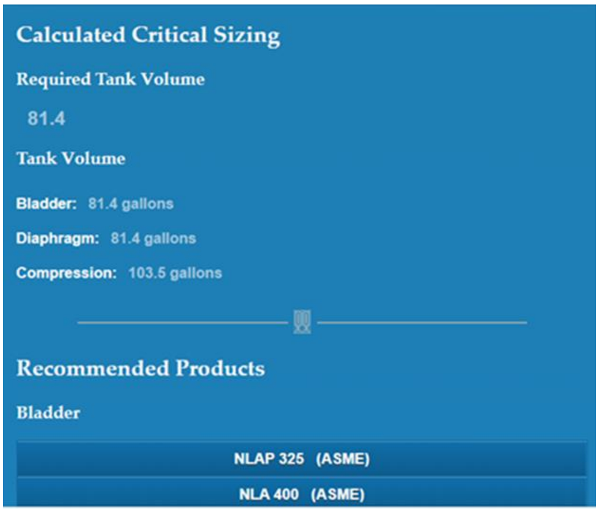


Figure 4-4: Selection for main pneumatic water tank.

4.6 Drainage System

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

Component of drainage system:

- Fixture units
- Trap
- Clean out
- Drainage pipe
- Stack and vent pipes
- Manholes
- Septic tank or municipal sewage system
- Accessories

The following figure 4-4 shows drainage system components:

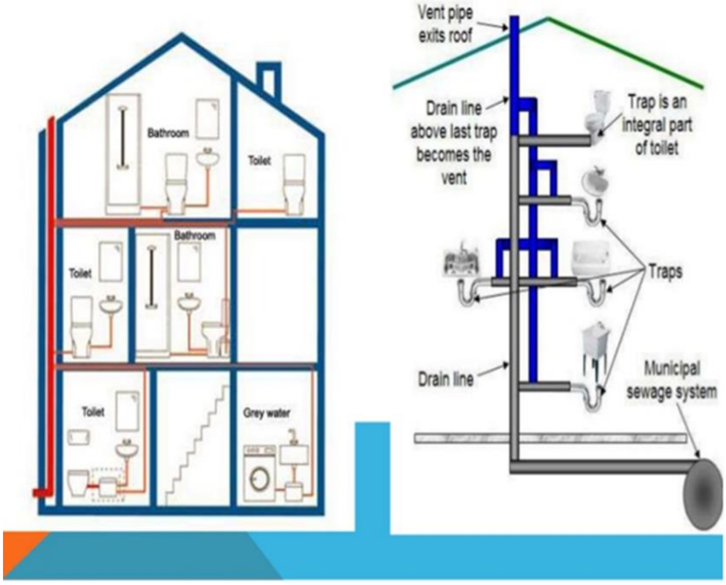


Figure 4-5: drainage system components.

4.6.1 Sanitary Drainage:

design and pipe sizing, Pipe size is calculated by using a concept of fixture units (DFU) instead of using gpm of drainage water. This unit takes into account not only the fixtures water uses but also its frequency of use, which is the DFU has a built–in diversity factor. This enables us, exactly as for water supply to add DFU of various fixtures to obtain the maximum expected drainage flow. Drainage pipes sized for a particular number of drainage fixture units.

The following tables shows the sizing of stack 1 and 2:

Table 4-9: Sizing of stack 1and 2

Stack			branch	
floor	Total DFU	Diameter(in)	Total DFU	Diameter(in)
sixth	13	4	13	4
Fifth	28	4	15	4
fourth	43	4	15	4
Third	58	4	15	4
Second	73	4	15	4
First	73	4	-	-
Ground	73	4	-	-

Table 4-10: Sizing of stack 3 and 4

Stack			branch	
floor	Total DFU	Diameter(in)	Total DFU	Diameter(in)
Fifth	14	4	14	4
fourth	28	4	14	4
Third	42	4	14	4
Second	56	4	14	4
First	56	4	-	-
Ground	56	4	-	-

Table 4-11: Sizing of stack 5

Stack			branch	
floor	Total DFU	Diameter(in)	Total DFU	Diameter(in)
sixth	7	4	7	4
Fifth	21	4	14	4
fourth	35	4	14	4
Third	49	4	14	4
Second	63	4	14	4
First	63	4	-	-
Ground	63	4	-	-

Table 4-12: Sizing of stack 6

Stack			Branch	
Floor	Total DFU	Diameter(in)	Toral DFU	Diameter
First	8	4	8	4
Ground	21	4	13	4

Table 4-13: Sizing of stack 7

Stack			Branch	
Floor	Total DFU	Diameter(in)	Toral DFU	Diameter
First	19	4	19	4
Ground	19	4	-	-

Table 4-14: Sizing of stack 8

Stack			Branch	
Floor	Total DFU	Diameter(in)	Toral DFU	Diameter
First	6	4	19	4
Ground	10	4	4	2

4.6.2 Storm Drainage

The design of the rain collection piping, whether exterior gutters, and leaders, or interior conductors and drain depends upon three factors**:** The amount of rain fall in a specified period of time the size of the area being drained, and the degree of pipe fill, that is whether a pipe or gutter runs 50%, 33% or 100% fill the general rule for the distribution of floor drains (FD):

- Every 100 m^2 from roof area needs one 4” FD.

4.7.3 manhole design

The design of the manholes depends on the ground type in the area, manhole height should not be less than 50 cm, the depth of the manholes depends on the distance between the manholes, and the slope of the pipe that connects them. The figure 4-6 below shows the details of the manholes:

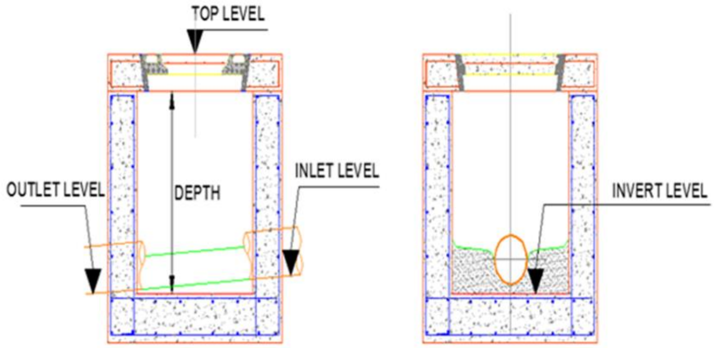


Figure 4-6: Manholes details

Manhole Calculation

The depth of the first manhole is 60 cm, the calculation of the second manhole done according to the first manhole and so on. The calculations are done by using these equations:

- Depth: (M2 = M1 + (Slope × Distance) + 5 + Level Difference) in cm
- Top level: Manholes face level on the ground
- (Invert level = Top level – Depth) in m
- Outlet level = - (Depth – 0.05) in m

Table 4-15: Diameter of manhole according to their depth

Depth(cm)	Diameter(cm)
70 – 80	60
80 – 140	80
140 – 250	100
250 -∞	125

Chapter 5

Building management system and internet of thing

5.1 Introduction

BMS is a computer-based control system, that monitors and manages a building 's mechanical and electrical equipment, such as Ventilation, lighting, power, and fire and security systems. Consisting of software and hardware, using protocols like C-Bus, Profibus, and BACnet. To link between building automation end-devices and control systems, working in hand with Internet of things (IoT), which is the connection of physical objects, software, and other technologies to the internet, to send and reserve data, making systems like lighting, heating, air conditioning, media, and security into smart systems. As information gathered by sensors and devices, is sent to the BMS controller, then the controller can process and perform the needed actions, according to a pre specified orders, to secure quality living and reducing labor effort .
BMS and IOT, technologies that can works together, providing secure storage and data management of building operation information, it ensures safety of humans and assets, with high security. Integrated BMS and IoT provides optimized operations for buildings, create and analyze real-time data, contributing to advance the buildings sustainability and resources saving, by implementing BMS and IoT we get the best solutions for many occurring problems.

Figure 5-1: Building Automation

5.2 Building Management System And Internet Of Thing In The Hotel

A building management system (BMS) and (IoT) is a control system that can be used to monitoring and manage the mechanical, electrical and electromechanical service in a facility. Such service can include power, heating, ventilation, air condition, physical access control, pumping stations, elevators and lights.

5.2.1 Function Of BMS And IoT

Management system and internet of thing to provide services, but also integrated with systems management administrative systems, and uses the term facilities management of the system that occupy the building and run by using computer-aided control.

By BMS and IoT:

- Monitor all equipment service in the building.
- Control and access to the best run.
- The registration request is used and displayed in the statistical information generation report. The printed log describes the condition of the building and is managed and displayed by all indicators of the building, and it is stored in iCloud.
- Show the status of the system and errors that occur in the control center, the coordination between all system work in disaster situations to achieve living out in a good manner and ensure their safety.
- The system also made a statement on the locations of fire screens and modules manifesting computer or on plates illustrative, especially referring to the shortest path and the best and safe access to the area of the fire, which helps fire fighters and residents.
- Building management system providing centralized control of all parts in the case of normal work and at the time of errors and malfunction.

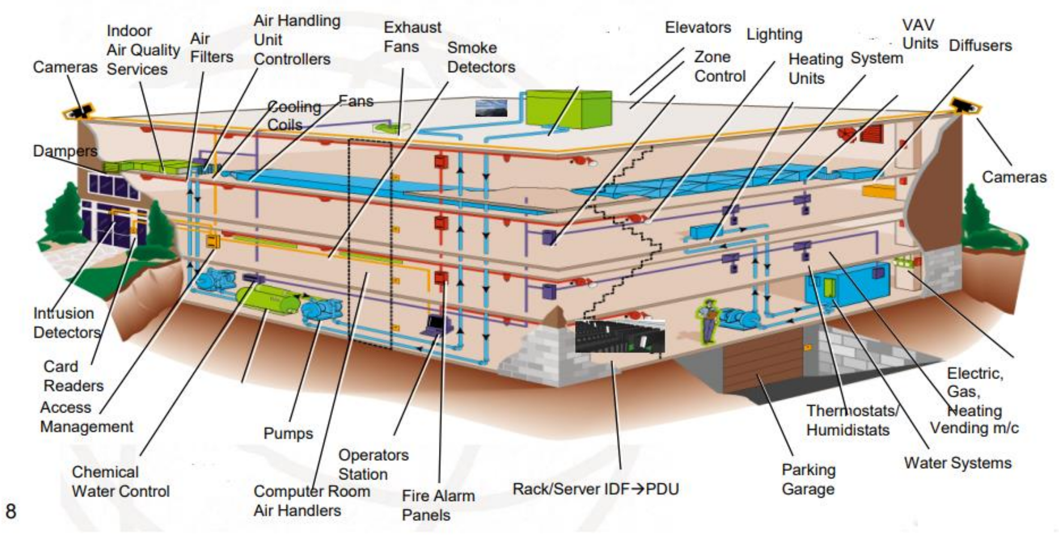


Figure 5-2: BMS and IoT functions [10]

5.3 Selection Of Component

5.3.1 Introduction

The building management system can link multiple control systems and facilitate the control of any building service through a communication network connected to the software. With this software, you can observe real-time performance and adjust settings. Usually, the system is converted to Web-based software, making the system intuitive to a wide range of users, and sometimes allowing the system to be monitored and adjusted from a remote location.

5.3.2 System Components

✓ **The SmartX AS-B server**

Building control stands for the use of an installation bus to make connection between system components and devices to system designed for a special electrical installation that controls and connects all the functions and processes in a building. All of these components have their own "intelligence" and can exchange information directly with each other.

The SmartX AS-B server is a robust device, which contains a built-in power supply, its used as a server that communicates over TCP/IP, and also to monitor and manage field bus devices, it has a 4GB memory used to for the application, historical data, and backup storage, it comes with 24 or 36 I/O, with different types like universal I/O, it contains various ports like Ethernet and usb, supports protocols such as IP, TCP and HTTP. shown in figure 5-3.

figure 5-3 : The SmartX AS-B server[11]

5.2 HVAC Control

The vrf controller is connected to the main DDC, making it part of BMS, Vrf system consists of indoor and outdoor units, room sub-controller, humidity, and CO2 sensors, the sensors send a signal to the controller, if current conditions are not in a specified range, to readjust it as preferred, when a client checks in the room temperature immediately will be set to 24C, after he puts the card in card reader, he's able to adjust it to his liking.

✓ **Variable refrigerant flow System**

DMS 2.5, the touch-type centralized controller adopts LCD color touch screen, which can control up to 128 indoor units and create up to 12 areas, with up to 10 scheduling options, and precise temperature control in multiple areas. Ethernet protocol, Figure 5.3 shows touch centralized controller.

Figure 5-4: Touch Centralized Controller[12]

✓ **Individual Wired Controls**

MWR-WG00UN, it will be distributed in each room on the floor and connected to the central controller on the floor (Touch centralized controller). Color screen, dual set points, 7-day programmable schedule, energy monitoring. Shown on figure 5-5.

Figure 5-5: Individual Wired Controls

HVAC system plan shown in figure 5-6

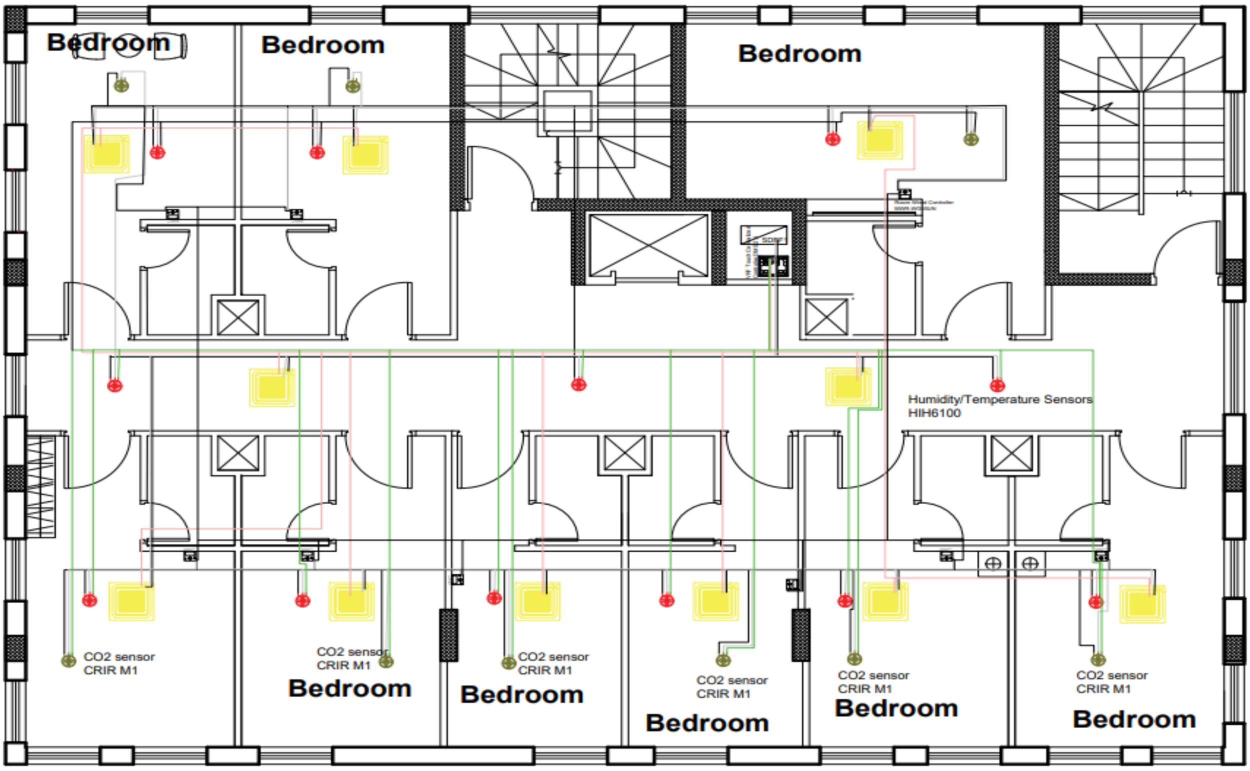
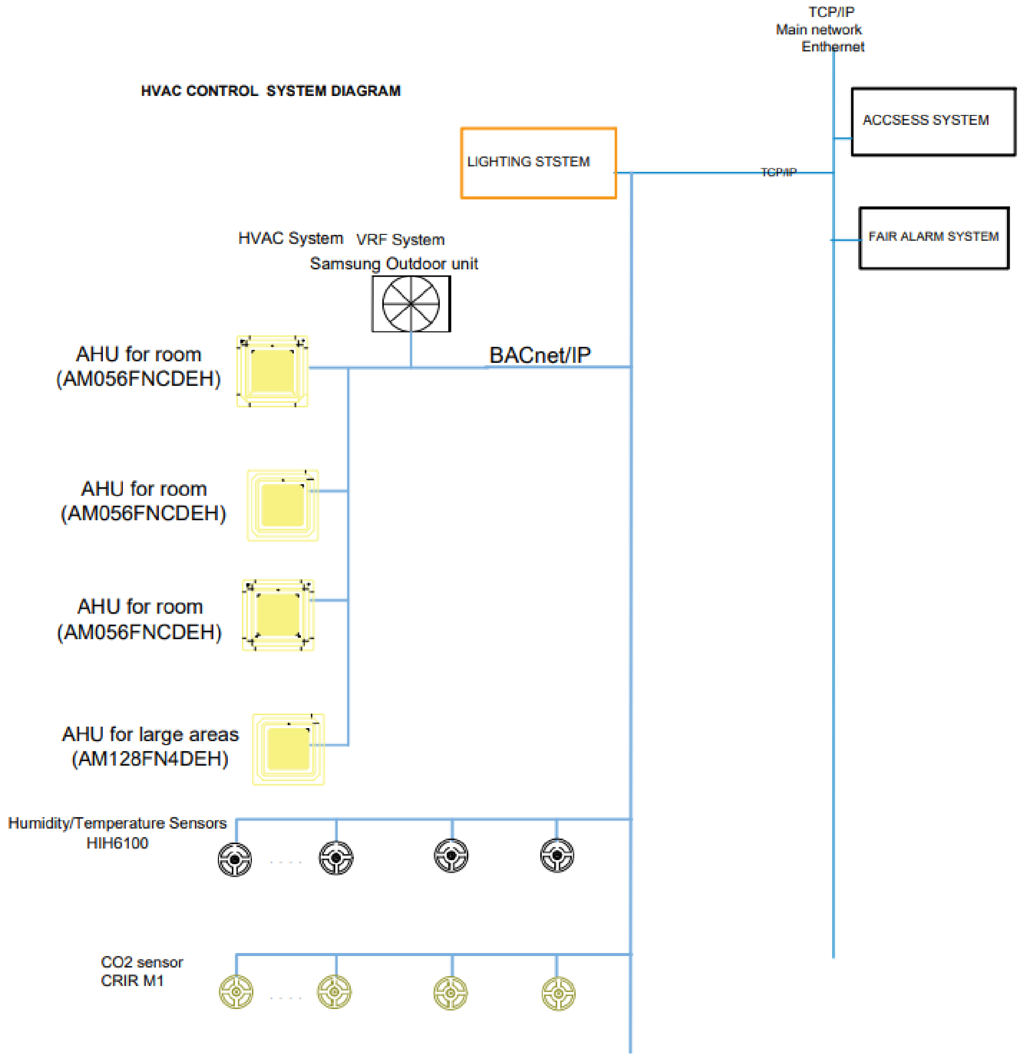


Figure 5-6: HVAC system plan

HVAC control system Diagram shown in figure 5-7:



HVAC control system Diagram shown in figure 5-7

conventional buildings can only control the indoor units, by adjusting them to a certain temperature, with no ability to monitor of fully control the system .In Smart buildings, vrf is monitored and controlled, resulting in fast troubleshooting and maintenance which extends the devices life, alarm notifications are sent to the specialist system, after only seconds of fault detection, which mean that something is not operating within the allowed limits, then evaluation is sent right away.

Monitoring can help to remotely see any failure event, in the cooling system like refrigerant gas leak, and monitor unoccupied rooms then turn off the system, or prepare suitable temperature for guests at their comfort level.

IoT enhances the HVAC system's effectiveness, the IoT embedded units can communicate when maintenance is required, based on the device's requirements, rather than being difficult and time consuming, IoT makes it quicker and easier. For example, if an AHU alarm is recorded, an order to clean the filter is sent to the decision-makers, clogged filters delay fresh airflow, resulting in more energy consumption, so the automatic maintenance alarm allows managers to take action whenever is needed.

5.3 Ventilation System

In conventional buildings the ventilation is traditionally controlled, turning on the vent then after time its turned on, Ventilation system usually consists of fans and a duct system, to get fresh air in rooms, exhaust vents are installed, to eliminate any unwanted moisture and air impurities, its suitable for all climates, using different sensing devices like CO, CO2, and humidity sensors, connected to the main DDC, when the controller is notified by a sensor, it automatically turns the vents on, making the system easier operate and handle. BMS and IoT integration makes the ventilation system fully automatic and controllable.
Heat recovery unit in rooms and corridors plane shown in figure 5-7.

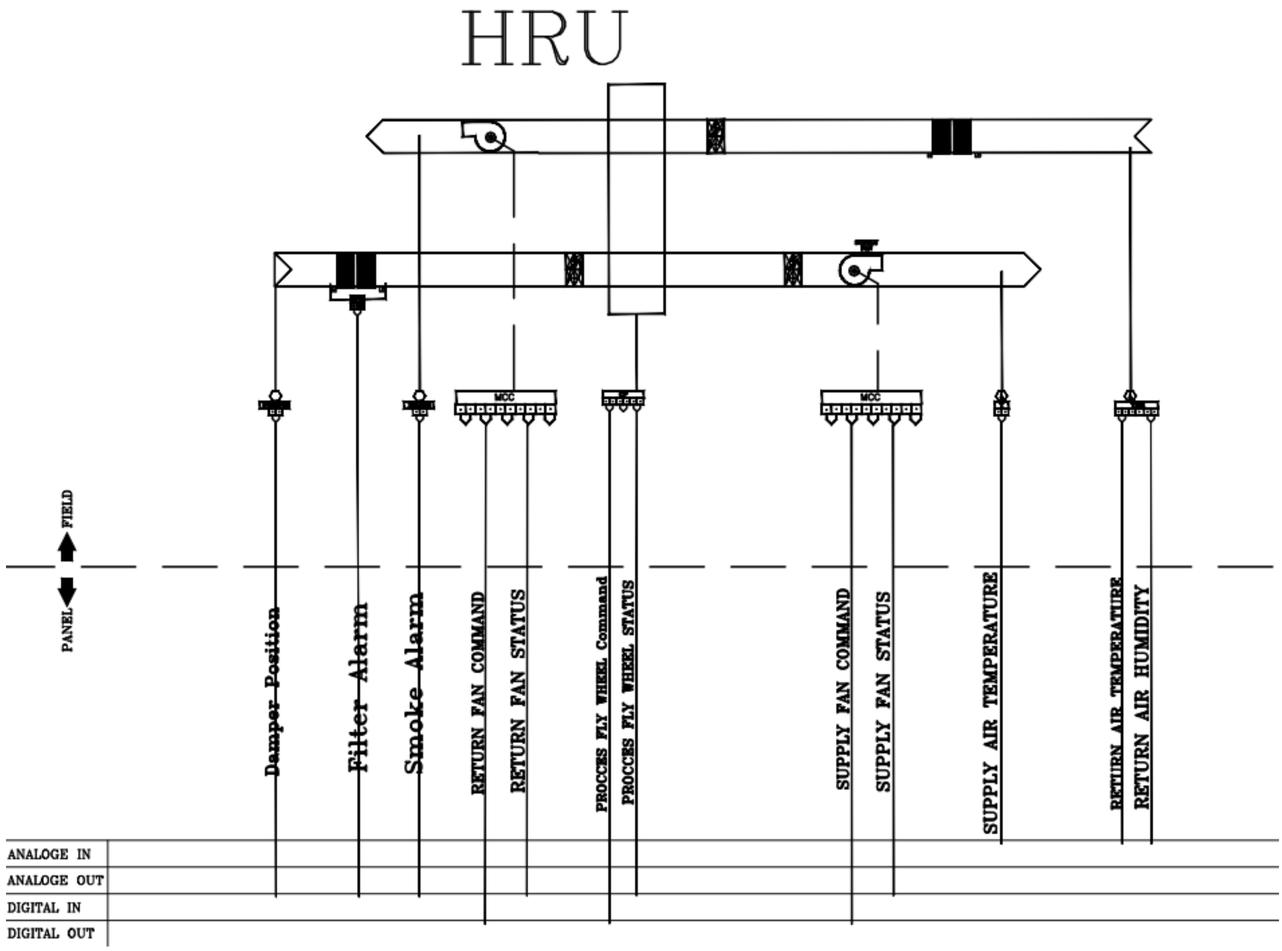


Figure 5-7: Heat Recovery unit control

Heat recovery unit in rooms and corridors, it supplies fresh air to corridors by positive pressure then to rooms by negative pressure and exit the rooms by the exhaust, this way guarantees only fresh air to enter the area, then by connecting an energy wheel used to heat the exiting air and transmit it to a radiator, heating the room if needed. In case of a fire the supply fans are switched off by the controller to make sure fires don't spread, also turning on the exhaust fan return to draw smoke from the affected areas. Exhaust fan control plan shown in figure 5-8.

Fans

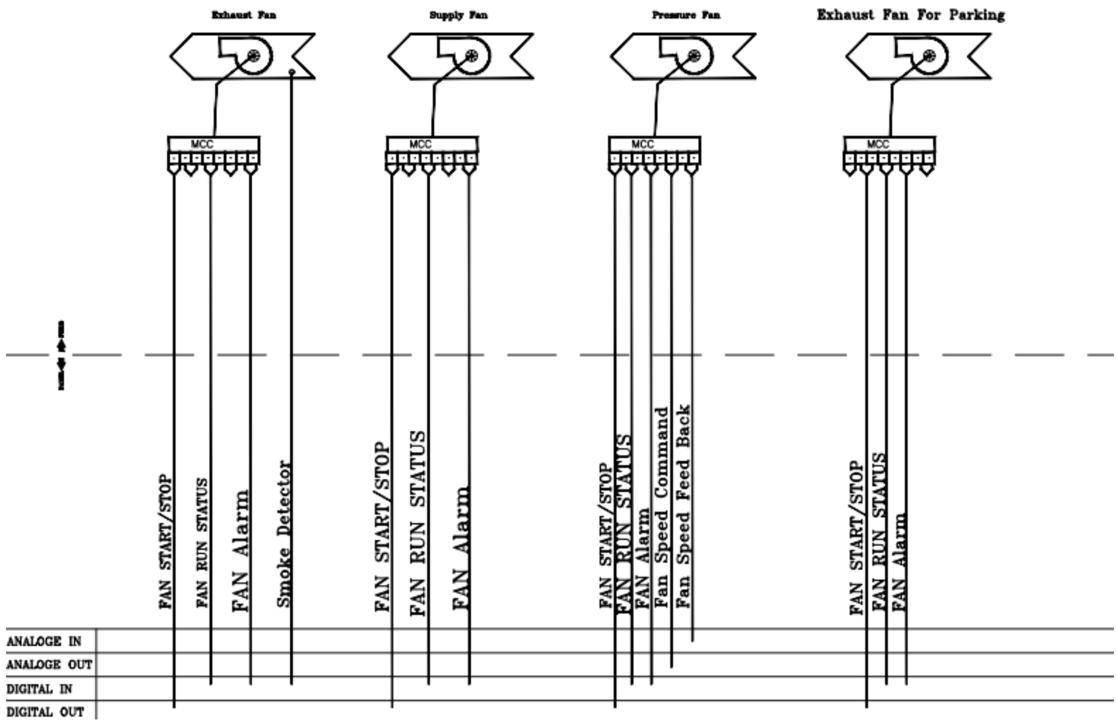


Figure 5-8: Exhaust fan control

By exhaust fan in Parking, ventilation fan is used to circulate air, is activated by a signal from a CO smoke detector, using two CO smoke detectors to cover the whole parking area.

5.4 Pumping System

Modern pumps benefit pumping system, by saving energy due to communication with building control systems, makes it convenient for the user, since its entirely controllable with suitable interface, our system controls the following pumps: transfer pump, fire pump, irrigation pump, and submersible pump.

5.4.1 Transfer Pump

Transfer pump control plan shown in figure 5-9.

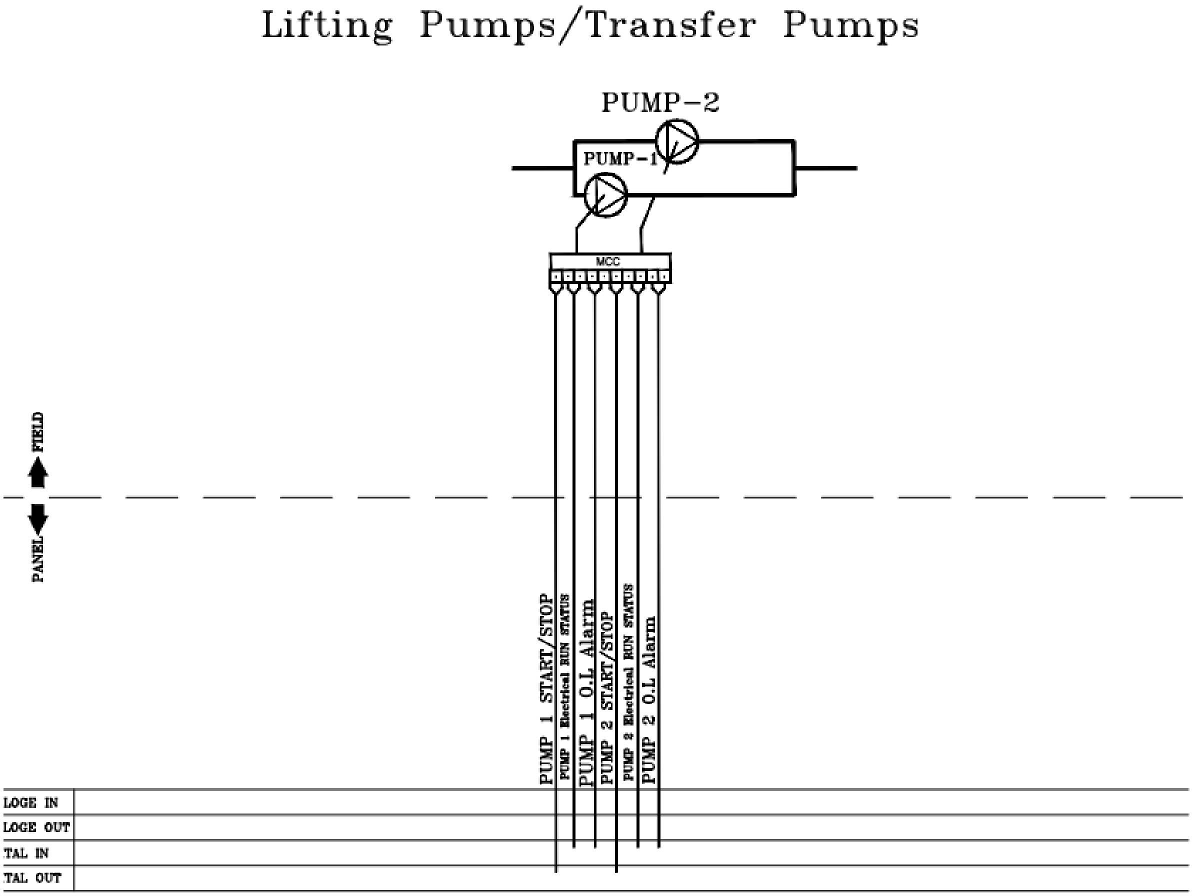


figure 5-9: Transfer pump control plan

Transfer pump is used to lift water from ground level tank to roof top tank, implementing two transfer pumps, as one of them works in full load and the other is on duty stand by, along with a float switch and a high-level sensor to insure a smooth operation.

5.4.2 Fire Pump

Fire pump provides high-pressure water in case of fiery occurrence, using two electrical pumps, depending mainly on a jockey pump to maintain a required pressure or compensate the loss of pressure, sustaining a required pressure all the time, by pumping water into pipes network, to reach the specific pressure, the pumps stay on standby, waiting for a fire notification.

Fire pump control plan shown in figure 5-10:

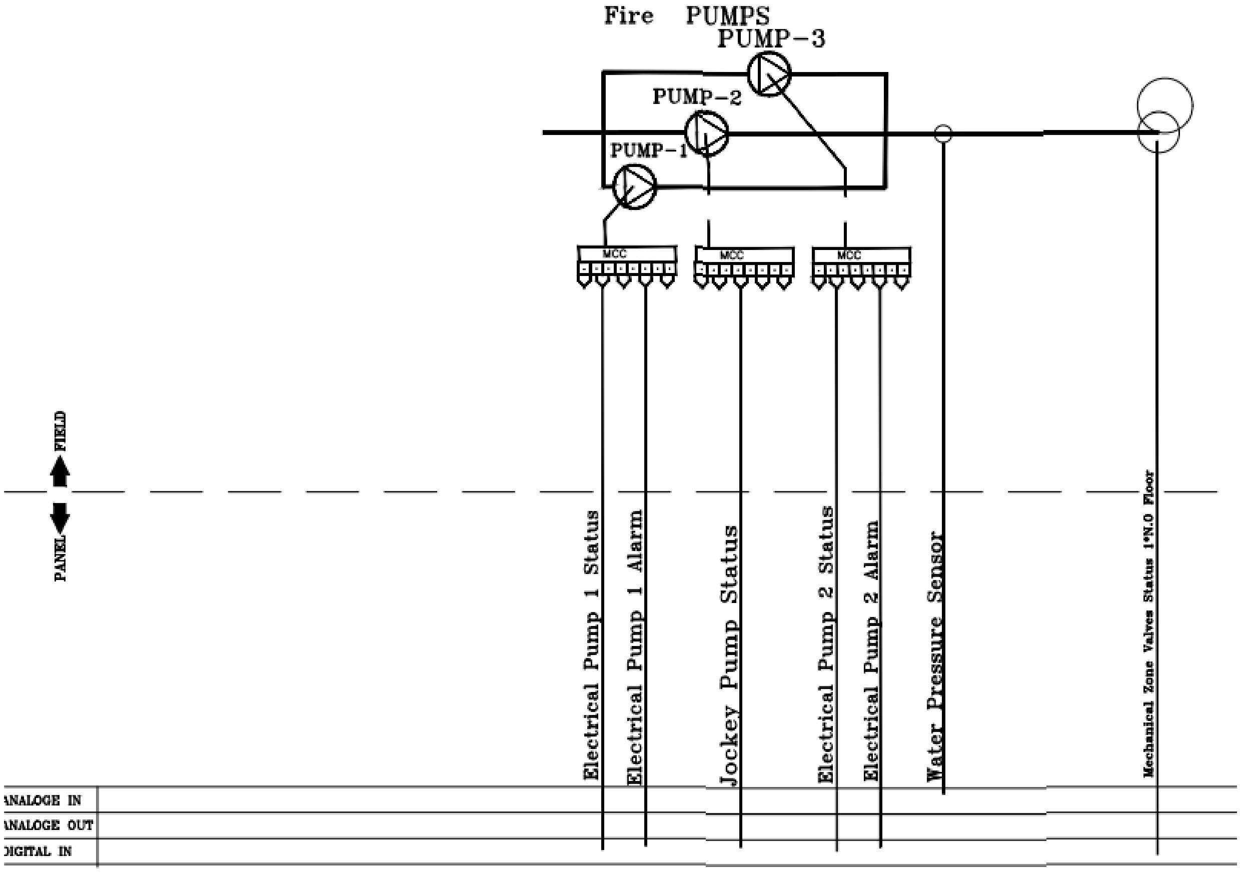


figure 5-10: Fire pump control plan

5.4.3 Irrigation Pump

Irrigation control plan shown in figure 5-11

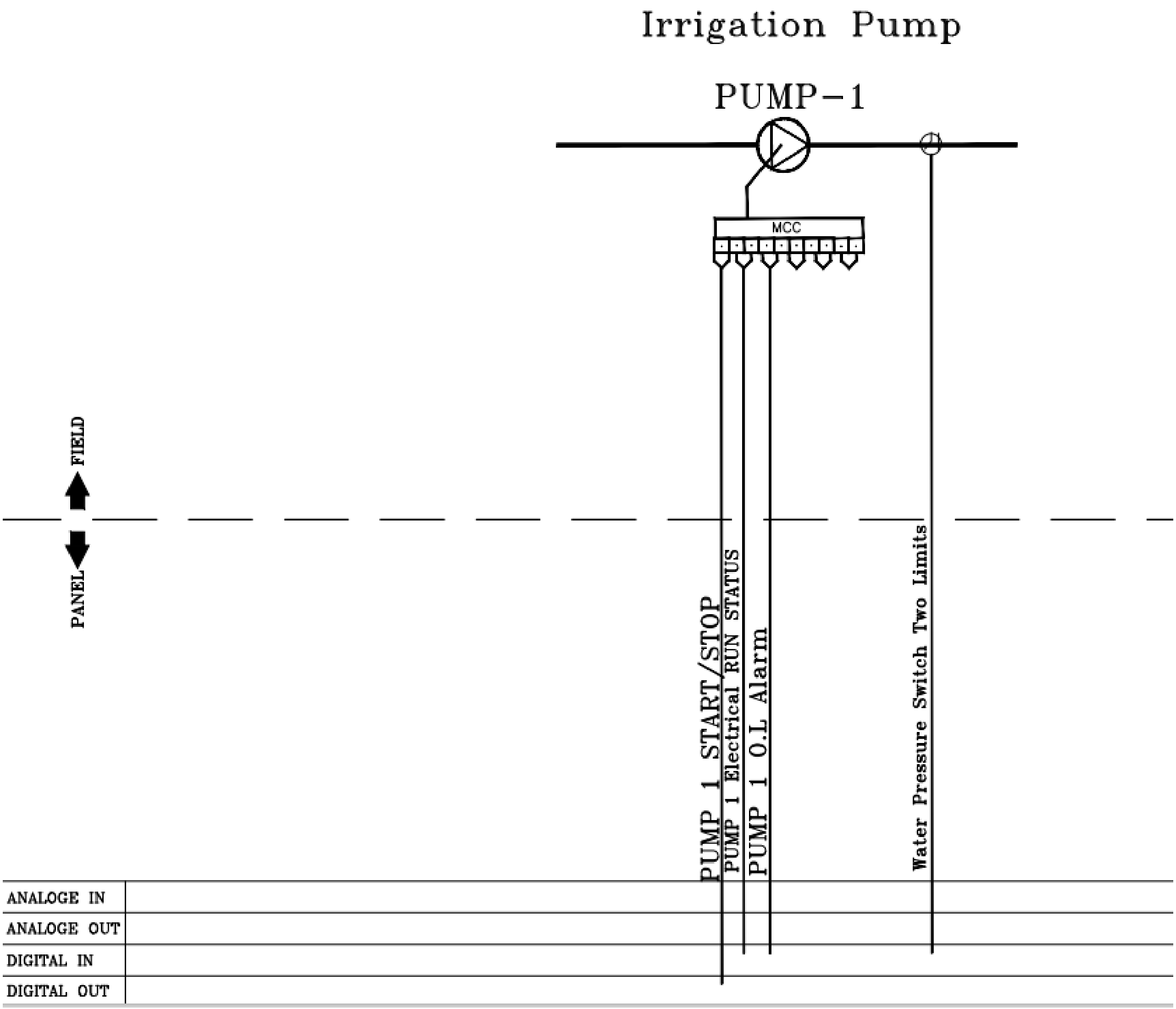


figure 5-11: Irrigation control plan

5.4.4 Submersible Pump

Submersible control plan shown in figure 5-12

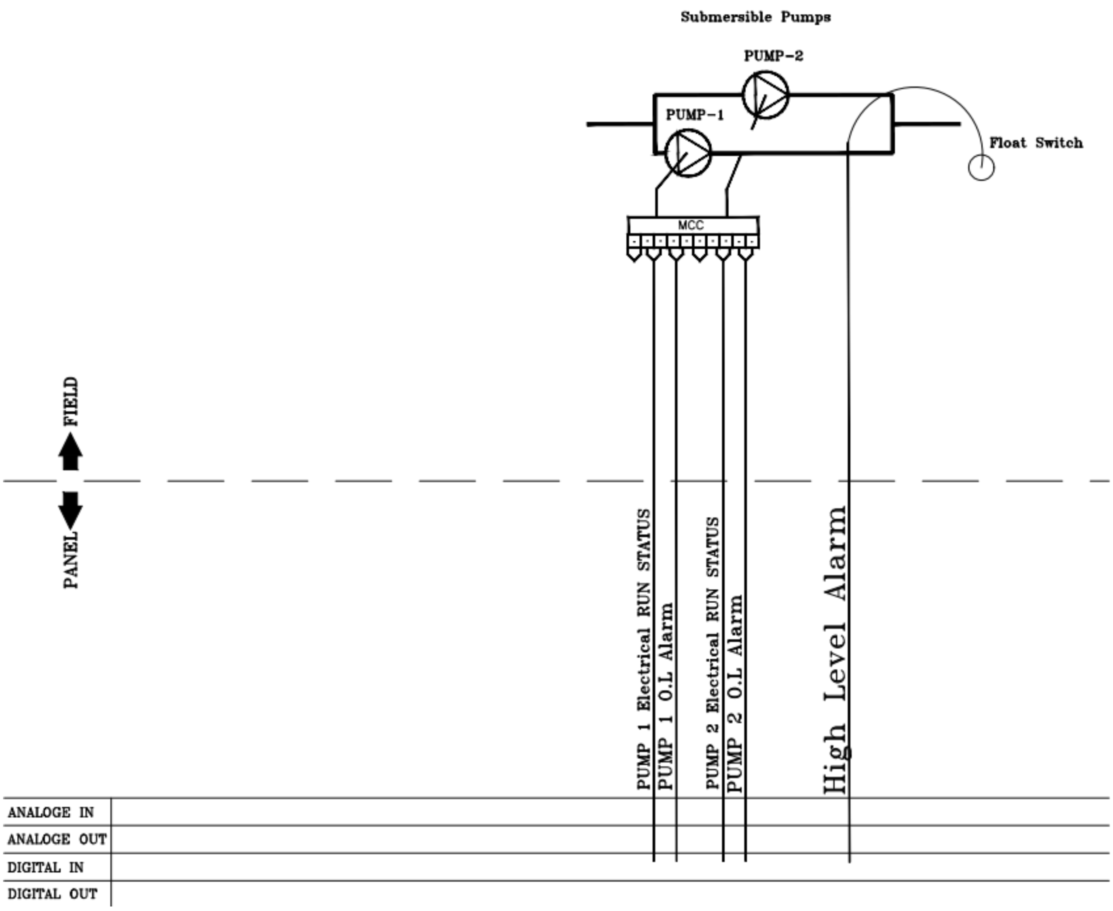


figure 5-12: Submersible control plan

5.5 fire Alarm Control

Intelligent fire alarm system using the Internet of Things (IoT), that will accelerate the evacuation process from the building, control and prevent the spread of fire, directly contacting the building administrator and security, and guide people to the emergency exit, reduce natural and physical disasters, and protecting valuable assets.
Fire Alarm control panel.

ESSER Honeywell

The Honeywell ESSER one of the best fire alarm panels, it meets the highest technical standards, and satisfy security requirements. Ideal for detection purposes, these panels provide complete fire protection for small- and medium-sized areas. It meets the fire safety needs, while also being prepared for tomorrow’s fire safety challenges, it consists of Up to 127 esserbus devices (fire detectors or manual call points), groups addressable, ATEX detectors for potentially explosive areas, Operating modes PM* and TM** for false alarm prevention. Figure 5- 13 shown the fire alarm control plane.

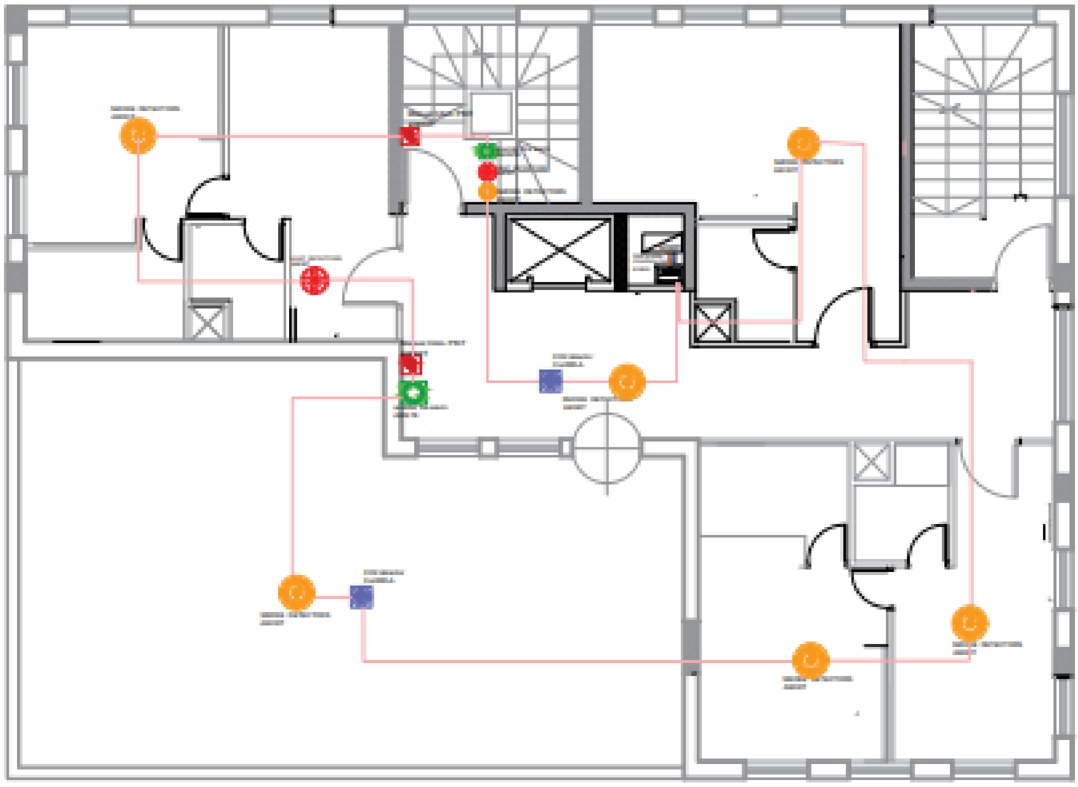


Figure 5-13: the fire alarm control panel

Figure 5- 14 shown fire alarm controller loop

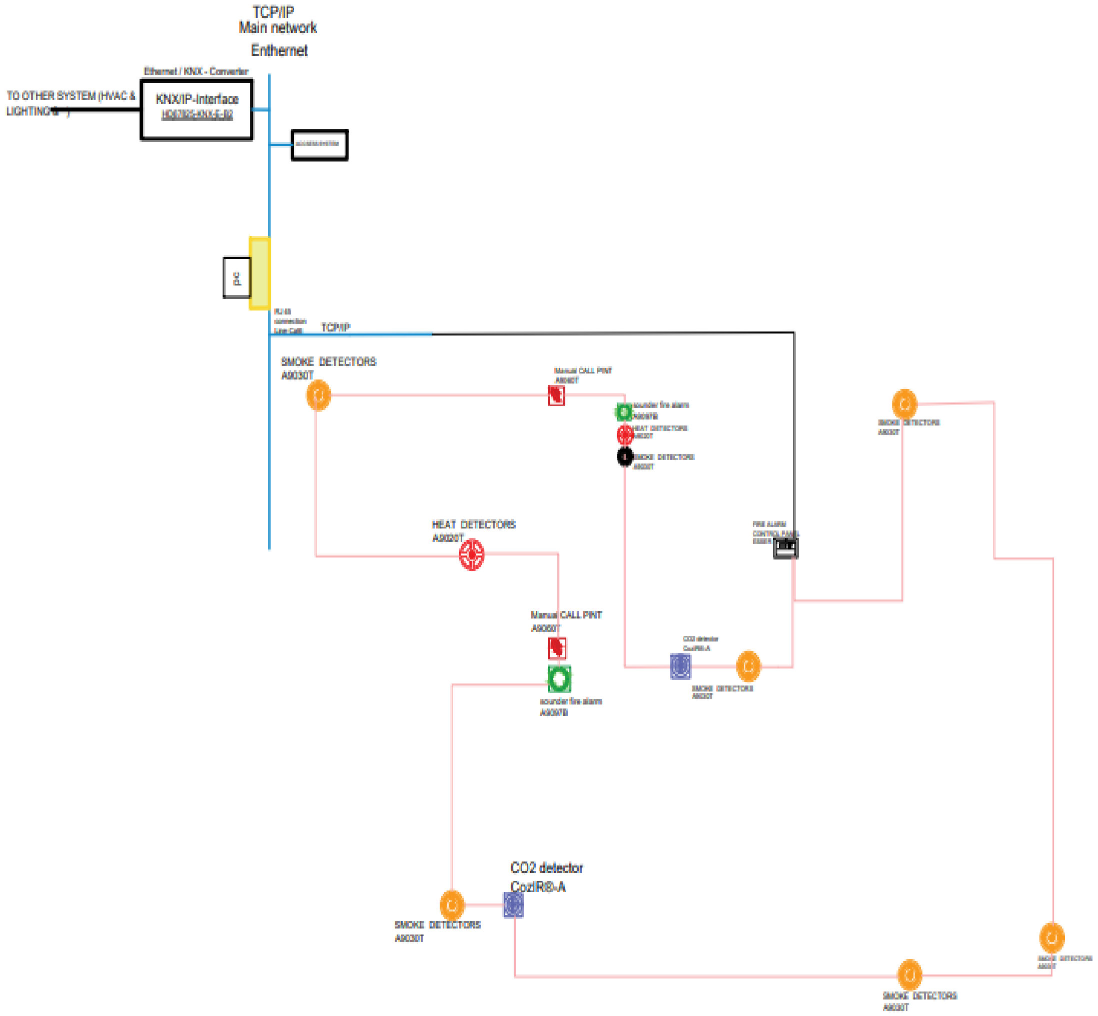


figure 5-14: fire alarm controller loop

figure 5-15 shown fire alarm control diagram

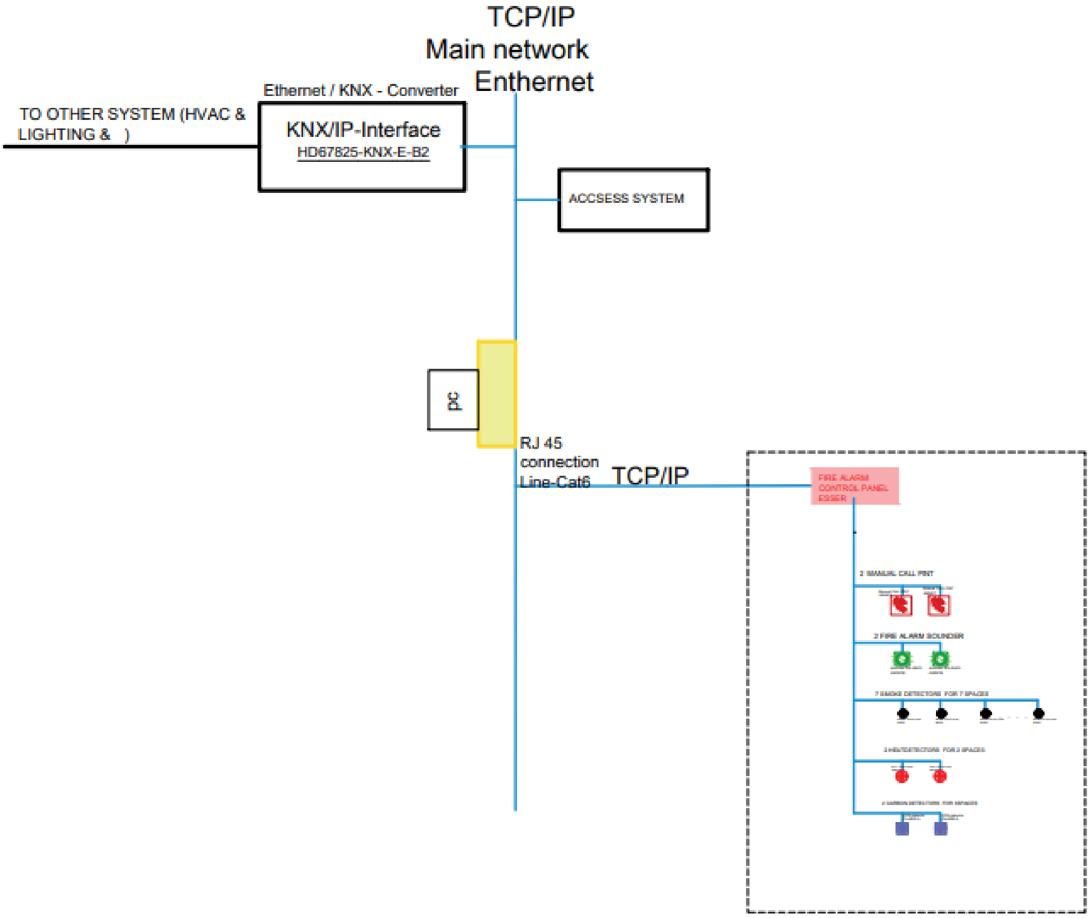


figure 5-15 fire alarm control diagram

Traditional fire alarms in the buildings, barely dose the job of keeping humans safe, it is full of faults, it causes financial losses, takes time to report fires to the fire station, it doesn't show all aspects, doesn't have a device to share location, when it is very important to have one, no clear evacuating orders, and there's no direct contact with the building security. It contains several devices, like an emergency light and buzzer

The intelligent fire detection system can be used in any part of the building, this system provides many advantages, it reduces the time required to evacuate the building, and the ability to communicate with the people involved in the evacuation process, helps keep people safe. On the other hand, it works to direct people to the nearest accessible exit, which summarizes the importance of having an intelligent fire detection system in every building. It lowers elevators to the ground floor and stops them from ascending, and shares losses and causes of fire with other buildings to avoid losses and increase safety.

5.6 Access System

Security Controller

SP-C Security Expert security purpose controller it's the central processing unit of the Security System, it communicates with all system modules, and stores all configuration and transaction information, analysis data, and reports alarms and system activity to a monitoring station, or the main computer, it allows large numbers of modules to be connected to the Network, up to 250 modules can be connected to the Security System, it has 2Gb storage memory.

Consisting of a card reader control panel at each room, to insert the card in, Data is preserved if power is lost, and Controller continues to operate if network connection is interrupted. magnetic door lock for maximum security, only opens when the card is inserted motion sensors. Figure 5- 16 shown Access system control plan

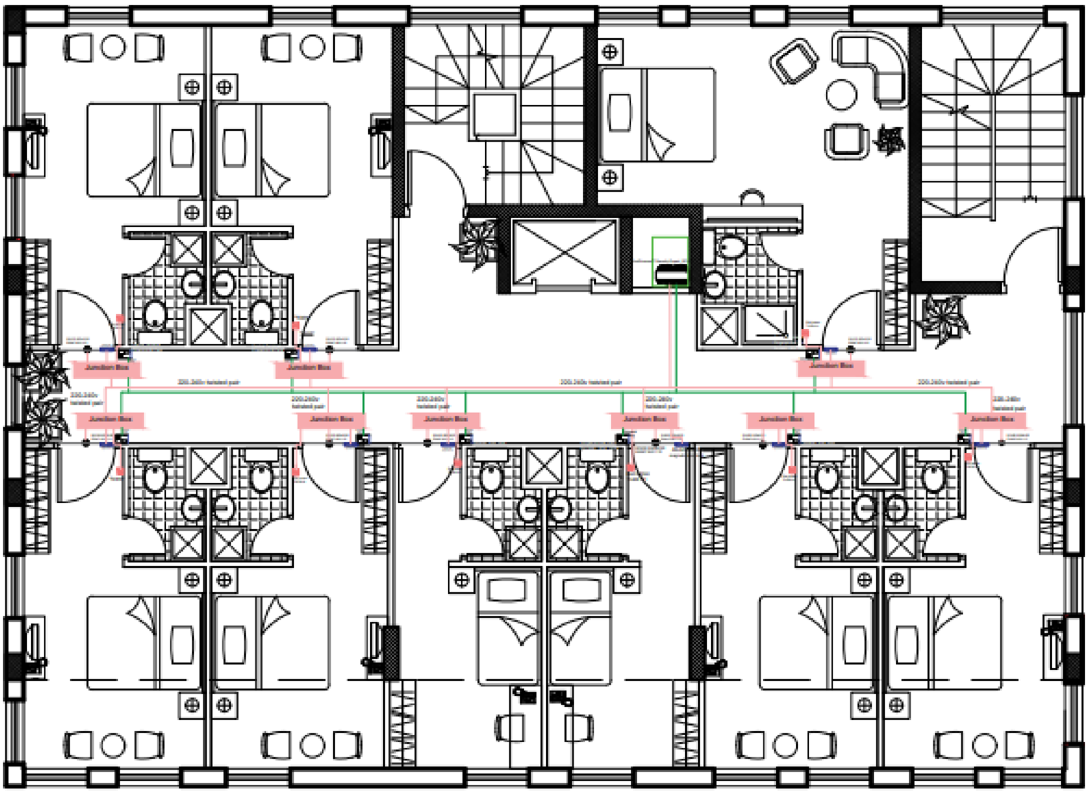


Figure 5- 16 Access system control plan

Figure 5-17 Access system control diagram

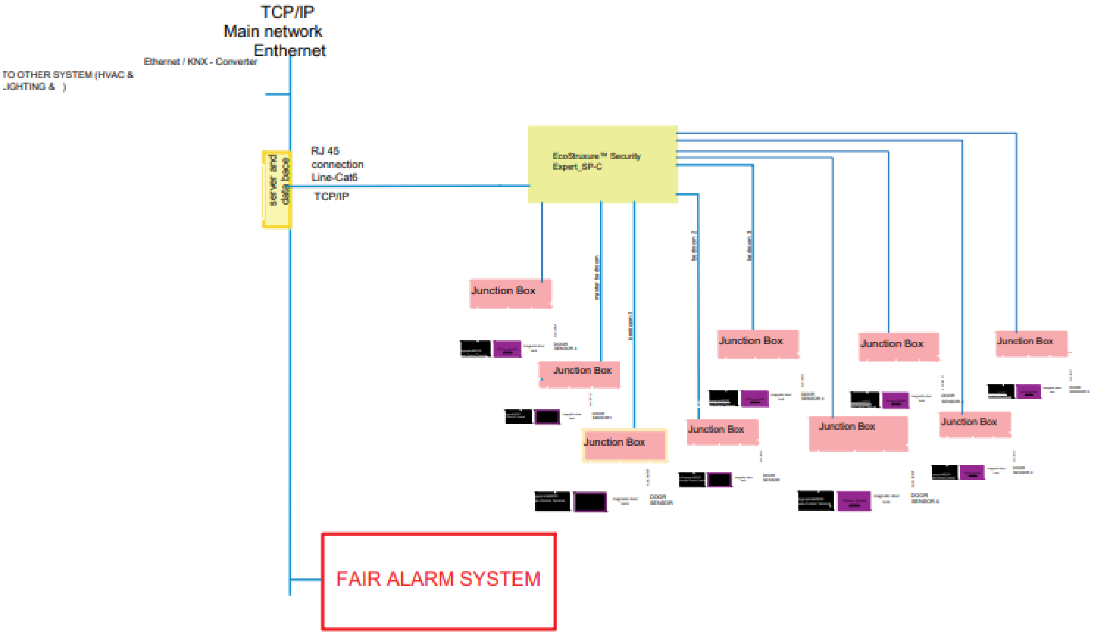


Figure 5-17 Access system control diagram

After using BMS, when a client checks in, the controller sets the temperature at a comfort level, then when the client enters the card in the card reader, the room remote control is enabled, and the client can set it as preferred, also enables other control options in the room. When the client checks out, the system sends a message to room service workers, the workers have special cards to open the doors for cleaning.

5.7 lighting system

A proper lighting control system contains a set of coherent devices , integrated in a suitable sequence, achieving this concludes in , dividing the area into zones to make controlling easier , taking advantage from daylight , as it can contribute in power saving, using sensing devices to control on and off status like occupancy sensor, constant monitoring to detect any faulty devices to perform corrective maintenance, integrating the system with other systems like HVAC, this strategies will result in having an intelligent lighting system, that manages energy efficiency ,optimize cost and quality.[13]

Lighting controller

Space Logic C-Bus DALI-2 Gateway offers the functionality of C-Bus and DALI systems, delivers efficiency for building automation system, it provides flexible installation, smooth dimming with Dali lights, its coast efficient as it has a compact size and requires less caballing, and Enhances system management and maintenance. Figure 5-17shown lighting system plan.

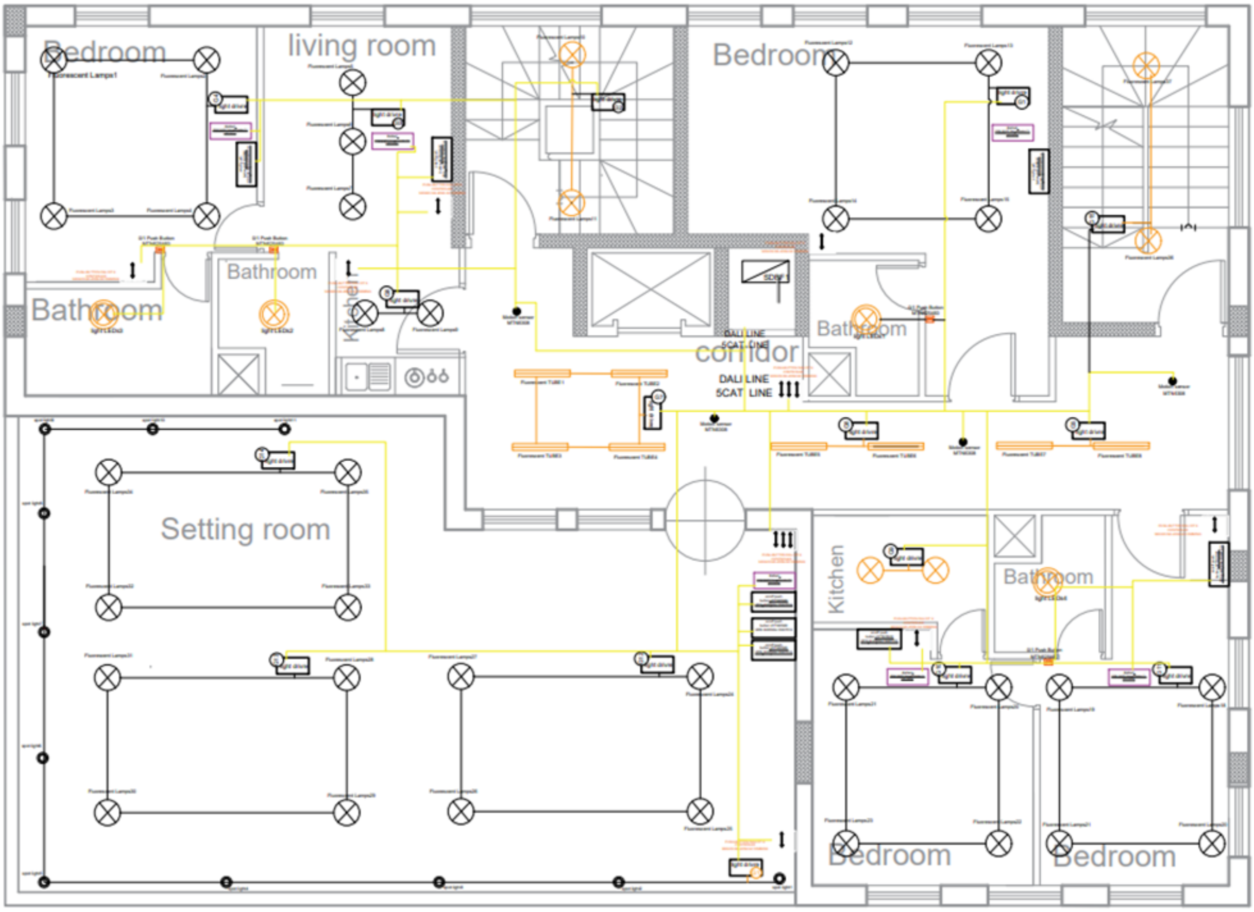


Figure 5-17: lighting control plan

Figure 5-18 shown lighting control plan

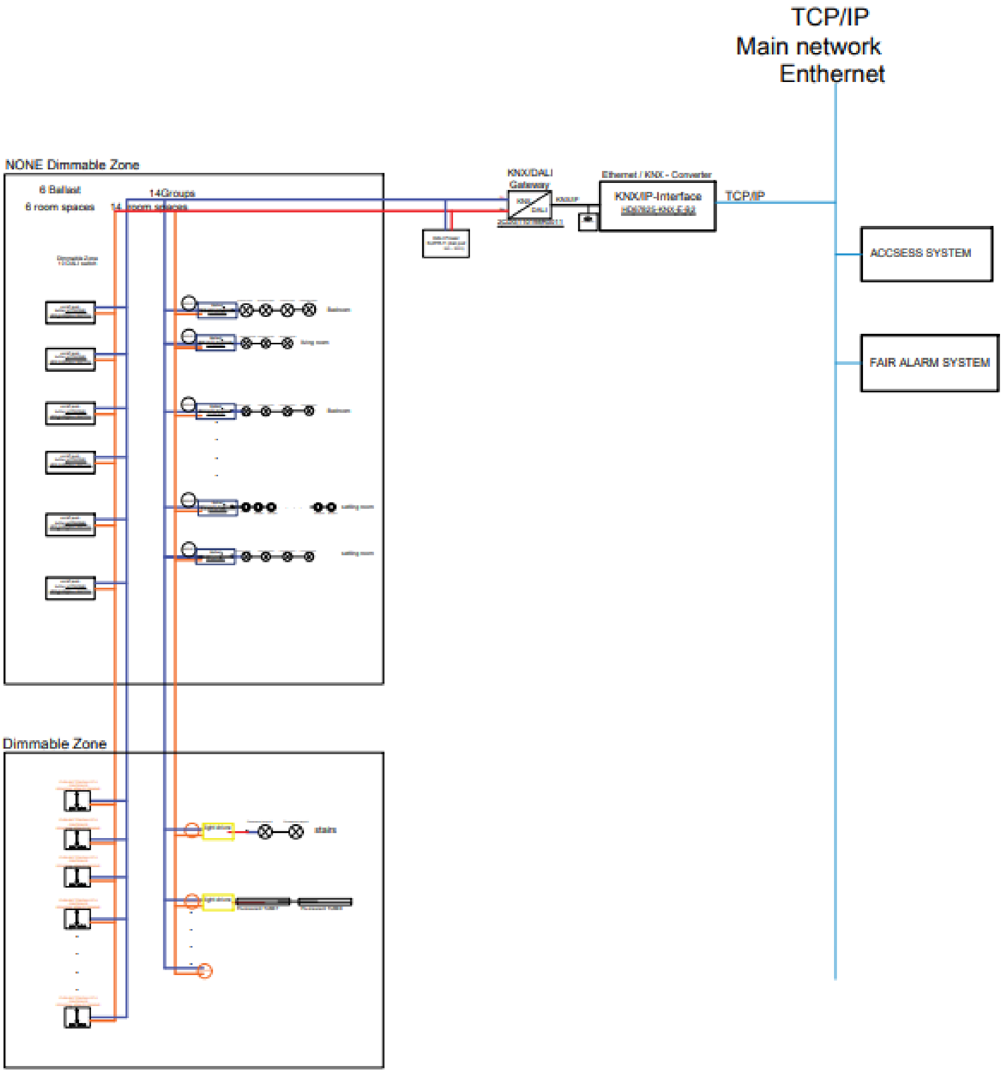


Figure 5-18 shown lighting control plan

The traditional lighting system works only in the classical conventional way, controlled by on/off buttons. and the traditional lighting system cannot be connected to other systems in the building, or make different light zones communicate with each other, or reduce electricity consumption. It can’t be monitored to detect any faults, so this delays the maintenance work.

Smart lighting systems consist of digital sensors, communications interfaces, and actuator drivers. programmed by using scenarios, and can be divided into lighting networks to operate remotely. They can control the level of illumination in a room when an external event occurs, for example, when a user has been detected by an occupancy sensor.

Smart lighting systems organized as lighting networks, allowing different types of lights to interact with each other, achieving synchronized operation. The lighting system works with different sensor technologies and communication interfaces. The modern-day IoT lighting principles aim to monitor and control lighting, depending on different environments with a wide range of digital sensors.

Lighting and blinds scenarios

In the hotel, the lighting inside the rooms is controlled according to the comfort of the guest. It is not possible to apply scenarios for lighting inside the rooms, but in the public places in the hotel such as the restaurant or the cafeteria, there are as follows:

✓ **Morning scenario**: During this period sunlight is the source of illumination, so the blind will be opened to allow sunlight to pass through. The sun's rays will contribute to the lighting, which will reduce the energy consumption of the lighting.

✓ **Night scenario**: During this period the sun will disappear, so we will use artificial lights.

Types of lighting in the building

Table 1-1: type of lighting in the hotel

Description	Use
Philips Led luminaire, surface mounted IP44 (SM150C LED24sd/830)	Kitchen and bathroom
Philips Led module Wall mounted IP65 (WL 120V LED16S/830)	Stairs
Philips LED Module, surface mounted IP20(SM 134V LED37S/830)	Bedroom
Philips LED Module, surface mounted IP20(SM531C LED15S/830)	Reception
Philips LED Module surface mounted IP40 (SM531C LED15S/840)	Corridors
Philips LED module surface mounted IP65(WL120V)	Barking
Philips LED module surface mounted IP65(WL131V)	Balcony
Philips LED module surface mounted IP65(WL131V)	entrance
Philips led spot IP12(PAR329SW)	General use

5.8 Types of sockets

1. Single and double sockets

- Current Rating :10 or 16 A
- Voltage Rating: 250 V.
- Applications: bedrooms, living room and general areas like corridors and reception.

Figure 5-19: Single and Double Sockets

2. **Power Sockets**
    - Current Rating: 20 or 32 A
    - Voltage Rating: 250 V.
    - Applications: Kitchen, Bathrooms, Laundry and Drilling Machines.

Figure 5-20 : ABB Connector 32A , 250V 6H IP44

3. **Weather proof sockets**

Normal socket with cover to maintain higher Index protection.

Applications:

- Corridors
- Kitchen
- Bath Room
- Outdoor
- Stores
- Factories

Figure5-21: Weather proof sockets

4. **<u>Three-phase socket</u>**
    - Current Rating: 16 A, 32 A, 63 A, 100 A, 125 A
    - Voltage Rating: 400 V.

Figure 5-22: Three-phase sockets

5. **<u>Column sockets</u>**
    - Current Rating: 20 A
    - Voltage Rating: 250 V.
    - Outlets=6, 12, 18, 24 outlets.
    - Applications: Commonly used in administrative buildings.

Figure 5-23: Column sockets

5.9 Budling management system Riser plan

The following figure 5- 24 shown BMS riser:

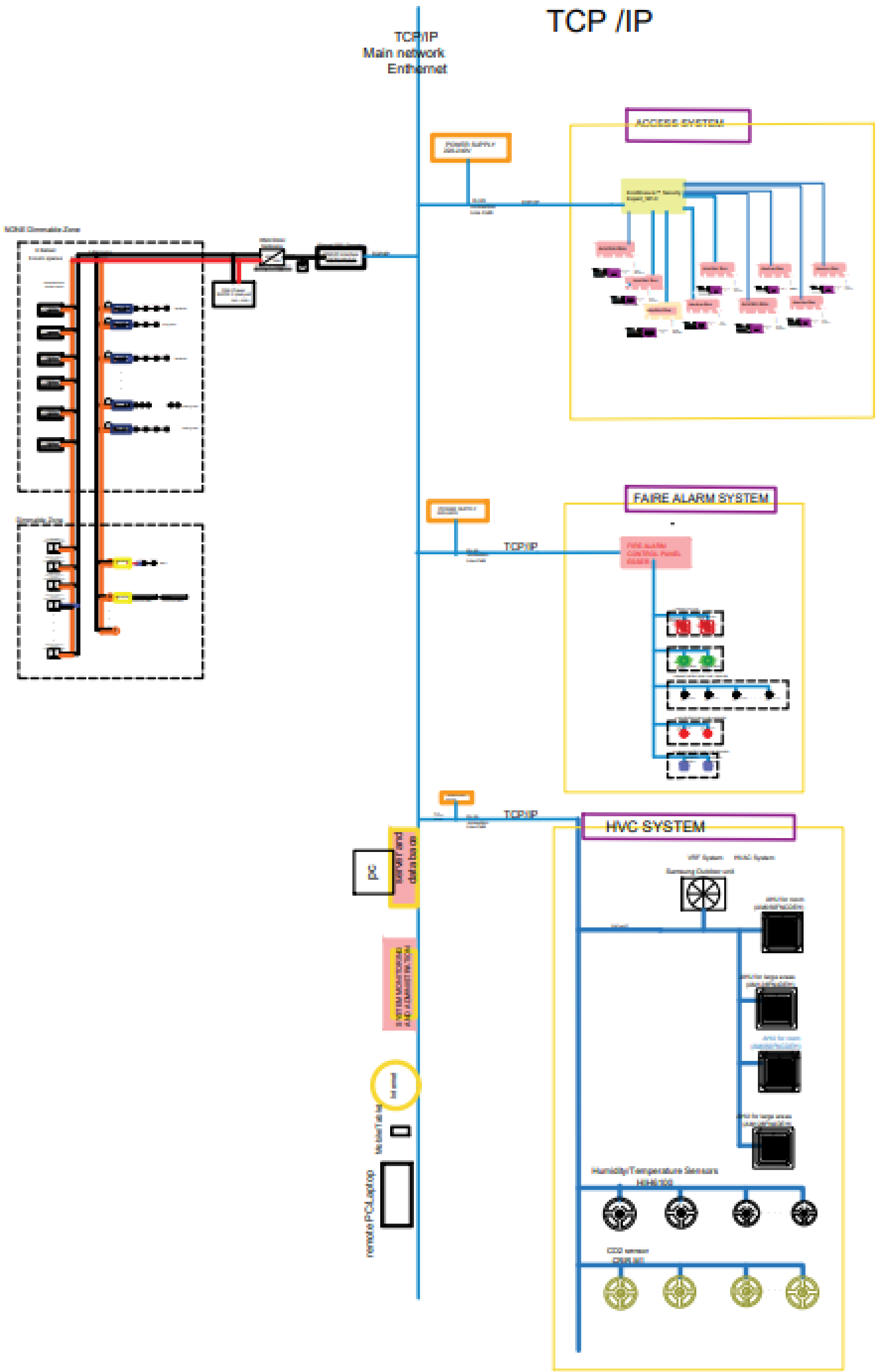


figure 5-24: BMS riser

This figure shows the BMS riser, Illustrates the connection of the HVAC system, access system, fire alarm system, and lighting system with the main DDC over TCP/IP, it shows all devices and sensors used, also connected to interface devices like mobile/tablet and PC.

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[11] smatrx controller

[12] schnieder. touch panel.

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Appendix

Appendix – A

A-1: Description of wall construction groups

TABLE 9-5 Description of wall construction groups.

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

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

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

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

A-3: Approximate CLTD values for sunlit roofs

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

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

A-4: Infiltration through window and door crack in cubic meter per hour per meter of crack

TABLE 6–1 Infiltration through window and door crack in cubic meter per hour per meter of crack.[1]

Type of Aperture	Remarks	Wind Speed, km/h 8.0	16.0	24.0	32.0	40.0
Double-hung wood-sash windows (Unlocked)	Average; non-weather-stripped.	0.7	2.1	3.9	5.9	8.0
	Average; weather-stripped.	0.4	1.3	2.4	3.6	4.9
	Poorly fitted; non-weather-stripped.	2.7	6.9	11.1	15.4	19.9
	Poorly fitted; weather-stripped.	0.6	1.9	3.4	5.1	7.1
	Around window frame; masonry wall, uncalked.	0.3	0.8	1.4	2.0	2.7
	Around window frame; masonry wall, calked.	0.1	0.2	0.3	0.4	0.5
	Around window frame; wood frame structure.	0.2	0.6	1.1	1.7	2.3
Double-hung metal windows	Non-weather-stripped; unlocked.	2.0	4.7	7.4	10.4	13.7
	Non-weather-stripped; locked.	2.0	4.5	7.0	9.6	12.5
	Weather-stripped; unlocked.	0.6	1.9	3.2	4.6	6.0
Single-sash metal windows	Industrial; horizontally pivoted.	5.2	10.8	17.6	24.4	30.4
	Residential casement	1.4	3.2	5.2	7.6	10.0
	Vertically pivoted	3.0	8.8	14.5	18.6	22.1
Doors	Well-fitted	2.7	6.9	11.0	15.4	19.9
	Poorly fitted	5.4	13.8	22.0	30.8	39.8

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

A-10: Shading coefficient for glass with interior shading

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

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

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

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

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

A-12: Solar heat gain factor for sunlit glass

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

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

A-13: Values of infiltration air coefficient for windows

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

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

A-19: Values Of The Factor SI

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

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

A-20: Values of the factor S2

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

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

A-21: Instantaneous heat gain from occupants

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

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

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

A-25: Latitude- month correction factor LM

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

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

A-26: Minimum outside air requirements for mechanical ventilation

Application	Maximum Occupancy Per 100 m^2	Ventilation Air Requirements	
		L/s/Person	L/s/m^2
Bath, toilets(3)	—	10.0	—
Hotels and motels:			
Bedrooms	—	—	7.5-15 L/s/room
Living rooms	—	—	5-10 L/s/room
Bathes	—	—	15-25 L/s/room
Lobbies	30	2.5-7.5	—
Conference rooms	50	3.5-17.5	—
Assembly rooms	120	3.5-17.5	—
Dormitory sleeping areas	20	8.0	—
Gambling casinos	120	15.0	—

A-27: inside & outside film resistance

Table A(2.2) Inside film resistance, R_i.

Element	Heat Direction	Material Type	R_i $m^2 \cdot °C/W$
Walls	Horizontal	Construction materials	0.12
		Metals	0.31
Ceilings and floors	Upward	Construction materials	0.10
		Metals	0.21
	Downward	Construction materials	0.15

Table A(2.3) Outside film resistance, R_o.

Element	Material Type	Less than 0.5 m/s	0.5 - 5.0 m/s	More than 5.0 m/s
		Outside Resistance R_o, $m^2 \cdot °C/W$		
Walls	Construction materials	0.08	0.06	0.03
	Metals	0.10	0.07	0.03
Ceilings	Construction materials	0.07	0.04	0.02
	Metals	0.09	0.05	0.02
Exposed floors	Construction materials	0.09	—	—

A-28: Overall heat coefficient for windows

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

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

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

TABLE A(2.5) Overall heat transfer coefficients for wood and metal doors, W/m²·°C.			
Door Type	**Without Storm Door**	**With Wood Storm Door**	**With Metal Storm Door**
25 mm-wood	3.6	1.7	2.2
35 mm-wood	3.1	1.6	1.9
40 mm-wood	2.8	1.5	1.8
45 mm-wood	2.7	1.5	1.8
50 mm-wood	2.4	1.4	1.7
Aluminum	7.0	—	—
Steel	5.8	—	—
Steel with:			
Fiber core	3.3	—	—
Polystyrene core	2.7	—	—
Polyurethane core	2.3	—	—

A-30 Palestinian code

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

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

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

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

Appendix (B)

B-1: Water supply fixture unit

Table A(4.1) 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[c]	Private	Flushometer	8	—
Bathroom group[c]	Private	Flush tank for closet	6	—
Bathtub	Private	Faucet	2	1/2
Bathtub	General	Faucet	4	1/2
Clothes washer	Private	Faucet	2	1/2
Clothes washer	General	Faucet	4	1/2
Combination fixture	Private	Faucet	3	1/2
Dishwasher[f]	Private	Automatic	1	1/2
Drinking fountain	Offices, etc.	Faucet 3/8 in.	0.25	1/2
Kitchen sink	Private	Faucet	2	1/2
Kitchen sink	General	Faucet	4	1/2
Laundry trays (1–3)	Private	Faucet	3	1/2
Lavatory	Private	Faucet	1	3/8
Lavatory	General	Faucet	2	1/2
Separate shower	Private	Mixing valve	2	1/2
Service sink	General	Faucet	3	1/2
Shower head	Private	Mixing valve	2	1/2
Shower head	General	Mixing valve	4	1/2
Urinal	General	Flushometer	5	3/4[e]
Urinal	General	Flush tank	3	1/2
Water closet	Private	Flushometer	6	1
Water closet	Private	Flushometer/tank	3	1/2
Water closet	Private	Flush tank	3	1/2
Water closet	General	Flushometer	10	1
Water closet	General	Flushometer/tank	5	1/2
Water closet	General	Flush tank	5	1/2

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

Fixture Branch[d]	Number of Fixture Units: Private Use	Number of Fixture Units: General Use
3/8	1	2
1/2	2	4
3/4	3	6
1	6	10

[a] For supply outlets likely to impose continuous demands, estimate continuous supply separately and add to total demand for fixtures.

[b] The given weights are for total demand. For fixtures with both hot and cold water supplies, the weights for maximum separate demands may be taken as three-quarters the listed demand for the supply.

[c] A bathroom group for the purposes of this table consists of not more than one water closet, one lavatory, one bathtub, one shower stall or one water closet, two lavatories, one bathtub or one separate shower stall.

[d] Nominal I.D. pipe size.

[e] Some may require larger sizes—see manufacturer's instructions.

[f] Data extracted from Code Table B.5.2.

Source. Reproduced with permission from The National Standard Plumbing Code, published by The National Association of Plumbing Heating Cooling Contractors.

B-2: Chart of friction head loss in schedule 40

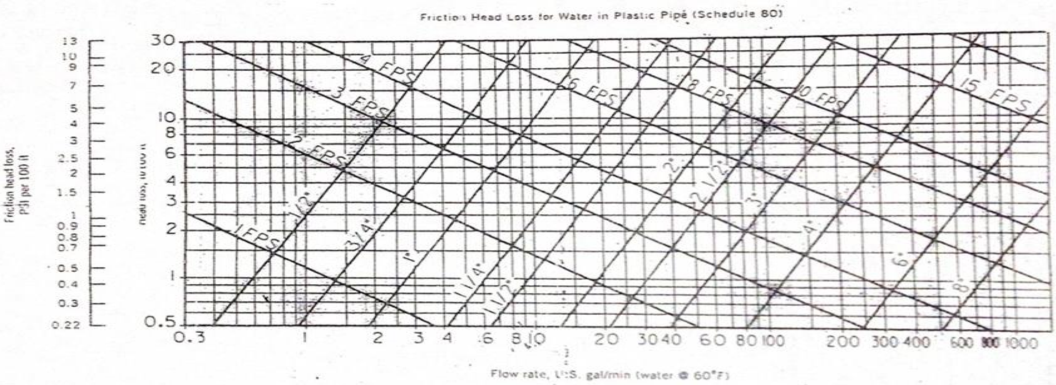

Figure A(4.1) Chart of riction head loss in Schedule 80 plastic pipe for water at 60°F, in feet of water and si per 100 ft of equivalent pipe length. Pipe sizes are nominal. (Reprinted by perm sion of the American Society of Heating, Refrigerating and Air-Conditioning Engin ers, Atlanta, Georgia, from the 1993 *ASHRAE Handbook—Fundamentals.)*

B-3: Minimum pressure required by Typical plumping Fixture

Table A(4.3) Minimum Pressure Required by Typical Plumbing Fixtures

Fixture Type	*Minimum Pressure, psi*
Sink and tub faucets	8
Shower	8
Water closet—tank flush	8
Flush valve—urinal	15
Flush valve—siphon-jet-bowl	
floor-mounted	15
wall-mounted	20
Flush valve—blowout bowl	
floor-mounted	20
wall-mounted	25
Garden hose	
5/8-in. sill cock	15
3/4-in. sill cock	30
Drinking fountain	15

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

B-4: Chart of friction head loss in schedule 40

Table A(4.7) Approximate Discharge Rates and Velocities[a] in Sloping Drains Flowing Half Full[b]

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

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

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

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

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B-5: table of estimating demand

Table A(4.2) Table for Estimating Demand

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

[a] Water Supply fixture units

Source. Reproduced with permission from The Na-
[illegible] Standard Plumbing Code, published by The Na-

B-6: drainage fixture unit valves for various plumbing fixture

TableA(4.4)Drainage Fixture Unit Values for Various Plumbing Fixtures

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

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

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B-7: Horizontal fixtures branches and stacks

Table A(4.5) Horizontal Fixture Branches and Stacks

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

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

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

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

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Table A(4.6) Building Drains and Sewers[a]

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

[a] On site sewers that serve more than one building may be sized according to the current standards and specifications of the Administrative Authority for public sewers.

[b] Not over two water closets or two bathroom groups, except that in single family dwellings, not over three water closets or three bathroom groups may be installed.

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Appendix (C)

C-1: Human comfort

HUMAN COMFORT

Application	Maximum Occupancy Per 100 m²	Ventilation Air Requirements	
		L/s/Person	L/s/m²
Game rooms	70	3.5-17.5	—
Ice arenas	—	—	2.50
Swimming pools	—	—	2.50
Gymnasium floors	30	10.0	
Ballrooms and discos	100	3.5-17.5	—
Bowling alleys	70	3.5-17.5	
Theaters:			
Ticket booths	60	10.0	—
Lobbies	150	10.0	—
Auditorium	150	8.0	—
Stages, studios	70	8.0	—
Transportation:			
Waiting rooms	100	8.0	—
Platforms	100	8.0	—
Vehicles	150	8.0	—
Workrooms:			
Meat processing	10	8.0	—
Photo studios	10	8.0	—
Darkrooms	10	—	2.50
Pharmacy	20	8.0	—
Bank vaults	5	8.0	—
Printing, duplicating rooms	—	—	2.50
Correctional facilities:			
Cells	20	10.0	—

C-2: Human comfort

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

[1] or 0.35 air change/hour [2] or 50 L/s intermittent or openable window.
[3] or 25 L/s intermittent or openable window.

Note: In some cases, exhaust air from one space is used as a supply air to another space

C-3: vrf in door unit Samsung

2-1. Indoor units

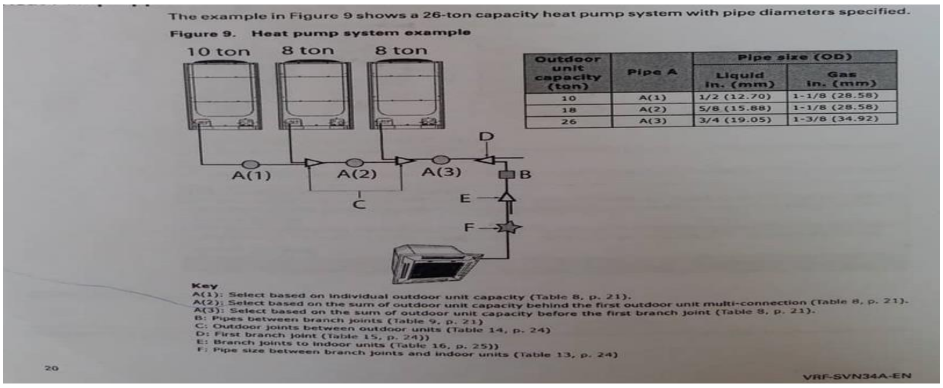
Type	Capacity (kW)												
	2.2	2.8	3.6	4.5	5.6	6.0	7.1	9.0	11.2	12.8	14.0	22.0	28.0
Slim 1 way cassette	●	●	●										
2 way cassette					●		●						
4 way cassette (S)				●	●		●	●	●	●	●		
4 way cassette (600 x 600)	●	●	●	●	●	●							
Slim duct	●	●	●	●	●		●	●	●	●	●		
MSP duct	●	●	●	●	●		●	●	●	●	●		
HSP duct									●	●	●	●	●
Console		●	●		●								
Ceiling					●		●						
Neo Forte	●	●	●		●		●						
Neo Forte (E)	●	●	●	●	●		●						
Floor Standing			●		●		●						

Heat pump Samsung

Heat Pump (Standard)

Model	AM080FXVAGH/EU	AM100FXVAGH/EU	AM120FXVAGH/EU	AM140FXVAGH/EU	AM160FXVAGH/EU	AM180FXVAGH/EU	AM200FXVAGH/EU	AM220FXVAGH/EU	AM240HXVAGH/EU	AM260HXVAGH/EU
AM080FXVAGH/EU	1									
AM100FXVAGH/EU		1								
AM120FXVAGH/EU			1							
AM140FXVAGH/EU				1						
AM160FXVAGH/EU					1					
AM180FXVAGH/EU						1				
AM200FXVAGH/EU							1			
AM220FXVAGH/EU								1		
AM240HXVAGH/EU									1	
AM260HXVAGH/EU										1
AM280HXVAGH1EU			1		1					
AM300HXVAGH1EU			1			1				
AM320HXVAGH1EU			1				1			
AM340HXVAGH1EU			1					1		
AM360HXVAGH1EU				1				1		
AM380HXVAGH1EU					1			1		
AM400HXVAGH1EU				1						1
AM420HXVAGH1EU							1	1		
AM440HXVAGH1EU								2		
AM460HXVAGH1EU			2					1		
AM480HXVAGH1EU			1	1				1		
AM500HXVAGH1EU			1		1			1		
AM520HXVAGH1EU			1			1		1		
AM540HXVAGH1EU			1				1	1		
AM560HXVAGH1EU			1					2		
AM580HXVAGH1EU				1				2		
AM600HXVAGH1EU					1			2		
AM620HXVAGH1EU						1		2		
AM640HXVAGH1EU							1	2		
AM660HXVAGH1EU								3		
AM680HXVAGH1EU			2					2		
AM700HXVAGH1EU			1	1				2		
AM720HXVAGH1EU			1		1			2		
AM740HXVAGH1EU			1			1		2		
AM760HXVAGH1EU			1				1	2		
AM780HXVAGH1EU			1					3		
AM800HXVAGH1EU				1				3		

C-5: Size of pipe A



Outdoor unit capacity (ton)	Pipe A	Pipe size (OD) Liquid in. (mm)	Gas in. (mm)
10	A(1)	1/2 (12.70)	1-1/8 (28.58)
18	A(2)	5/8 (15.88)	1-1/8 (28.58)
26	A(3)	3/4 (19.05)	1-3/8 (34.92)

C-6: Size of pipe F

Table 10. Pipe size between the branch joint and indoor unit (F)

Indoor unit capacity (MBH)	Pipe size (OD)	
	Liquid in. (mm)	Gas in. (mm)
Less than 20	1/4 (6.35)	1/2 (12.70)
24-52	3/8 (9.52)	5/8 (15.88)
68–78	3/8 (9.52)	3/4 (19.05)
78–96	3/8 (9.52)	7/8 (22.22)

C-8: Size of pipe B

Use Table 9 to determine the size of pipes between branch joints. (Refer to B in Figure 13, p. 32.)

Table 9. Pipe size between branch joints (B)

Indoor unit total capacity (MBH)	Branch pipe size (OD) when pipe is < 147.6 ft (45 m)		Branch pipe size (OD) when pipe is 147.6–295.3 ft (45–90 m)	
	Liquid in. (mm)	Gas in. (mm)	Liquid in. (mm)	Gas in. (mm)
Less than 51	3/8 (9.52)	5/8 (15.88)	1/2 (12.70)	3/4 (19.05)
51-75.9	3/8 (9.52)	3/4 (19.05)	1/2 (12.70)	7/8 (22.22)
76-95.9	3/8 (9.52)	7/8 (22.22)	1/2 (12.70)	1 (25.4)[(a)]
96-135.9	1/2 (12.70)	1-1/8 (28.58)	5/8 (15.88)	1-1/8 (28.58)
136-153.9	1/2 (12.70)	1-1/8 (28.58)	5/8 (15.88)	1-1/4 (31.75)[(b)]
154-239.9	5/8 (15.88)	1-1/8 (28.58)	3/4 (19.05)	1-1/4 (31.75)[(b)]
240-335.9	3/4 (19.05)	1-3/8 (34.92)	7/8 (22.22)	1-1/2 (38.1)[(c)]
336–460.9	3/4 (19.05)	1-5/8 (41.28)	7/8 (22.22)	1-5/8 (41.28)
461–577	3/4 (19.05)	1 5/8 (41.28)	7/8 (22.22)	2-1/8 (53.98)

(a) If 1 (25.4) pipe is not available on site, use 1-1/8 (28.58) pipe.
(b) If 1-1/4 (31.75) pipe is not available on site, use 1-3/8 (34.92) pipe.
(c) If 1-1/2 (38.1) pipe is not available on site, use 1-5/8 (41.28) pipe.

C-9: vrf in door unit Samsung

Heat Pump (Standard)

Type				DVM S(NEW)	DVM S(NEW)
Model Name				AM480HXVAGH1EU	AM500HXVAGH1EU
Power Supply			Ø, #, V, Hz	3,4,380-415,50	3,4,380-415,50
Mode			-	HEATPUMP	HEATPUMP
Performance	HP		HP	48.00	50.00
	Capacity (Nominal)	Cooling	kW	135.20	140.20
			Btu/h	461,300	478,400
		Heating	kW	152.10	157.50
			Btu/h	519,000	537,400
Power	Power Input (Nominal)	Cooling 1)	kW	34.65	36.75
		Heating 2)	kW	34.90	36.90
	Current Input (Nominal)	Cooling 1)	A	55.60	58.90
		Heating 2)	A	56.00	59.20
	MCA		A	118.20	126.90
	MFA		A	125.00	125.00
COP	EER (Nominal Cooling)		-	3.90	3.81
	COP (Nominal Heating)		-	4.36	4.27
	Energy Grade		-	ESEER 6.77	ESEER 6.69
			-	-	-
Compressor	Type		-	BBC Scroll x 4	BBC Scroll x 5
	Output		kW x n	(6.39) + (6.39) +	(6.39) + (4.96x2) +
	Model Name		-	DB-GB066FAVBBGx4	DB-GB066FAVBBGx3 + DB-GB052FAVABGx2
	Oil	Type	-	PVE	PVE
Fan	Type		-	Propeller	Propeller
	Output x n		W	(400.0) + (620.0x2) +	(400.0) + (620.0x2) +
	Air Flow Rate		CMM	220.0 + 255.0 + 290.0	220.0 + 255.0 + 290.0
			l/s	3,666.7 + 4,250.0 +	3,666.7 + 4,250.0 +
	External Static Pressure	Max.	mmAQ	8.00	8.00
			Pa	78.40	78.40
Piping Connections	Liquid Pipe		Ø, mm	19.05	19.05
			Ø, inch	3/4"	3/4"
	Gas Pipe		Ø, mm	41.28	41.28
			Ø, inch	1 5/8"	1 5/8"
	Discharge Gas Pipe		Ø, mm	-	-
			Ø, inch	-	-
	Installation Limitation	Max. Length	m	200 (220)	200 (220)
		Max. Height	m	110 (40)	110 (40)
Field Wiring	Power Source Wire		mm²	-	-
	Transmission Cable		mm²	0.75 ~ 1.50	0.75 ~ 1.50
Refrigerant	Type		-	R410A(GWP >150)	R410A(GWP >150)
	Factory Charging		kg	21.60	21.30
Sound	Pressure		dBA	68.00	68.00
	Power			89.00	89.00
External Dimension	Net Weight		kg	(190.0) + (235.0) +	(190.0) + (278.0) +
	Shipping Weight		kg	(206.0) + (254.0) +	(206.0) + (297.0) +
	Net Dimensions (WxHxD)		mm	(880x1,695x765) + (1,295x1,695x765) +	(880x1,695x765) + (1,295x1,695x765) +
	Shipping Dimensions (WxHxD)		mm	(948x1,887x832) + (1,363x1,887x832) +	(948x1,887x832) + (1,363x1,887x832) +
Operating	Cooling		°C	-5.0 ~ 48.0	-5.0 ~ 48.0

Itom NO	DISCRIPTION	Unit	Quality	Price/ Unit
1	**VRF**			
1.1	**Indoor Units**			
1.1.1	Ceiling VRF indoor units. Price includes all required electrical and gas connections, and operating perfectly. Price includes hangers, isolating valves, and electrical connection to power source. All connections and installation should be executed according to manufacturer instructions. Selection to be based on medium speed, external air pressure of 0.25 ", indoor temperature of 24 C and outdoor temperature of 30 C (summer) 4.7 C (winter)			
1.1.1.1	nominal capacity 5.6	**NO.**	20	
1.1.1.2	nominal capacity 4.1		3	
1.1.2	4-way cassette VRF indoor units. Price includes all required electrical and gas connections, and operating perfectly. Price includes hangers, isolating valves, and electrical connection to power source. All connections and installation should be executed according to manufacturer instructions. Selection to be based on medium speed, external air pressure of 0.25 ", indoor temperature of 24 C and outdoor temperature of 31.9 C (summer) 5.7 C (winter)			
1.1.2.1	nominal capacity 9	**NO.**	4	
1.1.٢.٢	nominal capacity 11.2	**NO.**	5	
1.1.٢.٣	nominal capacity 12.8	**NO.**	6	
1.2	**Out Door**			
1.2.1	AM120FXVA GH/EU	**NO.**	٢	
1.2.2	AM120FXVA GH/EU	**NO.**	٢	
1.2.3	AM120FXVA GH/EU	**NO.**	٢	
1.3	**Piping network**			
	Supply and install drain and insulated copper pipes for refrigerant 410 between indoor units and outdoor unit with sizes according to manufacturer instructions and calculations. Price includes all required fittings, hanging, insulation and digging.			
1.3.2	9.52mm	m	102	
1.3.3	12.7mm	m	132	

1.3.4	15.88mm	m	200	
1.3.5	19.05mm	m	157	
1.3.6	22.22mm	m	113	
1.3.7	28.58mm	m	130	
1.3.8	34.92mm	m	65	
1.3.9	41.28mm	m	47	
1.4	**Accessories**			
1.4.1	Refnet Joint	No.	٣٨	
1.4.2	Refrigerant Amount (R410 A)	Kg	١٦٠	
2	**VENTLATION**			
	Centrifugal Exhaust Fans set (one duty and one stand-by), complete as per drawings and specifications.			
2.1	100 cfm 0.8bar	No.	1	
2.2	200 cfm 0.8 bar	No.	6	
2.3	400 cfm 0.8 bar	No.	4	
3	**Water System**			
3.1	**Pumps**			
	Supply, install, test & commission water pump set including motor, interconnecting pipe work, complete with all valves, vents, manifolds, gauges, control panel, level switches, pressure vessel & frequency inverter etc., as per specifications and drawings. 4.2 bar and 78 gpm for cold water 4.2 bar and 51 gpm for hot water			
3.1.1	**L.P.** (Lifting pumps set /2 pumps)	SET	1	
3.1.2	**C.W.P.-1** (Set/2 booster pump) with	SET	1	
3.1.6	**H.W.P** (Set/2 (Directly feeds floors with hot water)	SET	1	
3.2	**Pipes**			
3.2.1	Galvanized steel pipes to BS1387 of various sizes for domestic cold and hot water above false ceiling, in walls, etc. Including fittings, supports, expansion loops, thermal insulation cladding of all external and trenches pipes.			
3.2.1.1	20 mm dia pipe (3/4")	m	٢٥	

3.2.1.2	25 mm dia pipe (1")	m	36.16	
3.2.1.3	32 mm dia pipe (11/4")	m	34.56	
3.2.1.4	40 mm dia pipe (1 1/2")	m	70	
3.2.1.5	50 mm dia pipe (2")	m	64.35	
3.2.1.6	65 mm dia pipe (2 1/2")	m	24	
3.2.2	Pex pipes to BS1387 of various sizes for domestic cold and hot water above false ceiling, in walls, etc. Including fittings, supports, expansion loops, thermal insulation cladding of all external and trenches pipes.	ML	320	
3.2.2.1	16 mm dia pipe	m	580	
3.3	**Water Manifolds**			
	Supply, install, test and commission wall hung type steel hot and cold water copper manifolds 16 mm dia outlets. The unit price shall include plug and washer, adaptors with O- rings, brackets, drain cocks, isolating ball valves with T-handle on all outlets, automatic air vent on each manifold, and all accessories and works required to complete the work as shown in the drawings and engineers' instructions.			
3.3.1	25 mm dia collector, 8 outlets (average)	No.	51	
4	**Firefighting System**			
4.1	Fire hose reel cabinet (double compartment) including isolating valve with SS304 fully recessed cabinet, 19 mm dia x ٢٥ m rubber hose, ABC 6 kg powder extinguisher and 4.5 kg CO_2 extinguisher.	No.	9	
4.2	Black seamless steel pipe.			
4.2.1	25mm dia pipe (1")	ML	530	
4.2.2	31.25 mm dia pipe (1 1/4")	ML	440	
4.2.3	37.5 mm dia pipe (1 1/2")	ML	210	
4.2.4	mm dia pipe (2")	ML	140	
4.2.5	mm dia pipe(2.5")	ML	90	
2.4.6	mm dia pipe(3")	ML	55	
2.4.7	mm dia pipe(4")	ML	40	
4.3	**Pumps**			

	Supply, install, test and commission fire pumps set, complete with all components including duty pump, split case (electric driven), emergency pump (diesel), jockey pump, centrifugal (electric driven). Price shall include electric control panels, pressurized tank, cork and foundation bed, controllers, accessories for all pumps including wiring connections, all components, water measuring devices including flow meter and sensor, pressure gauges, relief valves, gate valves, check valves etc., all electrical works needed to complete the work according to engineer's instructions. 552 gpm and 7.7 bar			
4.3.1	Electrical pump :552 **gpm, 7.7 bar**	No.	1	
4.3.2	Diesel pump : 552**gpm, 7.7 bar**	No.	1	
4.3.٣	Jockey pump 180 gpm, 2.5 bar	No.	1	
4.4	**Fire Extinguisher**			
4.5	K-type dry powder fire extinguishers.	No.	18	
4.6	CO_2 fire extinguishers.	No.	4	
4.7	Self-automatic extinguisher.	No.	6	
4.8	Siamese connection assembly complete with non-return valves. Outlet of 100m dia, and inlet of 65mm dia.	No.	1	
4.9	Supply and install landing valve, complete with fire hose rack.	No.	10	
4.10	Supply and install clean agent system with all accessories such as valves, control, nozzles, etc. All complete as per detailed specifications and drawings.	Set	18	
4.11	Supply and install Fire hydrant, pedestal type and maintain stand spot fitted with 75mm twin faced flanged fire hydrant, complete with isolating valve, an automatic shut-off valve, complete with all necessary mechanical fittings.	No.	9	
4.12	Supply and install Fire hydrant Cabinet, complete with all needed equipment's.,	No.	9	
4.13	Supply, lift into position, install, test, set to work, and commission sprinkler head as following and as per drawings Sprinkler head pendent recessed centre link type, Part No. 13577W/B (½ Inch)٥٦ diameter - ORIFICE 15 mm (½ Inch) NPT male connection bronze finish UL/FM approved.	No.	190	
4.14	Supply and install fire system for kitchen consists of 6 nozzles, heat detector sense fire and activate the wet chemical cylinder and wet chemical cylinders all according to drawings and specifications.	Set	1	
5	**Drainage System**			
5.2	**Water Closets**			

5.2.1	Supply install and test European water closet, heavy duty seat and cover, connection to treated cold water supply and drainage network and all fittings and works required to complete the work as per drawings and as per engineer's instructions. Price shall include hand spray hose (connected to domestic cold water), holding paper, and paper basket.	No.	46	
5.3	**Shower Tray**			
5.3.1	Supply installs and test shower tray (80cmx80cm) White Vitreous China connected to domestic cold and hot water supply and drainage network and all fittings and works required to complete the work as per drawings and as per engineer's instructions. Price shall include chrome plated shower mixer, chrome plated hand shower completes with flexible hose 150 cm long and chrome plated shower hanger, Pax pipes, 2" and 4" UPVC pipes needed to connect the tray to the nearest main drainage and supply it with water, Single robe/clothes hook with concealed mounting type	No.	41	
5.4	**Kitchen Sinks**			
5.4.1	Supply and install stainless steel single bowl kitchenette sink 60x50 cm, complete with faucet with mixer connection to domestic cold and hot water supply and drainage network and all fittings and works required to complete the work as per drawings, specifications and as per engineer's instructions.	No.	4	
5.5	**Lavatory**			
5.5.1	Supply and install laboratory model sink 46x46 cm made of anti-corrosion polypropylene with high resistance to acids, alkaline and base chemicals. Price shall include incorporated overflow, complete with threaded drainpipe, made as a single piece without joints. All according to drawings and specifications and as per engineer's instructions	No.	50	
5.6	**UPVC Pipes**			
	Supply, install, and test UPVC pipes and fittings for waste, soil, and rain water drainage services. Price includes all kinds of digging in concrete slabs and walls, supports, hangers and all rubber joints and sealants, syphon and connection to floor drain and flexible connections and all types of fittings. All done according to drawings, specifications and engineer's instructions.			
5.6.1	110 mm dia. (4")	m	330	
5.6.2	150 mm dia. (6")	m	38	
5.6.3	200 mm dia (8")	m	10	
5.6.4	50 mm dia. (2")	m	285	
5.7	**Floor Drains**			
	Supply, install, and test Floor drain 4" threaded 15x15cm chrome plated cover multi-inlet adjustable with trap. All complete with			

	floor clean out plug, HDPE syphon and all types of fittings. The rate shall include excavation and backfilling for all connections with drain pipes and fixtures. All done according to drawings, specifications. Floor Drain, Floor Trap & Floor Gully			
5.7.1	***FT-HDPE*** and with chromium plated cover, mesh and all accessories needed	No.	58	
5.7.2	***FD-HDPE*** and with chromium plated cover, mesh and all accessories needed	No.	44	
5.8	**Floor Cleanouts**			
	Supply, install, and test heavy duty nonadjustable 11x11 cm floor clean out with HDPE body, with gas and water tight ABS plug and frame, complete with all needed elbow and all types of fittings, all done according to drawings, specifications and the approval of the engineer.			
5.8.1	***FLOOR C.O HDPE*** with chromium plated cover, mesh and all accessories needed.		49	
5.9	**Roof Drains**			
	Supply installs and test (HDPE) Roof rain water drain size 4" with cover of 20x20 plastic mesh to be connected to rain water vertical pipes with all required fittings, price shall include the piping works until the connection to the vertical rain pipe, all done according to drawings, specifications and the approval of the Engineer. Roof drain HDPE with cover (RD)			
5.9.1	50 mm dia. (2")	No.	2	
5.9.2	100 mm dia. (3")	No.	2	
5.10	**Roof Vent**			
	Supply and install (HDPE) Roof vent with screened cap for vent stacks including connection to the vent pipe by solvent welding. The rate includes all needed connection accessories, all done according to drawings, specifications and the approval of the Engineer. Roof vent cap HDPE			
5.10.1	100 mm dia. (4")	m	53	
5.11	**Manholes**			
	Supply install and test precast concrete manholes of 15 cm thickness for walls and bottom slab with C.I. cover (medium cover) and frame all necessary excavation, blinding of 15cm thickness, back filling as specified to the required depth complete with iron steps, benching and plastering as shown in drawing and in accordance to specification, drawings, and approval of supervisor engineer. With C.I. cover (medium cover) and frame, iron steps as detailed on the drawings.			
5.11.1	Depth 60 cm - 80 cm Dia 60 cm	No.	1	
5.11.2	Depth 80 cm - 140cm. Dia 80 cm	No.	1	

5.11.3	Depth 140 cm - 250 cm. Dia 100 cm	No.	2	
5.11.4	Depth 250 cm - ∞ cm, Dia 120 cm	No.	5	

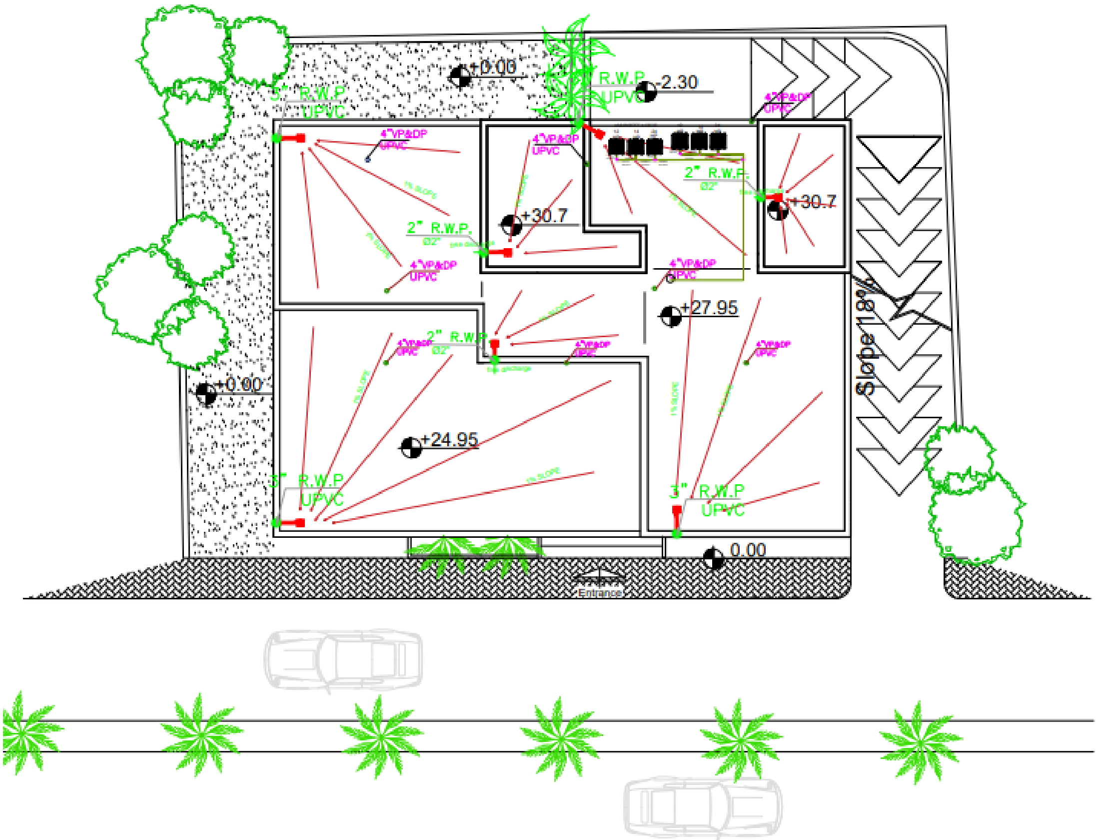
Appendix (D

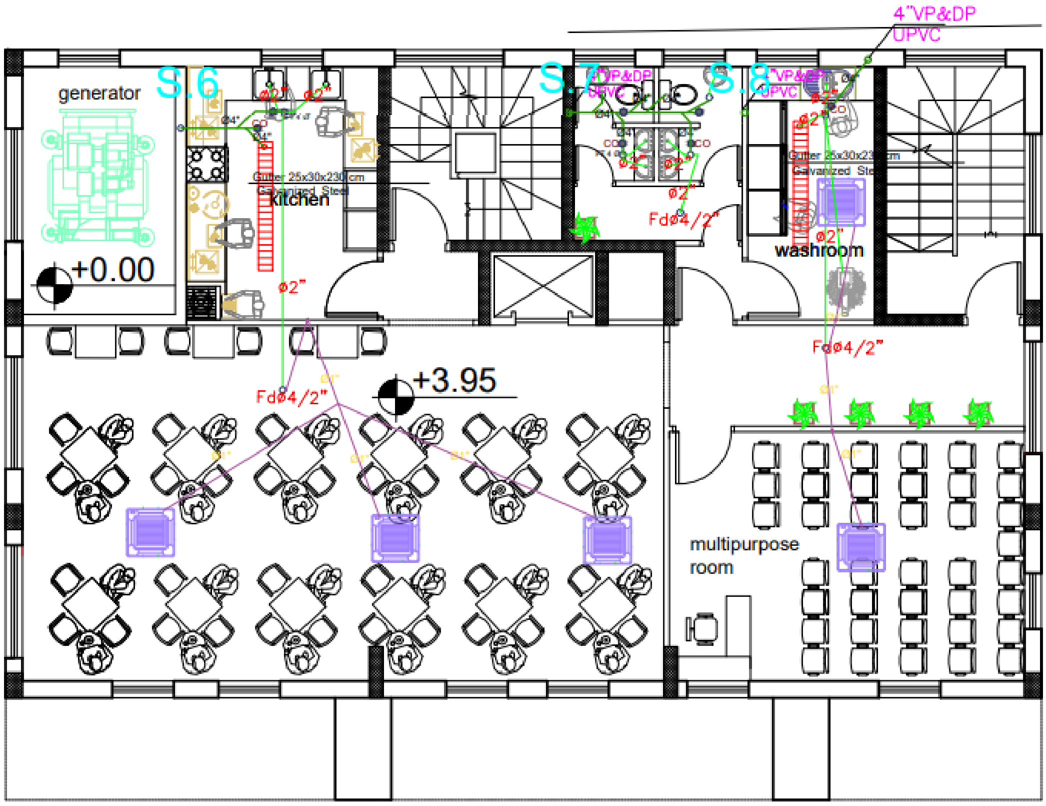
Mechanical Plan by Revit

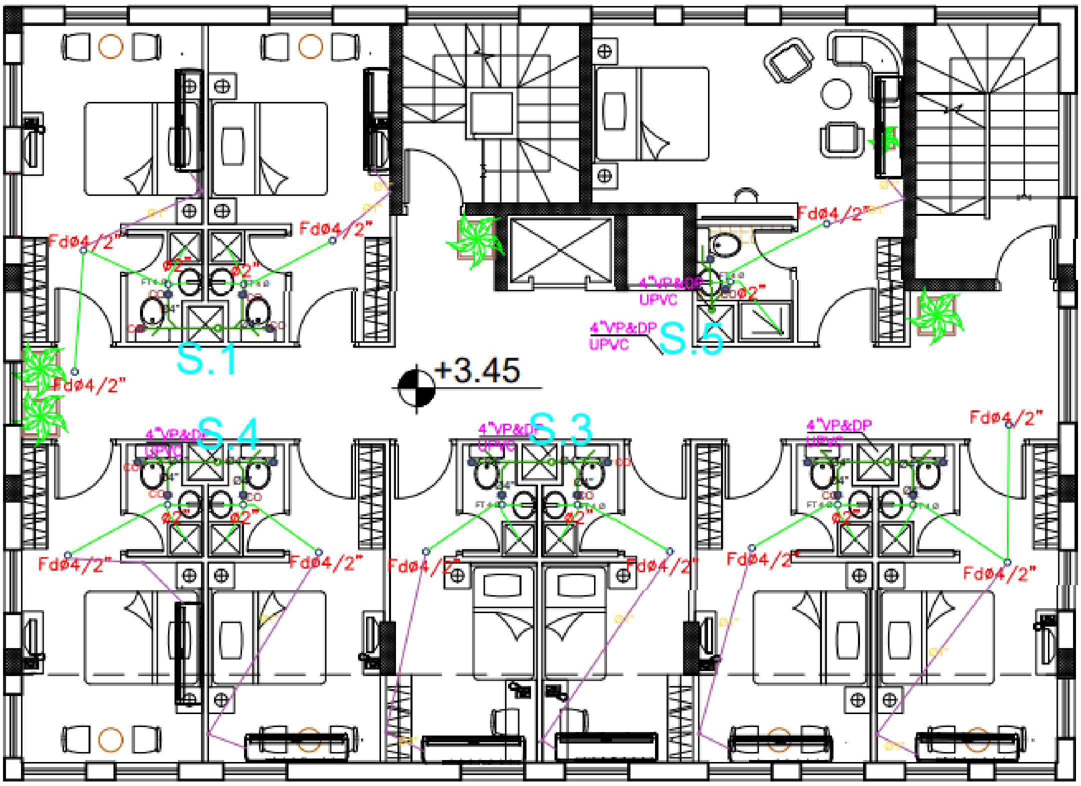
DWG.NO.	DWG.TITEL	SCALE
M00	LIST OF DRAWING	NTS
M01	SYMBOL AND ABBREVIATION	NTS
M02	SITE PLAN _MECHANICAL WORKS	1/150
M03	DRAINAGE LAYOUT FOR GROUND FLOOR	1/100
M04	DRAINAGE LAYOUT FOR FIRST FLOOR	1/100
M05	DRAINAGE LAYOUT FOR SECOND,THRID,Fourth AND FIFTH FLOOR	1/100
M06	DRAINAGE LAYOUT FOR SIXTH FLOOR	1/100
M07	DRAINAGE FOR ROOF WATER LAYOUT	1/100
M08	WATER DISTRIBUTION PLAN FOR GROUND FLOOR	1/100
M9	WATER DISTRIBUTION PLAN FRO FIRSIT FLOOR	1/100
M10	WATER DISTRIBUTION PLAN FOR SECOND,THRID,Fourth AND FIFTH FLOOR	1/100
M11	WATER DISTRIBUTION PLAN FOR SIXTH FLOOR	1/100
M12	WATER DISTRIBUTION PLAN FOR BACEMENT -1	1/100
M13	WATER DISTRIBUTION PLAN FOR BACEMENT -2	1/100
M14	VRF INDOR UNITS FOR GROUND FLOOR	1/100
M15	VRF INDOR UNITS FOR FIRST FLOOR	1/100
M16	VRF INDOR UNITS FOR SECOND,THRID,Fourth AND FIFTH FLOOR	1/100
M17	VRF INDOR UNITS FOR SIXTH FLOOR	1/100
M18	FIRE FIGHTING FOR GROUND FLOOR	1/100
M19	FIRE FIGHTING FOR FIRST FLOOR	1/100
M20	FIRE FIGHTING FORSECOND,THRID,Fourth AND FIFTH FLOOR	1/100
M21	FIRE FIGHTING FOR SIXTH FLOOR	1/100
M22	FIRE FIGHTING FOR BASEMENT -1 FLOOR	1/100
M23	FIRE FIGHTING FOR BASEMENT -2 FLOOR	1/100
M24	VENTILATION FOR GROUND FLOOR	1/100
M25	VENTILATION FOR FIRST FLOOR	1/100
M26	VENTILATION FOR SECOND,THRID,Fourth AND FIFTH FLOOR	1/100
M27	VENTILATION FOR SIXTH FLOOR	1/100
M28	VENTILATION FOR BASEMENT -1 FLOOR	1/100
M29	VENTILATION FORBASEMENT -2 FLOOR	1/100
M30	DRAINAGE DETAILES	1/100
M31	FIREFIGHTING DETAILES	1/100
M32	DETAILES OF BOILER	1/100
M33	Mechanical Details	1/100

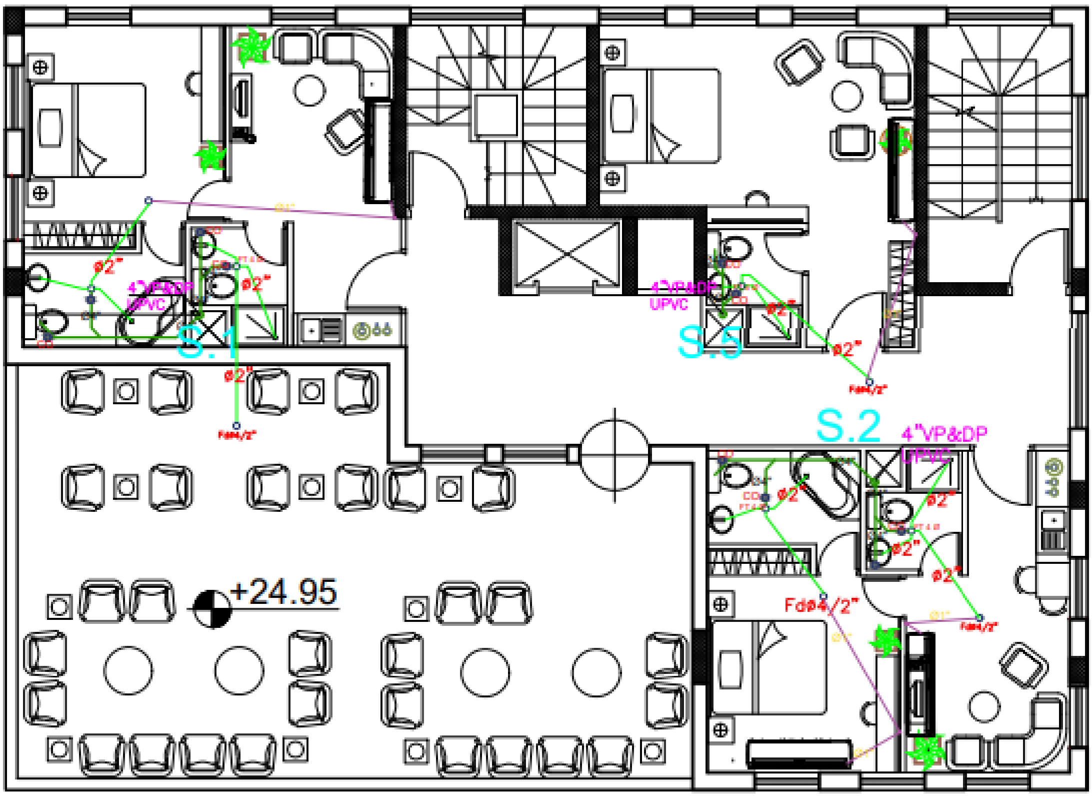
ABBR	DESIGNATION
	WATER MANHOLE
	GAS PIPE
	HOT WATER
	COLD WATER
	FLOOR TARP
	FLOOR DRAIN
	CLEAN OUT
	WATER COLLECTOR
	HOT AND COLD RISER
	SPLIT UNIT
	CASSETTE UNIT
	SEPARATION TUBE
	6 Kg POWDER FIRE EXTINGUISHER
	FIRE PIPE
	4.5 Kg CO2 FIRE EXTINGUISHER
	GAS CABINET
	GATE VALVE
	NON RETURN VALVE
	WATER COLLECTOR
CW	COLD WATER
HW	HOT WATER

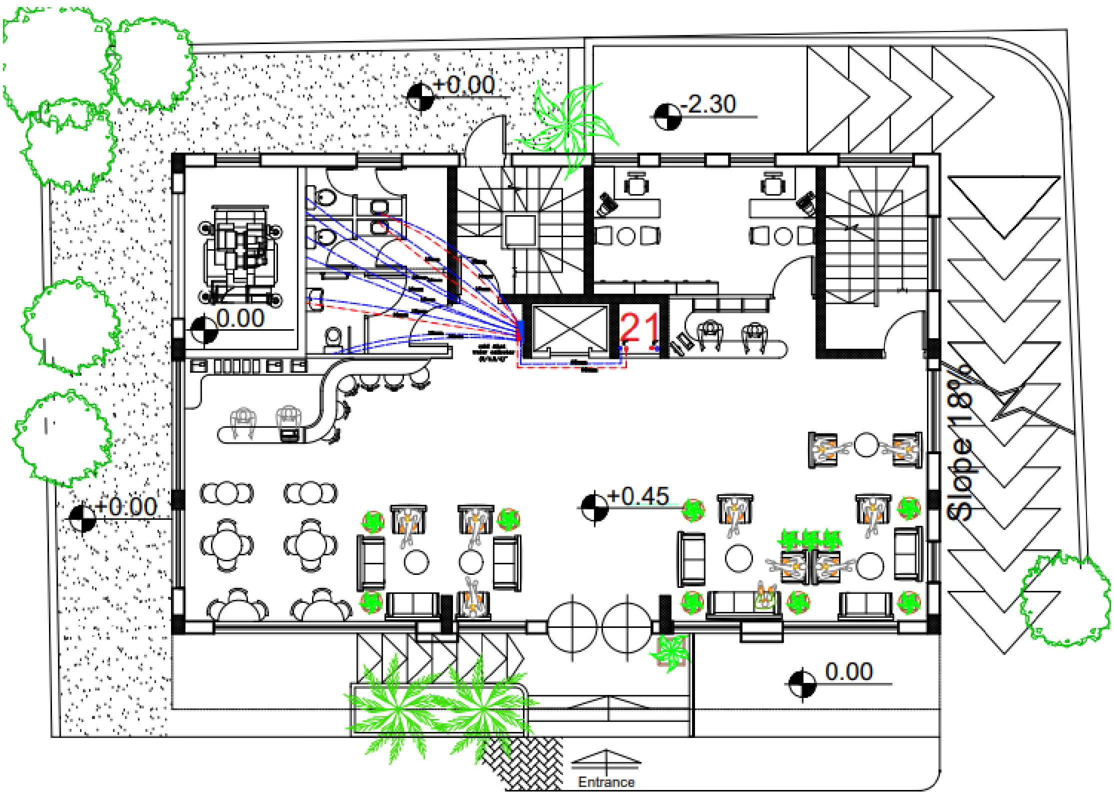
SYMBOL	DESIGNATION
	PUMP CONNECTION
	GATE VALVE
	STRAINER VALVE
	CABINET DETAILES
R.W.P	RAIN WATER PIPE
	PRESSURE RELIEF VALVE
	REGULATING (GLOBE) VALVE
	FLIXABLE CONNECTION
	BOILER
	PUMP
	AIR VENT
TB	TO BELLOW
V.P	VENT PIPE
	HEADER
	REFRIGERANT PIPE
	EXHAUST FAN
	KITCHEN HOOD
	VRF PIPE
	Ø2" UPVC PIPE
	Ø4" UPVC PIPE

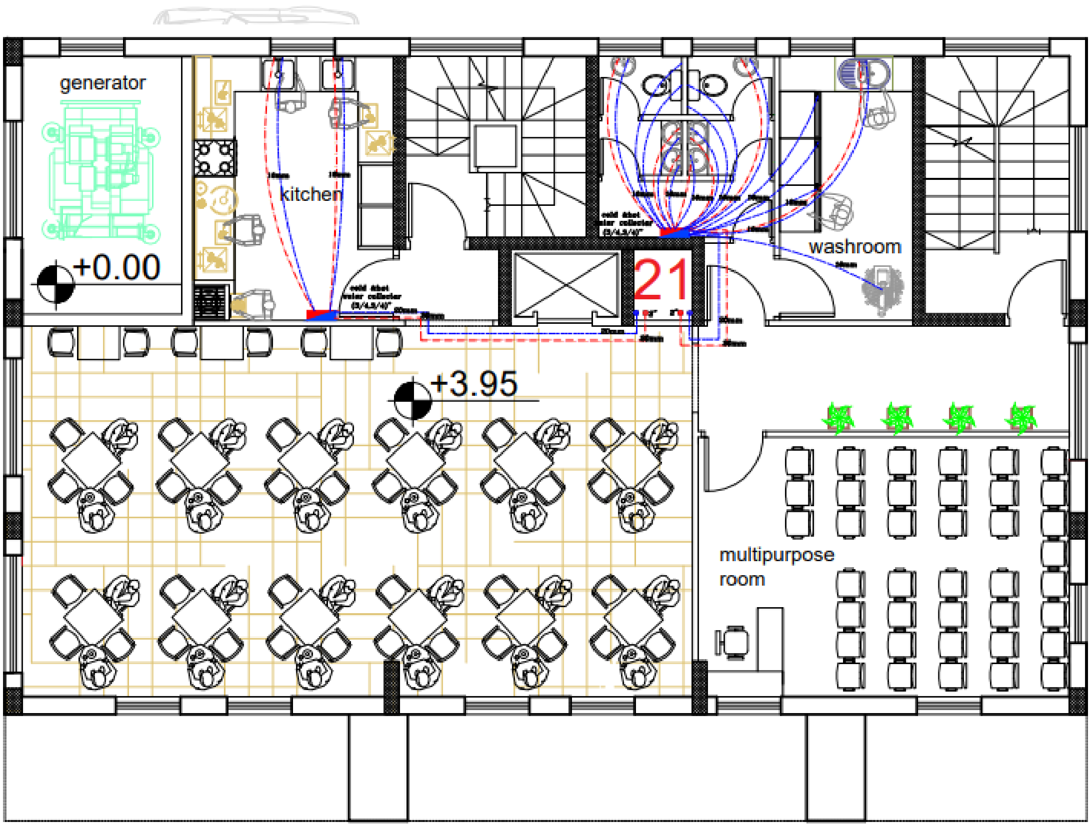

+0.00
R.W.P
UPVC
-2.30
4"VP&DP
UPVC
2" R.W.P
+30.7
+27.95
+24.95
3" R.W.P
UPVC
Slope 18%
0.00
Entrance

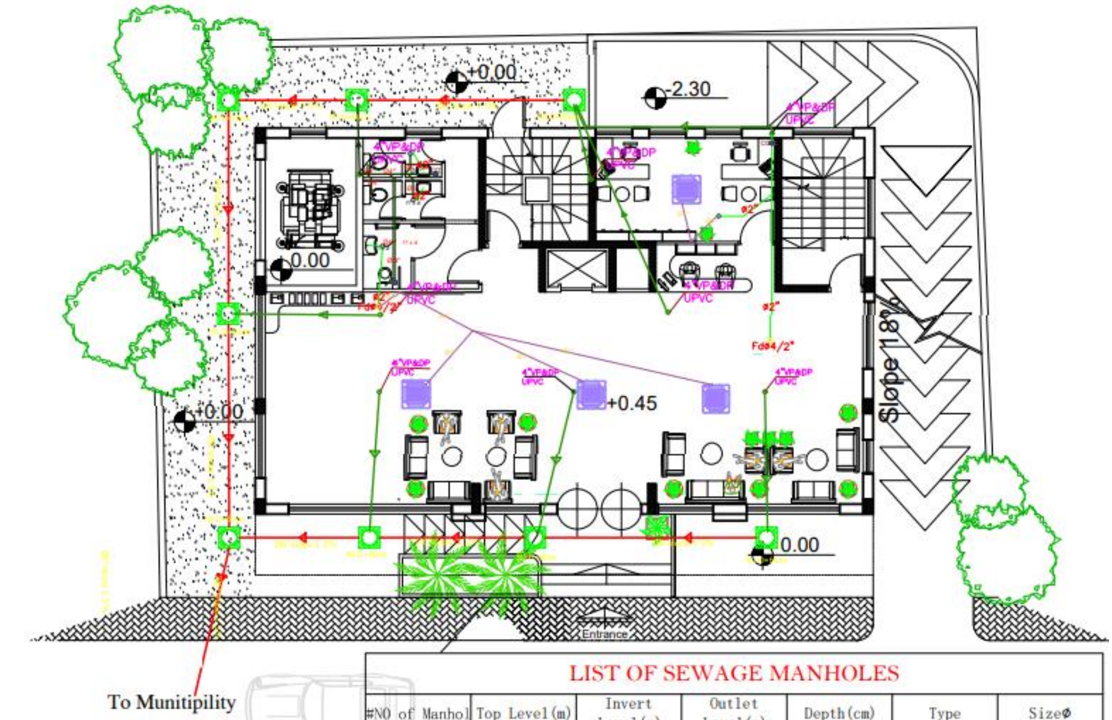

4"VP&DP
UPVC
generator
S.6
S.7
S.8
kitchen
washroom
+0.00
+3.95
Fdø4/2"
ø2"
multipurpose
room


S.1
S.5
S.4
S.3
+3.45
Fdø4/2"
ø2"
4"VP&DP
UPVC


S.1
S.5
S.2
+24.95
Fdø4/2"
ø2"
4"VP&DP
UPVC

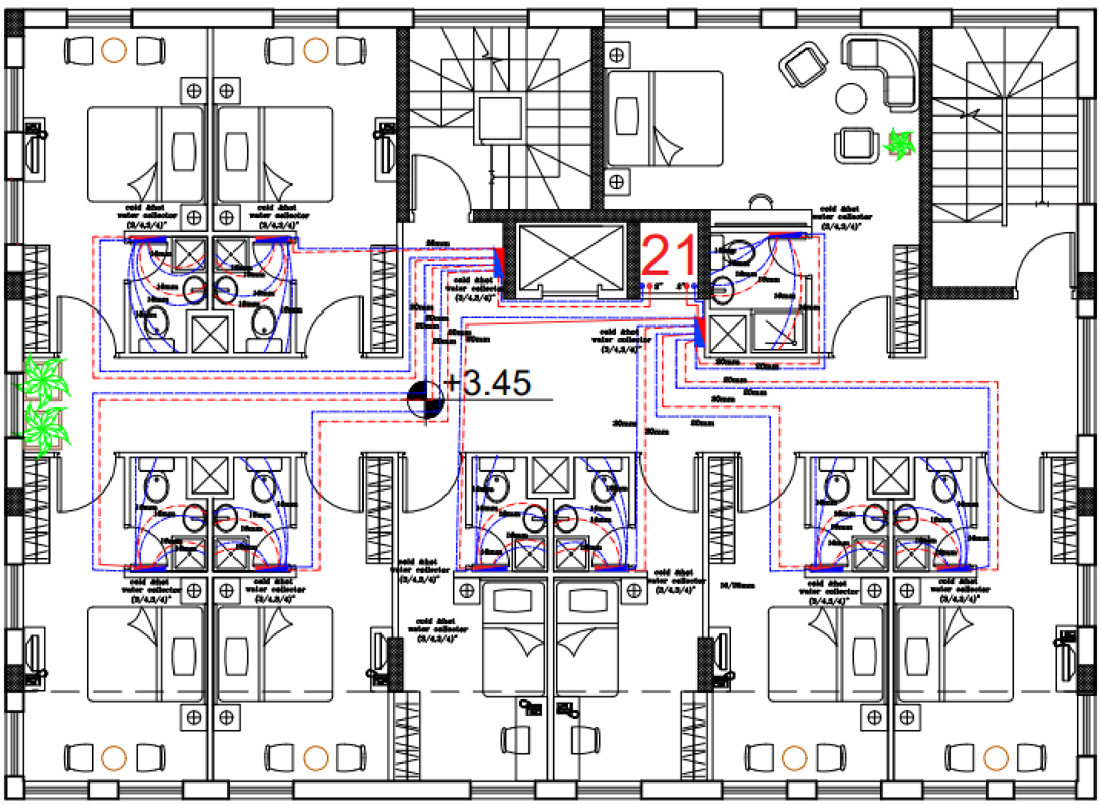

+0.00
-2.30
0.00
21
Slope 18%
+0.00
+0.45
0.00
Entrance

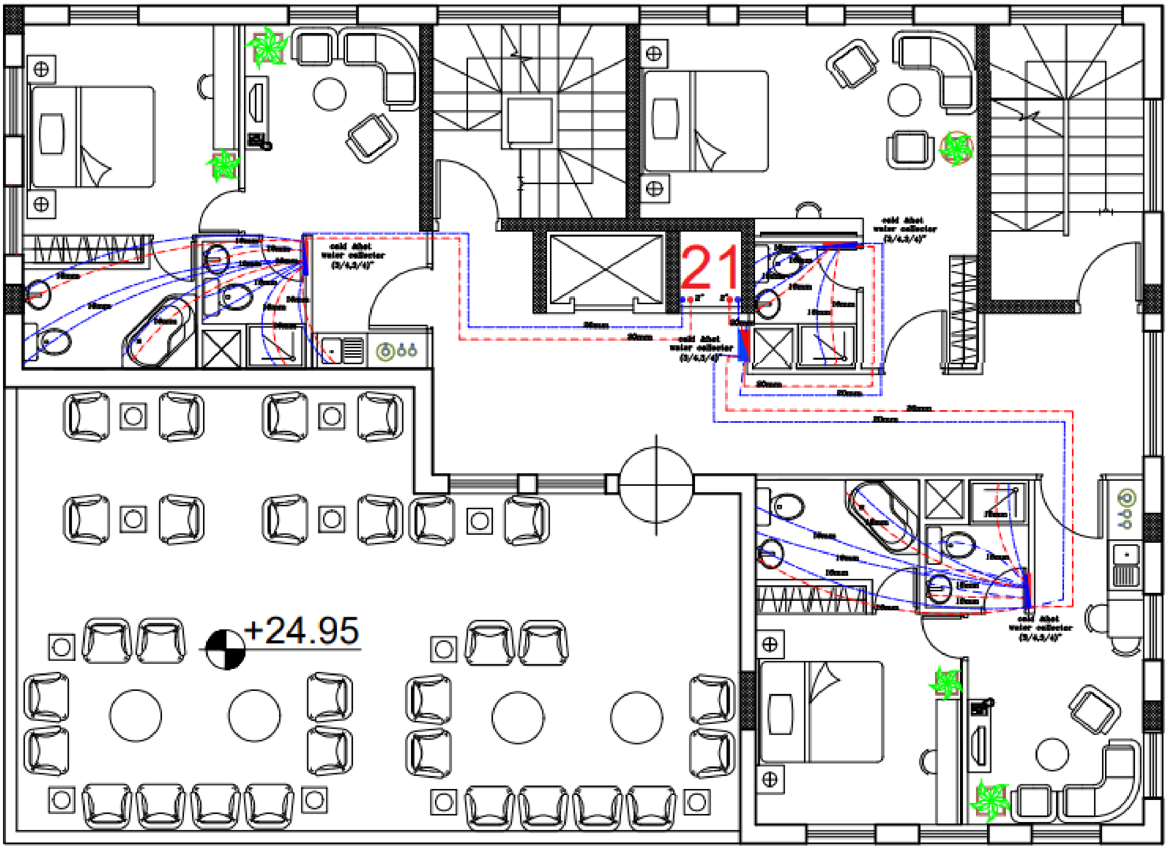

generator
+0.00
kitchen
21
washroom
+3.95
multipurpose
room

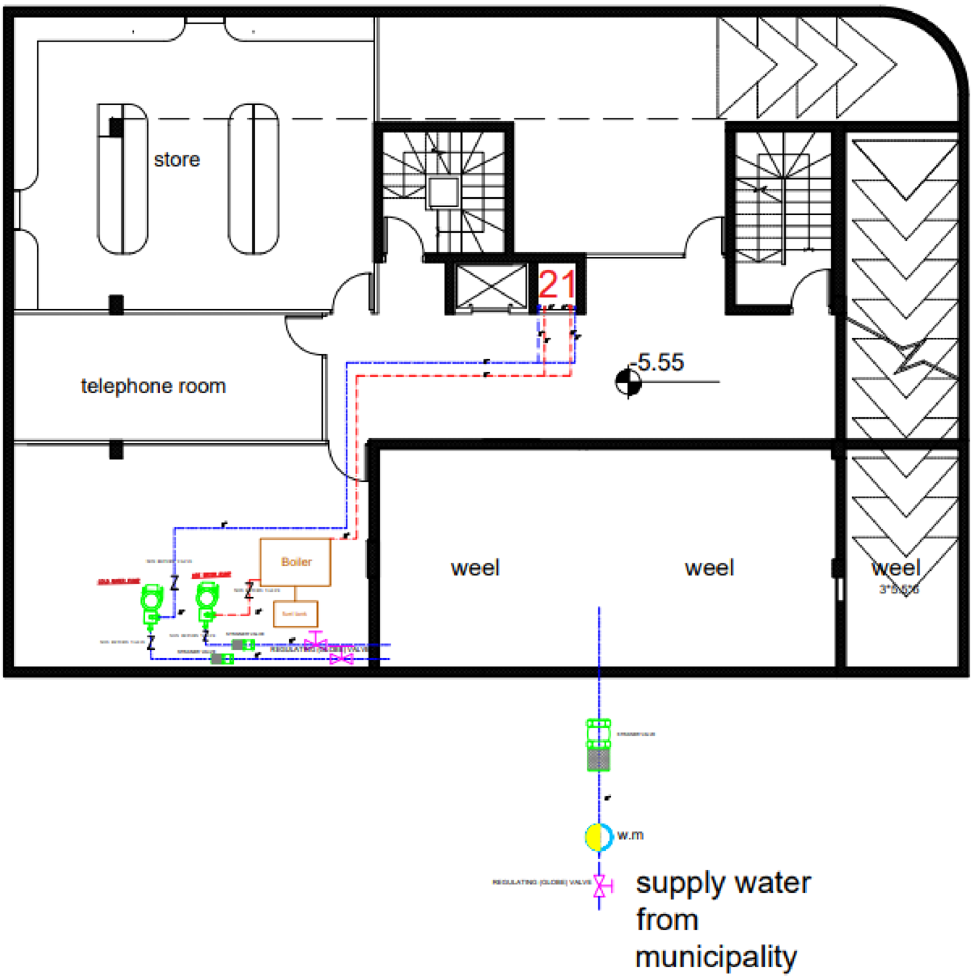


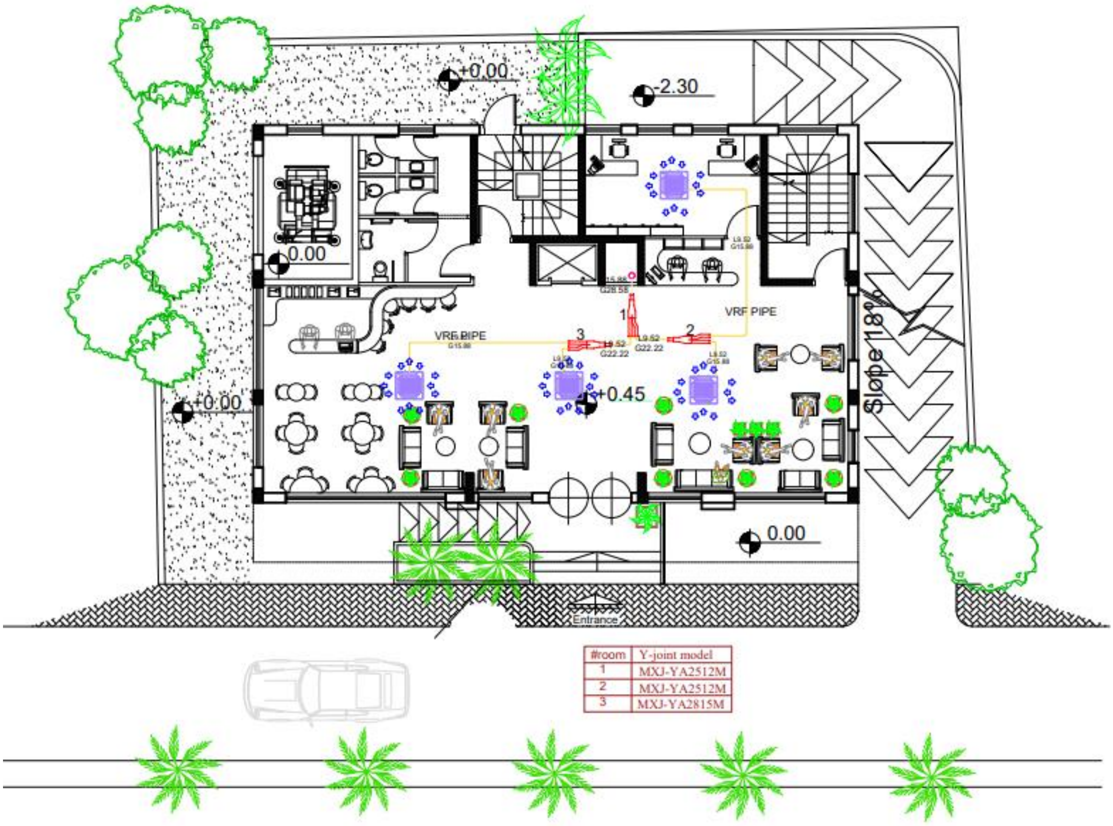
LIST OF SEWAGE MANHOLES

#NO of Manhol	Top Level (m)	Invert Level (m)	Outlet Level (m)	Depth (cm)	Type	Size∅
M.H1	750	749.90	749.85	60	Circular 8ton	60cm
M.H2	750	749.75	749.70	75	Circular 8ton	60cm
M.H3	750	749.60	749.55	90	Circular 8ton	60cm
M.H4	750	749.22	749.15	120	Circular 8ton	60cm
M.H5	750	749.44	749.40	105	Circular 8ton	60cm
M.H6	750	749.60	749.55	90	Circular 8ton	60cm
M.H7	750	749.75	749.70	75	Circular 8ton	60cm
M.H8	750	749.90	749.85	60	Circular 8ton	60cm

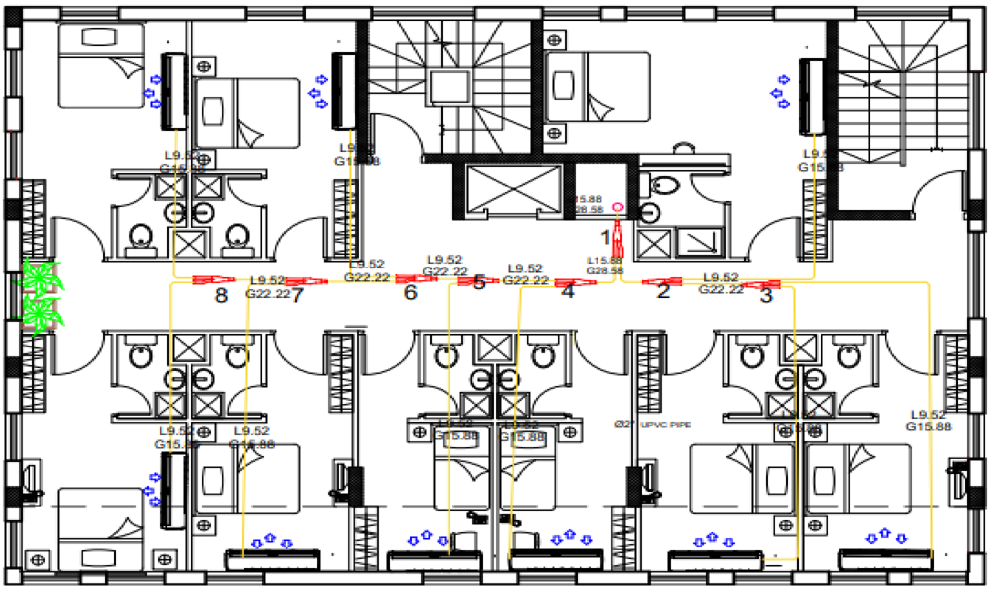



21
+24.95


store
telephone room
21
5.55
Boiler
weel
weel
weel
w.m
supply water
from
municipality

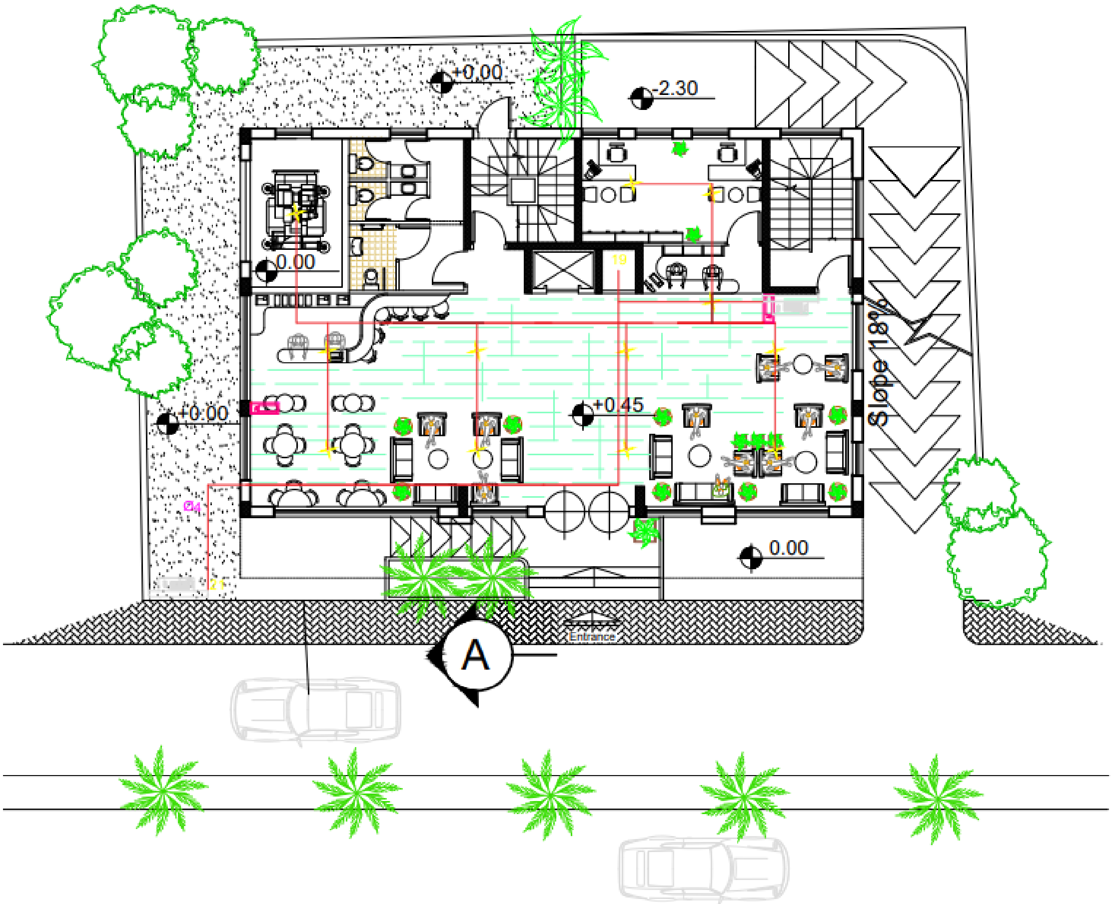


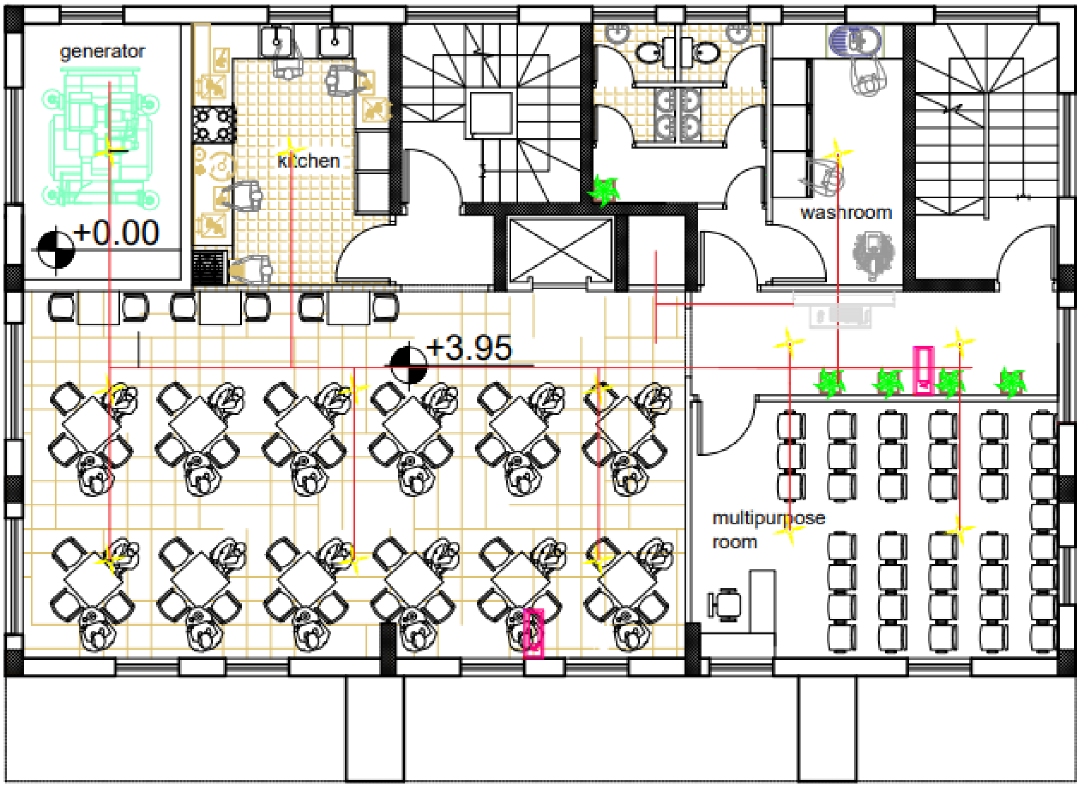
#room	Y-joint model
1	MXJ-YA2512M
2	MXJ-YA2512M
3	MXJ-YA2815M

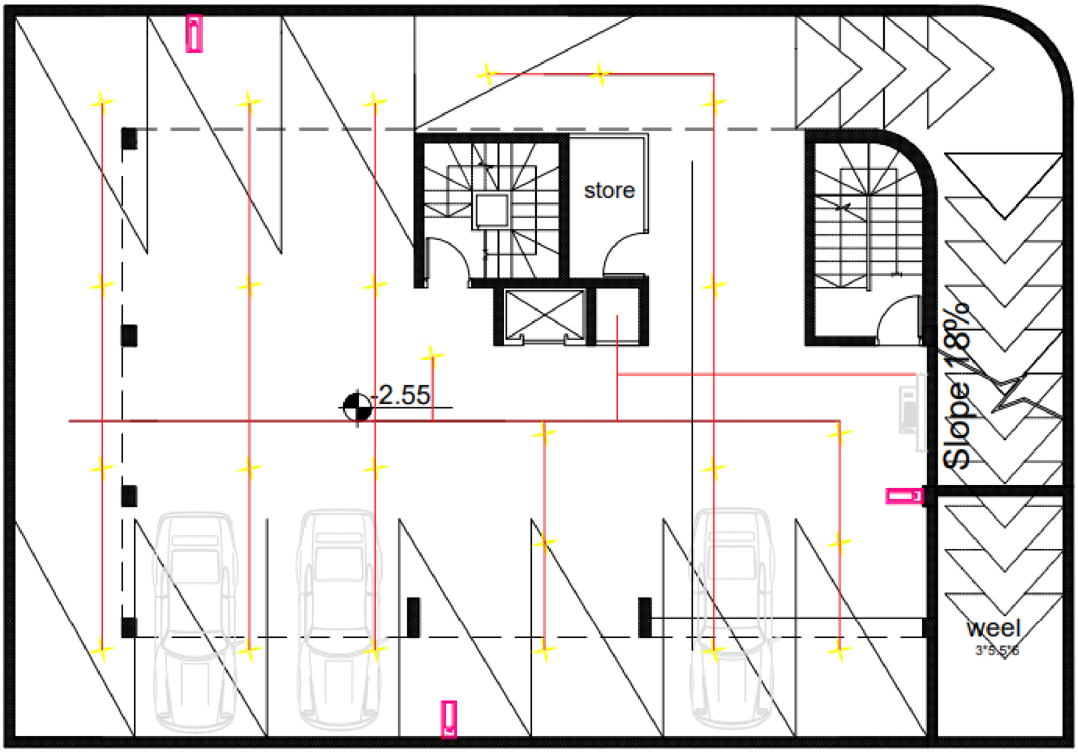


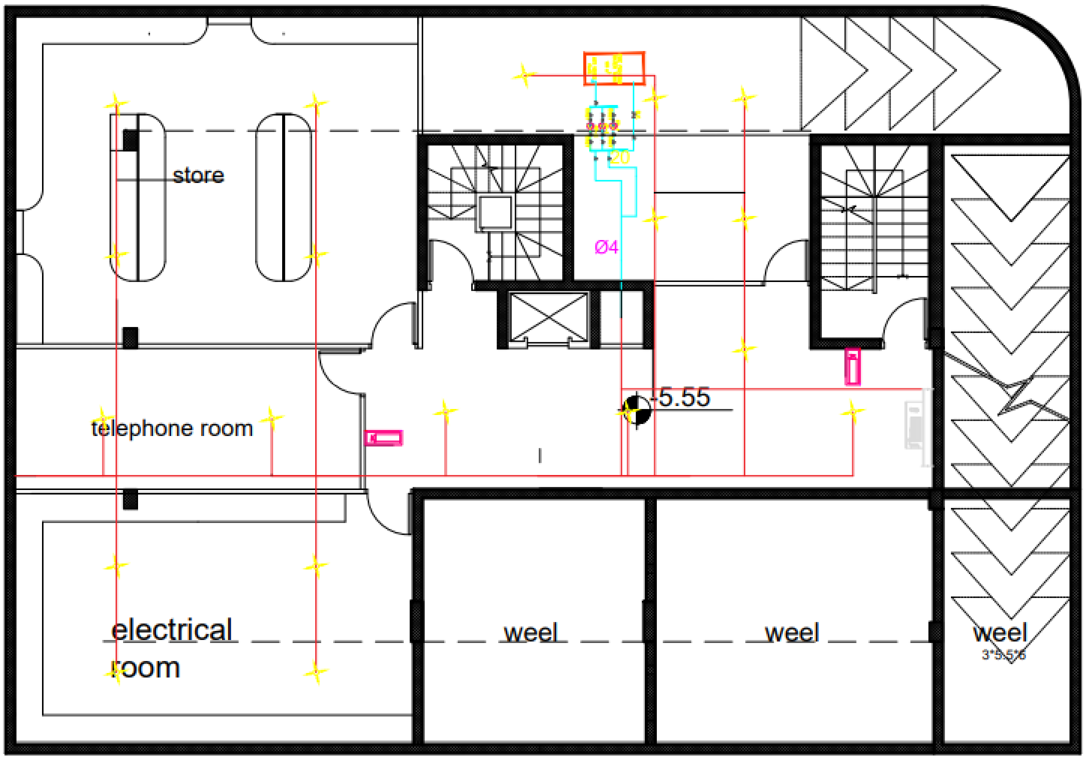
#room	Y-joint model
1	MXJ-YA1509M
2	MXJ-YA1509M
3	MXJ-YA2512M
4	MXJ-YA2512M
5	MXJ-YA2512M
6	MXJ-YA2815M
7	MXJ-YA2815M
8	MXJ-YA2815M

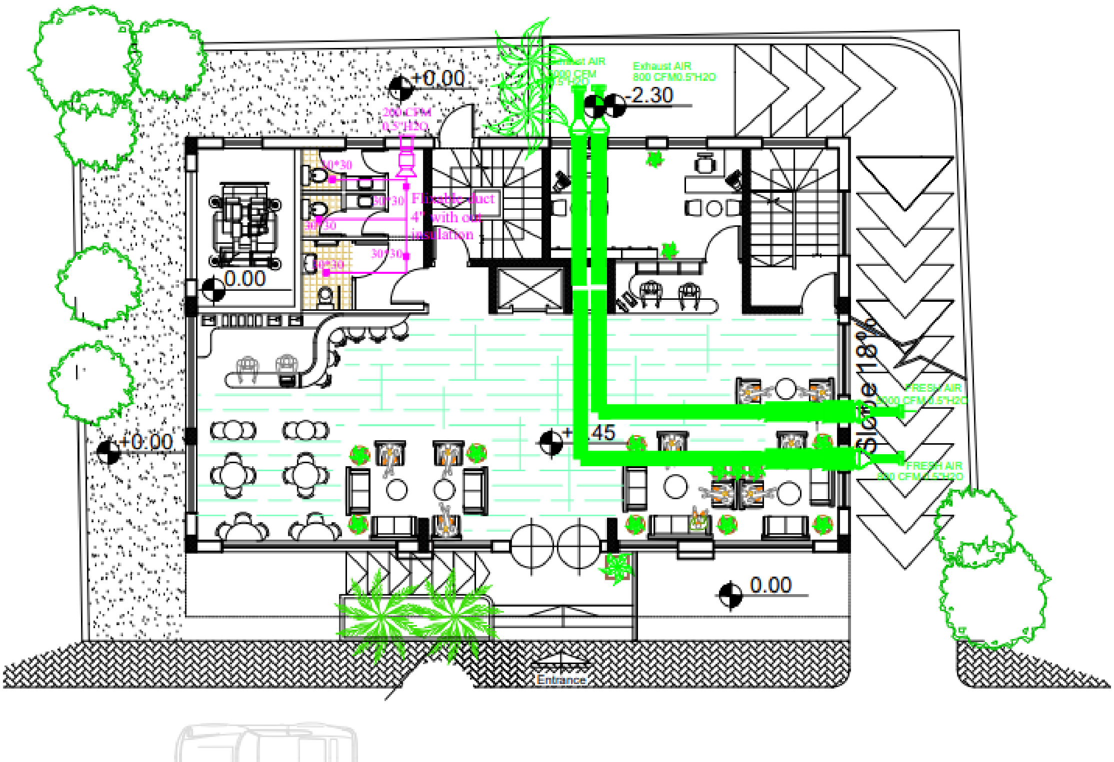
Mechanical Plan by AutoCAD

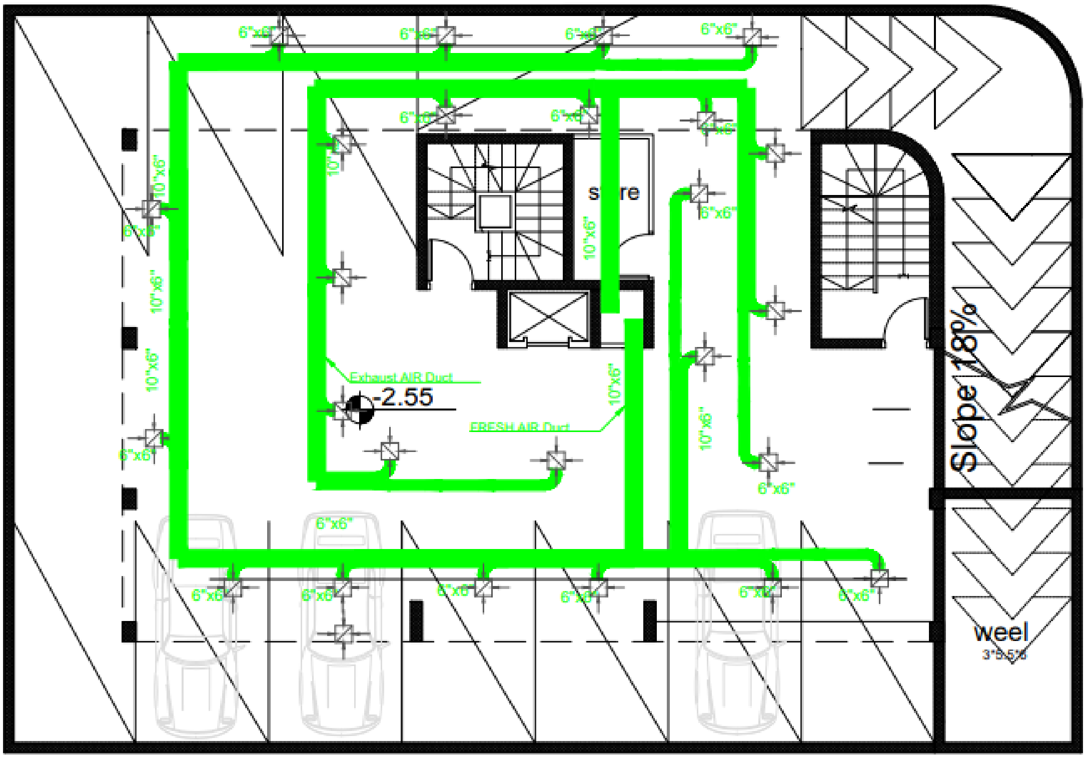


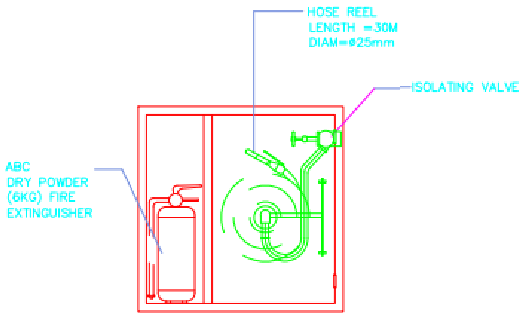

generator
kitchen
washroom
+0.00
+3.95
multipurpose
room


store
-2.55
Slope 18%
weel
3*5.5*6

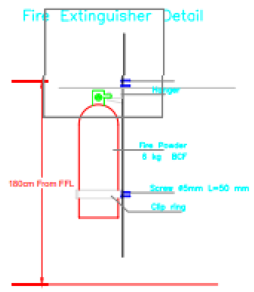

store
telephone room
-5.55
Ø4
electrical
room
weel
weel
weel
3*5.5*6

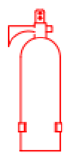

+0.00
-2.30
Exhaust AIR
0.00
+0.00
45
0.00
Slope 18%
Entrance



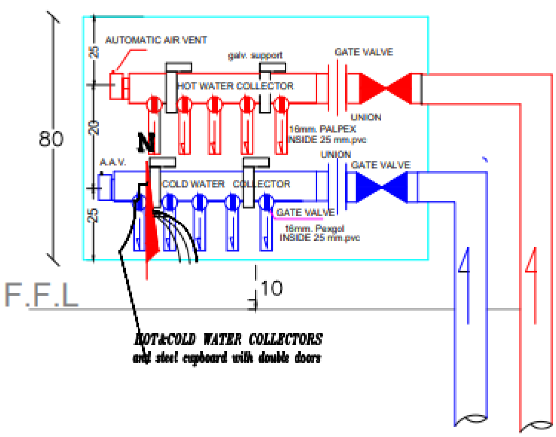


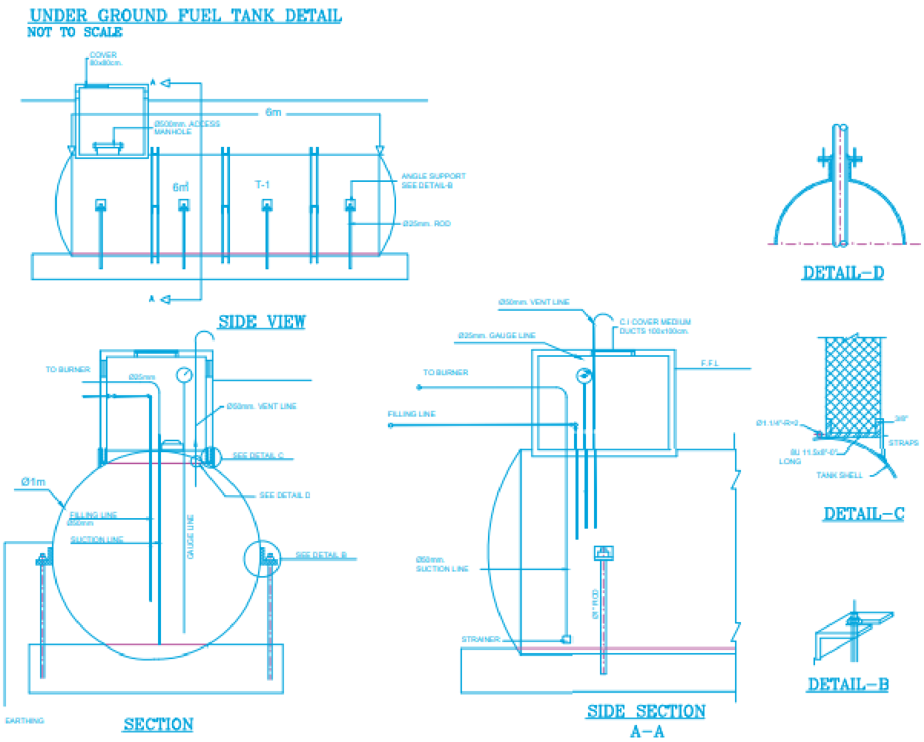
FIRE HOSE CABINET DETAIL



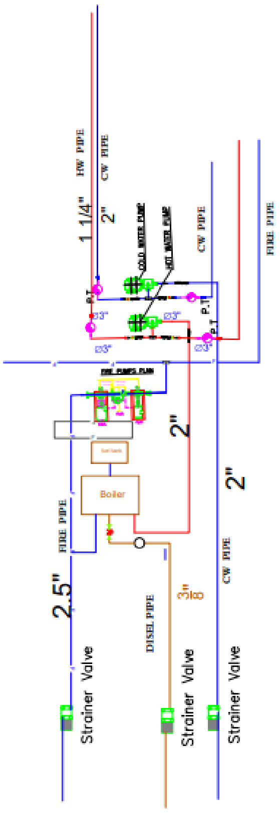


CARBON DIOXIDE EXTINGUISHER

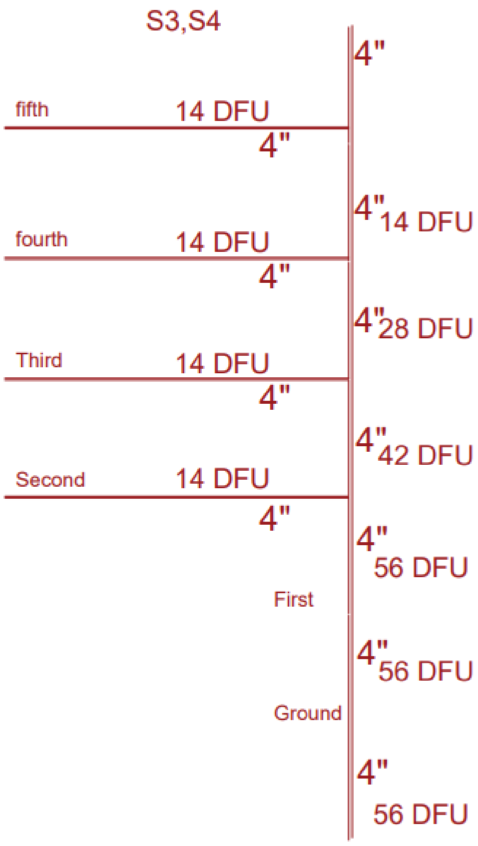




UNDER GROUND FUEL TANK DETAIL
NOT TO SCALE
COVER 80x80cm.
Ø500mm. ACCESS MANHOLE
6m
T-1
ANGLE SUPPORT SEE DETAIL-B
Ø25mm. ROD
SIDE VIEW
DETAIL-D
TO BURNER
Ø50mm. VENT LINE
SEE DETAIL C
SEE DETAIL D
Ø1m
FILLING LINE Ø50mm
SUCTION LINE
GAUGE LINE
SEE DETAIL B
EARTHING
SECTION
Ø50mm. VENT LINE
C.I COVER MEDIUM DUCTS 100x100cm.
Ø25mm. GAUGE LINE
TO BURNER
F.F.L
FILLING LINE
Ø50mm. SUCTION LINE
STRAINER
SIDE SECTION
A-A
DETAIL-C
STRAPS
TANK SHELL
DETAIL-B

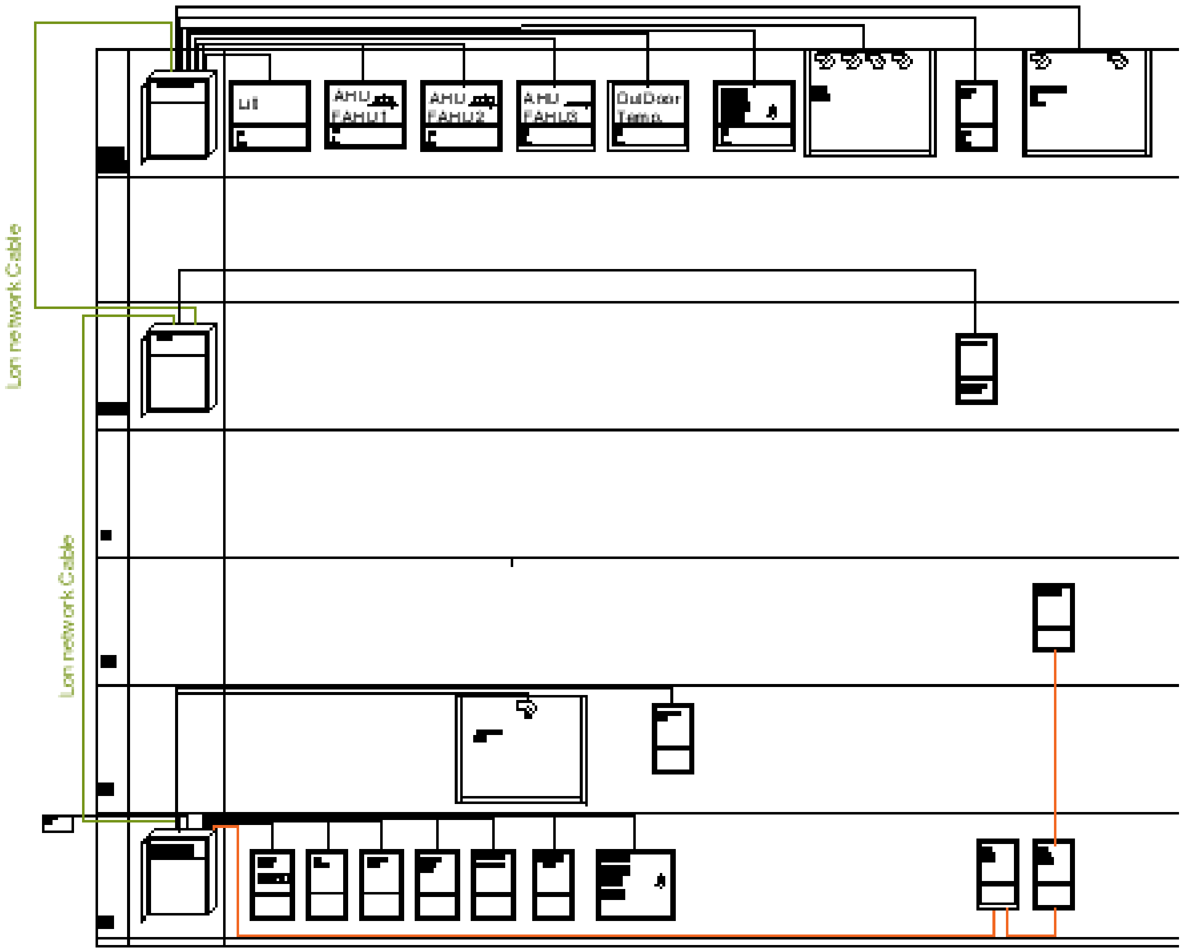


HW PIPE
CW PIPE
1 1/4"
2"
COLD WATER PUMP
HOT WATER PUMP
CW PIPE
FIRE PIPE
Ø3"
Ø3"
Ø3"
Ø3"
P.T
FIRE PUMPS PLAN
2"
Boiler
2"
FIRE PIPE
2.5"
DISEL PIPE
3"
CW PIPE
Strainer
Valve
Strainer
Valve
Strainer
Valve



S3,S4
4"
fifth
14 DFU
4"
4"
14 DFU
fourth
14 DFU
4"
4"
28 DFU
Third
14 DFU
4"
4"
42 DFU
Second
14 DFU
4"
4"
56 DFU
First
4"
56 DFU
Ground
4"
56 DFU

KNX Riser

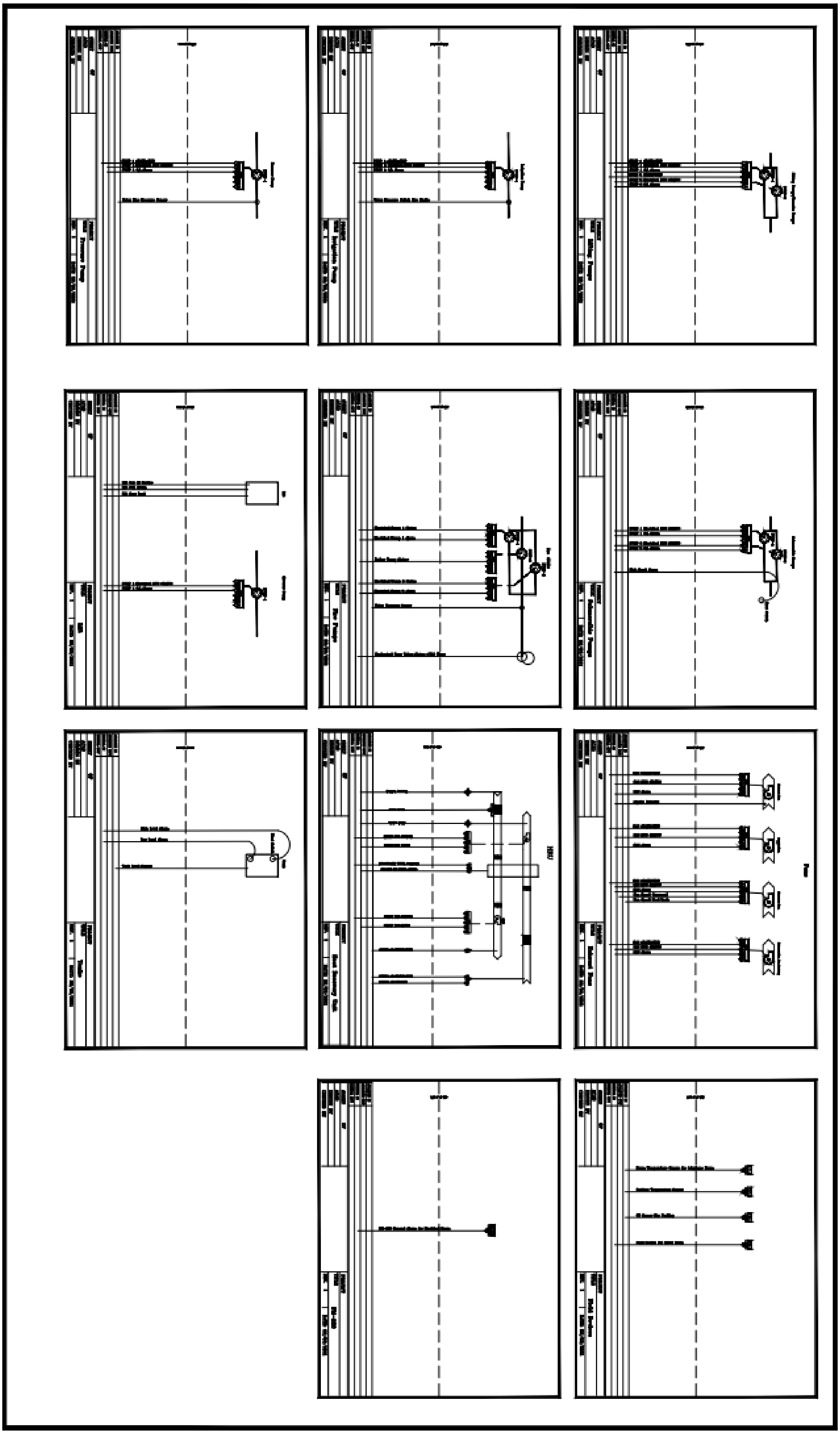


Modbus Cable 2*1 twisted shielded

Cat6A Cable

Cat7 Cable and connect to networks & bacnet integration with VRF,KNX,CCTV, Central Battery, Fire System

Lon Cable 2*1 twisted shielded



Integration Systems

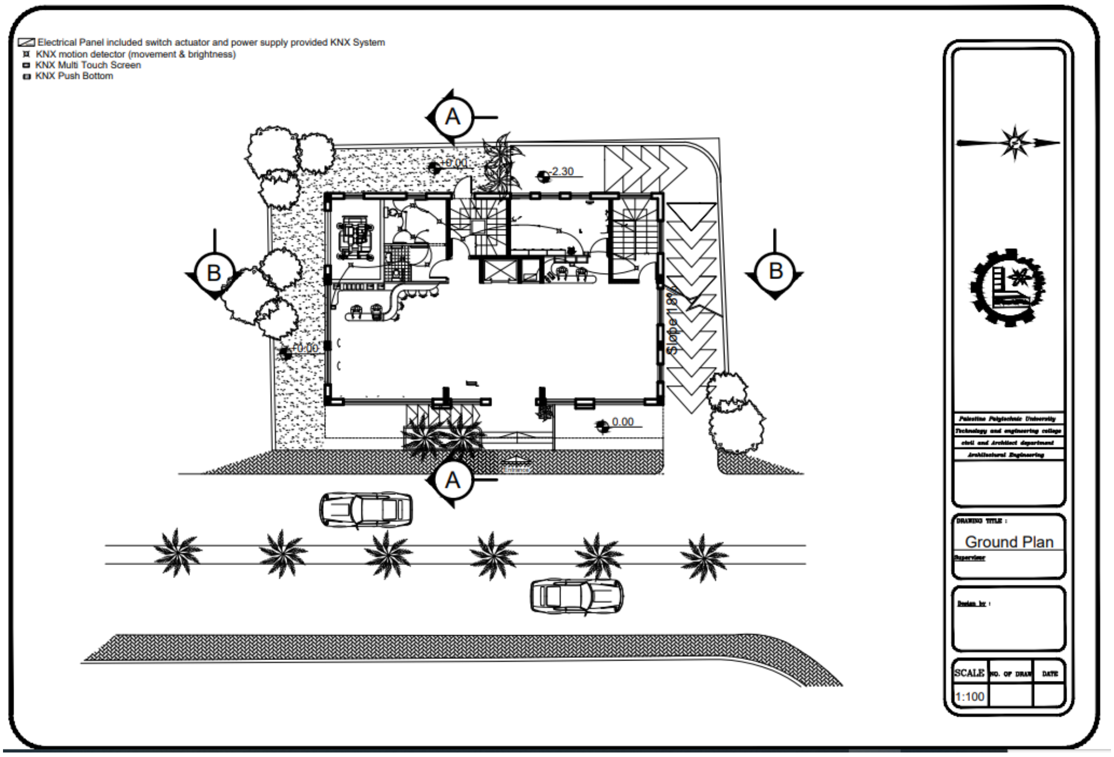
1- Main Distribution Boards Integration through Modbus Protocols,Reading All Electrical Reading: Volts,Current,Frequency,Power, Consumption

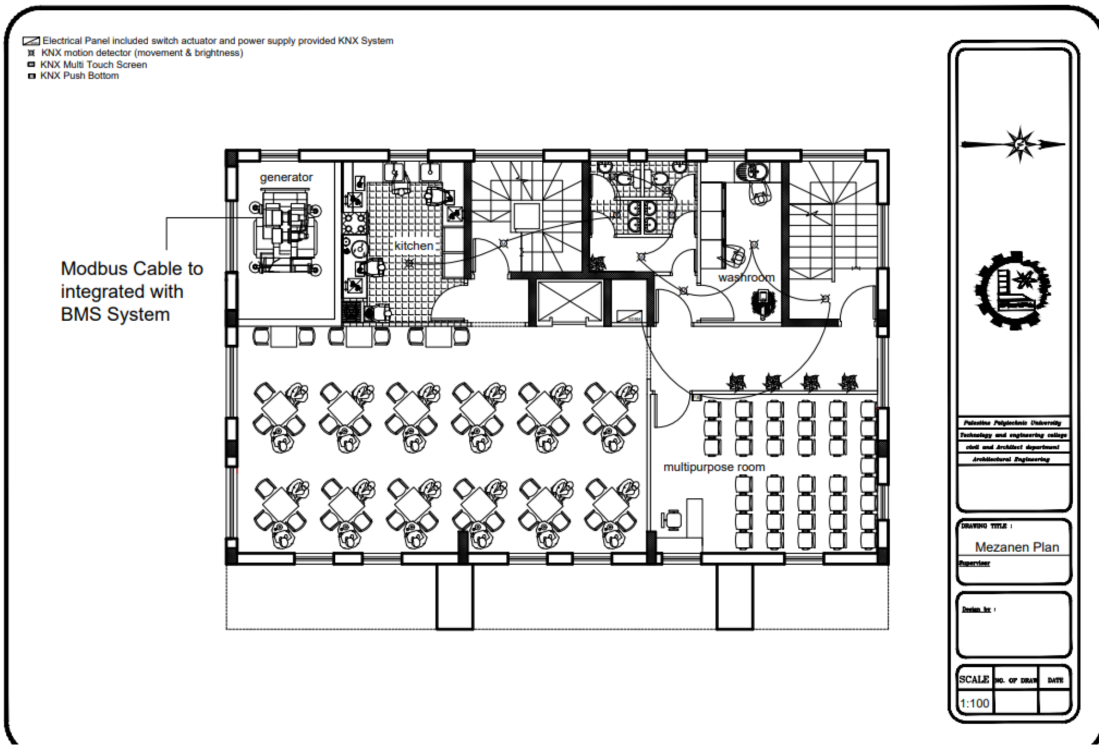
2- Generator Integration through Modbus Protocols,Reading :Volts,Current,Frequency,Power Battery Voltage,Oil Temperature, Oil Pressure,All Alarms

3- Fire System Integration through Lon Protocols,Reading :Zone Alarm,Flow Switch,Alarms Detect Fire Area, Monitor All Devices Smoke,Heat,Break Glass

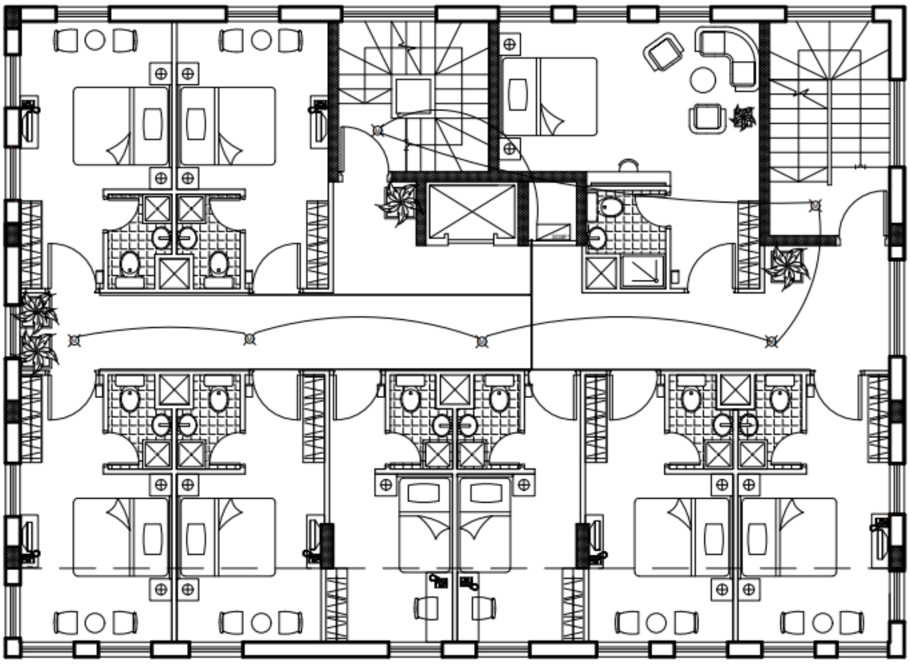
4- KNX System Integration through Bacnet Protocols,Reading and control : Electrical Light,Motion Sensor,Brightness,Dimming

4- VRF System Integration through Bacnet Protocols,Reading and control :
Indoor Unit: On/Off , Remote Enable , Temperautre Setpoint and limits, Room Temperature,Filter Status,.....
Outdoor Unit: All On/Off , All Temperature Set piont and limits,Alarms,.....

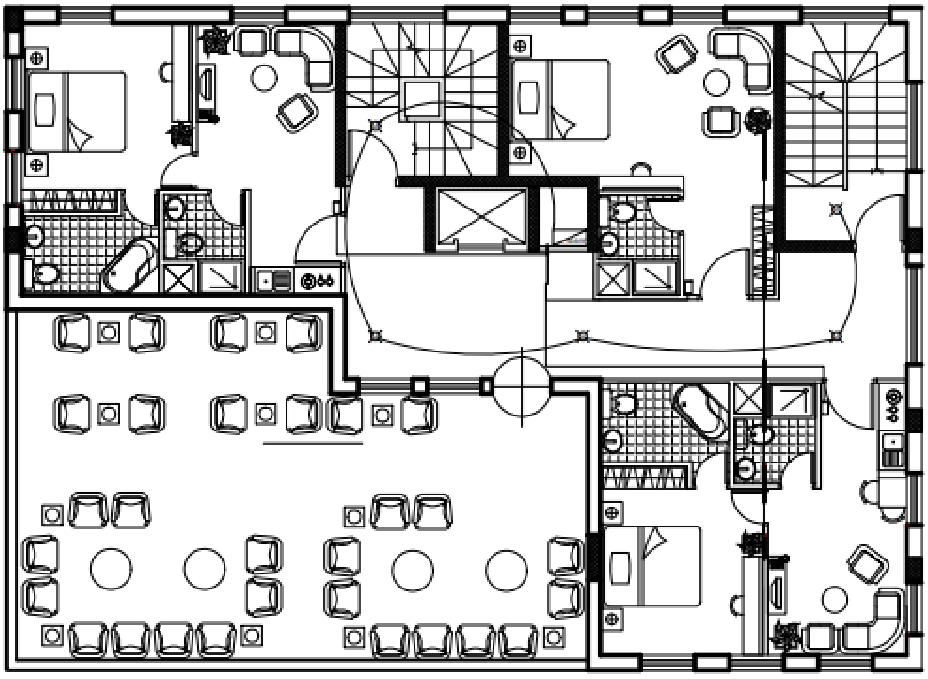




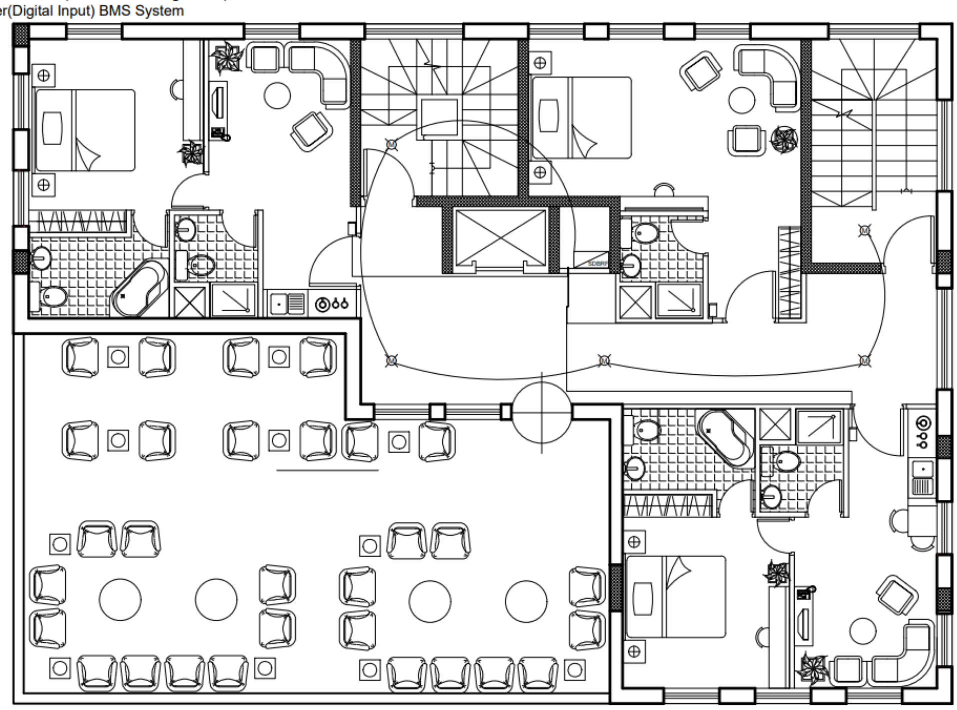
Electrical Panel included switch actuator and power supply provided KNX System
KNX motion detector (movement & brightness)
Card Reader(Digital Input) BMS System



Electrical Panel included switch actuator and power supply provided KNX System
KNX motion detector (movement & brightness)
Card Reader(Digital Input) BMS System



Electrical Panel included switch actuator and power supply provided KNX System
KNX motion detector (movement & brightness)
Card Reader(Digital Input) BMS System



Electrical Panel included switch actuator and power supply provided KNX System
KNX motion detector (movement & brightness)
CO Sensor(Analogue Input) BMS System