Palestine polytechnic university

College of engineering & technology

Mechanical engineering department

Graduation project:
Inspecting and Analyzing HVAC Equipment Utilized And Available in the Market with a Practical Case Study

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Abstract

This project will present HVAC equipment and systems , collecting catalogues of heating ventilation and air conditioning (HVAC) equipment, to be useful in any air conditioning system selection.

This project explains the practical side of HVAC systems which include selection of the system and installation process. After that it will study the local companies and collecting information about HVAC systems. Also to make a case study about the installation of split unit HVAC system , Additionally to collecting catalogues of the systems to make a database for student about HVAC systems and companies .

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CHAPTER ONE

INTRODUCTION

1.1 Introduction:

Human still thinking how to improve his life to be easy so as to be better ,this is the reason of spread industry and technology, and life became more easier than previous mode.

Building technology is very important nowadays to satisfy comfort condition for occupants to make their life easier specially most of their time be inside building whether to be in homes, offices , factories , hospitals, universities, schools, etc…for this reason engineering who design any kind of building make it as possible to be suitable with occupants necessities or facilities. The most important design after architecture design for any kind of building is to supply this building by mechanical design which involves domestic water system, heating ventilation and air conditioning system(HVAC), fire suppression, gas grid system, and drainage grid system.

Although some mechanical services are not necessary to be installed in every building, the existence of some other is basic mechanical system and very essential to be installed , for example domestic water system is forming the basic part of the building.

Some mechanical system such as air conditioning and ventilation are said to be luxuries; since they deal with a high level of technology from one side and their cost high relatively from another side.

But most application required to install them by many services such as some factories beside "domestic water, and drainage system" need ventilation system to exhaust polluted air that be produced from industrial process, to keep good climate for workers. Other applications need HAVC system besides to fire suppression and domestic water , drainage systems and others because the different mechanical installations are not less important for the occupants than other services so such installation must be in the best manner in addition to the continues maintenance needed to guarantee best performance.

Mechanical system should satisfy all requirements inside buildings also take into account the economic state on the level of long -range, so in this project HVAC system made to complete all requirements of occupants in the best way and comfort conditions , to select the best equipment and system which is suitable for building use.

1-2 project objective:-

* The main objective of this project is to make data base to be a reference for students about the relation between the theoretical side in the university and the practical side in the market of HVAC devices.

* Gather catalogues and procures to build a database for the equipments.

* To make a case study to compare the companies way in installation of HVAC systems and theoretical calculation way.

1-3 Project Benefits:-

* The first benefit is to fulfill the graduation requirement of Palestine Polytechnic University in mechanical engineering , and to be familiar with all HVAC systems installed in building and their companies to be ready to work in this field after graduation.
* It forms a reference for other students where they desire to know more about HVAC systems and HVAC companies and to have a background about the market of HVAC systems and working in this field.

* To be expert and familiar with HVAC systems in one side and best selection of them in other side.

1-4 First semester budget

Table (1-1) Budget

TASK	*COST(NIS)*
Using internet	**100**
Visiting companies	**150**
Buying books	**50**
Printing papers	**100**
TATAL	**400**

1-5 First Semester Time table

Table (1-2) Time table

WEEK / TASK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
select project name																
Gather information																
Writing introduction																
Visiting companies																
Collecting catalogues																
Printing final copy																

1-6 second semester budget

Table (1-3) Budget

TASK	*COST(NIS)*
Using internet	**100**
Visiting companies	**150**
Buying books	**50**
Printing papers	**100**
TATAL	**400**

1-7 second Semester Time table

Table (1-4) Time table

TASK \ WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Correcting chapters	■	■														
Gather information			■	■	■	■										
Writing introduction						■	■	■								
Visiting companies									■	■	■					
Collecting catalogues										■	■	■	■			
Printing final copy														■	■	■

CHAPTER TWO

THEORY OF HVAC

2-1 Introduction:

Many of our homes and most offices and commercial facilities would not be comfortable without year- round control of the indoor environment .

The "luxury label" attached to air conditioning in earlier decades has given way to appreciation of its practically in making our lives healthier and more productive. Along with rapid development in improving human comfort came the realization that goods could be produced better, faster , and more economically in a properly controlled environment. In fact , many goods today could not be produced if the temperature, humidity and air quality were not controlled within very narrow limits.

Heating and cooling of air are based on engineering principles. Heating and cooling practices of a given space are based on the laws of heat exchange. The design and operation of air conditioning systems are based on a branch of physics called thermodynamics. The actual process of attaining the required condition of air in a given enclosed space depends on a branch of physics called psychometric.

The circulation of conditioned air to the controlled spaces (supply air) and the introduction of outside fresh air into these spaces(ventilation air) is based on a branch of physics called fluid mechanics. The process of maintaining the air in an enclosed space at specific temperature level depends on the principles of heat transfer.

Thermal comfort of a human being depends on several factors. Prominent of these factors are temperature, physical activity, clothing and moisture content in the air. For winter, people wearing normal clothes and doing light activities feel comfort in temperature range of 18°C to 23°C .

On the other hand, temperature range of 20°C to 26°C is felt comfortable by people in the summer provided that they are clothed normally and practicing light activities. The use of different temperature ranges for summer and winter seasons are due to different clothing worn and due to the changes in the human body metabolism and habits of practices between summer and winter.

2-2 Heating ventilation and air conditioning(HVAC)

HVAC systems is the systems of air conditioning ,summer cooling or winter heating.

The basic purpose of HVAC system design in building and other applications is to provide a comfortable climate throughout the year since outdoor temperature and other climate factors vary widely with the season, it is apparent that the HVAC system must be dynamic and flexible to compensate for these changes. Similarly, the indoor comfort needs of occupant vary greatly depending on the type of space occupancy. A residential , laboratory ,manufacturing application, have widely different requirements which the HVAC system must satisfy to provide the conditions that will permit the space to be used as intended .

HVAC system could be called upon to do any or all of the following:-

* Maintain a uniformly comfortable warm indoor temperature in cold weather and maintain a uniformly comfortable cool indoor temperature during hot weather.

* Add humidity to the indoor air in winter and reduce it in summer.

* Assure that interior wall surface in winter will not have a chilling effect on nearby occupants.

* Control the velocity of the recirculated air ; it should be first enough to provide freshness and slow enough to avoid drafts.

* Exhaust odor-laden air from rooms such as kitchens , toilets and laboratories.

2-3 Heating systems

Heating is the process that maintains a given space at a temperature above that of the ambient temperature . Heating may involve the use of fireplaces or room stoves. These methods of heating are not efficient and inconvenient to operate.

Controlled inside temperatures can not be attained and uniform heat distribution is not possible when such heating devices are used. To overcome the inconveniences caused by the above heating methods, central heating systems were put in use. In such systems furnaces or boilers are used to supply the required amount of heat to a suitable heating medium, usually air or water, to the different parts of the space being heated. The furnace or the boiler must be placed in safe, ventilated location, usually the basement of the building. If the circulated medium is air, then the system is called warm air heating system. For such system, the warm air is forced to circulate throughout the spaces to be heated using a fan and duct system. On other hand, if hot water is used instead of warm air then the heating system is called hot water heating system or hydronic system . For this case, the hot water is forced to circulate though pipes to radiators or convectors located within the heated space, in general heating systems is classified as:

(1) Hot water heating systems.

(2) Warm air heating systems.

2-3-1 Hot water heating system :

In such systems the heating fluid is water and it is circulated through pipes to radiators which installed in heating spaces, using pumps which installed in suction or delivery line of the boiler(after or before the boiler).

The main devices of this systems is :

Boiler, pumps, radiators and expansion tank in addition to heat sensors ,pressure sensors and pipes.

2-3-2 Warm air heating systems

In warm air heating system , heat is directly transferred from a heating coil to the air, which is used to heat the required space. Warm air heating systems are either natural or forced systems. In natural warm air heating system, natural convention is used to circulate the heated air due to changes in its density. For this case , the circulation rate is proportional to the temperature differences between warm air and surrounding air .

In forced warm air heating systems, a fan is used to circulate the warm air to the heated spaces, thus better performance is obtained. This way of heating when we use the indoor unit as condenser , or cooling when we use the in door unit as evaporator is called air conditioning or air cooling ,so on this systems we can make air conditioning for air as heating or cooling of conditioned space, so the term of air conditioning implies much more than the control of inside temperature of a given space. It implies the controlling and maintaining of the following four atmospheric conditions that affect the human comfort :

- Temperature of the space air.
- Humidity or the moisture contents of that air.

* Purity and quality of the inside air.

* Air velocity and air circulation within the space.

So warm air heating system is a part of air conditioning when we use the indoor unit of the refrigeration cycle as condenser, and we can use the indoor unit as evaporator so that it called as cooling air conditioning.

In this systems the main parts of the system is the ducts , fans, supply air devices, chillers (heating or cooling coils),which is a part of a refrigeration cycle.

2-4 Refrigeration

2-4-1 Development of refrigeration

Modem refrigeration has many applications. The first and probably still the most important, is the preservation of food. Most foods kept at room temperature spoil rapidly. This is due to the rapid growth of bacteria. At common refrigeration temperatures of about (4°C) .

Bacteria grow quit slowly. Food at this temperature will keep much longer. Refrigeration preserves food by keeping it cool.

Other important uses of refrigeration include air conditioning, beverage cooling, and humidity control.

Many manufacturing processes also use refrigeration. The refrigeration industry became important commercially during the 18^{th} century. Early refrigeration was obtained by use of ice. Ice from lakes and Ponds was cut and stored in the winter in insulated storerooms, for summer use. The use of natural ice required building insulated containers or iceboxes for stores, restaurants, and homes. These units appeared on a large scale during the 19^{th} century.

2-4-2 mechanical refrigeration

There are four basic parts in a mechanical refrigeration System . the compressor pumps refrigerant vapor, the condenser releases heat from the refrigerant, similar to a vehicle's radiator releasing heat from the cooling system, the refrigerant, similar to a vehicle's radiator releasing heat from the cooling system, evaporator which is the area that absorbs heat from the refrigeration space.

Heat enters a refrigerator in many ways. It leaks through the insulated walls or enters when the door is opened. Still more heat is introduced when warm substances are placed in the refrigerator. Heat is not destroyed to make the refrigerator cold. It is simply removed from the refrigerated space and released outside.

2-5 Types of HVAC systems

HVAC systems have many types in heating or cooling, every types has a specific characteristics , the most important systems are:

•Central heating or cooling system.

• Split air conditioning systems.

•Window air conditioning system.

•Under floor heating systems.

2-5-1 Central heating or cooling system

Central cooling or heating plants generate cooling or heating in one location for distribution to multiple locations in one building or an entire campus or neighborhood, and represent approximately 25% of HVAC system applications.

Central cooling and heating systems are used in almost all classes of buildings, but particularly in very large buildings and complexes or where there is a high density of energy use. They are especially suited to applications where maximizing equipment service life and using energy and operational workforce efficiently are important.

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The following facility types are good candidates for central cooling or heating systems:

• Campus environments with distribution to several buildings.

• High-rise facilities.

• Large office buildings.

• Large public assembly facilities, entertainment complexes.

• Urban centers (e.g., city centers, districts).

• Shopping malls.

• Large hotels.

• Educational facilities.

• Hospitals and other health care facilities.

• Industrial facilities (e.g., pharmaceutical, manufacturing).

• Large museums and similar institutions.

• Locations where waste heat is readily available (result of power. generation or industrial processes).

Advantages of central systems

• Primary cooling and heating can be provided at all times, independent of the operation mode of equipment and systems outside the central plant.

• Using larger but fewer pieces of equipment generally reduces the facility's overall operation and maintenance cost. It also allows wider operating ranges and more flexible operating sequences.

• A centralized location minimizes restrictions on servicing accessibility.

• Multiple energy sources can be applied to the central plant, providing flexibility and leverage when purchasing fuel.

• Standardizing equipment can be beneficial for redundancy and stocking replacement parts.

• Major vibration and noise-producing equipment can be grouped away from occupied spaces, making acoustic and vibration controls simpler. Acoustical treatment can be applied in a single location instead of many separate locations.

Disadvantages of central systems

• Equipment may not be readily available, resulting in long lead time for production and delivery.

• Equipment may be more complicated than decentralized equipment, and thus require a more knowledgeable equipment operator.

• A central location within the building is needed.

• Additional equipment room height may be needed.

• Depending on the fuel source, large underground or surface storage tanks may be required on site.

• Heating plants require a chimney and possibly emission permits, monitoring, and treatments.

• Multiple equipment manufacturers are required when combining.

• System control logic may be complex.

• First costs can be higher.

• Special permitting may be required.

• Safety requirements are increased.

2-5-2 Split air conditioning systems

This systems is used in all types of buildings, specially in residential buildings ,and in small offices . In general , it used in small heating or cooling load spaces, in this systems the indoor unit is separated from out door unit and connected by tow pipes which is outlet and inlet of the indoor unit.

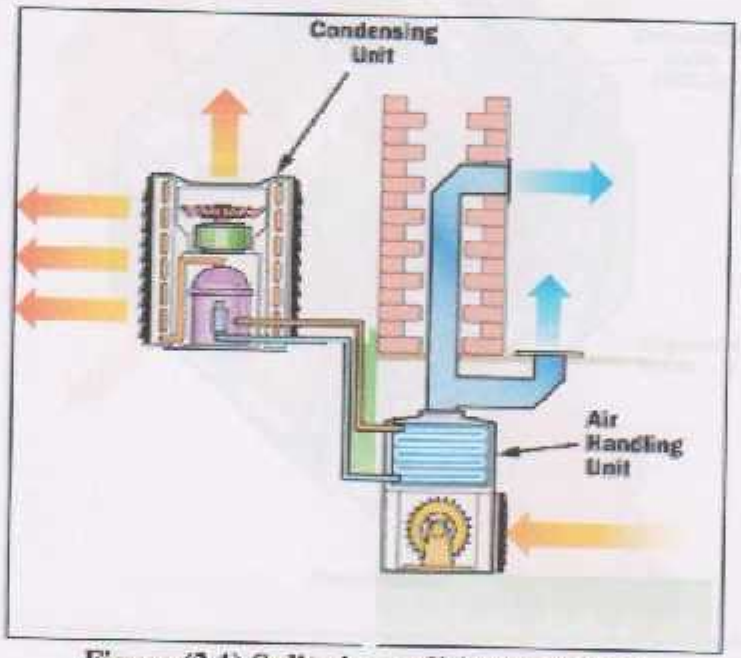

Figure (2.1) Split air conditioning system

Advantages of split systems

- Easy to install and transport.
- Low cost with respect to central systems.
- Easy to control.
- It used as heating system or cooling system on the same device.

Disadvantages of split systems

- It has many problems in electrical parts .
- It is not efficient in very high cold weathers or very high warm weathers.

2-5-3 Window air conditioning system

This system is not widely used because the split unit is more efficient from theoretical and practical side.

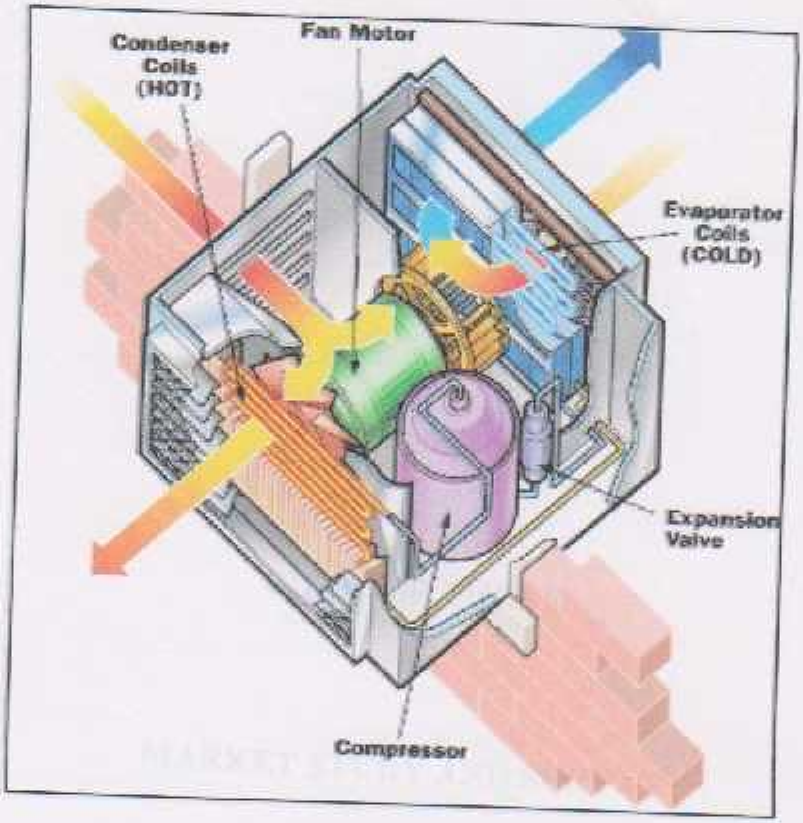

Figure (2.2) Window air conditioning system

Advantages of window systems

- Easy to install.
- Relatively low cost.

Disadvantages of window systems

- Not efficient for high load applications.

CHAPTER THREE

MARKET STUDY AND SURVAY

3.1 Template of questionnaire for HVAC local companies

Note : the goal of this questionnaire is to obtain a feedback from local companies about HVAC systems , in addition to obtain information that helps students to understand the practical side HVAC system so as to be able to work in market easily after graduation.

1- Company name..

2- Company telephone ....

3- Address of the company :

City.............................. street..................................

4- How many engineers in the company?

....

5- How many workers in the company?

In summer............................

In winter.............................

6- Do you use any software programs in your working field , if yes what is it?

....

....

7- What are the most important practical and theoretical things that student should know after graduation so as to be able to work in this field easily?

Practical knowledge ....

....

....

Theoretical knowledge ....

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8- What are the problems that you face in installing devices , and the problems after installation (maintaining process) ?

Installing problems ....

....

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After installing ....

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....

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9-What are the types of devices that you install (manufacturing companies) in heating , air conditioning and refrigeration field?

Heating ....

....

....

Air conditioning ....

....

....

Refrigeration ....

....

....

10- What are the best devices (manufacturing companies) in the market?

....

11- What are the practical courses that the student and the university should focus on in the plan so as to be useful in the market ?

....

3.2 Local companies of HVAC systems

Table (3-1) local companies addresses

Company name	address	telephone
Seder for air conditioning and refrigeration	الخليل – وادي الهرية	0599340136
Alzaro for air conditioning and refrigeration	الخليل- طلعة ادعيس	
Nairokh for air conditioning and refrigeration	الخليل – دوار المنارة	0599872000
Gaith for air conditioning and refrigeration	الخليل- شارع السلام	0599377125
Al mohtaseb for air conditioning and refrigeration	الخليل- راس الجورة	2221441
Al basel for air conditioning and refrigeration	الخليل - دورا	0599203825
Abed al ali hejeh for refrigeration	الخليل- دورا	0599445038
Maamon safadi for central heating	الخليل- عين سارة	2251738
Essa for air conditioning and refrigeration	الخليل- بيت عوا	

3.3 Results of the questionnaire:

How many engineers in the company?

The importance of this question is to know how many engineers does the company need in HVAC systems installation , from the load calculation to choice the equipment according to efficiency and cost .

All local companies said that they need one engineer , because the experience of the engineer has a good effect in working in this field , so there is no need to another engineer .

How many workers in the company?

The number of workers in all local companies are different in winter from that in summer , all companies said that the number of workers in summer is more than in winter , because in winter the customers prefer to use another types of heating systems which more efficient than the HVAC systems such as wood , oil and gas .

- The high efficiency of this types, because of the low temperatures in winter and the low efficiency of split units in this low temperatures , so the command on this equipment decreased in winter , and increased in summer .

In this questionnaire some companies said that they need tow workers in winter and six workers in summer , but other companies said that they need two workers in winter and five in summer.

The other companies said that they need three in winter and five in summer .

So the conclusion from this question is that the number of workers in the local companies are varies from tow to six workers.

Do you use any software programs in your working field , if yes what is it?

All local companies said that they don't use any computer software because they don't need it in their work.

But from the other side the use of computer software is important , specially in high load applications such as hospitals , banks , moles , etc...

All companies said that they don't use the theoretical calculations to calculate the load of the air conditioned spaces , they use prediction or expectation way.

This method is :

1 m² of volume needs 300btu(British thermal unit) .

In this project there is a case study to compare this way with the theoretical calculation way to specify the errors .

What is the most important practical and theoretical things that student should know after graduation so as to be able to work in this field easily?

This is the most important question in this questionnaire according to the advices of all companies because if its direct effect on students after graduation.

Theoretical knowledge:

All companies said that students should know all theoretical knowledge in HVAC systems , such as :

* The functionality of each device in HVAC systems .
* The electrical circuits of each system, and how to connect it .

* The effect of the positions of the outdoor and indoor units of air condition systems .
* Types , sizes , cost , and efficiency of each system.
* Best application for each system.

Example

• Central systems used widely in high load applications , such as hospitals , banks , etc…

• Split units below two ton of load , used in residential buildings , offices , etc..,
without duct system distribution .

• Split units over two ton of load , need duct system distribution .

• Its very important to know the problems and its causes of all systems.

Practical knowledge:

All companies said that the practical knowledge is very important for ▪ students because of its effect on the experience of them.

Some companies said that , the students should know how to use the installation equipment , refrigerant filling process and how to use the control devices such as remote control of each system.

Other companies said that the student should know how to use the measuring devices, such as clap meter and pressure measuring devices.

Note :
Clap meter : is a device that used to measure the voltage and ampere of the system.
Pressure measuring device : is a device that used to measure the high and low pressures of the refrigeration cycle.

Other companies said that the student should install devices in workshops of the university in order to be able to work in the market , and to improve his understanding of HVAC systems.

Other companies said that , the student must be able to use all the equipment of the installing and maintenance so as to have experience in this field.

In general all companies advised that the students must improve their practical knowledge in the university by:

* To improve the workshops of the university in refrigeration and air conditioning by preinstalled systems specially central systems .
* To install these systems by themselves .
* To learn or to know all the problems of the systems and its causes, and how to solve them.
* To improve their skills in working by their hands in work shops.

What is the problems that you face in installing devices , and the problems after installation (maintaining process) ?

Installation problems :

Most companies said that there is no problems in installing systems , but some times they may face some problems such as :

* The position of the outdoor and the indoor units .

According to the engineers experience , the outdoor unit must be lower than the indoor unit , so as to return the oil to the compressor after compression state.

* Very high buildings , because the installation of the outdoor unit becomes dangerous(in split systems).

After installation or maintenance:

* Some companies said that most problems after installation are electrical problems , such as problems in reverse valve or other problems , such as lose of refrigerant .
* Other companies said that most of the problems are electrical problems .
* Other companies said that the problems electrical and lose of refrigerant .
* Other companies said that most of the problems in refrigeration are frost on the evaporator and some times , electrical problems .
* Other companies said that the problems are electrical in general.

3.4 Case study of HVAC system installation:

The objective of this case study is to compare the theoretical calculation method for calculating heating or cooling load that we have studied in the university with the expectation way that the local companies use in the market , which is every $1m^3$ of volume needs 300 btu of load , then to decide if it is useful or has errors.

Description of the case study place

The case study place is the first floor of a house , this house is not actually built but its drawing and data for cooling load calculations are available.

Methodology

* Calculate the cooling load of the floor according to the theoretical calculations .
* Calculate the load according to the local companies way.
* Select the suitable HVAC system.
* Comparing the results.
* Specify the errors if exist.

CHAPTER FOUR

EQUIPMENTS CATALOGUES COLLECTION

4.1 Introduction

HVAC equipment manufactured by more than one company, every company has its own criteria in manufacturing and its product has a special properties either in shape and deign or in load and power.

So in this chapter every company of HVAC devices will be explained and its product will be presented by photos and catalogues.

In general the catalogue of any HVAC device explains so many properties of the device from the dimensions and load to the installation.

4.2 Sanyo Company

Sanyo is one of the most important companies of HVAC devices , because of its high technology and good efficiency .

Sanyo is a Japanese company founded in 1947 , and incorporated in 1950 , it has a net sales of 2.484 billion yen and 96.023 employees working in it.

Sanyo products

- Sanyo products available in 1 phase / 3 phases.
- Load capacity from 11.2kw to 15 kw(4HP-6HP).
- DC inverter compressors.

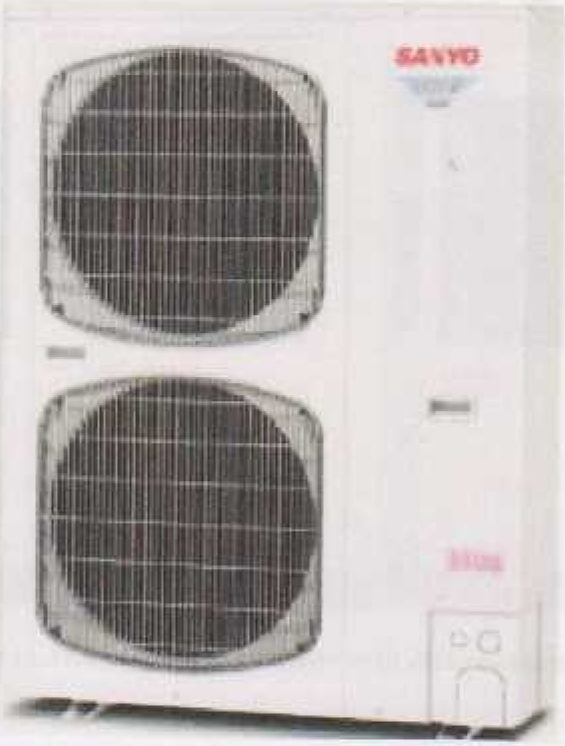


Figure (4.1) Sanyo out door unit

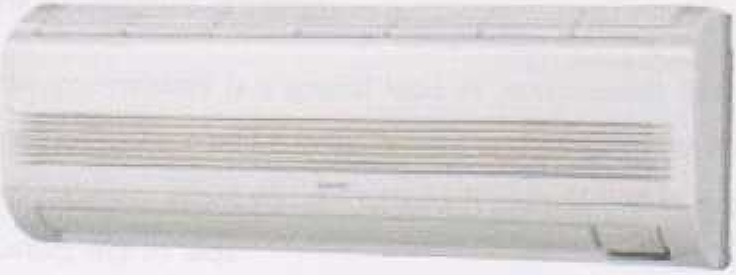


Figure (4.2) Sanyo indoor split unit

Figure (4.3) Sanyo out door units with different sizes

Inverter systems in Sanyo

Sanyo is one of the most companies that produce inverter compressors which has low consumption of energy.

Inverter compressors is a special kind of compressors that changes the load of the outdoor unit according to the needed load of the of the indoor unit by reducing the compressor speed without turn it off, In addition to reduce the start current by starting step by step.

Note :

For company equipment catalogue see appendix (A- 1).

4.3 Petra company

Petra company founded in 1987, Petra company had executed projects in more than 20 countries, The broader vision is to produce a wider Varity of HVAC equipment that meet a diversity of application requirements and to export to major worldwide markets.

Petra products

Petra lines of air – cooled water chillers (for example) , are designed to meet the most demanding requirements of air conditioning applications in all of building.

These packaged air _water chillers meet the highest engineering and performance standards that are characteristics of all Petra products. It has a load range form 35 to530 ton of refrigeration (TR).

Figure (4.4) Petra chiller

For fan coils unit it has a rang of load from 200 to 3000 cubic feet per minute (CFM).

For air handling units, the units are designed to be easy to install and manufacture, these units may be used for cooling and /or heating with supply and return duct with a load rang of 1500 to 9600 CFM.

Figure (4.5) Petra fan coil unit

Figure (4.6) Petra air handling unit

Ducted split units

- Wide rang of capacities from 12 to170TR.
- Outdoor unit supplied with axial fans for quiet operation.

Figure (4.7) Petra out door unit

Mini split units

- Wide rang of capacities from 0.75 to 4.2 TR.
- Long life washable plastic filter.

Figure (4.8) Petra indoor mini split unit(ceiling type)

Note :

For company equipment catalogues see appendix (A- 2) .

4.4 LG Company

LG company is the most famous company of HVAC equipments in the local market , because its products is easy to control and don't need maintenance all the time , which is very good for the customer , but from engineering view the high efficiency is the most important property .

LG products

Figure (4.9) LG split air conditioning system(indoor and out door units)

Figure (4.10) LG duct

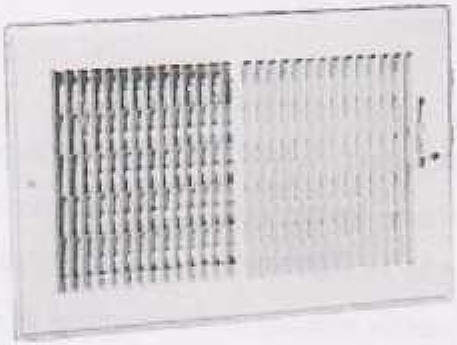


Figure (4.11) LG side grill

Note :

For company equipment catalogues see appendix (A- 3) .

4.5 Tadiran Company

Tadiran Company is a national company of HVAC system, its products are not mainly used in the local market because there is so many companies in the market that has a products that is more efficient and easy to deal with.

Note :

For company equipment catalogues see appendix (A- 4) .

4.6 Danfoss company

Danfoss is one of the largest industrial companies in Denmark, and it has efficient HVAC equipment in refrigeration and air conditioning.

Danfoss is widely manufactures the devices of refrigeration systems and air conditioning, such as compressors, expansion valves, outdoor units, radiators and floor heating pipes.

Note :

For company equipment catalogues see appendix (A- 5) .

Figure (4.12) Danfoss compressor

Figure (4.13) Danfoss condensing unit

4.7 Daikin company

Daikin company is a Japanese company established in 1924, it focused upon the air conditioning and heating systems. It produced an extensive rang of advanced air conditioning equipment including split unit, multi split , variable refrigerant volume(VRV) systems, water chillers for commercial and residential applications.

VRV in Daikin

It is a type of system consisting of anywhere up to 64 indoor units connected to one outdoor condensing unit. The refrigerant flow is varied by using either an inverter controlled variable speed compressor, or multiple compressors of varying capacity to respond to changes in the cooling or heating requirement. VRV systems are suitable for offices, restaurants, hotels, theatres, hospital, universities and industrial buildings among others. They are highly versatile and come with a variety of indoor units.

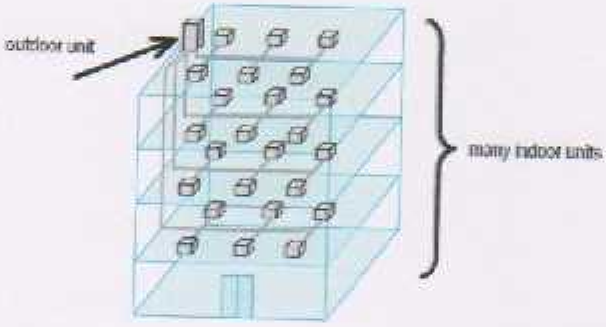


Figure (4.14) Daikin VRV system

Note :

For company equipment catalogues see appendix (A- 6) .

In addition to some companies that produce HVAC equipment with different loads such as :

1- Toshiba , produces a split units from 900 to 27000 btu.
2- Wind , produces a central systems from 28000 to 54000btu.
3- Electra , produces inverter systems for multi indoor spaces with different loads.
4- In addition to other companies such as carrier and pereg.

CHAPTER FIVE

CASE STUDY

5.1 Introduction

Air conditioning is a combined process that performs many functions simultaneously. It conditions the air, transports it, and introduces it to the conditioned space. It provides heating and cooling from its central plant or rooftop units.

It also controls and maintains the temperature, humidity, air Movement, air cleanliness, sound level, and pressure differential in a space within predetermined limits for the comfort and health of the occupants of the conditioned space or for the purpose of product processing.

The combination of processes in this commonly adopted term is equivalent to the current definition of air conditioning. Because all these individual component processes were developed prior to the more complete concept of air conditioning, the term HVAC is often used by the industry.

5.2 Air Conditioning Systems

An air conditioning, or HVAC, system is composed of components and equipment arranged in sequence to condition the air, to transport it to the conditioned space, and to control the indoor environmental parameters of a specific space within required limits.

Most air conditioning systems perform the following functions:

1. Provide the cooling and heating energy required
2. Condition the supply air, that is, heat or cool, humidify or dehumidify, clean and purify, and attenuate any objectionable noise produced by the HVAC equipment

3. Distribute the conditioned air, containing sufficient outdoor air, to the conditioned space

4. Control and maintain the indoor environmental parameters--such as temperature, humidity, cleanliness, air movement, sound level, and pressure differential between the conditioned space and surroundings-- within predetermined limits.

5.3 Cooling load Calculation of ground floor

5.3.1 Cooling load calculation

* Data analysis:

Outside design temperature T_{out} = 40 °C (in Hebron).

Inside design temperature T_{in} =24 °C.

Outside relative humidity = 40 %.

Inside design relative humidity = 50 %.

Daily range = 16 °C.

$T_{out,m}$ = 35 °C.

Where:

$T_{out,m}$: Is the out let mean temperature.

Tin: Inside temperature.

Tout: Outside temperature.

(CLTD) corrected = (CLTD+ LM) K + (25.5-Ti) + (To, m - 29.4) f

Where:

CLTD: Is called cooling load temperature difference from (APPENDIX B.3) for medium wall construction.

LM: Latitude correction factor for horizontal and vertical surfaces (APPENDIX B.4).

K: colors adjustment factor such that k=1.0 for dark colored roofs, & k=0.65 for Permanently Light colored walls.

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

5.3.2 Assumptions

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

Table (5.1) Project assumption

Outdoor Temperature(T_o)	40°C
Indoor Temperature(T_i)	24°C
Latitude	32° North
Day of calculations	21st day of July
Color of surfaces	light-colored surface
Ventilation	No ventilation

5.3.3 Conduction heat transfer through Surfaces

Over all heat transfer coefficient (U)-value For Walls and Windows

Before go on calculations, the details of the walls must be known; so the k-value of them can be calculated.

The following figure. showing the construction of the walls. And the table shows the U values for the walls

Where :

K (R thermal) : Is the thermal resistance of the layers.

U: Over all heat transfer coefficient.

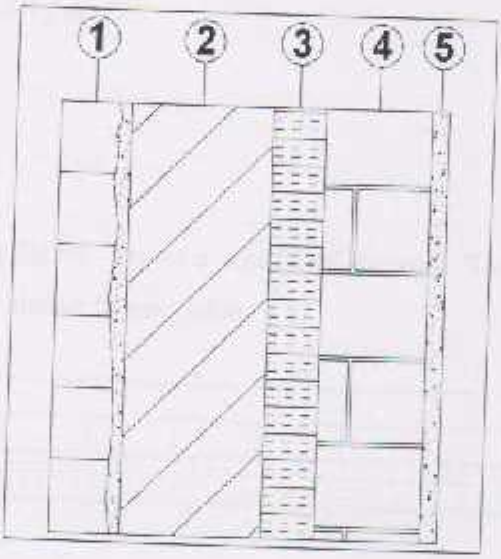


Figure (5.1) Wall construction

Table (5.2) Over all heat transfer coefficient for wall construction

Material (layer)	Thickness (cm)	k-value ($m^2.°C/W$)
Outside air film	--	--
(1) Stone with mortar	5	1.3
(2) Reinforced concrete	10	2
(3) Cavity filled with mineral wool	2	0.06
(4) Cement Block	10	1
(5) Lightweight plaster	1.3	0.180
Inside Air film	--	--

$$U_{wall} = \frac{1}{R_{r,total}} = 1.43\ W/m^2.°C$$

U-value For Roof

The following figure shows a section of the roof. The contents of the roof and their U-values are shown in next table.

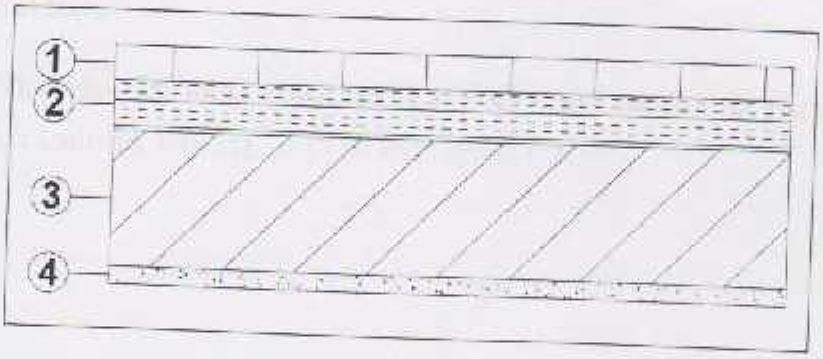


Figure (5.2) Roof construction

Table (5.3) Over all heat transfer coefficient for roof construction

Material	Thickness (cm)	k-value ($m^2.^oC/W$)
Outside air film	--	0.040
(1) Built-up roofing	1	0.060
(2) Insulation	2	0.06
(3) Reinforced concrete	10	2
(4) Lightweight plaster	1.3	0.180
Inside Air film	--	0.120
R_{roof}= 2.803 ($m^2.^oC/W$)		

$$U_{roof}=\frac{1}{R_{r,total}}=\frac{1}{2.803}=0.357\ W/m^2.^oC$$

- Total area of windows is: 24.16 m^2
- Total area of walls without windows: 183.16 – 24.16 = 159 m^2
- Total area of the roof: 98 m^2.

Sunlit Surfaces

The following Table shows the CLTDs for Sunlit Walls, roofs and windows (32^o North Latitude, July 21), at 17:00 PM.(group C).

Table (5.4) CLTD values for the walls

Side	CLTD (°C)
North (N) wall	7
East (E) wall	17
South (S) wall	12
West (W) wall	11
Roof	47
North (N) window	14
East (E) window	16
South (S) window	16
West (W) window	14

⇨ $= (U_{wall})\,(A_{wall})\,(CLTD_N + CLTD_E + CLTD_S + CLTD_W)$

⇨ $Q_{roof} = (U_{roof})\,(A_{roof})\,(CLTD_{Roof})$

Table (5.5) Area of each direction of sunlit glasses

Side	A (m^2)
North (N) window	14.32
East (E) window	12.6
South (S) window	19.17
West (W) window	8.1

$W_{indow} = (U_{window}) \sum [(A_{window})\,(CLTD)]$

Solar Radiation through Glass

The following table shows SHG and SC for each direction of Sunlit Glass (32° North Latitude, July 21) at 16:00.

Table (5.6) SHG,SC values for each direction of sunlit glass

Side	SHG	SC
North (N) window	126	0.25
East (E) window	678	0.25
South (S) window	227	0.25
West (W) window	678	0.25

Where:

SHG: solar heat gain factor.

SC: shading coefficient.

$Q_{radiation} = (SC) \sum [(SHG) (A_{window})]$.

5.3.4 Cooling load Calculation of living room

*Heat transferred through floor and ceiling:

$Q1 = (U) * (A) * (To - Ti)$

Where

A: Is the area of the room

Table (5.7) Heat gain from floor and ceiling of the living room

surface	Area m²	U W/m².c	ΔT °C	Q w
floor	15.12	2.1	5	185.76
ceiling	15.12	1.8	5	136.08

*Heat transferred through door:

Qd = (U * A)d * (To – Ti)

= 3.5 * 2.7 (40 -24)

= 140 W

* Heat gain due to solar effect (Qs) for wall and glass windows:

Qs = U * A*(CLTD) coor.

(CLTD) coor. = (CLTD +LM)*K + (25.5 – Ti) + (To, m – 29.4)*F

Where :

(CLTD)coor :CLTD corrected

Where :

K =0.65 for wall

K = 1for glass

F = 1

A south wall = 3*4 =12 m^2

A west wall = 4.3 * 3 = 12.9 m^2

(CLTD) coor (west wall) = (CLTD +LM)*K + (25.5 – Ti) + (To, m – 29.4)*F

(25.5 – Ti) = (25.5 -24)

= 1.5 °C

(To, m – 29.4) = (35 – 29.4)

= 5.6 °C

(CLTD) coor (west wall) = (20 +0)* 0.65+ (1.5) + (5.6)*1

= 20.1 °C

(CLTD) coor(south wall) = (14 -1.6)*0.65 + (1.5) + (5.6)*1

(CLTD) coor(west glass) = (7+0)*0.65 + (1.5) + (5.6)*1

= 11.65 °C

(CLTD) coor(south glass) = (7 – 1.6)*0.65 + (1.5) + (5.6)*1

= 10.6 °C

Q(west wall) = U *A * (CLTD) coor.

= (1.43)*(12.9)*(20.1)

= 370.7W

Q(south wall) = (1.43)*(12)*(15.1)

= 259.1W

Q(west glass) = (4.6)*(1.5)*(11.65)

= 80W

Q(south glass)= (3.46)*(1.5)*(10.6)

= 55W

Table (5.8) Heat gain from west and south walls and glasses of the living room

Surface	CLTD °C	LM	(CLTD)coor. °C	Q W
W-Wall	11	0.0	20.1	370.7
S-Wall	12	-1.6	15.1	259.1
W-glass	7	0.0	11.65	80
S-glass	7	-1.6	10.60	55

*Heat gain due to solar transmission through glass:

Qg = A* (SHG) * (SC) * (CLF)

Where:

CLF: Cooling load factor, with interior shading

For south glass: SHG = 227 w/m²

SC = 0.25

CLF = 0.27

For west glass: SHG = 678 w/m²

SC = 0.25

CLF = 0.81

Q(glass) = (1.5)*(227)*(0.25)*(0.27) + (1.5)*(678)*(0.25)*(0.81)

= 22.98 + 205.94

= 228.9 w

* Sensible heat gain due occupants o,c1 :

Qo,c1 = {10*(87)/1000}*(CLF)o,c

= (0.87)* (CLF)

= (0.87) *(0.87)

= 0.75 kW.

*Latent heat gain due occupants o,c2:

Qo,c2 = 10*(145 -87)/1000

= 0.58 kW.

*Heat gain due to lights:

Qlt = {30* (3.60 * 4.20)/1000}/ (CLF) lights

= (0.453)*(CLF).

= (0.453)*(0.96)

= 0.4348 kW.

*Heat transmitted due to infiltration Qf

Qf = (Vf/Vo)*(ho - hi)

= {(1)*(10)*(90 – 47.8)}/ {(0.91)*(1000)}

= 422 / 910

= 0.463 kW.

Where:

inside design condition 24°C db and 50% RH

Outside design condition 40°C db and 28°C wb temp.

Outside mean temperature. = 35°C.

→ from the psychometric chart :

Specific volume(Vo) = 0.91 m^3

Ho= 90 kj/kg

Hi = 47.8 kj/kg

Q total. =Q1+Qd+Qsolar+Qg+ (Qo,c1 + Qo,c2)+Qlt+Qf

$=140+370.7+259.1+80+55+228.9+750+580+434.8+158.76$
$+136.08+0.463$

Q total.(1) = 3.656 kW.

Similarly , the load of other rooms is calculated, so

The cooling load of all rooms is shown in the following table.

Table (5-9) cooling load for the floor rooms

Room	Cooling load (kW)
Salon room	3.883
Kitchen room	2
Food room	1.918
Living room	3.656
Office room	1.552
Tatal load	13

5.4 Duct sizing

In this section the duct size will be calculated according to the equal pressure drop method , this method depends on the pressure drop in the duct branch .

This pressure drop assumed to be constant in all branches.

Data

The cooling load for each room in the floor as following . all units in kW.

Table (5-10) cooling load for the floor rooms

ROOM	LOAD(kW)
Salon room	3.883
Kitchen room	2
Food room	1.918
Living room	3.656
office room	1.552

Assumptions

The velocity of the air in the main duct assumed to be 5 m/s.

The air properties assumed to be :

Cp(specific heat at constant pressure)=1 kJ/kg.k.

Tin =24°C , Tout = 40°C.

Air density , ρ = 1.25 kg/m^3.

Calculations

$V = Q / \rho Cp(Tout-Tin)$.

Where:

V: is the volumetric flow rate of the supply air(m^3/s) .

Q: is the cooling load (Kw).

So .

(Ti - Ts)

$V = Q / 1.25 * 1 * (40-24)$

$V = Q / 20$.

Volumetric flow rate calculations for each room

Salon room

$V = Q / 20$

= 3.883/ 20

= 0.19 m^3/s.

=190 L/s

Kitchen room

$V = Q / 20$

= 2/ 20

= 0.1 m^3/s

= 100 L/s

food room

$V = Q / 20$

= 1.918/ 20

= 0.096 m^3/s

= 96 L/s

Living room

$V = Q / 20$

$= 3.656 / 20$

$= 0.18\ m^3/s$

$= 180 L/s$

office room

$V = Q / 20$

$= 1.552 / 20$

$= 0.077\ m^3/s.$

$= 77 L/s$

Table (5-11) volumetric flow rate for the floor rooms

Room	Volumetric flow rate(m^3/s)
Salon room	0.19
Kitchen room	0.1
Food room	0.096
Living room	0.18
Office room	0.077
Σ(total)	0.64

For duct section A-B (main duct), $V_{(A-B)} = 0.64\ m^3/s$ and v (air velocity)= 5m/s. Therefore , from (APPENDIX B .5). we can obtain that .

Pressure drop $(\Delta P/EL)_{A-B}$ =0.7 Pa / m.

This pressure drop is constant fo:r all duct branches.

Also , since :

$V=A*v$

Where:

A: is the duct aria (m^2).

V: is the air velocity(m/s).

So the aria of the duct branch $_{A-B}$:

$A_{(A-B)}=0.64/5$

$=0.128m^2$.

$A=\pi d^2/4$

So :

d = 400mm.

for rectangular duct dimensions, . from (APPENDIX B.1)

Duct branch $_{(A-B)}$ dimensions = 275mm* 500mm

Similarly , for duct section $_{(B-C)}$ with flow rate of :

$V_{(B-C)}=0.64-(V_{(B-2)}+V_{(B-1)})$.

$=0.64-(0.1+0.19)$.

And Pressure drop $(\Delta P/EL)$ = 0.7 Pa/m.

Then (APPENDIX B.5) gives :

$d_{(B-C)}$ = 325 mm.

velocity(v) = 4.4 m/s.

the rectangular duct dimensions $_{(B-C)}$, from (APPENDIX B.1) .

Duct branch $_{(B-C)}$ dimensions = 225mm* 400mm.

The data of the other branches is in the flowing table.

Table (5-12) duct sizing for all sections

Duct section	Volumetric flow rate (m^3/s)	*ΔP/EL* (Pa/m)	Diameter (mm)	Air velocity (m/s)	Rectangular dimensions (mm)
A-B	0.64	0.7	400	5	275mm* 500mm
B-C	0.35	0.7	325	4.4	225mm* 400mm
C-D	0.254	0.7	275	4	250mm* 250mm
B-1	0.19	0.7	260	3.7	225mm*250mm
B-2	0.1	0.7	200	3.3	175mm*200mm
C-3	0.096	0.7	200	3.3	175mm*200mm
D-4	0.18	0.7	255	3.7	225mm*250mm
D-5	0.077	0.7	180	3	100mm*300mm

5.5 Equipment selection

The selection process is a process that needs catalogues for the equipments to be selected , so in this selection, chapter four (equipments catalogues collection) is necessary for this process.

In selection we may face devices that have not the same load or capacity of flow rate or diameter (ducts), or cooling load that we have in the calculations, so to solve this problem we select the smallest value in the catalogue that is bigger than the value we have in the calculations.

Example

If we want to select an air handling unit or out door unit which have the capacity of 12500 watt, and this capacity nit exist in the catalogue , in this case we select the smallest value which is bigger than it such as 13000 watt, so we select the device that have 13000 watt of cooling capacity.

This process supports the safety factor that we need in selection.

Indoor unit selection

In this project the air condition system is mini central system with a duct distribution which is covered by false ceiling.

So the indoor unit in this system is air handling unit which exists in the market sometimes as one unit with the out door unit .

So the catalogue of this air handling unit , gives a data for both units , which means that the selection will be for both units.

According to the calculations , the total load of the house is 13000 watt , so we need a catalogue that has this value or little more.

With backing to the (APPENDIX A.2.4), we find a catalogue that has this value , and the air handling unit in (APPENDIX A 2.3)

DNC 50 3PH	DNC 40 3PH	DNC 40			
44,400	38,000	38,000	BTU/h	Cooling	Capacity
13,000	11,130	11,130	W		
47,800	38,000	38,000	BTU/h	Heating	
14,000	11,130	11,130	W		
2.70	2.8	2.80	COP	Cooling	Cop
3.30	3.26	3.23	COP	Heating	
G	G	G			
4,810	3,970	3,970	W	Cooling	Power input
4,260	3,410	3,440	W	Heating	
3x10	3x8	18	A	Cooling	Amperes
3x9	3x7	16	A	Heating	
1,600	1,400	1,400	CFM	Total air flow	
2,720	2,380	2,380	M3/h		
50	40		Pa	Static pressure	
400/50/3N		230/50/1	V/Hz/Ph	Voltage/frequency/phase	
			mm	Dimensions	
1,025x300x760			W×H×D	Indoor unit	
900x970x340		900x970x340	W×H×D	Outdoor unit	
3/8"x3/4"		3/8"x3/4"	INCH	Pipe sizing	

From the catalogue data and the load of 13000watt we select the air handling unit with the type of DNC50 , which has the exact value of 13000watt cooling capacity.

Grills selection

Grills selection depend mainly on the air flow rate that the room need , so we need to select a grill or more to cover this air flow rate.

With referring to (APPENDIX B.2) using this table , and the volumetric flow rate of each room ,so we can select the grills as flowing .

Table (5-13) grills sizing

Room	Volumetric flow rate (L/s)	Size of grill (cm*cm)	Number of grills
Salon room	190	30 * 30	2
Kitchen room	100	23 * 23	1
Food room	96	23 * 23	1
Living room	180	30 * 30	1
Office room	77	15 * 15	1

5.6 Cooling load calculations according to the expectation way in the market

The expectation way in the market is a way that calculate the load of the application by expecting according to their experience in this field.

This way is :-

Every 1 m^3 of the conditioned space needs 300btu(British thermal unit), so in this section the load will be calculated according to this way and then compared with the theoretical way in the last section.

Cooling load calculations

$$V = A * H$$

Where:

V: is the volume of the room (m^3).

A: is the area of the room(m^2).

H: is the height of the ceiling(m).

$$Q = V * 300btu$$

Where:

Q: is the cooling load(btu).

Living room

$$V = 15.12 * 3$$

$= 45.36m^3$

$$Q = 45.36 * 300$$

=13608btu

office room

$$V = 11.22 * 3$$

$=33.66m^3$

$$Q = 33.66 * 300$$

=10098btu

food room

$$V = 10.73 * 3$$

$=32.19m^3$

$$Q = 32.19 * 300$$

=9657btu

Salon room

$$V = 20.58 * 3$$

$=61.74m^3$

$$Q = 61.74 * 300$$

=18522btu

Kitchen room

$$V = 13.32 * 3$$

$=39.96m^3$

$$Q = 39.96 * 300$$

=11988btu

$$Qtotal = \sum Q\ for\ all\ rooms$$

= 13608+10098+9657+18522+11988

= 63873btu

$$Q\ in\ ton\ of\ refrigeration\ (TR) = Qtotal/12000$$

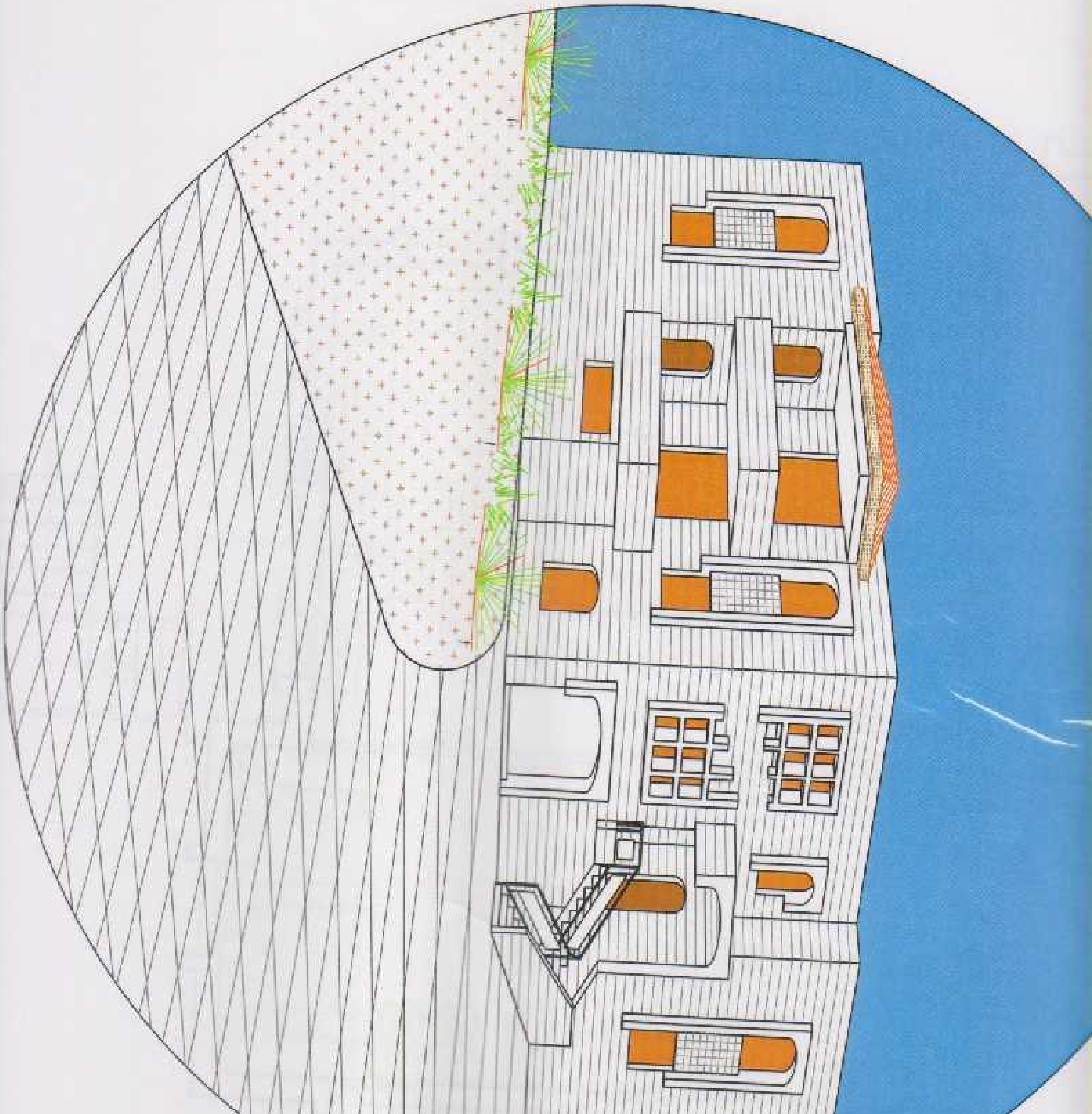
= 63873/12000

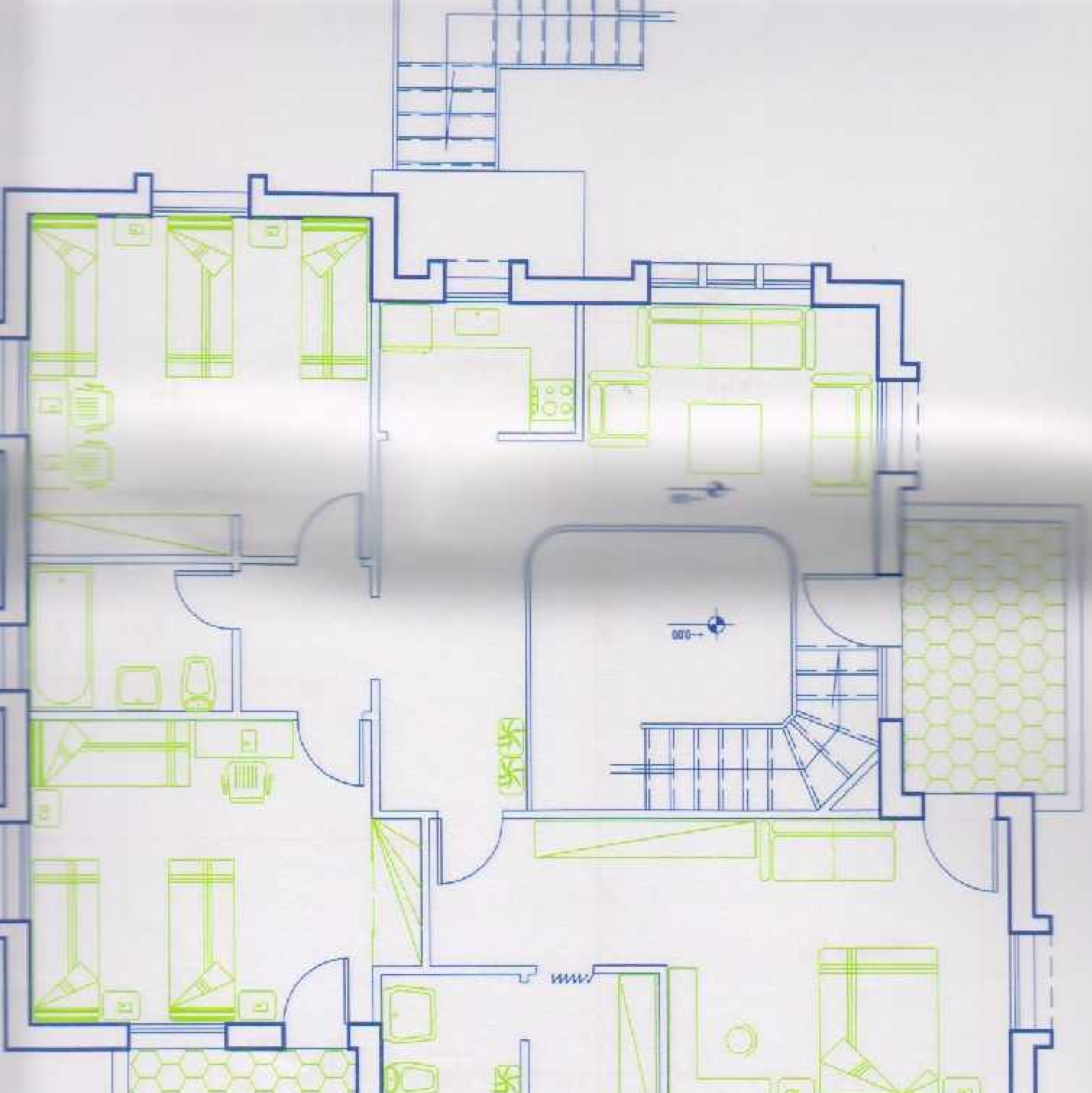
= 5.3TR

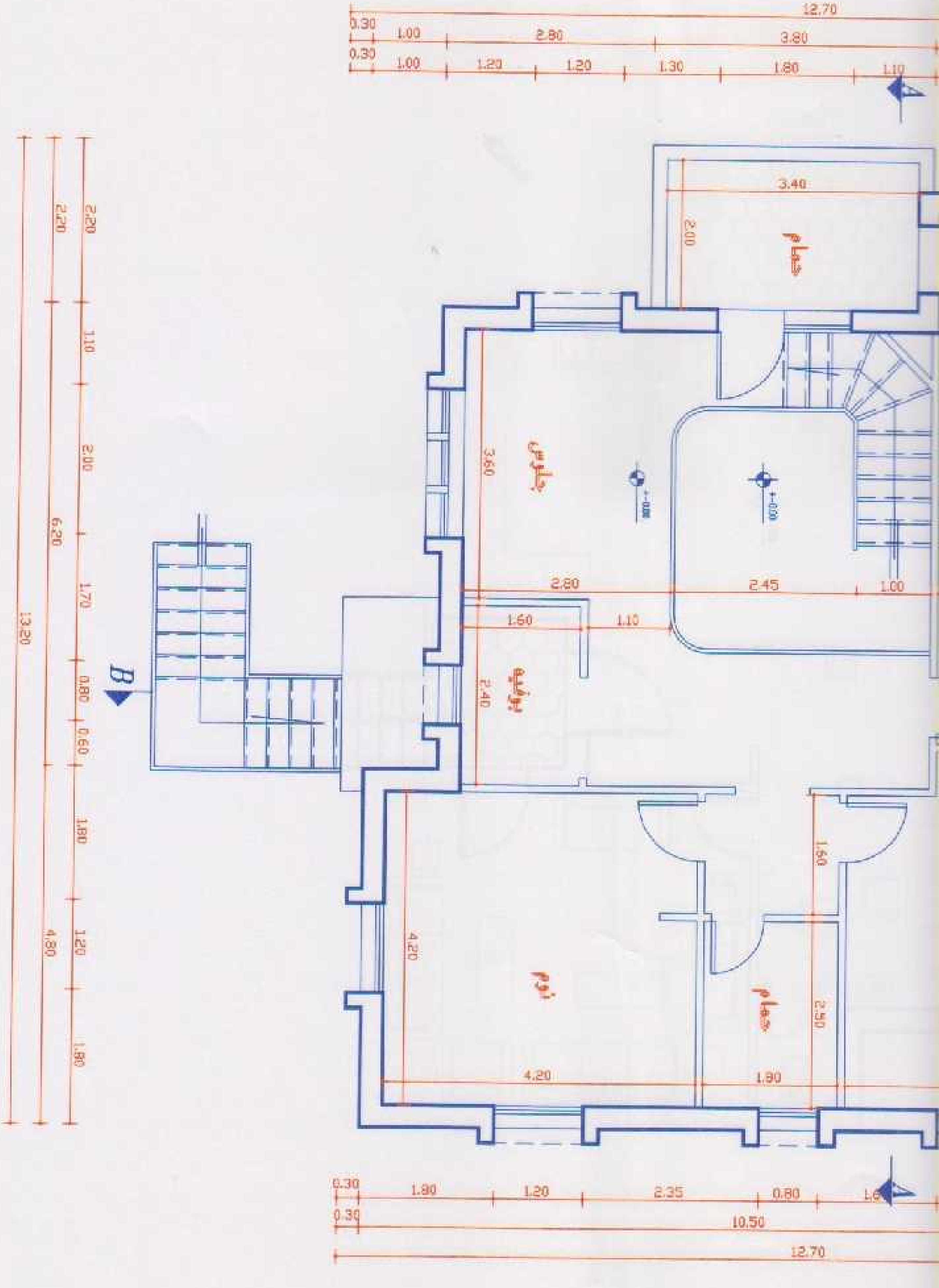
Comparison between theoretical calculations and expectation way calculations

According to the results of two ways of the same application it is clear that the expectation way for load calculation is not efficient, because it has 1.6TR additional to the real load which means increase in energy consumption and cost.

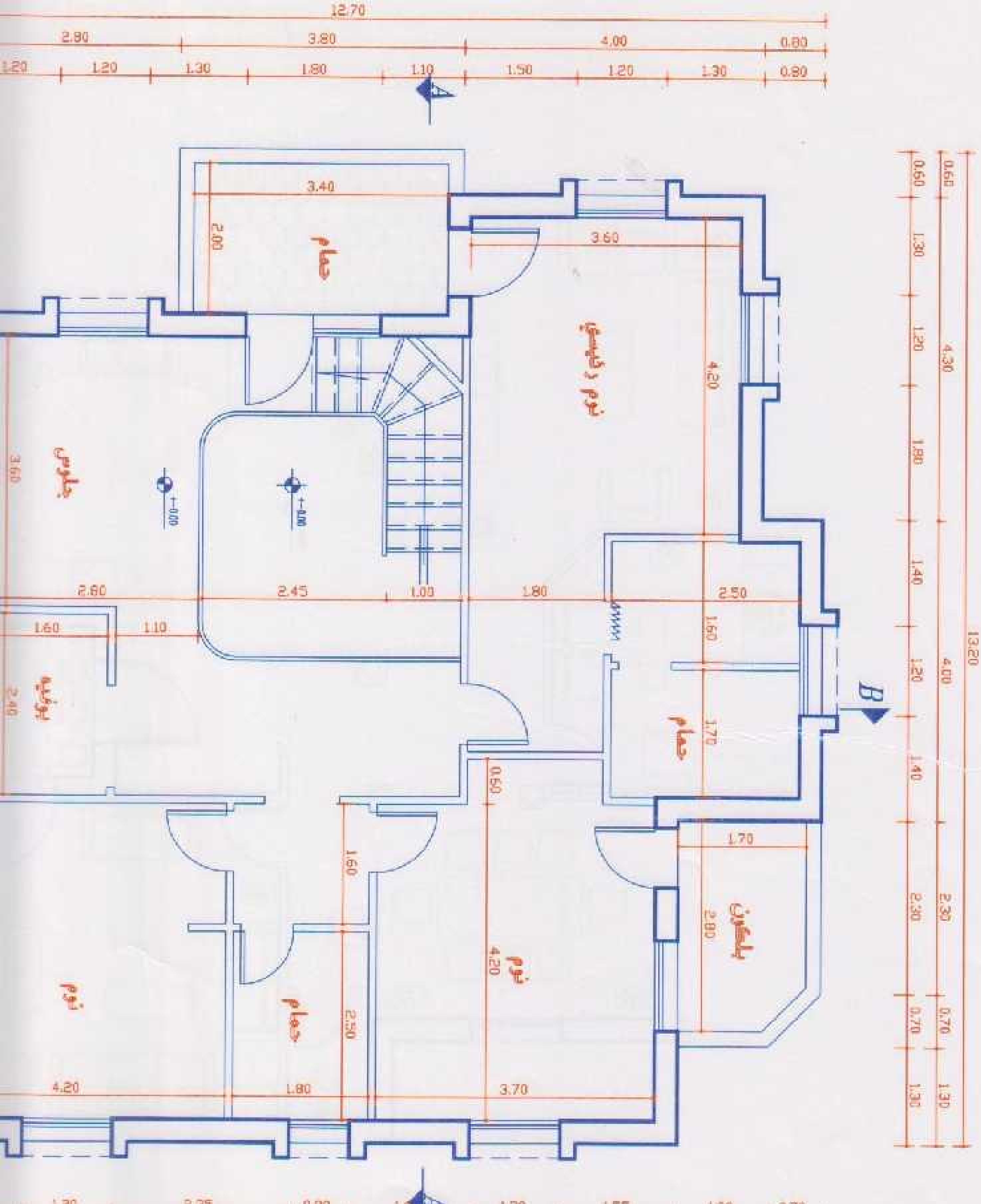
This increase of energy and cost expressed lose in cost and energy for the customer without use, so the theoretical way is more accurate and saving for energy and cost.

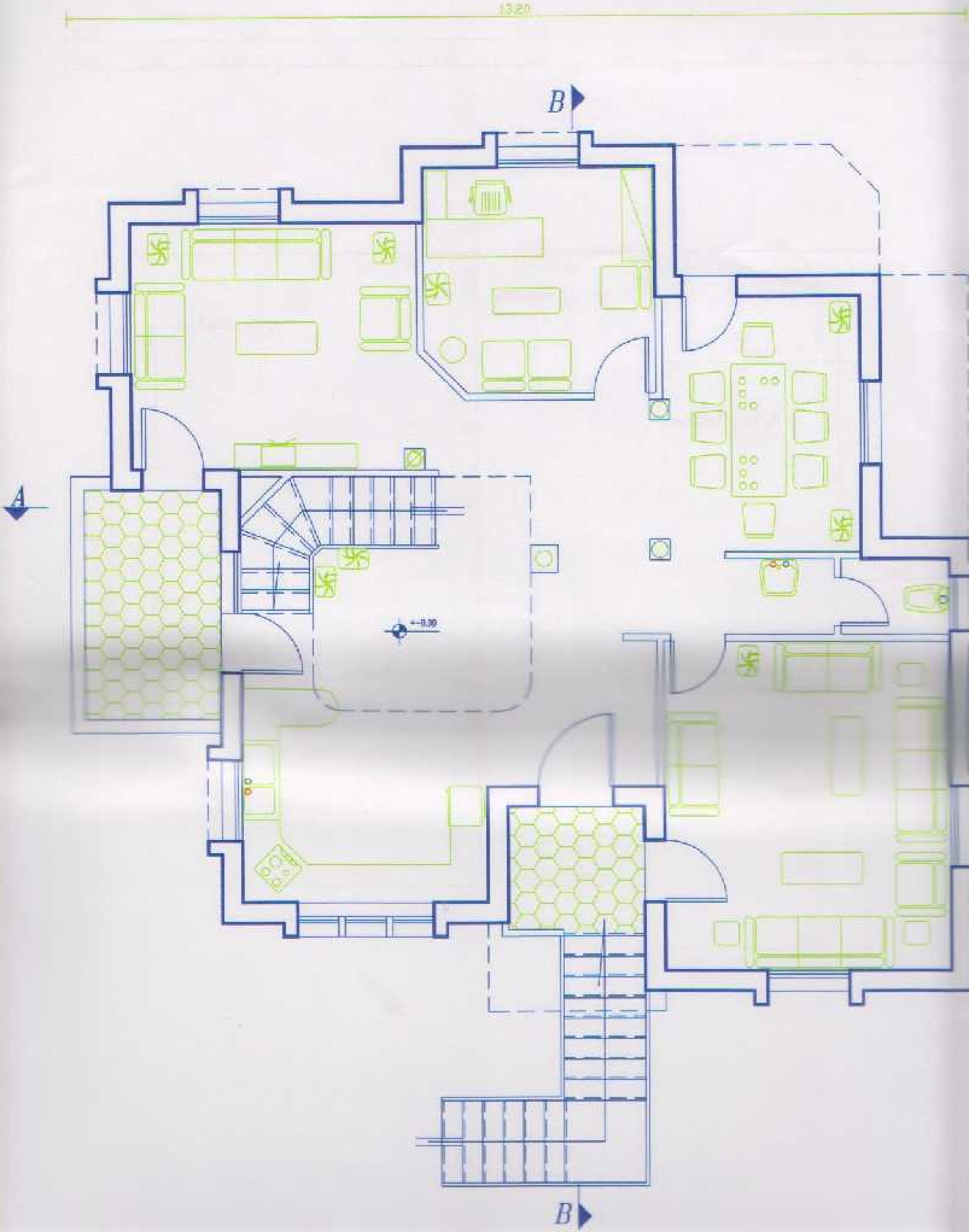


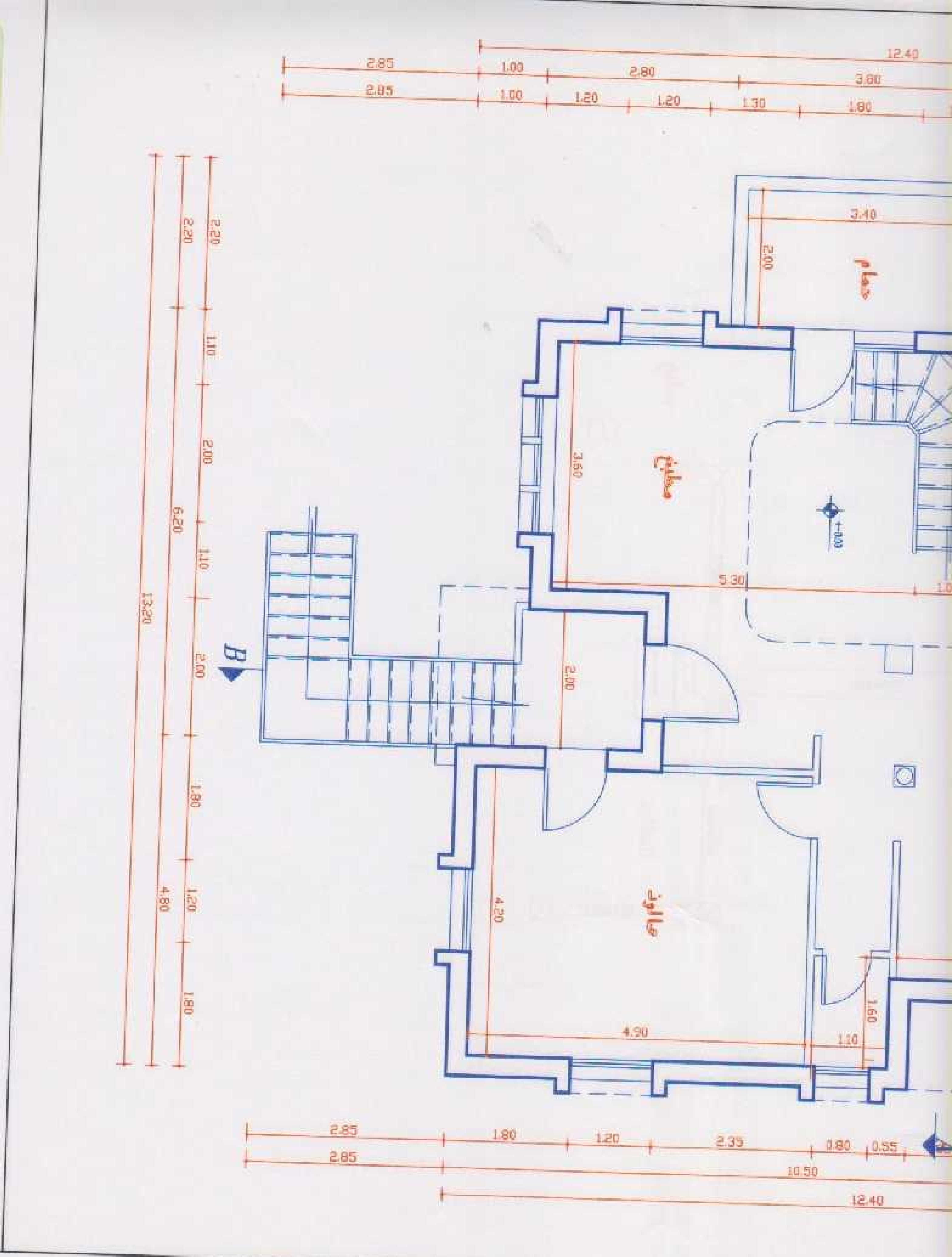




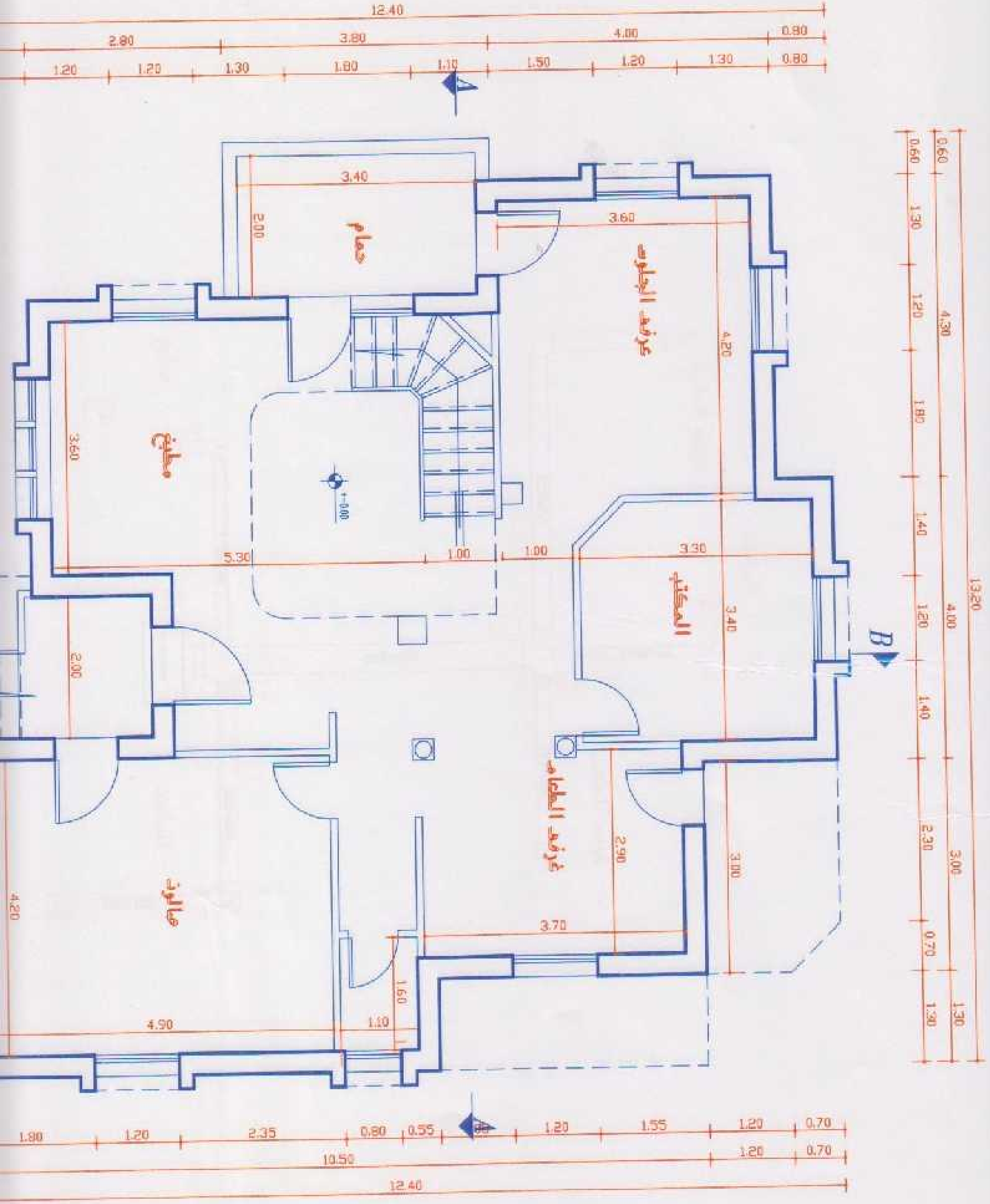
12.70
0.30
1.00
2.80
3.80
0.30
1.00
1.20
1.20
1.30
1.80
1.10
3.40
2.00
حمام
جلوس
3.60
2.80
2.45
1.00
1.60
1.10
بوفيه
2.40
B
نوم
حمام
4.20
1.60
2.50
4.20
1.90
2.20
2.20
1.10
2.00
6.20
1.70
13.20
0.80
0.60
1.80
4.80
1.20
1.80
0.30
1.80
1.20
2.35
0.80
0.30
10.50
12.70

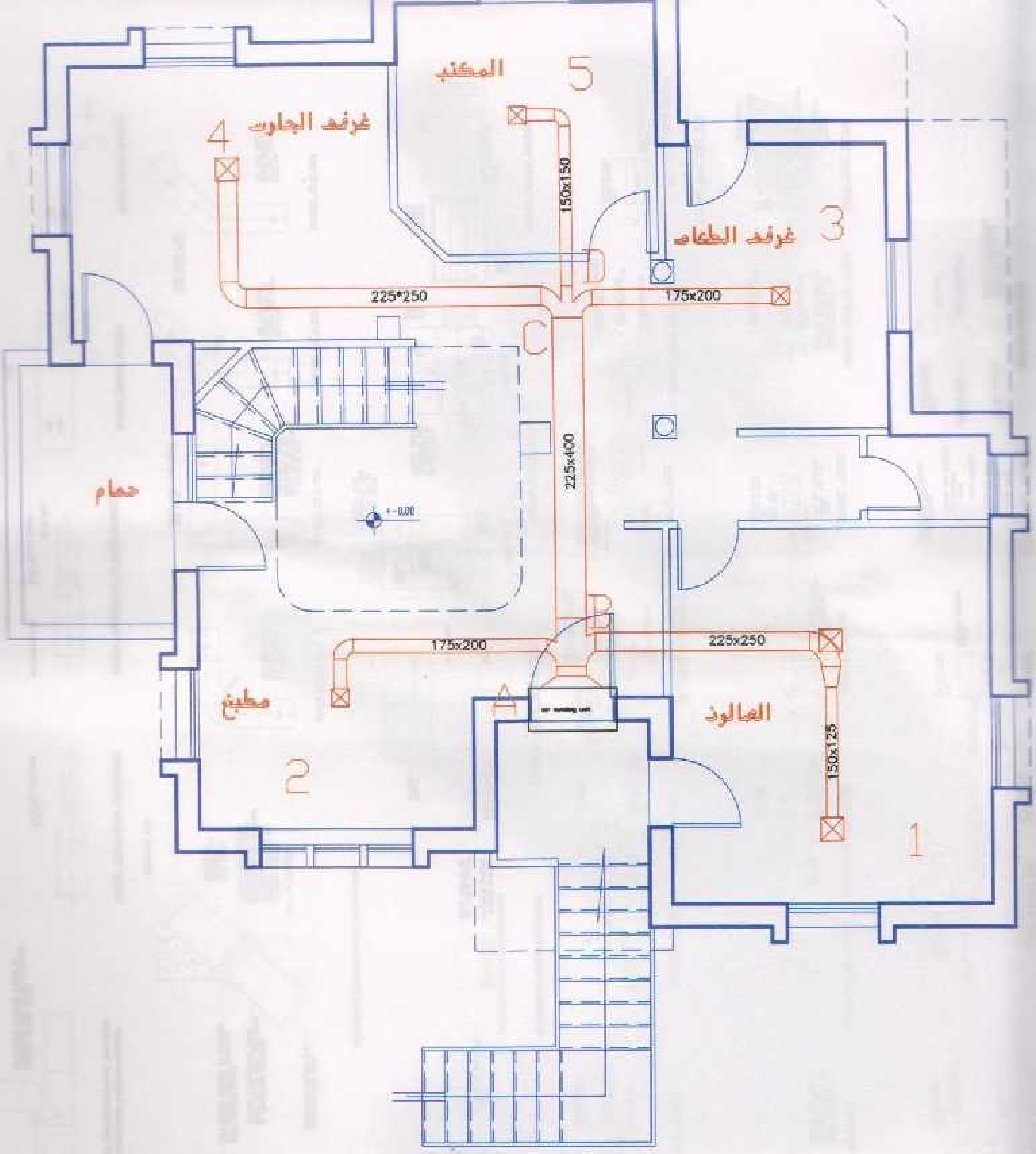

حمام
نوم رئيسي
جلوس
بوفيه
حمام
نوم
حمام
نوم
بلكون
B
12.70
10.50
13.20


13.20
B
A
±-0.30
B

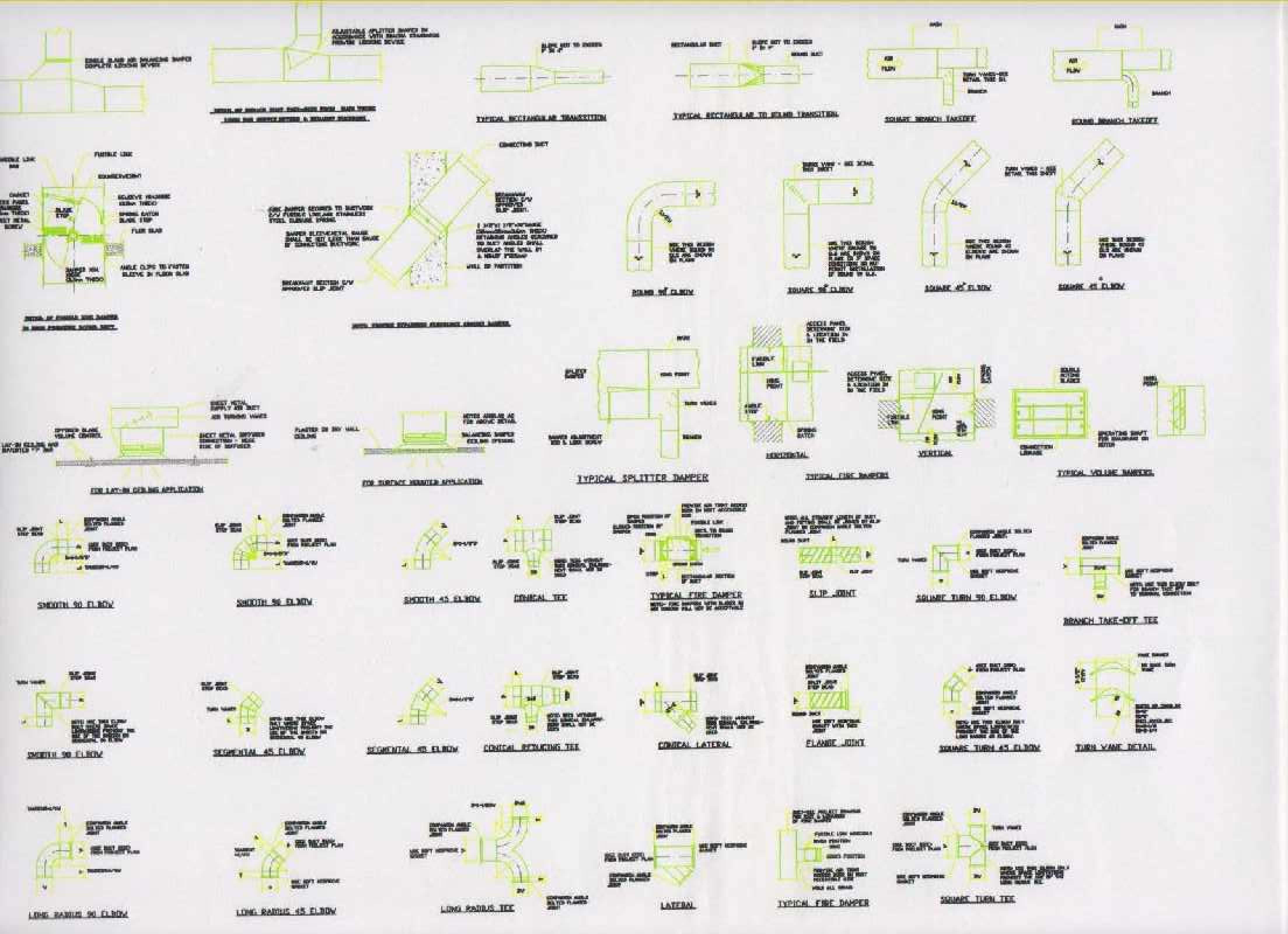


12.40
2.85
1.00
2.80
3.60
2.85
1.00
1.20
1.20
1.30
1.80
3.40
2.00
2.20
2.20
1.10
2.00
6.20
1.10
13.20
2.00
1.80
4.80
1.20
1.80
3.60
5.30
2.00
4.20
4.90
1.10
1.60
B
2.85
1.80
1.20
2.35
0.80
0.55
2.85
10.50
12.40


حمام
غرفة الجلوس
مطبخ
المكتب
غرفة الطعام
صالون
A
B



المكتب
5
غرفة الجلوس
4
غرفة الطعام
3
150x150
225*250
175x200
C
225x400
حمام
+-0.00
175x200
225x250
مطبخ
A
air handling unit
الصالون
150x125
2
1


TYPICAL RECTANGULAR TRANSITION
TYPICAL RECTANGULAR TO ROUND TRANSITION
SQUARE BRANCH TAKEOFF
ROUND BRANCH TAKEOFF
ROUND 90° ELBOW
SQUARE 90° ELBOW
SQUARE 45° ELBOW
SQUARE 45 ELBOW
HORIZONTAL
VERTICAL
TYPICAL SPLITTER DAMPER
TYPICAL FIRE DAMPERS
TYPICAL VOLUME DAMPERS
FOR LAY-IN CEILING APPLICATION
FOR SURFACE MOUNTED APPLICATION
SMOOTH 90 ELBOW
SMOOTH 90 ELBOW
SMOOTH 45 ELBOW
CONICAL TEE
TYPICAL FIRE DAMPER
SLIP JOINT
SQUARE TURN 90 ELBOW
BRANCH TAKE-OFF TEE
SMOOTH 90 ELBOW
SEGMENTAL 45 ELBOW
SEGMENTAL 45 ELBOW
CONICAL REDUCING TEE
CONICAL LATERAL
FLANGE JOINT
SQUARE TURN 45 ELBOW
TURN VANE DETAIL
LONG RADIUS 90 ELBOW
LONG RADIUS 45 ELBOW
LONG RADIUS TEE
LATERAL
TYPICAL FIRE DAMPER
SQUARE TURN TEE

CHAPTER SIX

CONCLUSION

6.1 Conclusion

1) According to the theoretical calculations and the expectation method in the market, it is clear that the expectation method is not efficient , because of the additional load without any use which mean lose in energy , tine and money.

2) HVAC equipment may have more than one catalogue according to the HVAC company but the same properties exist in any catalogue but in different description.

APPENDIX A

Appendix A-1

Sanyo Company catalogues

Figure (A.1.1) Concealed ducted indoor unit

Model name (SPW-)			UR74GXH56B	UR94GXH56B	UR124GXH56B	UR164GXH56B	UR184GXH56B	UR254GXH56B	UR364GXH56B	UR484GXH56B
Power source			220/230/240V, 1 phase-50, 60Hz							
Cooling capacity		kW	2.2	2.8	3.6	4.5	5.6	7.3	10.6	14.0
		BTU/h	7,500	9,600	12,000	15,000	19,000	25,000	36,000	47,800
Heating capacity		kW	2.5	3.2	4.2	5.0	6.3	8.0	11.4	16.0
		BTU/h	8,500	11,000	14,000	17,000	21,000	27,000	39,000	54,600
Power input	Cooling	kW	0.084/0.106/0.105			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Heating	kW	0.082/0.088/0.094			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Running amperes	Cooling	A	0.45/0.45/0.47			0.45/0.45/0.44	0.44/0.45/0.45	0.83/0.86/0.88	1.44/1.45/1.46	1.42/1.43/1.44
	Heating	A	0.40/0.41/0.42			0.41/0.40/0.39	0.38/0.40/0.41	0.78/0.81/0.84	1.39/1.40/1.41	1.36/1.37/1.38
Fan motor	Type		Sirocco fan *1					Sirocco fan *2	Sirocco fan *3	
	Airflow rate (H/M/L)	m³/min	10/8.5/7			12/10.5/8		18/15/13	30/26/21	33/30/25
	Output	kW	0.05					0.07	0.14	
	External static pressure	Pa	40(65)			40(62)		50(92)	78(122)	78(113)
Power sound level (H/M/L)		dB(A)	40/37/33			41/39/35		45/41/38	49/44/42	51/48/44
Pressure sound level (H/M/L)		dB(A)	(32/29/26/22			(33/30/28/25		(38)34/30/27	(42)38/35/31	(44)40/37/33
Dimensions	Height	mm	310							
	Width	mm	760					1006	1480	
	Depth	mm	530							
Piping connections	Liquid Flare	mm	6.35					9.52		
	Gas Flare	mm	12.7					15.88		
	Drain piping		VP-25							
Net weight		kg	24			25		37	43	

Figure (A.1.2) Concealed ducted indoor unit catalogue

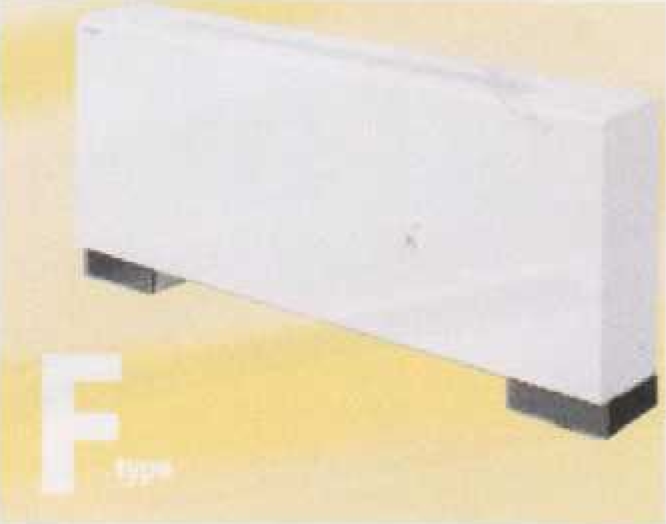


Figure (A.1.3) Floor standing type(indoor unit)

Floor Standing type

Model name (SPW-)			FR74GXH56B	FR94GXH56B	FR124GXH56B	FR164GXH56B	FR184GXH56B	FR254GXH56B
Power source			220/230/240V, 1 phase-50, 60Hz					
Cooling capacity		kW	2.2	2.8	3.6	4.5	5.6	7.1
		BTU/h	7,500	9,600	12,000	15,000	19,000	24,000
Heating capacity		kW	2.5	3.2	4.2	5.0	6.3	8.0
		BTU/h	8,500	11,000	14,000	17,000	21,000	27,000
Power input	Cooling	kW	0.051/0.056/0.061		0.079/0.086/0.091	0.136/0.126/0.115	0.116/0.126/0.136	0.152/0.163/0.179
	Heating	kW	0.035/0.042/0.045		0.064/0.070/0.076	0.101/0.091/0.079	0.079/0.091/0.101	0.112/0.123/0.130
Running amperes	Cooling	A	0.24/0.25/0.26		0.37/0.38/0.39	0.58/0.56/0.54	0.54/0.56/0.58	0.72/0.72/0.73
	Heating	A	0.17/0.18/0.19		0.30/0.31/0.32	0.43/0.41/0.37	0.37/0.41/0.43	0.52/0.54/0.56
Fan motor	Type		Sirocco fan *1			Sirocco fan *2		
	Airflow rate (H/M/L)	m³/min	7/6/5		9/7/6	12/9/8	15/13/11	17/14/12
	Output	kW	0.01		0.02	0.02	0.03	0.06
Power sound level (H/M/L)		dB(A)	44/41/38		53/46/40	48/46/42	50/47/42	52/49/46
Pressure sound level (H/M/L)		dB(A)	33/30/28		39/36/29	38/36/31	39/35/31	41/38/35
Dimensions	HxWxD	mm	615x1065x230			615x1380x230		
Piping connections	Liquid (Flare)	mm	6.35					9.52
	Gas (Flare)	mm	12.7					15.88
	Drain piping		VP-20					
Net weight		kg	29			39		

Figure (A.1.4) Floor standing type catalogue

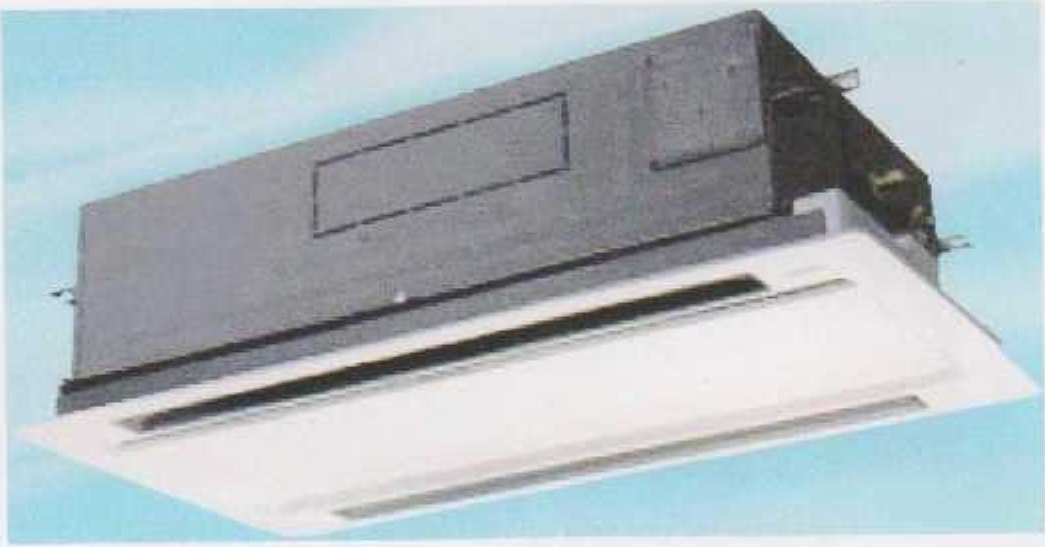


Figure (A.1.5) Semi –concealed type (2 way air discharge)

Indoor units specifications

Model name (SPW-)			SR74GXH56B	SR94GXH56B	SR124GXH56B	SR164GXH56B	SR184GXH56B	SR254GXH56B
Power source			220/230/240V, 1 phase-50, 60Hz					
Cooling capacity		kW	2.2	2.8	3.6	4.5	5.6	7.3
		BTU/h	7,500	9,600	12,000	15,000	19,000	25,000
Heating capacity		kW	2.5	3.2	4.2	5.0	6.3	8.0
		BTU/h	8,500	11,000	14,000	17,000	21,000	27,000
Power input	Cooling	kW	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0.135/0.145/0.154
	Heating	kW	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Running amperes	Cooling	A	0.45/0.45/0.45	0.44/0.45/0.45	0.44/0.45/0.45	0.45/0.45/0.45	0.45/0.45/0.45	0.64/0.65/0.66
	Heating	A	0.29/0.29/0.36	0.28/0.29/0.30	0.28/0.29/0.30	0.30/0.29/0.29	0.29/0.29/0.36	0.46/0.48/0.49
Fan motor	Type		Sirocco fan *1					Sirocco fan *2
	Airflow rate (H/M/L)	m³/min	8/7/6	9/8/7	9.5/8.6/7.6	11/9/8		19/16/14
	Output	kW	0.03					0.05
Power sound level (H/M/L)		dB(A)	40/38/35	44/40/37	45/42/39	46/44/40		49/46/44
Pressure sound level (H/M/L)		dB(A)	30/27/24	33/29/28	34/31/28	35/33/29		38/35/33
Dimensions	Height	mm	350 + <8>					
	Width	mm	840 <1060>					1140 <1360>
	Depth	mm	600 <680>					
Piping connections	Liquid (Flare)	mm	6.35					9.52
	Gas (Flare)	mm	12.7					15.88
	Drain piping		VP-25					
Net weight		kg	25 + <7>					30 + <8>

Figure (A.1.6) Semi –concealed type 2 way air discharge catalogue

Figure (A.1.7) Semi –concealed type (one way air discharge)

Indoor units specifications

Model name (SPW-)			LDR94GXH56B	LDR124GXH56B	LDR164GXH56B	LDR184GXH56B	LDR254GXH56B
Power source			220/230/240V, 1 phase-50, 60Hz				
Cooling capacity		kW	2.8	3.6	4.5	5.6	7.3
		BTU/h	9,600	12,000	15,000	19,100	25,000
Heating capacity		kW	3.2	4.2	5.0	6.3	8.0
		BTU/h	11,000	14,000	17,000	21,000	27,000
Power input	Cooling	kW	0.105/0.110/0.115	0.105/0.110/0.115	0.105/0.110/0.115	0.110/0.115/0.120	0.115/0.120/0.125
	Heating	kW	0.075/0.080/0.085	0.075/0.080/0.085	0.075/0.080/0.085	0.080/0.085/0.090	0.085/0.090/0.095
Running amperes	Cooling	A	0.50/0.50/0.51	0.50/0.50/0.51	0.50/0.50/0.51	0.53/0.53/0.54	0.55/0.55/0.56
	Heating	A	0.36/0.37/0.38	0.36/0.37/0.38	0.36/0.37/0.38	0.38/0.39/0.40	0.40/0.41/0.42
Fan motor	Type		Sirocco fan ×2				
	Airflow rate (H/M/L)	m³/min	12/10/9		12/11/10	13/11.5/10	18/16/13
	Output	kW	0.05				
Power sound level (H/M/L)		dB(A)	47/45/44		47/46/45	49/47/45	55/51/47
Pressure sound level (H/M/L)		dB(A)	36/34/33		36/35/34	38/36/34	45/40/38
Dimensions	Height	mm	200 + <20>				
	Width	mm	1,000 <1,230>				
	Depth	mm	710 <800>				
Piping connections	Liquid (Flare)	mm	6.35				9.52
	Gas (Flare)	mm	12.7				15.88
	Drain piping		VP-25				
Net weight		kg	21 + <5.5>				22 + <5.5>

Figure (A.1.8) Semi –concealed type one way air discharge catalogue

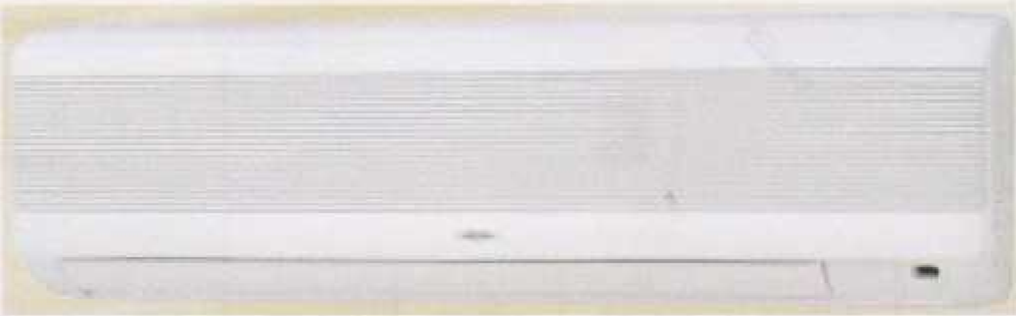


Figure (A.1.9) Wall split type

Model name (SPW-)			KR74GXH56B	KR94GXH56B	KR124GXH56B	KR164GXH56B	KR184GXH56B	KR254GXH56B
Power source			220/230/240V, 1 phase-50, 60Hz					
Cooling capacity		kW	2.2	2.8	3.6	4.5	5.6	7.3
		BTU/h	7,500	9,600	12,000	15,000	19,000	25,000
Heating capacity		kW	2.5	3.2	4.2	5.0	6.3	8.0
		BTU/h	8,500	11,000	14,000	17,000	21,000	27,000
Power input	Cooling	kW	0.031/0.033/0.035					0.049/0.052/0.055
	Heating	kW	0.031/0.033/0.035					0.049/0.052/0.055
Running amperes	Cooling	A	0.15/0.15/0.15					0.23/0.23/0.24
	Heating	A	0.15/0.15/0.15					0.23/0.23/0.24
Fan motor	Type		Cross flow fan *1					
	Airflow rate (H/M/L)	m³/min	10/8/6			12/10/8		16/14/12
	Output	kW	0.011			0.015		0.023
Power sound level (H/M/L)		dB(A)	47/43/39					53/49/46
Pressure sound level (H/M/L)		dB(A)	36/32/28					42/38/35
Dimensions	Height	mm	285					330
	Width	mm	995					1140
	Depth	mm	203					228
Piping connections	Liquid (Flare)	mm	6.35					9.52
	Gas (Flare)	mm	12.7					15.88
	Drain piping		VP-13					
Net weight		kg	14					21

Figure (A.1.10) Wall split type catulogue

■Outdoor unit specifications

Appearance							
HP			8	10	12	14	16
Model name		(SPW-)	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Power supply			380-400V±15V-3 phase/50Hz				
Capacity	Cooling	kW	22.4	28.0	33.5	40.0	45.0
		Btu/h	76,400	95,500	114,300	136,500	152,600
	Heating	kW	25.0	31.5	37.5	45.0	50.0
		Btu/h	85,300	107,500	128,000	152,600	170,600
COP	Cooling	W/W	3.74	3.56	3.50	3.45	3.38
	Heating	W/W	4.05	4.03	3.91	3.91	3.79
Dimensions (H×W×D)		(mm)	1,887 × 850 × 850 (+60)				
Net weight		kg	245	295	285	345	345
Electrical rating	Cooling	Running amperes (A)	10.1/9.6/9.3	12.8/12.2/11.8	16.6/14.8/14.2	19.6/18.6/17.9	22.5/21.2/20.6
		Power input (kW)	5.99	7.90	9.58	11.6	13.3
	Heating	Running amperes (A)	10.4/9.9/9.5	12.1/12.2/11.6	15.7/14.9/14.3	19.4/18.5/17.8	22.3/21.2/20.4
		Power input (kW)	6.17	7.79	9.60	11.5	13.2
	Starting amperes	(A)	7/7/7	59/57/54	69/65/17	68/71/72	78/82/82
Air circulation		m³/min	150	160	180	200	220
Refrigerant amount at shipment		(kg)	12.0	12.0	12.0	14.0	14.0
Piping connection	Gas pipe	(mm)	ø19.05	ø22.22	ø25.4	ø25.4	ø28.58
	Liquid pipe	(mm)	ø9.52	ø9.52	ø12.7	ø12.7	ø12.7
	Balance pipe	(mm)	ø6.35	ø6.35	ø6.35	ø6.35	ø6.35
Ambient temperature operating range			Cooling: dry -10°C ~ 43°C (DB); Heating -15°C ~ 15°C (WB)				
Pressure sound	Normal mode	dB(A)	54.5	56.0	58.0	61.0	62.0
	Silent mode	dB(A)	51.5	52.0	52.0	55.0	55.0
Power sound	Normal mode	dB(A)	65.5	66.5	67.5	71.5	72.0

Figure (A.1.11) Out door unit catalogue

Appendix A-2

Petra Company catalogues

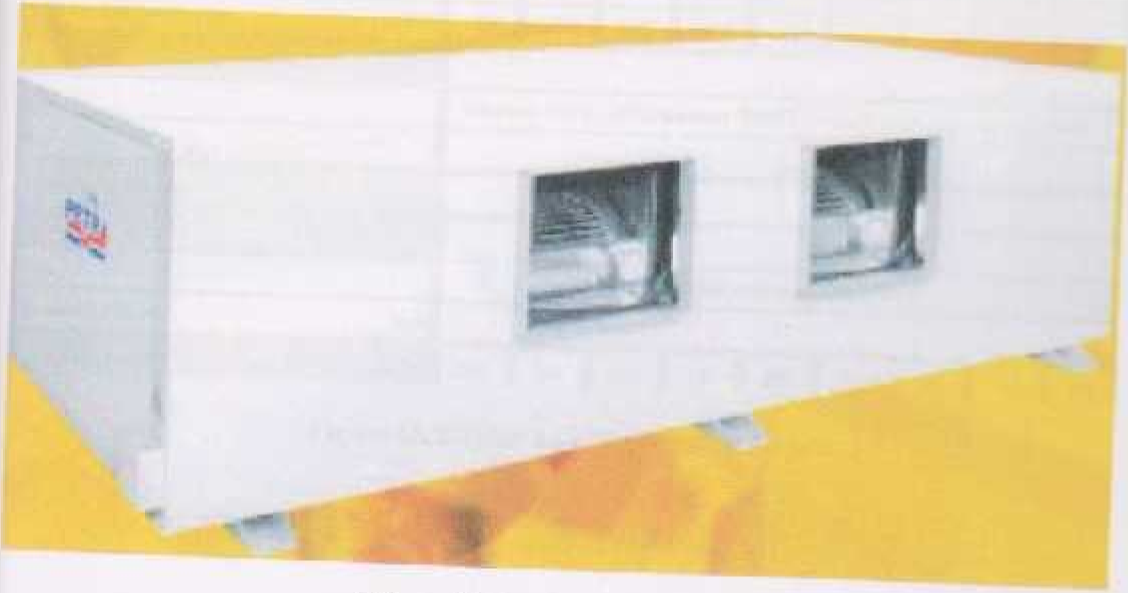


Figure (A.2.1)Air handling unit

Model	[CM]	15	20	24	30	36	48	62	72	96
Power supply	Ph / Hz	3Ph/50 or 60 Hz (see electrical data tables)								
Control voltage	Volt	220 - 240								
Unit casing		Heavy gauge galvanized steel without paint								
Insulation		1/2" Thick fiber-glass or equivalent								
Coil		Copper tubes, Aluminium fins								
Face area (total)	Ft^2	3.12	4.00	4.75	6.15	7.58	9.92	12.08	15.00	20.00
Tube diameter	Inch	3/8" (STD)								
Fan		Centrifugal double inlet double width, forward curved fan								
No.		1	1	1	1	1	2	1	1	2
Drive type		Belt driven								
Fan model		PETRA 6	PETRA 6	PETRA 6	PETRA 7	PETRA 7	PETRA 6	PETRA 9	PETRA 9	PETRA 9
Total air flow (nominal)	CFM	1500	2000	2400	3000	3800	4800	6000	7500	9600
Fan motor										
Type		Induction - TEFC - IP55 Protection - Class F insulation thermal over load protection								
No.		1								
Drain connection size	Inch	1								
Air filter										
Type		Aluminum mesh media (Washable)								
Nominal thickness*	Inch	1								
Operating weight	lb	242	275	286	341	396	551	661	738	881

Figure (A.2.2)Air handling unit catalogue

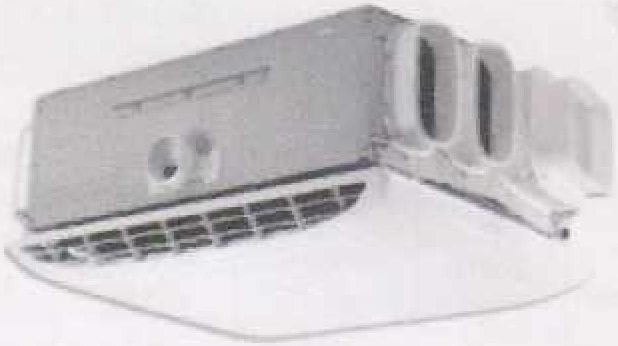


Figure (A.2.3)Air handling unit

DNC 50 3PH	DNC 40 3PH	DNC 40			
44,400	38,000	38,000	BTU/h	Cooling	Capacity
13,000	11,130	11,130	W		
47,800	38,000	38,000	BTU/h	Heating	
14,000	11,130	11,130	W		
2.70	2.8	2.80	COP	Cooling	Cop
3.30	3.26	3.23	COP	Heating	
G	G	G			
4,810	3,970	3,970	W	Cooling	Power input
4,240	3,410	3,440	W	Heating	
3x10	3x8	18	A	Cooling	Amperes
3x9	3x7	16	A	Heating	
1,600	1,400	1,400	CFM	Total air flow	
2,720	2,380	2,380	M3/h		
50	40		Pa	Static pressure	
400/50/3N		230/50/1	V/Hz/Ph	Voltage/frequency/phase	
			mm	Dimensions	
1,025x300x760			W×H×D	Indoor unit	
900x970x340		900x970x340	W×H×D	Outdoor unit	
3/8"x3/4"		3/8"x3/4"	INCH	Pipe sizing	

Figure (A.2.4)Air handling unit catalogue

Figure (A.2.5) Chiller

MODEL APS	45-1S	55-1S	60-1S	60-2S	75-1S	80-2S	90-1S	90-2S
Power supply Volt/Phase/Hz	See electrical data table							
Casing and finishing	Heavy gauge, galvanized steel, with oven-baked weatherproof, polyester powder electrostatic paint							
Compressor	Compact scroll, semi hermetically sealed, with flanged on oil separator							
No.	1	1	1	2	1	2	1	2
Grade of oil	BSE 170 or equivalent							
Oil charge Liter (Each)	15	15	15	9	22	9	22	13
Cooler	Shell and tube							
No. of coolers	1							
Refrigerant	R 22							
Control	Electronic expansion valve							
Refrigeration circuits	1	1	1	2	1	2	1	2
Water connection size inch	3	4	4	4	4	4	5	5
Inlet/Outlet diameter inch	3	4	4	4	4	4	5	5
Condenser	Copper tubes - Aluminum fins							
Fins per inch	12	12	16	12	12	12	12	12
Rows	4	4	3	4	3	4	3	4
Total face area Ft^2	68.6	68.6	120.3	137.2	120.3	137.2	120.3	137.2
Fan	Propeller (Axial)							
No.	2	2	2	4	4	4	4	4
Total air flow rate CFM	43063	43063	41841	40949	62254	65934	67940	86126
Approx. operating weight lb	3783	3832	3908	6112	6755	6453	7128	7300

Figure (A.2.6) Chiller catalogue

Figure (A.2.7) Ducted out door split units

MODEL	[DSP]	15	20	25	29	32	35	40	47	53
Power supply	Phase/Hz	1 / 50 or 60 (See electrical data tables)					3 / 50 or 60 (See electrical data tables)			
Control voltage	Volt	220 - 240								
Unit casing		Heavy gauge galvanized steel, with oven baked weatherproof, polyester powder electrostatic paint								
Compressor		Hermetically sealed, Reciprocating type								
No.		1								
Grade of oil		3 GS or equivalent								
Oil charge (Total)	Liter	1.24	1.24	1.24	1.06	1.06	1.06	1.24	1.95	1.95
Condenser coil		Copper tube - Aluminum fins								
Fins per inch		12								
No. of rows		2								
Face area (Total)	ft^2	5.50	5.50	5.50	5.50	6.88	6.88	8.25	10.54	10.54
Tube diameter	Inch	3/8								
Condenser fan		Propeller [Axial]								
No.		1	1	1	1	1	1	1	2	2
Drive type		Direct driven								
Nominal air flow (50 Hz)	CFM	2200	2200	2200	2200	3300	3300	3300	4400	4400
Nominal air flow (60 Hz)	CFM	2500	2500	2500	2500	3600	3600	3600	5000	5000
Refrigerant circuit		1								
Refrigerant type		R - 22								
Control		Expansion drive								
No. of refrigerant circuits		1								
Refrigerant lines sizes										
Suction line diam. (Inch)		1/2"	1/2"	5/8"	5/8"	5/8"	5/8"	5/8"	7/8"	7/8"
Liquid line diam. (Inch)		3/8"	3/8"	3/8"	3/8"	3/8"	3/8"	3/8"	1/2"	1/2"
Operating weight	lb	141.1	149.9	149.9	154.3	165.3	165.3	165.3	242.5	264.6
Sound pressure level	dB (A)									
@ 3.3 ft		52	53	54	57	58	53	57	55	61
@ 10 ft		46	47	48	51	52	51	51	49	55

Figure (A.2.8) Ducted out door split unit catalogue

Figure (A.2.9) Wall type split system

Model	Cooling only	HPW 9	HPW 12	HPW 20	CPW 25	HPW 30	HPW 36
	Cooling & Heating				HPW 25		
n of refrigeration		0.75	1.00	1.50	2.00	2.50	3.00
oling capacity (BTU/Hr)		9000	12000	18000	24000	30000	36000
ating capacity (BTU/Hr)		10400	1300	20000	27000	30700	37000
ectrical (indoor)	Power	220-240V / 1Ph / 50Hz					
	F.L.Amp.	0.16	0.16	0.26	0.52	0.33	0.38
n	Type	Cross flow fan wheel					
	Speed	Three speeds					
il	Type	Copper tubes - Aluminum fins					
	No. of Rows	2	2	2	2	2	2
ontrols		Wireless					
ir filter		Cleanable, cartridge type filter with (carbon filter or electro-static filter)					
efrigeration connection (inch)	Type	Flare					
	Liquid	1/4	1/4	1/4	3/8	3/8	1/2
	Section	1/2	1/2	1/2	5/8	5/8	3/4
ain connection (inch)		5/8					
imensions (mm)	Height	250	250	286	330	330	355
	Width	750	750	906	1080	1080	1450
	Depth	188	188	235	222	222	230
eight (Kg)		8.5	8.5	13.5	17.0	17.0	18.0
ecommended circuit breaker		10A 1 Phase	10A 1 Phase	20A 1 Phase	25A 1 Phase	32A 1 Phase	16A 3 Phase

Figure (A.2.10) Wall type split system catalogue

Appendix A-3

LG catalogues

Figure (A.3.1) Diffuser grill

Product Specifications	
WIDTH INCHES	8
DESCRIPTION	Round Ceiling Diffuser
CONSTRUCTION	Steel
COLOR FINISH	White
WEIGHT LBS	0.7
DUCT SIZE INCHES	8
MANUFACTURERS PART NUMBER	1500W8
BRAND	AmeriFlow

Figure (A.3.2) Diffuser grill specifications

Figure (A.3.3) Circular duct

Product Specifications	
LENGTH FEET	25
DIAMETER INCHES	2
TYPE	S-TL
COLOR FINISH	Gray
MAX. TEMPERATURE	250F
MANUFACTURERS PART NUMBER	0526-0200-0002-10
BRAND	Thermaflex
MIN. TEMPERATURE	0 F
PACKAGE QUANTITY	9
VELOCITY	6000 CFM

Figure (A.3.4) Circular duct specifications

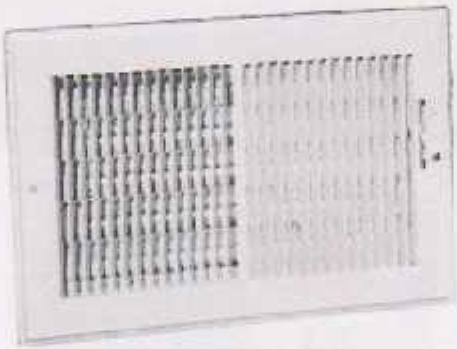


Figure (A.3.5) Side grill

Product Specifications	
LENGTH INCHES	7-1/4
HEIGHT INCHES	1-7/8
WIDTH INCHES	13-1/4
DESCRIPTION	2-way Ceiling / Sidewall Register
CONSTRUCTION	Steel
COLOR FINISH	White
WEIGHT LBS	1.6
TOP FINISH	Painted
DUCT SIZE INCHES	12"x6"
MANUFACTURERS PART NUMBER	356W12X6
BRAND	AmeriFlow
PACKAGE QUANTITY	1

Figure (A.3.6) Side grill specifications

Figure (A.3.7) Single split wall type

pecifications

ngle Split Wall Mounted Type ART COOL

			LS-C076Z*C0	LS-C096Z*C0	LS-C126P*S0	LS-H076Z*C0	LS-H096Z*C0
		(Btu/hr)	7,000	9,000	12,000	7,000	9,000
		(Btu/hr)				7,300	9,300
Parts							
Frequency/Phase		(V,Hz,Ø)	220-240,50/1	220-240,50/1	220-240,50/1	220-240,50/1	220-240,50/1
Input,	Cooling/Heating	(Watt)	660	900	1,200	660/540	900/870
Current,	Cooling/Heating	(A)	3.0	4.0	5.5	3.0/2.9	2.9/3.8
		(Btu/hr.W)	10.61	10.0	10.00	10.61	10.00
		(Btu/hr.W)				3.34	3.13
Circulation	In/Out	(m³/min)	6.2/15	7.0/19	9.5/24	6.2/15	7.0/26
Removal		(l/hr)	1.0	1.2	1.5	1.0	1.2
Level	In/Out	(dB(A),High, [m])	32/44	34/44	36/44	32/44	34/44

Figure (A.3.8) Single split wall type catalogue

Features							
PLASMA Air Purifying System			•	•	•(Dual)	•	•
4 Way Auto Swing					•		
Gold Fin			•	•	•	•	•
Jet Cool			•	•	•	•	•
Temperature Control			Thermistor	Thermistor	Thermistor	Thermistor	Thermistor
CHAOS Wind		(Auto Wind)	•	•	•	•	•
Air Deflection			4-Way	4-Way	4-Way	4-Way	4-Way
Steps		(Fan / Cool)	3/5	3/5	3/5	3/5	3/5
Air Direction Control (up & down)			Auto	Auto	Auto	Auto	Auto
Remote Controller Type			Wireless LCD	Wireless LCD	Wireless LCD	Wireless LCD	Wireless LCD
Setting Temperature Range		(Cool)	18-30	18-30	18-30	18-30	18-30
Setting Temperature Range		(Heat)				16-30	16-30
Temperature Increment			1	1	1	1	1
Self Diagnosis			•	•	•	•	•
Timer			24Hr ON/OFF	24Hr ON/OFF	24Hr ON/OFF	24Hr ON/OFF	24Hr ON/OFF
Sleep Operation			•	•	•	•	•
Soft Dry Operation			•	•	•	•	•
Auto Restart			•	•	•	•	•
Defrost Operation						•	•
Hot Start						•	•
Compressor		(type)	Rotary	Rotary	Rotary	Rotary	Rotary
Installation & Shipping							
Net Dimensions	Indoor WxHxD	(mm)	899x272x143	899x272x143	1,030x298x150	899x272x143	899x272x143
	Outdoor WxHxD	(mm)	575x235x260	770x540x245	770x540x245	575x325x260	770x540x245
Net Weight	Indoor/Outdoor	(Kg)	8/26	8/31	9/34	8/26	8/31
Stuffing Q'ty	With S/Parts	(20ft/40ft)	125/260	102/214	96/207	125/260	102/214
	Without S/Parts	(20ft/40ft)					
Service Valve	Liquid/Gas	ø(mm)	6.35/9.52	6.35/9.52	6.35/12.7	6.35/9.52	6.35/9.52

Figure (A.3.9) Single split wall type catalogue (cont…)

Figure (A.3.10) Window type

Product Specifications	
WIDTH INCHES	18-9/16
DEPTH INCHES	13-7/8
HEIGHT INCHES	20-11/16
COLOR FINISH	White
ASSEMBLY	Assembled
BTU COOLING	7000
BTU HEATING	3850
CFM HIGH	205
COOLING SQ. FT.	300
MODEL	653535
PHASE	1
PINTS / DAY	LG Window Air Conditioner 7000 BTU Heat Cool
SPEEDS	2
TEMPERATURE RANGE COOLING (F°)	60-88
TEMPERATURE RANGE HEATING (F°)	60-88
VOLTS	115
WARRANTY YEARS	5
WEIGHT LBS	60
ENERGY EFFICIENCY RATING (EER)	9.7
MEGAHERTZ (MHZ)	60
APPROVAL	UL SA7244
REFRIGERANT	R-410A
DECIBELS (DBA)	49

Figure (A.3.11) Window type catalogue

Appendix A-4

Tadiran Company catalogues

. Nomenclature

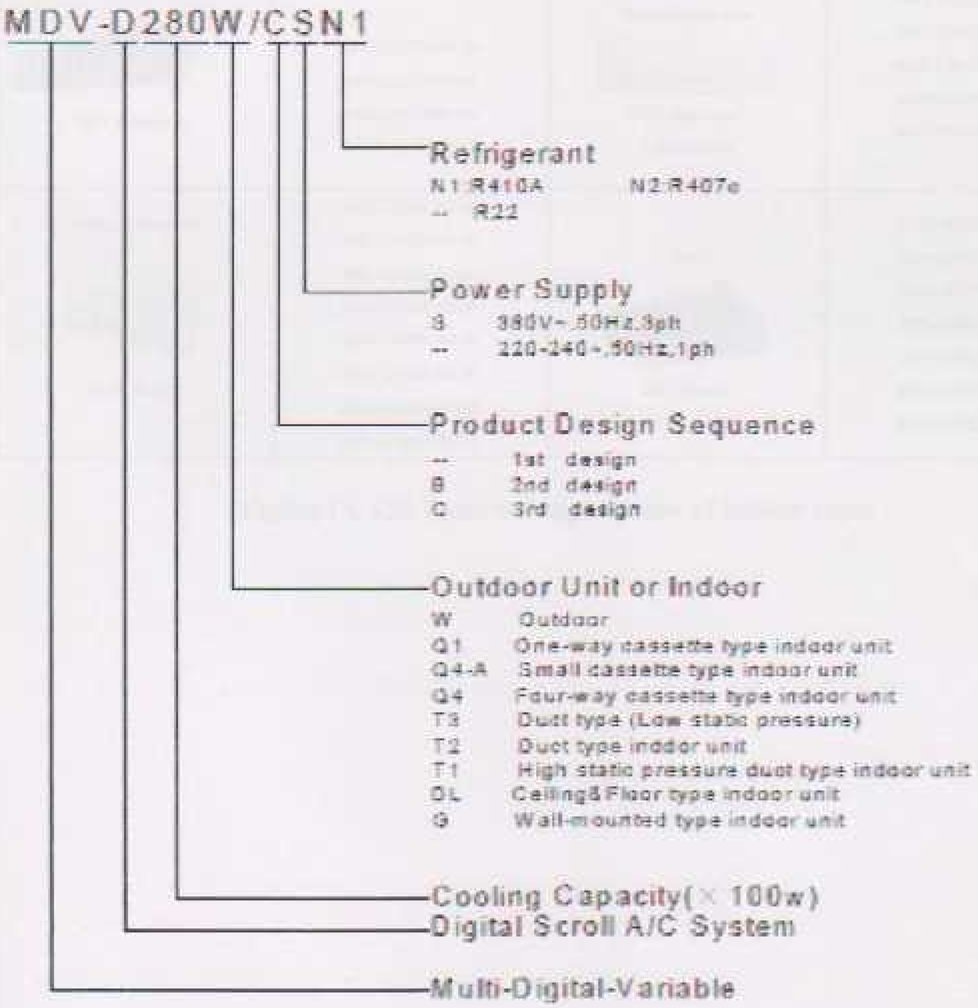


Figure (A.4.1) Explanation of model name of the units

External Appearance	Model Name	External Appearance	Model Name
Four way cassette  EEV Beside	MDV-D56Q4/N1 MDV-D71Q4/N1 MDV-D80Q4/N1 MDV-D90Q4/N1 MDV-D112Q4/N1	Compact four way cassette  EEV Beside	MDV-D28Q4/BN1 MDV-D36Q4/BN1 MDV-D45Q4/BN1
All plastic duct  EEV Separated	MDV-D22T3/N1-A3 MDV-D28T3/N1-A3 MDV-D36T3/N1-A3	Wall mounted unit  EEV Separated [illegible] Inside	MDV-D22G/N1-E1 MDV-D28G/N1-E1 MDV-D36G/N1-E1 MDV-D45G/N1-E1 MDV-D56G/N1-E1
Ceiling & floor unit  EEV Inside	MDV-D36DL/N1-B MDV-D45DL/N1-B MDV-D56DL/N1-B MDV-D71DL/N1-B MDV-D80DL/N1-B MDV-D90DL/N1-B MDV-D112DL/N1-B MDV-D140DL/N1-B	Duct  EEV Beside	MDV-D45T2/CN1 MDV-D56T2/CN1 MDV-D71T2/CN1 MDV-D80T2/CN1 MDV-D90T2/CN1 MDV-D112T2/CN1 MDV-D140T2/CN1

Figure (A.4.2) External appearance of indoor units

Indoor Unit, Four-Way Cassette

Model			TMA-D5604/N1	TMA-D7104/N1	TMA-D8004/N1	TMA-D9004/N1	TMA-D11204/N1
Capacity	Cooling	kw	5.6	7.1	8	9	11.2
	Heating	kw	6.3	8	9	10	12.5
Power Supply		v,hz,ph	220-240,50,1				
Rated Power		W	100	100	100	130	145
Performance	Air Flow Volume	m³/h	1000	1200	1200	1320	1860
	Noise Level	dB(A)	38	42	42	44	44
Net Dimension	Body (LxHxD)	mm	840x240x840	840x240x840	840x240x840	840x310x840	840x310x840
	Panel (LxHxD)	mm	950x40x950	950x40x950	950x40x950	950x40x950	950x40x950
Packing Dimension	Body (LxHxD)	mm	955x260x955			955x325x955	
	Panel (LxHxD)	mm	1030x145x1030	1030x145x1030	1030x145x1030	1030x145x1030	1030x145x1030
Net Weight	Body	kg	25	25	25	34	34
	Panel	kg	6	6	6	6	6
Gross Weight	Body	kg	32	32	32	42	42
	Panel	kg	11	11	11	11	11
Qty per 20'/40'/40'HQ	Outdoor Unit	Pieces	72/149/168			56/126/144	
Pipe Diameter	Liquid Side	mm	ø9.53 (3/8")				
	Gas Side	mm	ø15.9 (5/8")				
	Drainage Water Side	mm	Outside Diameter ø32				

Figure (A.4.3) Four way cassette indoor unit catalogue

Indoor Unit, High Static Pressure Duct

Model			TMA-D45T1/N1-B	TMA-D56T1/N1-B	TMA-D71T1/N1-B	TMA-D80T1/N1-B
Capacity	Cooling	kw	4.5	5.6	7.1	8
	Heating	kw	5	6.3	8	9
Power Supply		v,hz,ph	220-240,50,1		220-240,50,1	
Rated Power		W	150	150	160	160
Performance	Air Flow Volume	m³/h	1600		1680	
	Static Pressure	Pa	70	70	70	70
	Noise Level	dB(A)	45	45	49	49
Net Dimension	(LxWxD)	mm	1000x298x800	1000x298x800	1000x298x800	1000x298x800
Packing Dimension	(LxWxD)	mm	1305x370x940	1305x370x940	1305x370x940	1305x370x940
Net Weight		kg	38	38	40	40
Gross Weight		kg	45	45	47	47
Qty. per 20'/40'/40HQ	Indoor Unit	Pieces	60/140/164		60/140/164	
Pipe Diameter	Liquid Side	mm	φ6.35 (1/4")		φ9.53 (3/8")	
	Gas Side	mm	φ12.7(1/2")		φ15.9(5/8")	
	Drainage Water Side	mm	Outside Diameter φ32			

Figure (A.4.5) High static pressure duct indoor unit catalogue

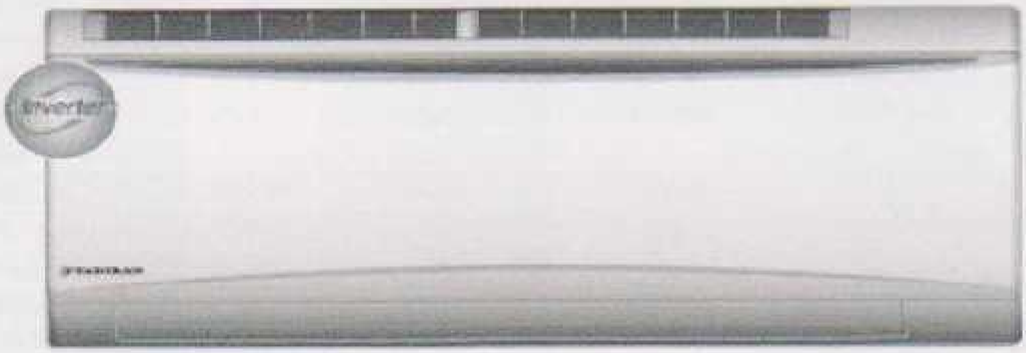


Figure (A.4.6) Split in door unit (inverter type)

Model		MVA10G1-09H	MVA10G1-12H	MVA10G1-18H
Capacity				
Cooling	Btu/h	9000 (2050-11200)	12000 (4000-13000)	17500 (5500-23000)
	KW	2.6 (0.6-3.3)	3.5 (1.2-4.0)	5.1 (1.6-6.7)
Heating	Btu/h	10000 (3200-13200)	13000 (4100-14600)	17000 (5100-22000)
	KW	2.9 (0.9-3.9)	3.8 (1.2-4.2)	5.0 (1.5-6.0)
Electrical data				
Power Supply	V, Hz, Ph	220-240, 50, 1	220-240, 50, 1	220-240, 50, 1
Power Input Cooling	W	859 (240-1,050)	1080 (350-1,400)	1601 (400-2,300)
Power Input Heating	W	898 (240-1,340)	1050 (360-1,420)	1460 (360-2,100)
Operating Current Cooling	A	3.8 (1.2-5.0)	4.9 (1.7-6.5)	7.0 (1.8-10.0)
Operating Current Heating	A	3.8 (1.2-6.1)	4.7 (1.8-6.6)	6.5 (1.6-9.5)
Performance				
EER Cooling	Btu/W, W/W	11.1, 3.26	11.1, 3.26	10.9, 3.21
COP Heating	W/W	3.62	3.63	3.41
Airflow Volume Indoor	m^3/h	570	600	800
Noise Level Indoor (High/Med/Low)	dB(A)	38/31/29	42/36/30	44/40/37
Noise Level Outdoor	dB(A)	52	54	56
Net Dimensions & Weight				
Indoor Unit (LxWxH)	mm	770x250x195	790x265x195	920x292x315
Outdoor Unit (LxWxH)	mm	700x590x285	760x590x285	845x695x335
Net Weight Indoor/Outdoor	Kg	8.0/26.5	9.0/34.5	11.5/52
Gross Dimensions & Weight				
Indoor Unit (LxWxH)	mm	800x340x270	875x375x285	1005x360x295
Outdoor Unit (LxWxH)	mm	887x405x355	887x655x355	965x755x395
Gross Weight Indoor/Outdoor	Kg	10.0/42.5	11.0/42.5	15/56
Piping Connection				
Liquid Side	mm	6.35	6.35	6.35
Gas Side	mm	9.53	12.7	12.7
Applicable Area	m^2	16-24	20-30	28-40

Figure (A.4.7) Split in door unit (inverter type) catalogue

Appendix A-5

Danfoss Company catalogues

BD250GH and second generation BD350GH

R134a, -30°C, +15°C evap.

Dedicated for cabin cooling in trucks during night-times, very silent operation, 850 W cooling capacity.

BD35F multivoltage

R134a, 30°C, -10°C evap.

All mobile applications for portable boxes, boats, trucks etc., 15-120 W cooling capacity, can be powered with AC and DC, 85-265 V AC 50/60 Hz, 12-24 V DC, automatic selection between AC and DC.

BD35F/50F/80F Basic

R134a, -30°C, -10°C evap.

All mobile applications for port-able boxes, boats, trucks etc., 5-140/20-180/35-220 W cooling capacity.

Figure (A.5.1) Danfoss compressors series

BD100CN

R290, -40°C, -10°C evap.

Stationary freezer application, not approved for vehicles, solar powered systems, ice cream boxes up to 200 l, pharmaceutical applications, 260 W cooling capacity.

BD35K

R600a, -30°C, +10°C evap.

Stationary application, solar-powered vaccine coolers etc., 100-200 l cooleazrs, 15-120 W cooling capacity.

BD35F with EMI electronic

Designed for boats and trucks if risk of electric inference with radio and navigation equipment, 15-140 W cooling capacity.

Figure (A.5.2) Danfoss compressors series (cont...)

Data Sheet (Replaces CD.4

General

Compressor	PL20F
Code number	101G0100

Application

Application		MBP
Evaporating temperature range	°C	-25 to 0
Voltage range	V/Hz	198 - 254 /50
Motor type		RSIR
Max. ambient temperature	°C	38
Comp. cooling at ambient temp.	32°C	S
	38°C	S

Design

Displacement	cm^3	1.41
Oil quantity	cm^3	150
Maximum refrigerant charge	g	300
Free gas vol. in compressor	cm^3	800
Weight without electrical equipment	kg	3.8

Figure (A.5.4) Danfoss compressors data sheet

Motor

Motor size	watt	29
LRA (rated after 4 sec. UL984) LST	A	1.2
Cut-in current LST	A	5.7
Resistance, main and start winding (25°C)	Ω	84.0/19.0
Approvals		EN 60335-2-34 with Annex AA

Dimensions

Height	mm	A	129
		B	127
		B1	120
		B2	73
Suction connector	location/I.D. mm	C	6.2 ±0.09
Process connector	location/I.D. mm	D	6.2 ±0.09
Discharge connector	location/I.D. mm	E	5.0 +0.12/+0.20
Compressors on a pallet	pcs.		150

Figure (A.5.5) Danfoss compressors data sheet(cont…)

Capacity (EN 12900/CECOMAF) watt

Comp.\°C	-25	-23.3	-20	-15	-10	-5	0
PL20F	16.0	19.0	25.4	36.5	49.6	64.9	82.6

Capacity (ASHRAE) watt

Comp.\°C	-25	-23.3	-20	-15	-10	-5	0
PL20F	19.7	23.4	31.3	45.0	61.3	80.3	102

Power consumption watt

Comp.\°C	-25	-23.3	-20	-15	-10	-5	0
PL20F	42.0	43.4	46.4	51.5	57.2	63.3	69.7

Current consumption A

Comp.\°C	-25	-23.3	-20	-15	-10	-5	0
PL20F	0.35	0.35	0.36	0.37	0.39	0.41	0.43

COP (EN 12900/CECOMAF) W/W

Comp.\°C	-25	-23.3	-20	-15	-10	-5	0
PL20F	0.38	0.44	0.55	0.71	0.87	1.03	1.19

COP (ASHRAE) W/W

Comp.\°C	-25	-23.3	-20	-15	-10	-5	0
PL20F	0.47	0.54	0.67	0.87	1.07	1.27	1.47

Test conditions	EN 12900/CECOMAF	ASHRAE
Condensing temperature	55°C	55°C
Ambient and suction gas temp.	32°C	32°C
Liquid temperature	55°C	32°C
Static cooling, 220V 50Hz,		
PTC consumption incl		

Figure (A.5.6) Danfoss compressors data sheet(cont…)

Compressor	Code no	Capacity [W]																Power consumption			COP [W/W]		
		Evaporating temperature [°C]																					
		-45	-40	-35	-30	-25	-23.3	-20	-15	-10	-6.7	-5	0	5	7.2	10	15	-35	-10	5	-35	-10	5
TN1406	106B0001								335	405	455	483	574	680	733				289	291		1,41	2,34
TN1410	106B0002								573	692	779	827	981	1162	1253				430	432		1,62	2,69
TN1416	106B0003								1006	1214	1366	1450	1721	2039	2198				706	715		1,71	2,85
TN1410	106B0004								712	860	967	1027	1219	1444	1536				538	545		1,6	2,65
TN1416	106B0005								1187	1433	1612	1711	2031	2406	2564				851	863		1,68	2,79

...conditions

...charge pressure	90 bar
...cooler outlet temp	20°C
...tion gas temperature	20°C
...ient temperature	32°C

Figure (A.5.7) CO2 refrigerant compressor data sheet

…pressor	Code numbers		EN 12900 (CECOMAF) Capacity [W] Evaporating temperature [°C]														
	Compressor	Compressor with oil cooling	-35	-30	-25	-23.3	-20	-15	-10	-6.7	-5	0	5	7.2	10	15	20
[illegible]	103G0250				26	31.6	39.3	53	69.4	82	89	112	149	153	172	209	
[illegible]	102G4251		11	22.4	35.5	40.5	50.9	69	90.4	107	116	145	179	196	219	264	
[illegible]	102G4350			25.3	40.9	46.7	59.1	80.5	106	125	136	170	211	231	258	312	
[illegible]	102G4452			40.8	58.3	65.3	80.3	107	140	165	180	226	280	306	342	413	
[illegible]	102G4550			55.6	79	87.9	107	139	178	206	224	279	341	372	414	497	
[illegible]	103G6660			47.7	83.3	96.5	124	171	226	267	290	365	452	494	552		
[illegible]	103G6680	103G6690		61.7	99	113	142	193	254	299	325	408	505	553	618		
[illegible]	103G6780	103G6790		84.9	123	138	171	228	298	351	381	478	592	647	722		
[illegible]	103G6880	103G6890		91.9	136	152	188	250	324	380	412	516	638	697	779		
[illegible]	103G6980			115	170	191	233	307	395	463	501	628	780				
[illegible]	104G8000		23	60	113	135	183	268	369	445	486	618	764	833	925	1100	
[illegible]	104G8240	104G8250	64.6	113	175	199	252	348	464	553	603	768	960	1054	1182	1437	
[illegible]	104G8520	104G8530			164	206	290	424	568	672	726	908	1110	1207	1340	1600	
[illegible]	104G8820	104G8830			283	318	394	526	684	804	870	1087	1337	1459	1624	1950	
[illegible]	104G8140				333	370	453	606	792	934	1012	1268	1560	1700	1889	2257	
[illegible]	104G8280		129	226	350	399	505	696	928	1106	1206	1535	1920	2108	2364	2875	
[illegible]	104G8580				328	413	581	847	1137	1344	1457	1815	2220	2415	2679	3201	
[illegible]	104G8880				566	636	788	1052	1368	1607	1740	2174	2674	2918	3248	3900	
[illegible]	104G8180				667	741	907	1212	1584	1868	2025	2536	3120	3400	3778	4511	

Figure (A.5.8) CO2compressor capacities at variable evaporating temperatures

Model designation				
Compressor design	Optimization level	Compressor size	Application range	Start characteristics
PL TL NL FR SC GS	Blank Standard energy level S Semi-direct intake E Energy-opti-mized (optimized motor)	Nominal displacement in cm^3 Exception: For PL compressors the capacity at rating point is stated.	F R134a LBP/(MBP) FT R134a LBP/(MBP) tropical G R134a LBP/MBP/ HBP GH R134a Heat pumps GHH R134a Heat pumps (opt.) MF R134a MBP	Blank => universal (principal rule) X = HST characteristics (expansion valve)

Examples

TL	S	4	FT	
NL	E	10	MF	
SC		15	GHH	
GS		26	MF	X

Figure (A.5.9) Model designation

Appendix A-6

Daikin Company catalogues

Figure (A.6.1) Slim concealed ceiling unit

[illegible]			20	25	32
Cooling capacity		kW	2.2	2.5	3.6
Heating capacity		kW	2.5	3.2	4.0
Nominal input	cooling	kW	0.086	0.086	0.089
	heating	kW	0.067	0.067	0.070
Dimensions (HxWxD)		mm	200 x 750 x 620		
Weight		kg	21	21	21
Casing			Galvanised steel plate		
Air flow rate (H/L)		m³/min	8.0/6.4	8.0/6.4	8.0/6.4
External static pressure		Pa	-		
Sound pressure level (H/L)		dB(A)	33/29	33/29	33/29
Sound power level		dB(A)	-		
Refrigerant type			R-410A		
Drain-up height		mm	750		
Piping connections	liquid/gas	mm	ø6.4/ø12.7		
Air filter			Removable, washable, mildew proof		
Power supply		V/Hz	1~, 50Hz, 220-240V		

Figure (A.6.2) Slim concealed ceiling unit catalogue

Figure (A.6.3) Round flow ceiling mounted cassette

FXFQ-P8				20	25	32	40	50	63	80	100	125
Cooling capacity			kW	2.2	2.8	3.6	4.5	5.6	7.1	9.0	11.2	14.0
Heating capacity			kW	2.5	3.2	4.0	5.0	6.3	8.0	10.0	12.5	16.0
Nominal input	cooling		kW	0.052			0.063	0.093	0.085	0.120	0.173	0.256
	heating		kW	0.045			0.055	0.067	0.114	0.108	0.176	0.246
Dimension	(HxWxD)		mm	204x840x840						246x840x840		288x840x840
Weight	unit		kg	20.0				21.0		24.0		26.0
Casing				Galvanised steel								
Air Flow Rate	cooling	high/low	m³/min	12.5/9.0			12.5/9.0	15.5/10.0	16.5/11.0	23.5/14.5	26.5/17.0	33.0/20.0
	heating	high/low	m³/min	12.5/9.0			12.5/9.0	15.0/9.5	17.5/12.0	23.5/14.5	28.0/17.5	33.0/20.0
Sound power (nominal)	cooling		dBA	49			50	51	51	55	58	60
Sound pressure	cooling	high/low	dBA	31/28			31/28	33/28	34/29	38/32	41/33	44/34
	heating	high/low	dBA	31/28			33/28	33/28	36/30	38/32	42/34	44/34
Refrigerant	name			R-410A								
Power Supply				1~ 220-240 / 50Hz								
Piping Connection	liquid / Gas / Drain	diameter	mm	6.35/12.7/32	6.4/12.7/32					9.5/15.9/32		
Air Filter				Resin net with mold resistance								
Drain-up height			mm	750								
Decoration Panel	model			[illegible]								
	colour			[illegible]								
	dimension (HxWxD)		mm	50x950x950								
	weight		kg	5.5								

Figure (A.6.4) Round flow ceiling mounted cassette catalogue

APPENDIX B

TABLE 10–2 Circular equivalent diameters of rectangular ducts for equal pressure drop and flow rate[a].

Lgth. Adj.	Length of One Side of Rectangular Duct, mm																			
	100	125	150	175	200	225	250	275	300	350	400	450	500	550	600	650	700	750	800	900
100	109																			
150	133	150	164																	
200	152	173	189	204	219															
250	169	190	210	228	244	259	273													
300	183	207	229	248	266	281	299	314	328											
400	207	235	260	283	301	323	343	361	378	405	437									
500	227	258	287	313	337	360	381	401	420	455	488	518	547							
600	242	279	310	339	365	390	414	436	437	496	533	567	598	628	556					
700	261	298	331	362	391	418	443	467	490	533	573	610	644	677	708	737	765			
800	275	314	350	383	414	442	470	496	520	567	609	649	687	722	755	787	818	847	875	
900	289	330	367	400	435	465	494	522	548	597	643	686	726	763	798	833	866	897	927	984
1000	301	344	384	420	454	486	517	546	574	626	674	719	762	802	840	876	911	944	976	1037
1200	324	370	413	453	490	525	558	590	620	677	731	780	827	872	914	954	993	1030	1066	1133
1400	344	394	439	482	522	559	595	629	662	724	783	835	886	934	980	1024	1066	1107	1146	1220
1600	362	415	463	508	551	591	629	665	700	766	827	885	939	991	1041	1088	1133	1177	1219	1298
1800	379	434	485	533	577	619	660	698	735	804	869	930	988	1043	1096	1146	1195	1241	1286	1371
2000	395	453	506	556	602	646	688	728	767	840	908	973	1034	1092	1147	1200	1252	1301	1348	1438
2200	410	470	525	577	625	671	715	757	797	874	945	1013	1076	1137	1195	1251	1305	1356	1406	1501
2400	424	486	543	597	647	695	740	784	825	905	980	1050	1116	1180	1241	1299	1355	1409	1461	1561
2600	437	501	560	616	668	717	764	810	853	935	1012	1085	1154	1220	1283	1344	1402	1459	1515	1617
2800	450	516	577	634	688	738	787	834	879	964	1043	1119	1190	1259	1324	1387	1447	1506	1562	1670

Figure (B.1) Circular equivalent diameter of rectangular ducts

TABLE 19-[illegible] Manufacturer performance data for selecting square supply air diffusers of four way flow pattern

Size cm	Neck Velocity m/s	2.00	2.25	2.50	2.75	3.00	3.25	3.50
15 × 15	$\dot{V}$, L/s	45	50	55	60	65	70	[illegible]
	Thr, m	[illegible]	[illegible]	1.2-4.3	1.8-5.5	2.4-6.0	2.4-6.1	[illegible]
	ΔP, Pa	[illegible]	10.5	13.4	14.9	17.9	20.2	[illegible]
23 × 23	$\dot{V}$, L/s	100	112	125	135	150	160	175
	Thr, m	[illegible]	1.8-4.3	2.3-4.9	3.0-5.5	3.0-6.1	3.0-5.7	[illegible]
	ΔP, Pa	13.1	13.9	15.7	18.4	21.7	22.4	26.6
30 × 30	$\dot{V}$, L/s	180	200	225	250	270	295	305
	Thr, m	2.4-4.3	[illegible]	[illegible]	4.3-6.7	4.3-7.3	4.9-7.9	[illegible]
	ΔP, Pa	11.5	13.2	17.2	20.4	23.7	24.4	31.6
38 × 38	$\dot{V}$, L/s	280	315	350	380	415	455	495
	Thr, m	3.1-6.1	4.3-6.7	4.9-7.3	4.8-7.9	6.1-8.5	6.1-9.1	6.1-9.8
	ΔP, Pa	12.0	15.9	19.2	21.7	25.2	28.9	33.6
46 × 46	$\dot{V}$, L/s	405	455	505	560	610	665	700
	Thr, m	4.9-7.3	5.5-7.9	6.1-9.1	6.1-9.3	6.1-10.4	6.1-11.0	6.1-11.6
	ΔP, Pa	13.2	16.2	19.2	23.4	26.7	30.6	35.1
53 × 53	$\dot{V}$, L/s	550	620	690	755	825	895	970
	Thr, m	5.5-9.1	6.1-9.8	7.3-10.4	7.3-11.0	7.3-11.6	7.9-12.2	7.9-12.8
	ΔP, Pa	13.7	16.7	19.9	22.4	27.5	31.4	35.9
61 × 61	$\dot{V}$, L/s	720	810	900	990	1080	1215	1305
	Thr, m	6.7-10.4	7.3-11.0	7.3-11.6	7.9-12.2	8.5-14.0	9.1-14.6	9.1-15.2
	ΔP, Pa	14.7	17.4	20.5	27.6	27.9	31.9	36.6
91 × 91	$\dot{V}$, L/s	1620	1800	2025	2250	2475	2700	2925
	Thr, m	9.1-15.2	10.4-16.5	11.0-17.1	12.2-18.3	12.8-19.0	14.3-20.7	14.6-21.0
	ΔP, Pa	15.9	20.5	23.9	22.1	35.6	40.6	45.3

Figure (B.2) grill selection data

Group No.	Description Of Construction	U_{o}, W/m²·°C
	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

TABLE 3-6 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

Figure (B.3) CLTD values for walls

TABLE 9-2 Latitude-Month correction factor LM, as applied to walls and horizontal roofs, north latitudes.

Lat.	Month	N	NNE NNW	NE NW	ENE WNW	E W	ESE WSW	SE SW	SSE SSW	S	Horizontal Roofs
16	December	−2.2	−3.3	−4.4	−4.4	−2.2	−0.5	2.2	5.0	7.2	−5.0
	Jan./Nov.	−2.2	−3.3	−3.8	−3.8	−2.2	−0.5	2.2	4.4	6.5	−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	−1.5	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	−2.7	−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

Figure (B.4) LM values

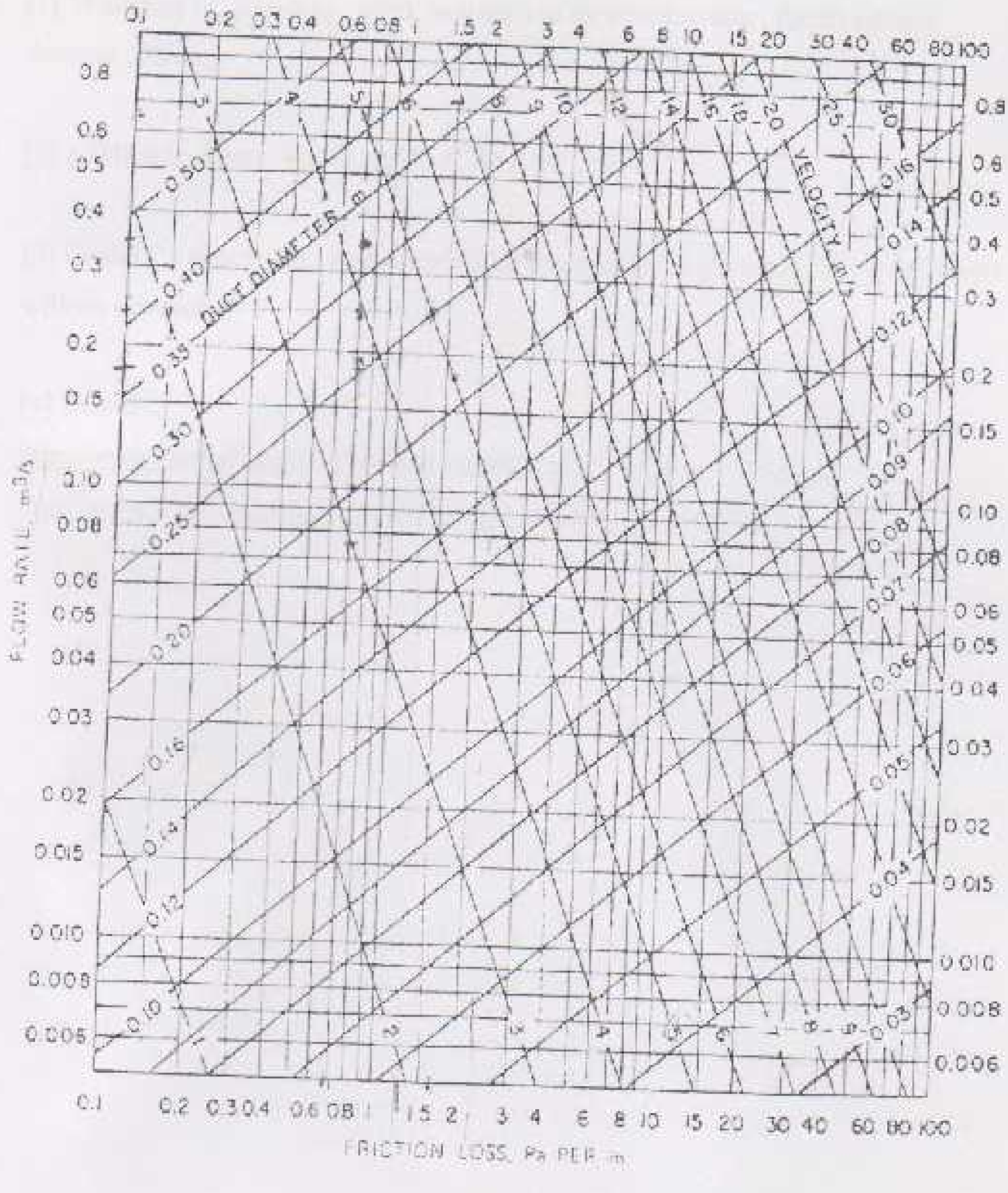


FIGURE 10-5 (a) Pressure drop (ΔP/EL), for low flow rates of air in galvanized steel ducts, based on round duct diameter.

Figure (B.5) pressure drop chart

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