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Sudan University Of Science and Technology

College of Engineering

Mechanical Engineering

Department of Production

Operation and Maintenance Of Chiller System

Mushaireb tower (case study)

تشغيل وصيانة نظام التكيف المركزي

ابراج مشيرب (دراسة حالة)

A Project Submitted In Partial Fulfillment for the Requirements

Of the degree of B.Eng (Honor) In Mechanical Engineering

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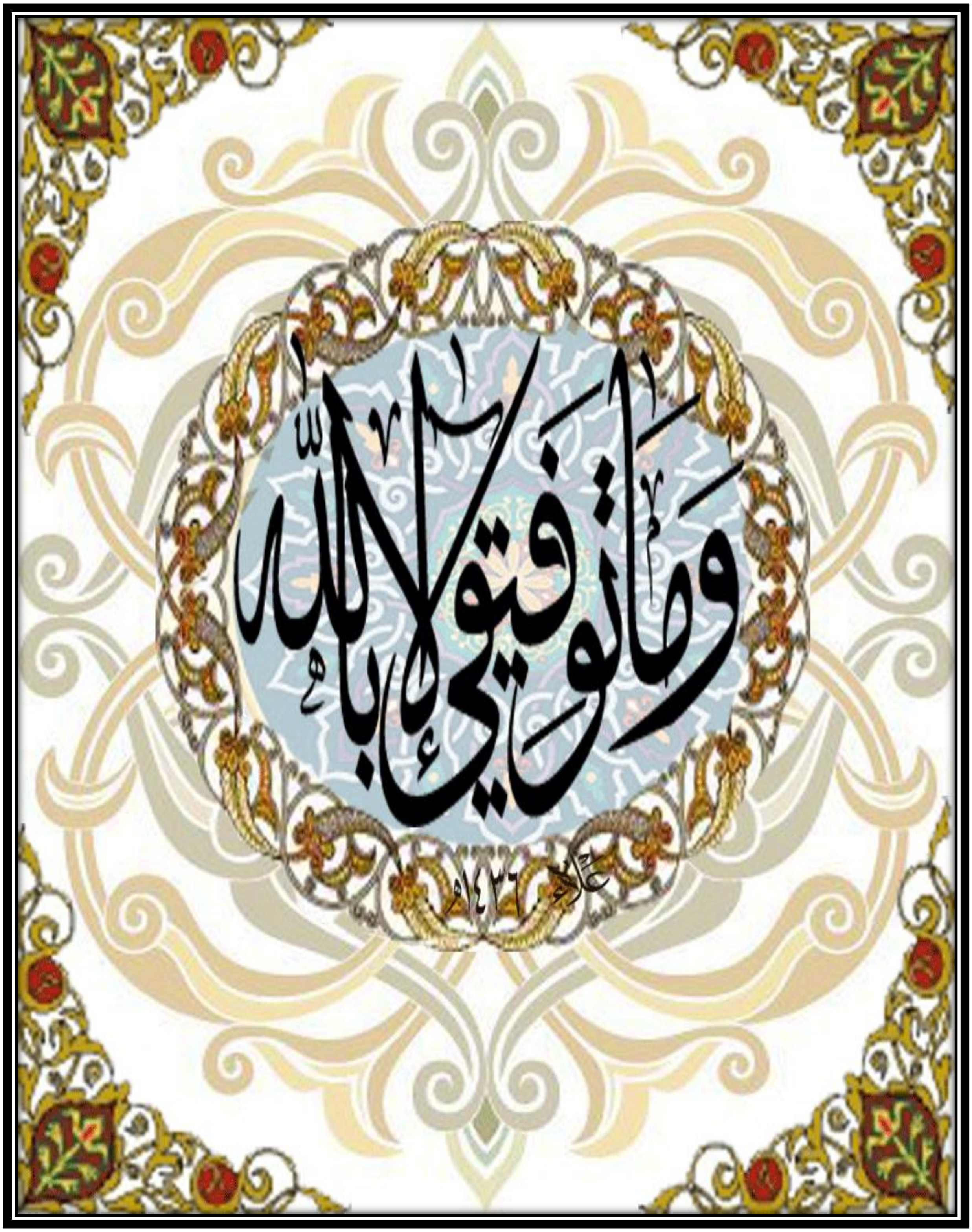
October 2017

بسم الله الرحمن الرحيم



إهداء

الي

من رآني قلبها قبل عينها وحضنتني أحشاءها قبل يدها ذلك النبع الصافي وشجرتي التي لا تذبُل وظلي الذي آوي اليه في كل حين (أمي)

قدوتي ونبراسي الزي ينير دربي ومن علمني ان أصمد أمام أمواج البحر الثائرة ومن رفعت رأسي عالياً افتخاراً به (أبي)

من كانت لها بصمة الاشراف لاداء هذا العمل القويم (مشرفة المشروع)

إخوتي وأخواتي وأساتذتي الأجلاء نُورُ دربي الي كل من غرس حرف في عقلي ليُنير قلبي

وإلي كل زملائي ورفقاء دربي

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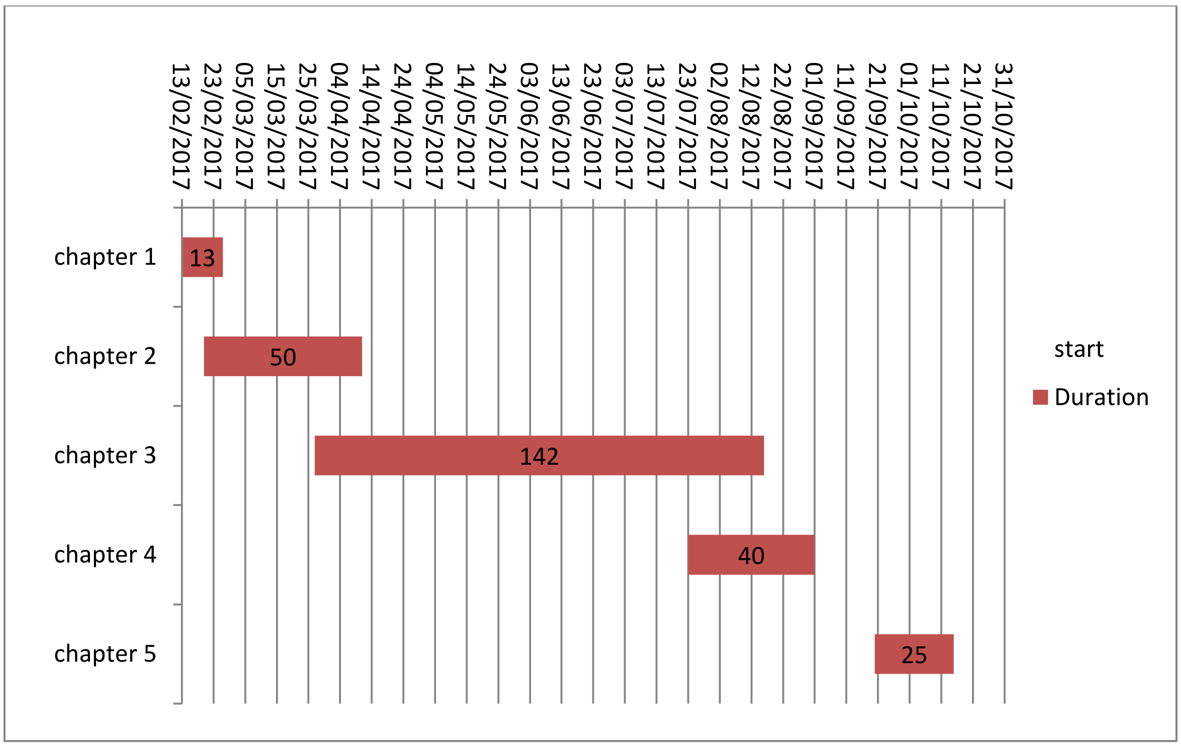
Abbreviations:

HVAC	Heating ventilation & air condition
AC	Air condition
COP	Coefficient of performance
AHU	Air handling unit
VAV	Variable air volume
IAQ	Indoor air quality
VSD	Valve speed drive
DDC	Direct digital control
EER	Energy efficiency Ratio
ACCA	Air conditioning contactors association
FCU	Fan coil unit
NTU	Number of transfer unit
PD	Pressure drop
TC	Total capacity
HP	Horse power
NPSH	Net positive suction head
K	Pressure drop coefficient
T	dry-bulb temperature of air stream
L/G	Water to air ratio
DX	Direct expansion

ASHRAE	American Society of Heating-Refrigerating Air conditioning Engineers

<u>Gantt chart</u>



Abstract

This project aims for operating & maintaining technically and economically for mushaireb tower's air Conditioning System in order to accomplish a higher efficiency and reducing system running cost.

It`s focused at the operation & maintenance schedules in order to reach the highest system efficiency and reduce running cost of the system as well as taking best practices of O&M , thus the project achieved to the agendas of operation and maintenance of the system above ,taking into account the best screening steps before ignition.

Thus project accessed to the highest performance of system as well as reducing running cost of the damage that occur as result of the lack regular preventive maintenance and control during operation.

All results reached by field visits and follow-up Mushaireb`s tower operating and maintenance of the system and recorded the results then required analysis done.

المستخلص

يهدف هذا المشروع لتشغيل و صيانة نظام التكيف في ابراج مشيرب بصورة تقنية و اقتصادية للوصول لكفاءة أعلى للنظام و تقليل التكلفة.

تم تطبيق جدول التشغيل اليومي للنظام و تحسين جدول الصيانة الدورية , بغرض الحصول على أفضل أداء للنظام وتقليل التكلفة التشغيلية أثناء عمل النظام,باتباع خطوات الفحص اثناء التشغيل فتم الحصول على اعلى اداء للنظام كما تم تقليل تكلفة الاعطال التى تحدث نتيجة لعدم الصيانة الدورية والرقابة اثناء التشغيل وكل النتائج تم التوصل اليها بواسطة العمل والزيارات الميدانية لابراج مشيرب ومتابعة عمليات التشغيل والصيانة وتسجيل النتائج وبعمل التحليل اللازم تم التوصل الي الاهداف.

Chapter one

1. 1Introduction:

Air conditioning, or more specifically, heating, ventilating, air ventilating, air conditioning, and refrigeration (HVAC&R), was first systematically developed by Dr. Willis H. Carrier in the early 1900s. Because it is closely connected with the comfort and health of the people, air conditioning became one of the most significant factors in national energy consumption. Most commercial buildings in the United States were air conditioned after World War II.

In 1973, the energy crisis stimulated the development of variable-air-volume systems, energy management, and other HVAC&R technology. In the 1980s, the introduction of micro process or based direct-digital control systems raised the technology of air conditioning and refrigeration to a higher level. Today, the standards of a successful and cost-effective new or retrofit HVAC&R projects include maintaining a healthy and comfortable indoor environment with adequate outdoor ventilation air and acceptable indoor air quality with an energy index lower than that required by the federal and local codes, often using off-air conditioning schemes to reduce energy costs.(1)

The indoor coil is an air-to-liquid heat exchanger with rows of tubes that pass the liquid through the coil. Finned surfaces connected to these tubes increase the overall surface area of the cold surface thereby increasing the heat transfer characteristics between the air passing over the coil and liquid passing through the coil. The type of liquid used depends on the system selected. (2)

1.2 Problem statement:

The tower’s Air Conditioning system during the operating procedure provides less load than it should be delivering at the manufacturer efficiency. This makes the system operation procedure less economically by raising the running cost of the system.

1.3 Project aim and Objectives

I / Reduce the chiller running cost.

II / Reach a higher performance for the chiller .

III/ Implement preventive maintenance plan for the chiller.

1.4 Project scope:

Mushaireb Tower's Chiller system.

*(*Air-cooled chiller system)

Chapter two

2.1 Air Conditioning:

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. [1]

2.2 Types of Air condition systems:

There are two categories:

2.2.1 According to the thermal zone:

The thermal zone is the zone the chiller will serve , and it's classified into:

2.2.1.1. Local systems:

A local (AC) system serves a single thermal zone and has its major components located within the zone itself, on the boundary between the zone and the exterior environment, or directly adjacent to the zone. In general, space conditioning energy cools from a local system will not pass through another zone on its way to the space being conditioned. Serving only a single zone, local (AC) systems will have only one point of control -typically a thermostat for active systems. A portable electric heater being used to heat a living room represents a local space heating system - the equipment is located in the room being heated, the heater realistically serves no other building space, and the output enters the room directly without passing through other building spaces each local system generally does its own thing, without regard to the performance or operation of other local systems. Although a local system is truly an isolated system, it is common to view a collection of such independent elements as part of a larger full-building (AC) system. This view is not unreasonable -even though there is no formal structure connecting the separate units to forge a larger system.

2.2.1.1.1 COMPONENTS TYPE OF THE LOCAL SYSTEM:

I-A window air conditioner:

Is a packaged unit consisting of a vapor compression refrigeration cycle (a compressor, condenser, evaporator, and expansion valve), with

A fan, a filter, appropriate controls, and a housing. Window air-conditioners are designed for installation in a framed or unframed opening in a vertical building enclosure element, and take their name from the fact that they are often installed in window openings.

II- Split systems:

The close coupling of evaporator and condenser components in small-scale single-zone systems using window, unitary or packaged equipment is often too restrictive for many architectural applications. Window and unitary units, for example, must penetrate vertical elements of the building envelope with substantial impact on aesthetics and envelope integrity. Having all system components in a single location also limits installation flexibility. A through-wall air-conditioner, for example, can only be installed where there is a wall available; interior spaces cannot be reasonably conditioned with such equipment. Rooftop units work well for single-story buildings, but don’t fit into multistory schemes. The split system provides a solution to these potential problems. [3]

2.2.1.2 Central system:

A central (AC) system may serve one or more thermal zones and has its major components located outside of the zone or zones being served usually in some convenient central location in, on, or near the building.

Space conditioning (thermal) energy from a central system must pass through zone boundaries on its way to the space or spaces being conditioned. Central AC systems will have as many points of control (thermostats) as there are zones. The nature of the thermal energy transfer medium used by a central system provides a means of sub-classifying central (AC) systems. If conditioning is transferred only by means of heated or cooled air, the system is termed an all-air system. If conditioning is transferred only by means of hot or chilled water, the system is termed an all-water system. If conditioning is transferred by a combination of heated/cooled air and hot/chilled water, then the system is termed an air-water system. [3]

Advantages of Central systems are allow major equipment components to be isolated in a mechanical room ,Easy to locate a central mechanical space in such a way as to reduce noise and aesthetic impacts on building occupants, Central AC systems also offer opportunities for economies of scale and Central systems are also amenable to centralized energy management control.

Disadvantages As system size and sophistication increase, maintenance may become more difficult and may be available from fewer provides if specialists are needed , Large, centralized systems tend to be less intuitive than smaller ,The conditioning effect from a central (AC) system must be conveyed throughout a building and The need to transfer conditioned air or water imposes space and volume demands on a building. Large duct sizes. [4]

2.2.2 According to the cooling fluid:

The cooling fluid is the main factor for cooling and the (AC) system could be classified by the cooling fluid into:

2.2.2.1 All-Air Systems:

A four primary types of all-air systems are commonly encountered in new and existing buildings. Single zone and multi-zone systems are constant volume, variable supply-temperature systems that are controlled at the central air handler. Terminal reheat and dual duct systems are constant volume, variable temperature systems that are terminally controlled a control approach that increases system flexibility and adaptability. The variable air volume system is a variable flow, constant temperature system with terminal control. The dual duct and multi-zone systems are multiple path systems with two or more separate supply air ducts, while the single zone, terminal reheat, and variable volume systems are single path systems with one common main supply duct. Numerous variations and hybrids of these systems may be encountered. For example, induction terminal units that supply a constant air volume to a space by mixing variable quantities of conditioned air and plenum air are quite common. All air systems require that the majority of air supplied to a space is returned to the air handling unit for reconditioning or exhausted from the building. This "return" air may be conveyed in a return air duct system or through plenums formed by various elements of a building, such as a suspended ceiling and the building structure.

I- Single zone:

A single zone system consists of an air handling unit, a heat source and cools source, distribution ductwork, and appropriate delivery devices. A completely integrated equipment approach may be used, where the heat and cools sources are an integral part of the air handler package; or separate heat and cools sources may provide heating and cooling effect to a remote air handler as illustrated. The integrated package is most commonly a rooftop unit, as access to the exterior environment for heat rejection or combustion air is readily available.

In a single zone all-air system, one control device (most commonly a thermostat) located in the zone controls the operation of the system. Control may be either modulating or on-off in nature. On-off control is all-or-nothing, it simply starts and stops the heating or cooling effect; air circulation may also start and stop along with heating/cooling or may be set for continuous operation. As this type system serves only one zone, control is normally effected at the air handling unit (AHU) through a change in supply air temperature or the stopping/starting of the system.

The primary advantage of a single zone central system is its simplicity Single zone systems are the most basic and least complex of central all-air systems.

II-Multi-zone:

In a multi-zone all-air system, individual supply air ducts are provided for each zone in a building. Cool air and hot (or return) air are mixed at the air handling unit to suit the needs of each zone. Once mixed at the air handler, air for a particular zone cannot be intermingled with air for any other zone -- thus the need for separate supply ducts. A special air handling unit, with parallel air flow paths at the heating and cooling coils and internal mixing dampers, is used for this type system. Due to physical restrictions on duct connections and damper size, the normal commercial multi-zone air handler is limited to a maximum of around 12 zones. If more zones are required, additional air handlers may be used. [3]

III-Dual duct:

The dual duct all-air system, is a terminal-controlled adaptation of the multi-zone concept. A central air handling unit provides two conditioned air streams. These air streams are distributed throughout the area served by the air handling unit in separate and parallel ducts. A terminal mixing box is provided for each zone. Under the control of the zone thermostat, the air streams are mixed in the terminal box to provide a supply air temperature that will properly condition the zone. A dual duct system generally exhibits advantages and disadvantages similar to those experienced with a multi-zone system. The primary difference is that the dual duct system, using terminal control, is more flexible with respect to changes in zoning requirements.[3]

IV-Variable volume:

A variable air volume (VAV) Air Conditioning system changes the quantity of air supplied to a space in response to changes in loads. This is a major operational difference from the four constant volume systems discussed above and opens up a number of energy-efficiency options. A central air handling unit supplies air through a common duct pathway to all spaces conditioned by the unit. Each zone is provided with a (VAV) box (terminal control box) that adjusts air supply volume in response to the zone thermostat. The temperature of air supplied by the air handling unit may be varied occasionally to adapt to building-wide changes in loads, but day to day control of each zone is achieved through modulation of supply air flow rate. A basic (VAV) system cannot provide simultaneous heating and cooling. [6]

2.2.2.2 All-water Systems:

In an all-water system, conditioning effect is distributed from a central plant to conditioned spaces via heated or cooled water. Water is an effective heat transfer medium, thus distribution containers (pipes) generally may be of relatively small volume (compared to air ducts). On the other hand, water cannot be directly dumped into a space through a diffuser, requiring a more sophisticated delivery device. All-water heating-only systems employ a variety of delivery devices, including baseboard radiators, convectors, unit heaters, and radiant floors. All-water cooling only systems are rare; valance units (a ceiling-located counterpart of a baseboard radiator) are the most common delivery device for such systems. If full air conditioning is considered, the most common delivery device is the fan coil unit.

I- Fan coil:

A fan-coil unit is a small-scale air handling unit with circulation fan, cooling and/or heating coil, filter, and appropriate controls. Fan-coil units are available for vertical installation (typically along a wall at the intersection with the floor, or horizontal installation (typically suspended from the ceiling, Fan-coil h out sings may be exposed to occupants (with appropriate styling and finishes), or may be concealed in a plenum or soffit, as a central system, individual fan-coil units are supplied with conditioning effect produced at a central location (a central plant); in an all-water system, the heating effect is produced by a boiler and the cooling effect by a chiller.

Fan-coil control is typically achieved through control of water flow through the coil using a control signal from the zone thermostat. Further control is sometimes provided by a multi-speed fan option. Occupants can usually adjust supply air louvers to provide some control over air distribution patterns. The most critical performance issue facing an all-water fan-coil system is ventilation air. Fan-coil units installed on an exterior wall can be equipped with an outdoor air connection so that ventilation may be provided. Fan coils installed in interior zones cannot easily provide such outdoor air ventilation. An air-water fan-coil system can overcome this constraint. In a fan-coil system, a major system component (the fan-coil unit itself) is installed in or adjacent to occupied spaces, requiring that filter changes and maintenance of fans and coils occur in these spaces. Fan noise may be a concern in some critical occupancies. [3]

2.2.2.3 Air water Systems:

An air-water system incorporates the main benefits of all-air and all-water approaches in a hybrid system. The volume-saving advantages of an all-water system are combined with the outdoor ventilation benefits of an all-air system. Usually, the majority of space load is carried by conditioned water with just enough central air supply to meet ventilation demands. Historically this has resulted in a system where 80-90 % of the space load is dealt with by heated or cooled water and 10-20% by heated or cooled air. Two main delivery approaches are used in air-water systems; the fan-coil and the induction unit.

I-**Fan-coil**:

Externally, an induction unit looks very much like a fan-coil unit; the difference is internal. An induction unit employs high velocity air flow from a central air handling unit to induce a flow of room air into and through the cabinet. This induction effect replaces the motive force provided by the fan in a fan coil unit. The mixture of central air (termed primary air) and room air (secondary air) passes through a coil in the unit and is conditioned to suit the needs of the zone.

Filtration of the secondary room air at the induction cabinet is common. Figure 8 shows a typical induction unit, while Figure 8 provides a schematic diagram of an air-water induction system. [6]

2.3 Major AC&R Problems:

I- Poor indoor air quality (IAQ)—sick building syndrome. Poor indoor air quality causes the sick building syndrome

II- Insufficient communication between design professionals, construction groups, and operators. Effective operation requires a knowledgeable operator to make adjustments.

III- Overlooked commissioning. Commissioning means testing and balancing all systems, functional testing and adjusting of components and the integrated system, and adjusting and tuning the direct digital controls. An air conditioning system is different from the manufacturing products having models and prototypes. [1]

2.4 Air Conditioning Components:

Air conditioning system components may be grouped into three functional categories: source components, distribution components, and delivery components. Source components provide or remove heat or moisture.

Distribution components convey a heating or cooling medium from a source location to portions of a building that require conditioning. Delivery components serve as an interface between the distribution system and occupied spaces. Compact systems that serve only one space or zone of a building (local systems) often incorporate all three functions in a single piece of equipment. Systems that are intended to condition multiple spaces in a building (central systems) usually have distinctly different equipment elements for each function.

2.4.1 Cooling Process Components:

I-Vapor Compression Refrigeration Unit:

A vapor compression unit establishes a heat sink through the flow of a refrigerant in a fixed loop between a compressor, a condenser, an expansion valve, and an evaporator. The compressor (in centrifugal, reciprocating, or screw configurations) as shown in figure (2.1) adds energy to the refrigerant that increases its pressure. From the compressor, high-pressure, high-temperature refrigerant is circulated to a condenser. The condenser indirectly exposes the refrigerant to air or water of lower temperature.

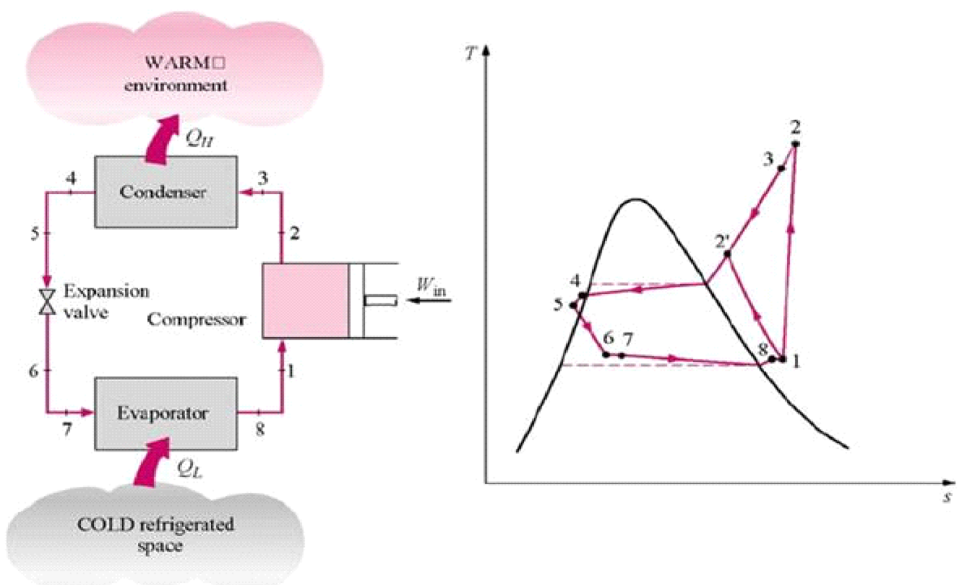


Figure (2.1): Vapor Compression Refrigeration

II-Absorption Refrigeration Unit:

The basic concept behind an absorption refrigeration unit is the same as that for a vapor compression unit; the means of execution, however, is substantially different. Water, acting as the refrigerant, is circulated between a generator, a condenser, an evaporator, and an absorber. Heat is added to the generator, which causes the refrigerant to evaporate. The vapor-state refrigerant is conveyed to the condenser where heat is removed by transfer to condenser water or air and the refrigerant is condensed to liquid. The refrigerant is then transferred to the evaporator where it accepts heat from room air or chilled water. The fully evaporated (gaseous) refrigerant then travels to the absorber and from the absorber to the generator where the cycle continues. The components of the absorption refrigeration process are shown in illustrates the operation of this type of refrigeration cycle.

III-Evaporative Cooling Unit:

Evaporative cooling is a basic sychrometric process in which air is sensibly cooled while it is simultaneously humidified. An evaporative cooler is a packaged unit that contains components to govern this process in a manner that can produce reasonable cooling capacities. Dry air is pulled into the evaporative cooler by a fan. The dry air is passed through some porous media that is wetted with water [6].

2.5 Chillers:

Chillers are a key component of air conditioning system for large buildings. They produce cold water to remove heat from the air in the building, they also provide cooling for process loads such as file server rooms and large medical imaging equipment. As with other types of air conditioning systems, most chillers extract heat from water by mechanically compressing a refrigerant, Chillers are complex machines that are expensive to purchase and operate. A preventive and predictive maintenance program is the best protection for this valuable asset.

Chillers commonly use more energy than any other piece of equipment in large buildings. Maintaining them well and operating them smartly can yield significant energy savings

Figure (2.2): Chiller

2.5.1 Systems Chiller and associated Air Conditioning:

A chiller is a refrigeration unit designed to produce cool (chilled) water for space cooling purposes. The chilled water is then circulated to one or more cooling coils located in air handling units, fan-coils, or induction units. Chilled water distribution is not constrained by the 100 foot separation limit that applies to (DX) systems, thus chilled water-based cooling systems are typically used in larger buildings. Capacity control in a chilled water system is usually achieved through modulation of water flow through the coils; thus, multiple coils may be served from a single chiller without compromising control of any individual unit.

2.5.2Types of Chillers:

The chillers are classified into:

2.5.2.1 According to Mechanical Compression:

Mechanical compression chillers are classified by compressor type:

I-Reciprocating:

Similar to a car engine with multiple pistons, a crankshaft is turned by an electric motor, the pistons compress the gas, heating it in the process. The hot gas is discharged to the condenser instead of being exhausted out a tailpipe. The pistons have intake and exhaust valves that can be opened on demand to allow the piston to idle, which reduces the chiller capacity as the demand for chilled water is reduced. This unloading allows a single compressor to provide a range of capacities to better match the system load. This is more efficient than using a hot-gas bypass to provide the same capacity variation with all pistons working. Some units use both methods, unloading pistons to a minimum number, then using hot-gas bypass to further reduce capacity stably. Capacities range from 20 to 125 tons.

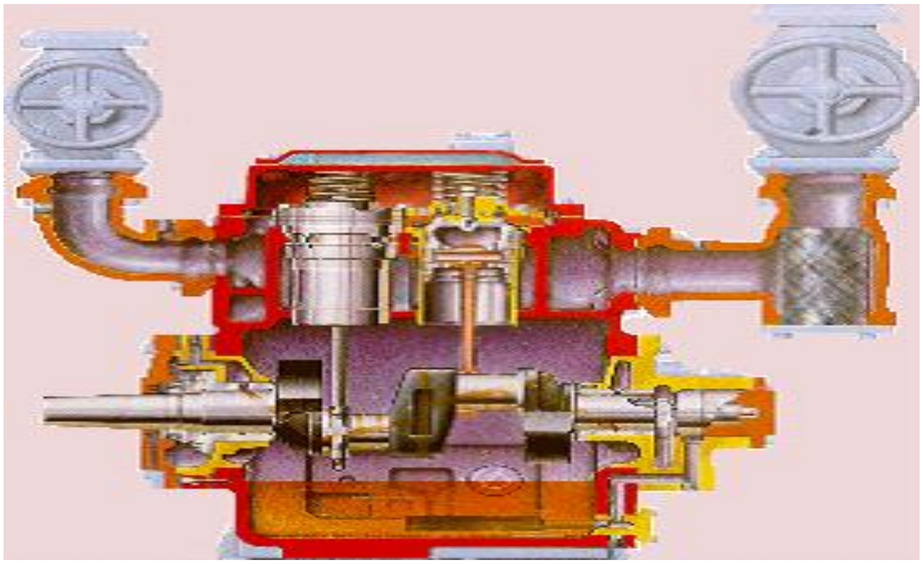


Figure (2.3): Reciprocating compressor

II-Rotary Screw:

The screw or helical compressor has two mating helically grooved rotors in a stationary housing. As the helical rotors rotate, the gas is compressed by direct volume reduction between the two rotors. Capacity is controlled by a sliding inlet valve or variable-speed drive (VSD) on the motor. Capacities range from 20 to 450 tons.

Figure (2.4): Rotary Screw

III-Centrifugal:

The centrifugal compressor operates much like a centrifugal water pump, with an impeller compressing the refrigerant. Centrifugal chillers provide high cooling capacity with a compact design. They can be equipped with both inlet vanes and variable-speed drives to regulate control chilled water capacity control. Capacities are 150 tons and up.

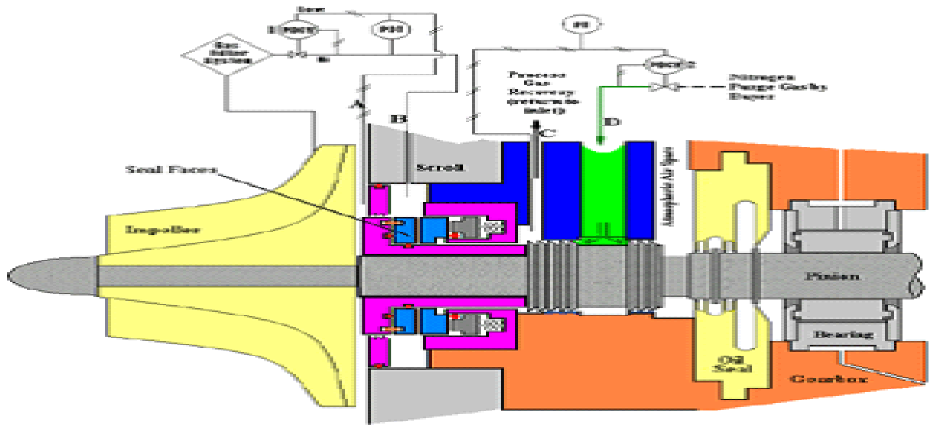


Figure (2.5): Centrifugal

2.5.2.2 According to condenser:

There are two types of condenser:

I- Air-cooled condenser chiller:

chiller with an air-cooled condenser provides a packaged chiller, which would be installed outside of the building envelope.

II- **water-cooled condenser chiller**:

Chillers from this type provide cooling the condenser with cool water coming from the cooling tower to reject the heat.

2.5.3 Chillers Controls:

All chiller need to be properly controlled for safety and efficient operation. A chiller today uses microprocessors, electronic sensors, and digital. User interfaces that have changed the look of chiller equipment control system. This technology is referred to a Direct Digital Control (DDC). [10]

Figure (2.6):Chiller control

2.5.4 Safety Issues

Chillers are typically located in a mechanical equipment rooms. Each type of refrigerant used in a chiller compressor has specific safety requirements for leak detection and emergency ventilation. Consult your local mechanical code or the International Mechanical Code for details. The EPA has enacted regulations regarding the use and handling of refrigerants to comply with the
Clean Air Act of 1990.

2.5.5 Key Components For Chiller:

There are four common components for the chiller and one more for the water cooled

I-Evaporator:

Chillers produce chilled water in the evaporator where cold refrigerant flows over the evaporator tube bundle. The refrigerant evaporates (changes into vapor) as the heat is transferred from the water to the refrigerant. The chilled water is then pumped, via the chilled-water distribution system to the building's air-handling units.

The chilled water passes through coils in the air handler to remove heat from the air used to condition spaces throughout the building. The warm water (warmed by the heat transferred from the building ventilation air) returns to the evaporator and the cycle starts over.

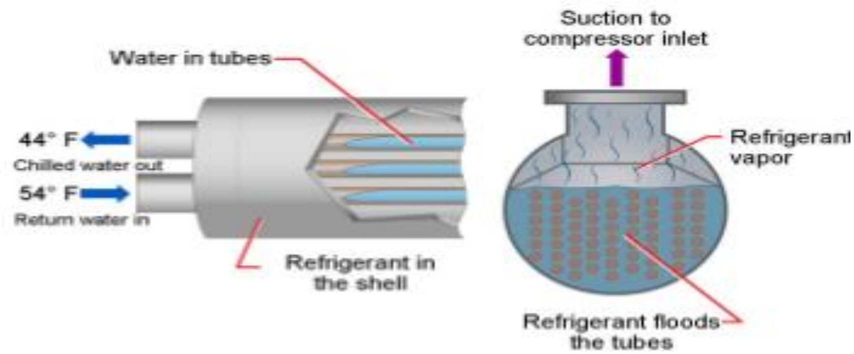


Figure (2.7): Evaporator

II - Compressor:

Vaporized refrigerant leaves the evaporator and travels to the compressor where it is mechanically compressed, and changed into a high-pressure, high temperature vapor. Upon leaving the compressor, the refrigerant enters the condenser side of the chiller.

III - Condenser:

Inside the condenser, hot refrigerant flows around the tubes containing the condenser-loop water. The heat transfers to the water, causing the refrigerant to condense into liquid form. The condenser water is pumped from the condenser bundle to the cooling tower where heat is transferred from the water to the atmosphere. The liquid refrigerant then travels to the expansion valve.

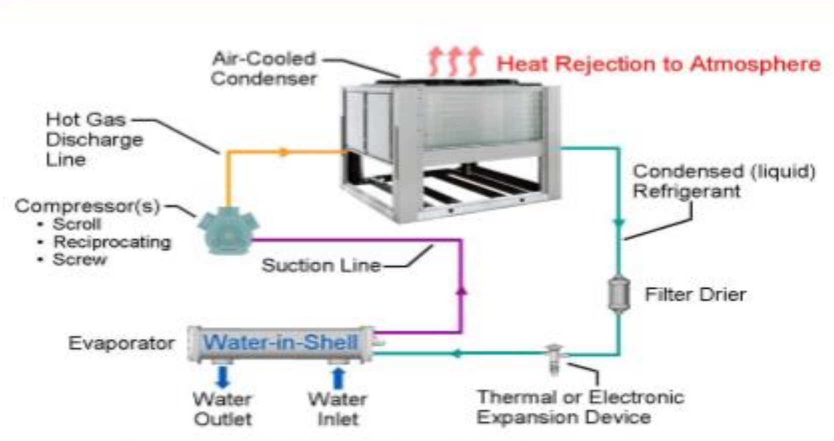


figure (2.8): Condenser

IV - Expansion valve

The refrigerant flows into the evaporator through the expansion valve or metering device. This valve controls the rate of cooling. Once through the valve, the refrigerant expands to a lower pressure and a much lower temperature. It flows around the evaporator tubes, absorbing the heat of the chilled water that's been returned from the air handlers, completing the refrigeration cycle. [7]

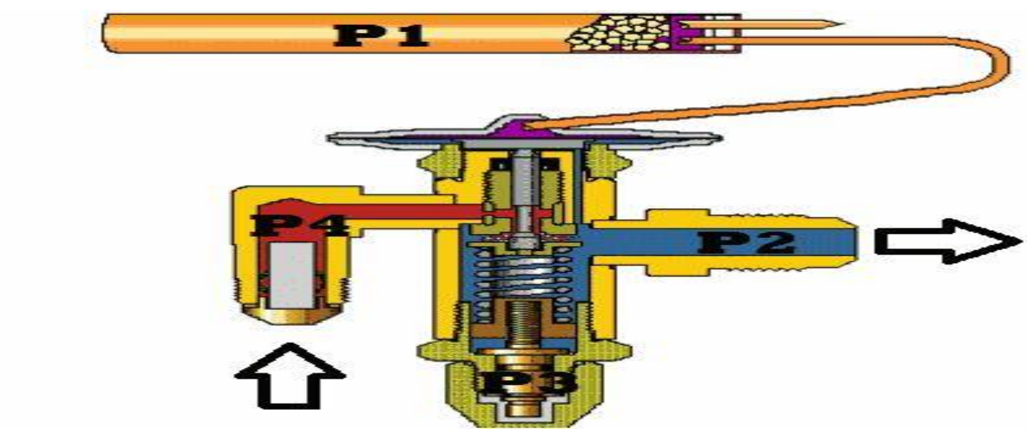


Figure (2.9): Expansion Valve

V- Cooling Tower:

A cooling tower is a heat rejection device, installed outside of the building envelope, through which condenser water is circulated. Refrigerant in the refrigeration cycle is condensed in a refrigerant-to-water heat exchanger. Heat rejected from the refrigerant increases the temperature of the condenser water, which must be cooled to permit the cycle to continue. The condenser water is circulated to the cooling tower where evaporative cooling causes heat to be removed from the water and added to the outside air. The cooled condenser water is then piped back to the condenser of the chiller. A cooling tower is a latent heat exchanger, where the magnitude of heat flow is a function of the quantity of water that is evaporated -- which is primarily a function of the relative humidity of the outside air [1].

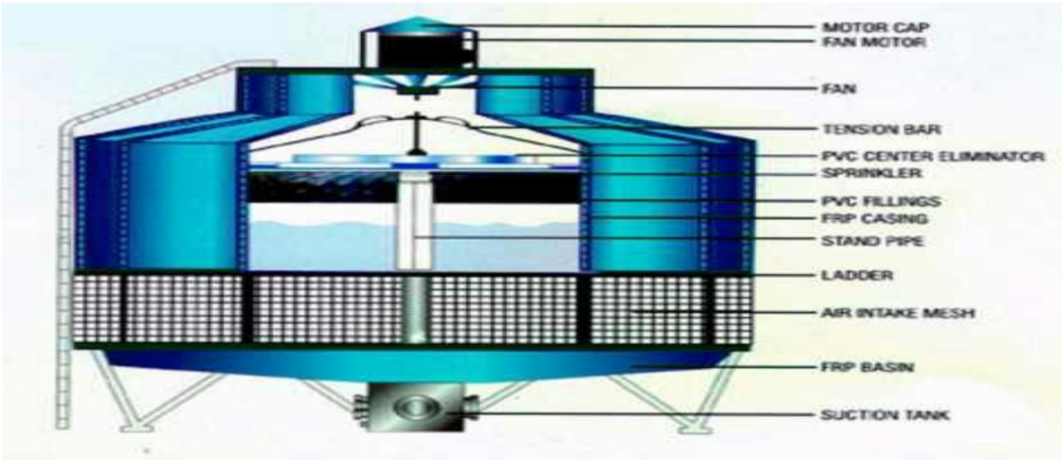


Figure (2.10): Cooling Tower

2.6 Air Handling Units (AHU):

Air handling units are equipment packages, usually pre-assembled but sometimes site-built, that house several major components necessary for the operation of air-based central (AC) systems. As noted in Figure 26, an air handler consists of a sheet metal enclosure, a fan, a heating coil or heat source and/or a cooling coil (as required), an air filter, occasionally a humidifier, and necessary control devices. The fan provides the motive energy for air circulation. A filter is provided to remove indoor pollutants from the air stream (refer to Vital Signs module: Health in the Built Environment). The heating or cooling coil act as secondary sources receiving heating or cooling media from a boiler or a chiller and transferring the conditioning effect to the air stream. Electric resistance coils may also be used as a heat source. On-site combustion at the air handling unit serves as a common heat source for rooftop air handling units. A humidifier may be required to add moisture to the air under certain conditions. Dehumidification (moisture removal) is accomplished through the cooling coil. Control devices such as mixing dampers and valves are often part of an air handling unit [6].

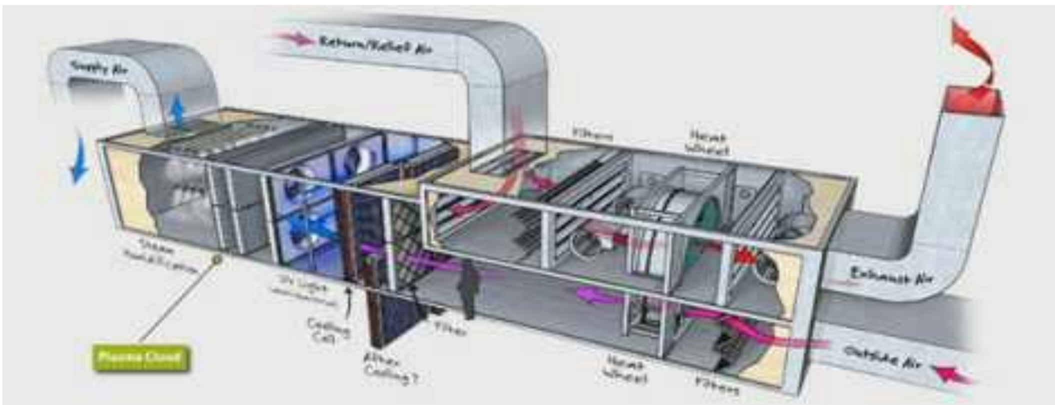


Figure (2.11): Air Handling Unit

2.7 Delivery components:

The cooling effect produced at a source and distributed by a central system to spaces throughout a building needs to be properly delivered to each space to promote comfort. In air-based systems, heated or cooled air could theoretically just be dumped into each space. Such an approach, however, does not provide the control over air distribution required of an air-conditioning system. In water-based systems, the heated or cooled media (water or steam) cannot just be dumped into a space. Some means of transferring the conditioning effect from the media to the space is required. Devices designed to provide the interface between occupied building spaces and distribution components are collectively termed delivery device.

I-Diffuser:

A diffuser is a device designed specifically to introduce supply air into a space, to provide good mixing of the supply air with the room air, to minimize drafts that would discomfort occupants.

II-Register:

Registers, Figure 28, are similar to diffusers except that they are designed and used for floor or sidewall air supply applications or as return air inlets

III-Grille:

Are simply decorative covers for return air inlets; they are used to block sightlines so that occupants cannot see directly into return air openings. [6]

2.8 Previous Studies:

1- Design and selection of and air condition system for international university of Africa mosque:

*International university of Africa

*Supervised by: Dr. OBAI YOUNIS TAHA, (July 2016)

*Abstract:

I/ calculate the building cooling load refrigerating

II/ free stand split system were selected

2-Usage and sizing of expansion tank chillers and boilers

*University of Khartoum

*Supervised by: Dr. Mohamed Ahmed Abdelbagi Sirag (August 2015)

*Abstract:

I/ Load calculation using CLTD / CLF for hotel in kassala

II/ optimum system was selected for the building

3-**Thermal design of cooling tower**

Khartoum University

*Supervised by: Dr. Salah Ahmed Abdalla Ahmed, (November 2016)

*Abstract

I/ NTU is calculated by using merker equation

II/ various design requirement are discussed

III/ tower dimension, water consumption rate, exit air temperature, and power requirement are calculated.

Chapter Three

3.1 Project Flow Chart:

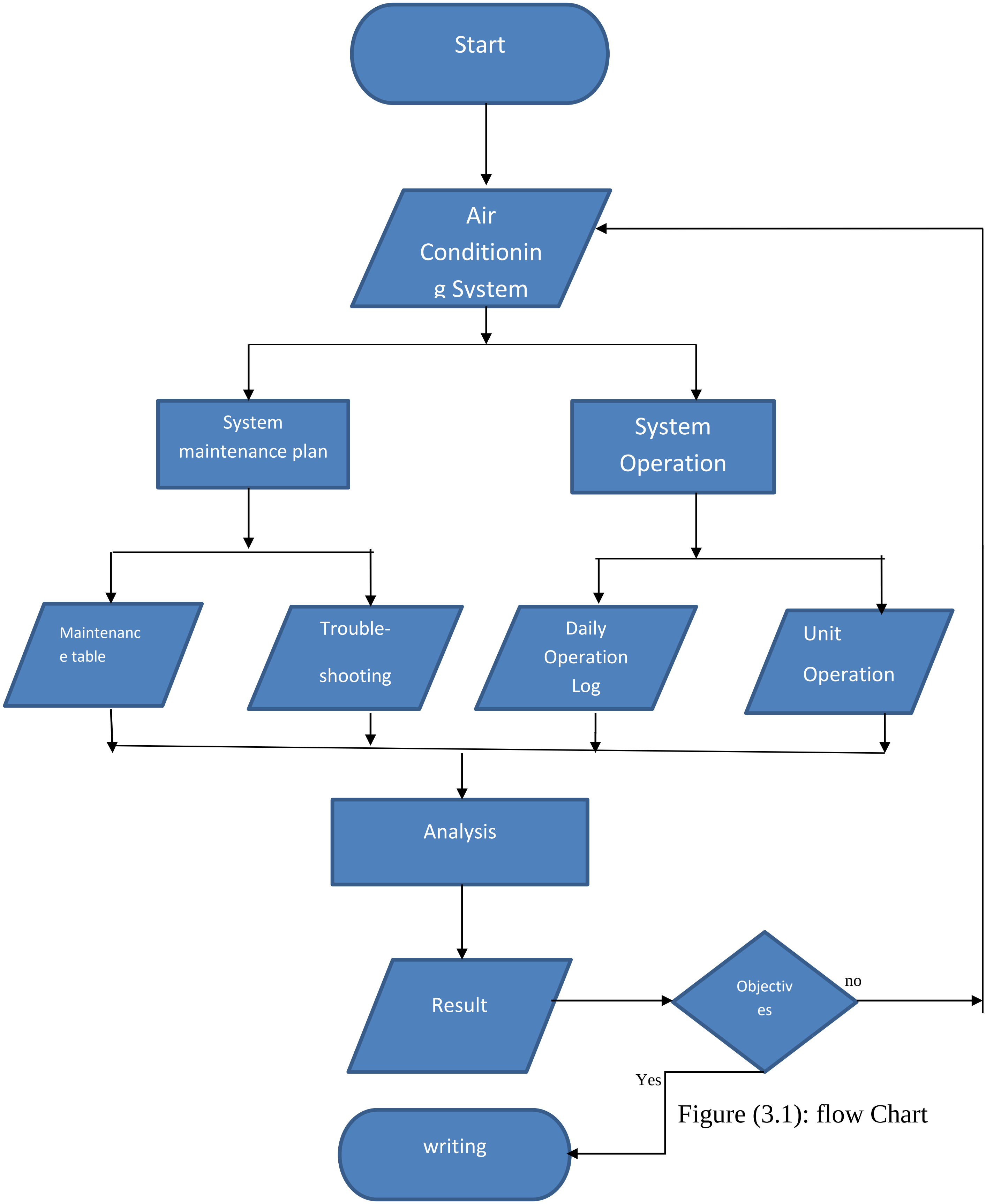


Figure (3.1): flow Chart

3.2 System Operation:

The unit should be started up only by a refrigeration technician who is familiar with accepted operation practices for refrigeration systems.

Use small screw unit start-up report to record all temperature, pressure, electrical readings and control settings. AC equipment have been making an effort to make the systems they manufacture more efficient. This was originally driven by rising energy costs, and has more recently been driven by increased awareness of environmental issues. Additionally, improvements to COP measures performance, but this dimensionless measure has not been adopted. Instead, the EER has traditionally been used to characterize the performance of many AC systems. EER is the Energy Efficiency Ratio based on a 35 °C (95 °F) outdoor temperature.

3.2.1 Chillers used in the building:

Load calculation for the building from table (3.1) the load are:

-T.C of building = 1281kw

-TR of the building = 366 TR

-Chiller (240-5HR)

-Chiller (240-5HR)

-Safety chiller (240-5HR)

3.2.2 Chiller specification:

(-) Air-cooled chiller

(-) Flooded evaporator

(-) Horizontal screw compressor

(-) Heat recovery

(-) 50 Hz

3.2.3 System layout:

A single chiller contains two compressors and two evaporator

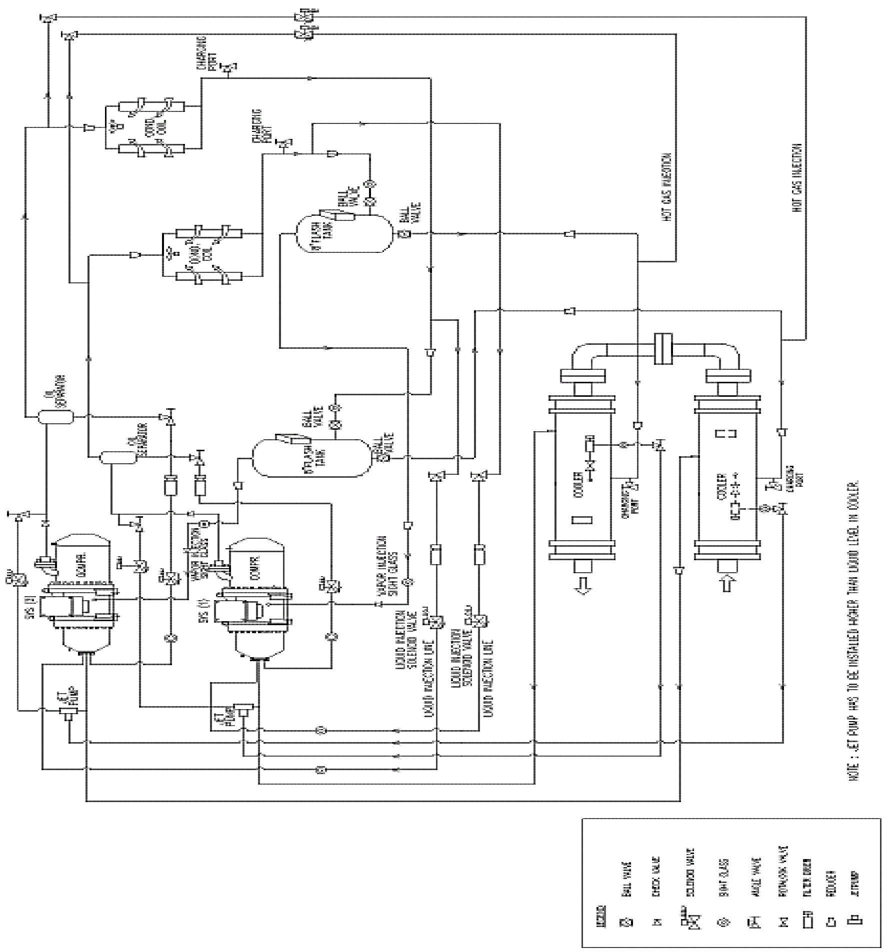
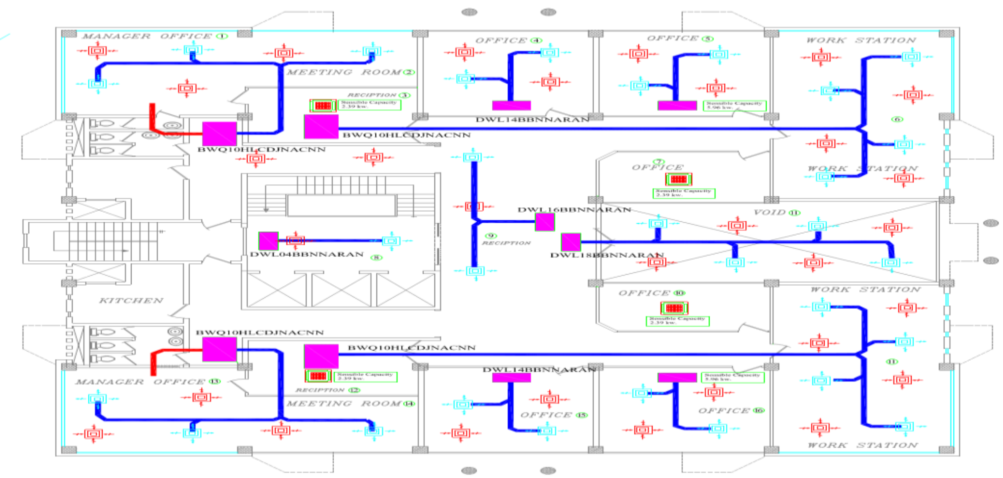
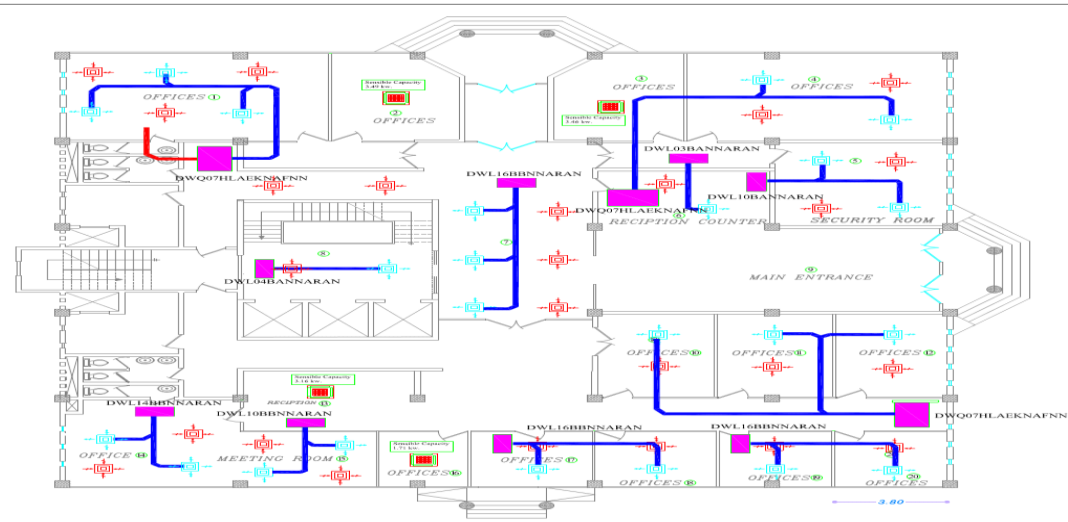


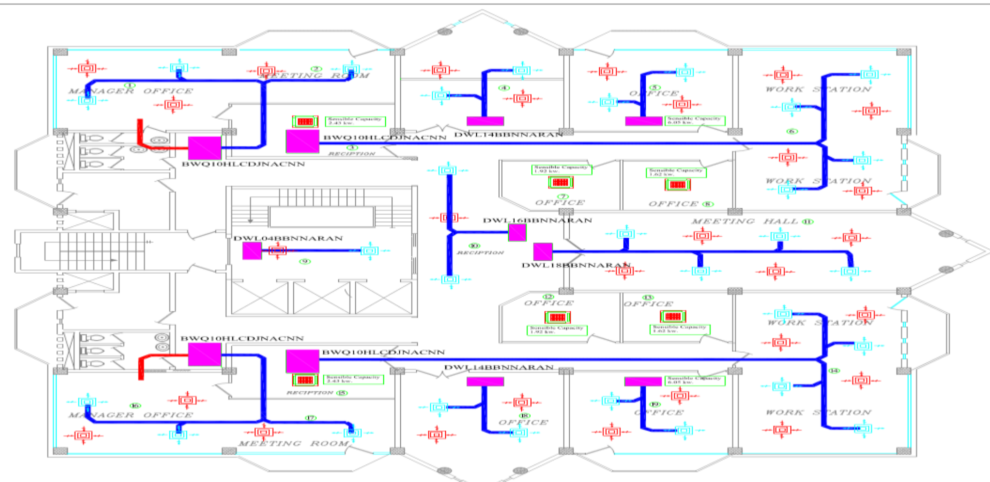
Figure (3.2) : Chiller layout



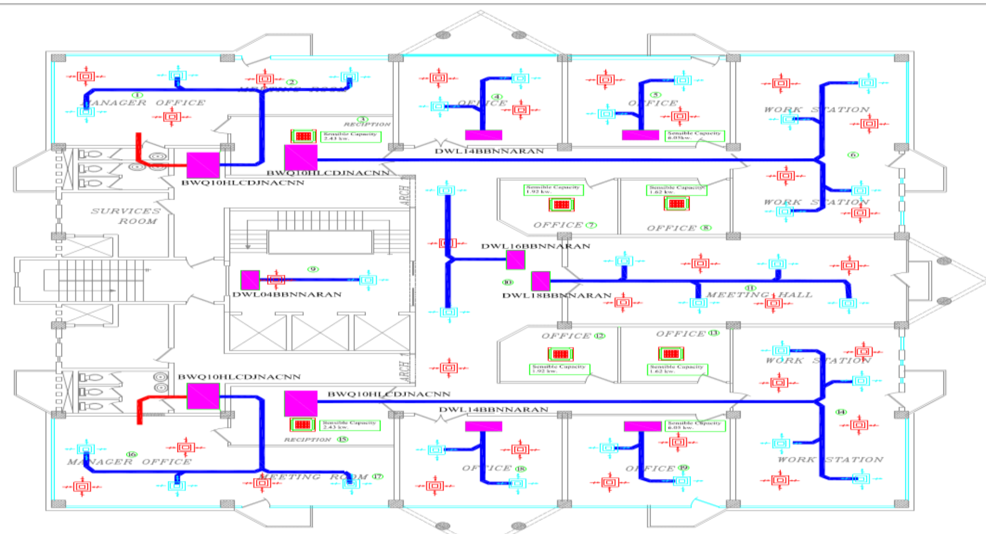
FIRST FLOOR PLAN



GROUND FLOOR PLAN



3rd - 7th -9th FLOOR PLAN



2 nd. FLOOR PLAN

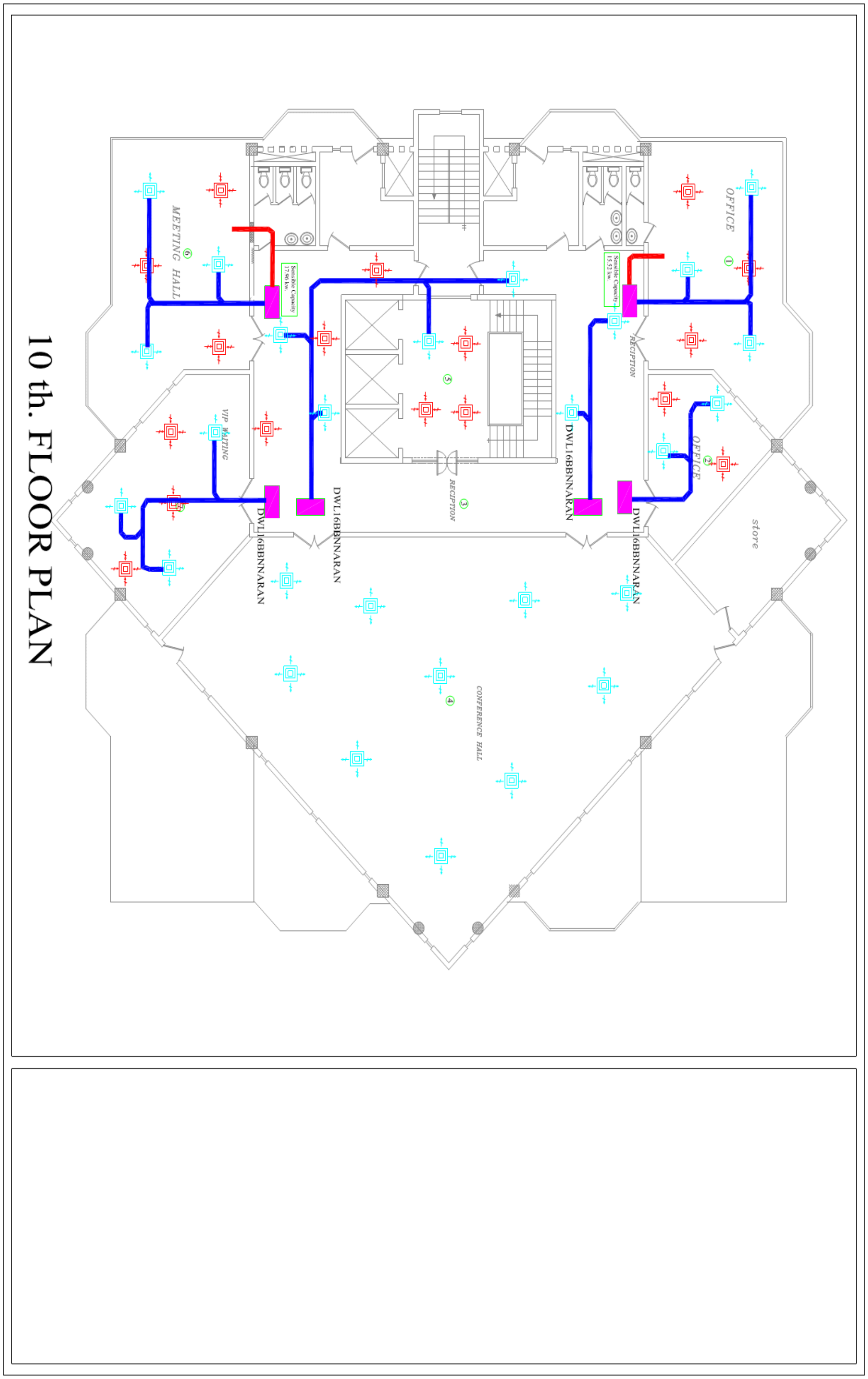


Figure (3.3) :Duct system distribution.

Table (3.1) Load calculation:

Zone	Total capacity(Kw)
Ground floor	**159**
First floor	**184**
Second floor	**199**
3rd .4th .5th floor	**172×3**
6th. 10th floor	**223**
Total	**1281**

3.2.4 Unit operation:

These units may equipped with manifold installed manual discharge valve must be opened before attempting to start:

3.2.4.1 Start-up

I- High/low voltage value of the system. In the case of the unit shut-down and ، waterless in a long time, the liquid and gas of the system shall be equivalent and close to the saturation pressure corresponding to the current ambient temperature. The correlation of saturation temperatures and pressures (the pressures in the list are gage pressures, among which, the atmospheric pressure is 0.1MPa) of R134a refrigerant.

II- Inspect whether the oil heating of the unit is normal, before startup, it is necessary to inspect whether the oil heating in the unit is available, and whether there is the condition that the oil heater does not work because of no power supply.

III- Inspect whether there is alarm for trouble of the display screen, if there is, the trouble must be corrected.

IV- Inspect the electronic expansion valve control module for alarm trouble.

V- Inspect whether various temperature points displayed on the display screen are within the normal range, before the operation of the unit, the showed temperatures of discharge fin and the ambient temperature are close to the current actual ambient temperature, and whether the entering and leaving water temperatures are close to the water temperature at the user side.

VII - Start on pump. Inspect whether the flow in the water pump meets the requirements of the unit.

VIII - Inspect whether the power supply of the unit is stable.

X- Start on chiller.

XI- Running parameters.

3.2.4.1.1 Seasonal Start-Up:

I- check drives for wear, rust, propeller clearance, etc. and make necessary repairs. & adjustment. Grease main fan shaft bearings.

II- check & clean condenser fin surface if necessary, use a warm water soap solution, being careful not to bend the fins. Comb out bent fin areas.

III- check al power supply connections at all points, and all control terminal screws for tightness.

IV- energize main power to unit & leave on for at least 24 hours in order for compressors to thoroughly warm up.

V-start chilled water pump and verify correct flow-rate glycol % if required, bleed-off system air if necessary.
VI- open main discharge valve in discharge header.
VII- open liquid valve on seal opt.
VIII- turn control circuit power switch on, and all compressor circuit switches, press computer keyboard reset key.

3.2.4.2 Shut – Down:

To shut down in the unit with compressors on or off, turn each individual compressor switch, do not close any valve the chilled water pump then be turned off. Finally, do not open the main unit disconnect .main power is required to keep the sump heaters.

3.2.4.2.1 Seasonal Shut-Down:

I- Turn off chilled water pump.

II- Close manual discharge valve.

III- Close Liquid valve on seal pot.

- it's recommended that an oil sample be taken from each compressor & submitted for lab analysis.

3.2.5 Operating Log for Chillers:

Operating stage includes collecting data for the chiller while running, the data is collected for the chiller every two hours

3.3.5.1 data collected before maintenance :

Name :....................../......................../........................ Date :..........................

Chillers No					2	2	2	2	2	2	2	2
Time					8:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00
Operating Hours												
KW Input					191	187	188	189	190	183	173	184
Compressor 1		Oil level	1\4	3\4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4
		Oil pressure P.S .I.D	17	62	36.2	38.0	36.0	39.9	35.4	35.4	37.1	36.5
		Oil Temperature °F	80	180	174.1	173.1	152.0	149.7	153.3	140.6	146.7	147.7
		Discharge Temperature °F			123.0	125.5	129.0	130.2	133.5	121.8	138.6	130.4
		Full load	25%	100%	75%	73%	76%	74%	75%	73%	70%	76%
Motor 1		Volts	360	440	392	390	388	392	398	399	403	400
		Amps	108.5	477	302	295	288	294	326	158	302	328
		Temperature °F			165	167	168	169	173	115	169	173
Cooler	Ref.	Evaporator pressure P.S .I.G	28	75	36.6	38.1	39.2	39.8	37.2	50.0	34.6	38.3
	liquid 1	Inlet Temperature °F	40	95	48.3	49.8	51.6	52.3	49.1	56.3	46.4	50.8
		Inlet pressure P.S.I	Δ P=10	~15P.S.I	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
		Outlet Temperature °F	40	95	43.4	45.1	46.8	47.1	44.5	55.7	42.0	45.8
		Outlet pressure P.S.I	Δ P=10	~15P.S.I	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
		Set point			42.0	42.0	42.0	42.0	42.0	42.0	42.0	42.0
		Saturation Temperature			41.6	43.2	44.3	44.8	42.3	53	39.6	43.4
Condenser 1	Refrigerant	Condenser pressure P.S .I.G	75	160	116.9	119.2	123.9	126.1	128.3	92.4	123.3	125.2
		Condenser Saturation			96.7	97.7	100.4	101.0	102.4	83.9	99.1	100.3
	liquid	Inlet Temperature °F	75	95								
		Inlet pressure P.S.I	Δ P=10	~15P.S.I								
		Outlet Temperature °F	85	105								
		Outlet pressure P.S.I	Δ P=10	~15P.S.I								
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Name :……………………/……………………/…………………… Date :………………………

Chillers No					2	2	2	2	2	2	2	2
Time					8:00 AM	10:00 AM	12: PM	14: PM	16:00 PM	18: PM	20: PM	22: PM
Operating Hours												
KW Input					170	178	177	174	178	181	162	175
Compressor	2	Oil level	1\4	3\4	1/4	1/4	1/4	1/4	1/4	1/4	1/4	1/4
		Oil pressure P.S .I.D	17	62	34.1	35.8	34.7	33.7	34.4	55	35.2	34.1
		Oil Temperature °F	80	180	136.1	135.8	136.5	136.5	142.4	143.1	151	141.7
		Discharge Temperature °F			116.8	119.3	120.4	121.0	123.3	120.3	121.7	120.8
		Full load	25%	100%	68%	70%	71%	70%	73%	72%	62%	70%
Motor		Volts	360	440	393	391	390	392	400	400	405	400
		Amps	108.5	477	263	282	275	289	312	313	270	307
		Temperature °F			136	139	142	143	145	142	137	145
Cooler 2	Ref.	Evaporator pressure P.S .I.G	28	75	32.6	33.7	35.4	36.7	34.6	40.8	33.5	34.9
	liquid	Inlet Temperature °F	40	95	48.2	49.7	51.5	52.3	48.9	56.5	46.4	50.6
		Inlet pressure P.S.I	Δ P=10 ~15P.S.I		2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
		Outlet Temperature °F	40	95	41.8	43.1	45.1	45.5	43.2	49.1	41.8	44.4
		Outlet pressure P.S.I	Δ P=10 ~15P.S.I		2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
		Set point			42	42	42	42	42	42	42	42
		Saturation Temperature			37.5	38.6	40.1	41.6	39.4	45.1	38.4	39.9
Condenser	Refrigerant	Condenser pressure P.S .I.G	75	160	105.9	110.7	112.6	114.2	114.1	114.2	107.1	111.4
		Condenser Saturation			90.9	93.5	94.2	95.1	95.3	95.3	91.8	93.8
	liquid	Inlet Temperature °F	75	95								
		Inlet pressure P.S.I	Δ P=10 ~15P.S.I									
		Outlet Temperature °F	85	105								
		Outlet pressure P.S.I	Δ P=10 ~15P.S.I									
REMARK												

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3.3 Maintenance:

Inspection, service, access, and maintenance to prevent system failure and component deterioration are essential factors to guarantee that air filters, coils, ducts, dampers, and other system components are properly and efficiently operated, in order to ensure the long term safe operation, to extend the service life of unit, reduce the failure and repair, should be regularly maintained and checked on the unit, during operation of the unit, should irregularly check the water temperature, oil level of compressor, high and low pressure, voltage, current electric control box on the door of the emergency stop switch used in machine repair, debugging or emergency shutdown and so on, such as abnormal timely find out the reasons, troubleshooting.

3.3.1 Periodic inspection:

Read essential temperatures and pressure periodically to see that they indicate normal operation, it is a good idea to record this reading on a log sheet, if any abnormal operation is observed, try to remedy it, see trouble shooting guide section.

3.3.2 Monthly inspection:

Remote dirt and debris from condenser coil .shut unit down open main disconnect, inspect control panel, checking for loose wire .burned contacts signs for overheated wire ,etc, restart unit and check performance of controls check sign glasses for proper refrigerant charge.

3.3.3 Maintenance safety considerations:

Engineers working on the electric or refrigeration components must be authorized, trained and fully qualified to do so. All refrigerant circuit repairs must be carried out by a trained person, fully qualified to work on these units. He must have been trained and be familiar with the equipment and the installation. All welding operations must be carried out by qualified specialists. Any manipulation (opening or closing) of a shut-off valve must be carried out by a qualified and authorized engineer. These procedures must be carried out with the unit shut-down. Note, the unit must never be left shut down with the liquid line valve closed, as liquid refrigerant can be trapped between this valve and the expansion device. (This valve is situated on the liquid line before the filter drier box.) during any handling, maintenance and service operations the engineers working on the unit must be equipped with safety gloves, glasses, shoes and protective clothing. Never work on a unit that is still energized. Never work on any of the electrical components, until the general power supply to the unit has been cut using the disconnect switch (e s) in the control box(e s). If the work is interrupted, always ensure that all circuits are still deenergized before resuming the work.

3.3.4 Chiller Maintenance plan:

3.3.4.1 Chiller Maintenance:

The chiller already have a maintenance table in the catalogue

table (3.4).

The developed summary table for chiller maintenance:

Table (3.5): Maintenance Summary

Description	**Comments**	**Maintenance Frequency**
Fill out daily log	Check all setpoints for proper setting and function. Make sure there are no unusual sounds and the space temperature is acceptable.	Daily (4×)
Chiller use/sequencing	Turn off or sequence unnecessary chillers.	Daily
Check chilled water reset settings and function	Check settings for approved sequence of operation at the beginning of each cooling season.	Annually
Check chiller lockout set point	Check settings for approved sequence of operation at the beginning of each cooling season.	Annually
Clean evaporator and condenser tubes	Indicated when pressure drop across the barrel (tube bundle) exceeds manufacturer's recommendations, but at least annually.	Annually
Verify motor amperage load limit	Motor amperage should not exceed manufacturer's specification.	Annually
Compressor motor and assembly	Conduct vibration analysis: Check all alignments to specifications. Check all seals. Lubricate where necessary.	Annually
Compressor oil system	Perform analysis on oil and filter. Change if necessary. Check oil pump and seals Check oil heater and thermostat Check all strainers, valves, etc.	Annually
Electrical connections	Check all electrical connections and terminals for full contact and tightness.	Annually
Check refrigerant condition	Add refrigerant if low. Record amounts and address leakage problems.	Annually
Check for condenser and evaporator tube corrosion and clean as needed.	Indications include: poor water quality, excessive fouling, and age of chiller. Eddy current testing may be done to assess tube condition.	As needed

3.3.4.2 Replacing dry filter:

Before replacing dry filter core filter, directly close the angle valves at both ends to discharge the residual refrigerant in the dry filter. After the replacement, fix the end cover tight, extract vacuum, and then add 2~3kg refrigerant.

3.3.5 Trouble shooting:

There are multipal problems occurs when maintaining the chiller , those problems can be managed by known methods .

The used chiller already has a trouble shooting table (3.6) that covered all of the common problems and it's sufficant.

The table is provided in the appendix and shows all of the common solutions for the common problems .

3.3.6 Checked components:

Every component that been maintained is presented on a check list to keep track of the maintenance plan for the chiller.

All main components are maintained by a trained technician using a qualified tools for measuring and maintaining the component.

The table blew shows the components that been maintained and the maintenance frequency .

Table(3.7): maintenance check list

Check list:

N		Daily	Weekly	Monthly	3Month	Annual
1	Check water temperature inlet and outlet	✓				
2	Make sure that presence of non-natural sounds	✓				
3	Check the oil level	✓				
4	Check oil temperature	✓				
5	Check gas (freon) pressure	✓				
6	Check chiller load	✓				
7	Check volt & ampere	✓				
8	Check (Δ V) for condenser and evaporator		✓			
9	Check leakages		✓			
10	Clean facilities			✓		
11	Check electric boards			✓		
12	Make oiler and lubricant required				✓	
13	Clean feed and control boards				✓	
14	oil Change					✓
15	Change oil filters					✓
16	Condenser wash					✓
17	Check operation and protection devices					✓
18	freon filters Change					✓
19	Check electric coils & cables connection					✓
20	Check freon package					✓

3.3.7 data collected for operation after maintenance :

The data is collected every 2 hours for a period of 14 hours.

Name :……………/……………/…………… Date :……………

Chillers No					2	2	2	2	2	2	2	2
Time					8:00	10:00	12:00	14:00	16:00	18:00	20:00	22:00
Operating Hours												
KW Input					143	169	166-1	161	166	154	155	161
Compressor 1		Oil level	1\4	3\4	1/2	1/2	1/2	1/2	1/2	1/2	1/4	1/2
		Oil pressure P.S .I.D	17	62	35-6	34-8	37-5	35-3	37-6	36-7	35-2	36-7
		Oil Temperature °F	80	180	159-8	158	159-7	159-3	156-1	148-8	144-8	145-7
		Discharge Temperature °F			140-6	141-3	143	142-8	139-8	141-7	137-2	136-7
		Full load	25%	100%	58%	63%	61%	60%	63%	58%	59%	70%
Motor		Volts	360	440	393	397	401	400	399	398	400	400
		Amps	108.5	477	227	274	267	266	275	254	256	263
		Temperature °F			158	168	166	167	169	163	163	161
Cooler 1	Ref.	Evaporator pressure P.S .I.G	28	75	40-2	40-8	39-8	39-7	42-9	38-9	39-4	39-8
	liquid	Inlet Temperature °F	40	95	52-2	53-7	52-3	52-4	55-5	51-9	55-4	53
		Inlet pressure P.S.I	Δ P=10 ˜15P.S.I		3	3	3	3	3	3	3	3
		Outlet Temperature °F	40	95	49-2	50-4	49-4	49-4	52-3	48-9	50	50-9
		Outlet pressure P.S.I	Δ P=10 ˜15P.S.I		5	5	5	5	5	5	5	5
		Set point			42	42	42	42	42	42	42	42
		Saturation Temperature			45-2	45-7	44-7	44-7	47	44-9	44-4	44
Condenser	Refrigerant	Condenser pressure P.S .I.G	75	160	123	132	131-2	130-6	131-5	125-1	122-3	123-7
		Condenser Saturation			99	103	103-2	103	103-6	100-9	99-8	99-8
	liquid	Inlet Temperature °F	75	95								
		Inlet pressure P.S.I	Δ P=10 ˜15P.S.I									
		Outlet Temperature °F	85	105								
		Outlet pressure P.S.I	Δ P=10 ˜15P.S.I									
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Name :……………………/……………………/…………………… Date :……………………

			Min	Max								
Chillers No					2	2	2	2	2	2	2	2
Time					8:00 AM	10:00 AM	12:00 PM	14:00 PM	16:00 PM	18:00 PM	20:00 PM	22:00 PM
Operating Hours												
KW Input					154	126	140	147	145	143	141	131
Compressor 2		Oil level	1\4	3\4	1/2	1/2	1/2	1/2	1/2	1/2	1/2	1/2
		Oil pressure P.S .I.D	17	62	36	34.6	34	35	35.1	34.3	34.4	32.1
		Oil Temperature °F	80	180	145	144.2	143	145	145.1	144.2	144.2	142
		Discharge Temperature °F			138	142.5	140	137	137.9	136.9	136.9	132.1
		Full load	25%	100%	58%	48%	49%	57%	58%	54%	54%	50%
Motor		Volts	360	440	401	405	405	394	402	396	399	403
		Amps	108.5	477	242	217	230	233	243	235	240	245
		Temperature °F			156	153	153	153	154	153	156	188
Cooler 2	Ref.	Evaporator pressure P.S .I.G	28	75	38	32.8	35	36	39	38	39	38
	liquid	Inlet Temperature °F	40	95	52	44.3	44	56	51	51	52	52
		Inlet pressure P.S.I	Δ P=10	˜15P.S.I	3	3	3	3	3	3	3	3
		Outlet Temperature °F	40	95	48	42.8	45	47	47	46	47	47
		Outlet pressure P.S.I	Δ P=10	˜15P.S.I	5	5	5	5	5	5	5	5
		Set point			42	42	42	42	42	42	42	42
		Saturation Temperature			43	37.8	39	41	42	41	43	43
Condenser	Refrigerant	Condenser pressure P.S .I.G	75	160	120	113.5	115	115	120	114	119	118
		Condenser Saturation			98	94.6	90	81	98	82	97	99
	liquid	Inlet Temperature °F	75	95								
		Inlet pressure P.S.I	Δ P=10	˜15P.S.I								
		Outlet Temperature °F	85	105								
		Outlet pressure P.S.I	Δ P=10	˜15P.S.I								
REMARK												

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Chapter Four

4.1 Analysis:

This section provides the system's efficiency and operating log analysis, chiller's status and the cost analyze. Analysis done using charts and statistical methods.

4.2 Efficiency Analysis:

There are three analysis for the chiller efficiency

4.2.1 Chiller Items Situation:

This schedule defines chiller's items

Δ: can be improved ○: sufficient

Table (4.1): chiller items evaluation

Evaluated item		Air cooled Chiller system
Economical efficiency	Initial cost(equipment + installation)	○
	Running cost	Δ
	Facility space	○
Air conditioning grade	Zoning	○
	Temperature/humidity control	○
Safety maintenance	Ease of individual measurement	Δ
	Safety against hazard	○

The table shows the features of the system wither its sufficient or could be improved.

All of the important features are included into this table, we find that this chiller system is great in saving the running cost and could work with a good COP efficiency, but can't deal properly with partial loads.

4.2.2 Operating log:

This analyze is done by comparing the factor’s data during time elapses before and after the proper maintenance.

Before maintenance:

Table (4.2): Data before maintenance

compressor 1										AVERAGE
	oil level	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	oil pressure	36.2	33	36	39.3	35.4	35.4	37.1	36.5	36.1125
	oil temperature	174.1	173.1	152	149.7	153.3	140.6	146.7	147.7	154.65
	full load	75%	73%	76%	74%	75%	73%	70%	76%	0.74
cooler 1										AVERAGE
	evaborater pressure	36.6	38.1	39.2	39.8	37.2	30	34.6	38.3	36.725
	outlet temperature	43.7	45.1	46	47.1	44.5	55.7	42	45.8	46.2375
	outlet pressure	5	5	5	5	5	5	5	5	5
condenser										AVERAGE
	condenser pressure	116.9	119.2	123.9	126.1	128.3	92.4	123.3	125.2	119.4125
	condenser saturation	96.7	97.7	100.4	101	102.4	83.9	99.1	100.3	97.6875

compressor 2										AVERAGE
	oil level	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
	oil pressure	34.1	35.8	34.7	33.7	34.7	35	35.2	34.1	34.6625
	oil temperature	136.1	135.8	136.5	136.5	142.2	143.1	151	141.7	140.3625
	full load	68%	70%	71%	70%	73%	72%	62%	70%	0.695
cooler 2										AVERAGE
	evaborater pressure	32.6	33.7	35.4	36.7	34.6	40.8	33.5	34.9	35.275
	outlet temperature	41.8	43.1	45.1	45.5	43.2	49.1	41.8	44.4	44.25
	outlet pressure	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4	2.4
condenser										AVERAGE
	condenser pressure	105.9	110.7	112.6	114.2	114.1	114.2	107.1	111.4	111.275
	condenser saturation	90.9	93.5	94.2	95.1	95.3	95.3	91.8	93.8	93.7375

After maintenance :

Table (4.3) : Data after maintenance

compressor 1										Average
	oil level	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	oil pressure	35.6	34.8	37.5	35.3	37.6	36.7	35.2	36.7	36.175
	oil temperature	159.8	158	159.7	159.3	156.1	148.8	144.8	145.7	154.025
	full load	58%	63%	61%	60%	63%	58%	59%	70%	0.615
cooler 1										AVERAGE
	evaborater pressure	40.2	40.8	39.8	39.7	42.9	38.9	39.4	39.8	40.1875
	outlet temperature	49.2	50.4	49.4	49.4	52.3	48.9	50	50.9	50.0625
	outlet pressure	5	5	5	5	5	5	5	5	5
condenser										AVERAGE
	condenser pressure	123	132	131.3	130.6	131.5	125.1	122.3	123.7	127.4375
	condenser saturation	99	103	103.2	103	103.6	100.9	99.8	99.8	101.5375

compressor 2										AVERAGE
	oil level	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	oil pressure	36	34.6	34	35	35.1	34.3	34.4	32.1	34.4375
	oil temperature	145	144.2	143	145	145.1	144.2	144.2	142	144.0875
	full load	58%	48%	49%	57%	58%	54%	54%	50%	0.535
cooler 2										AVERAGE
	evaborater pressure	38	32.8	35	36	39	38	39	38	36.975
	outlet temperature	48	42.8	45	47	47	46	47	47	46.225
	outlet pressure	5	5	5	5	5	5	5	5	5
condenser										AVERAGE
	condenser pressure	120	113.5	115	115	120	114	119	118	116.8125
	condenser saturation	98	94.6	90	81	98	82	97	99	92.45

Comparing operating log before maintenance to the log after maintenance we find :

by comparing all of the factors data are reduced .

i- The average load of the

- compressor 1 is reduced

from 74% → to 61.5%

compressor2 is reduced

from 69.5→ to 53.5 %

4.2.3 Chiller Performance:

Chiller COP and EER for the chiller diagram to the load capacity that the chiller deliver

Chiller COP before maintenance:

COP= (Average Kw cooling / Average Kw electricity)

Average Kw electricity= (159.3875 +141.125)/2=150.256 Kw electricity

Average Kw cooling = [(1821*.615) + (1821*.535)]/2=1047.075 Kw cooling

COP = 1047.075/150.256 = 6.968

Chiller COP after maintenance:

COP= (Average Kw cooling / Average Kw electricity)

Average Kw electricity= (185.625+174.375)/2=180 Kw electricity

Average Kw cooling = [(1821*.74) + (1821*.695)]/2=1306.5675 Kw cooling

COP = 1306.5675/180 = 7.25

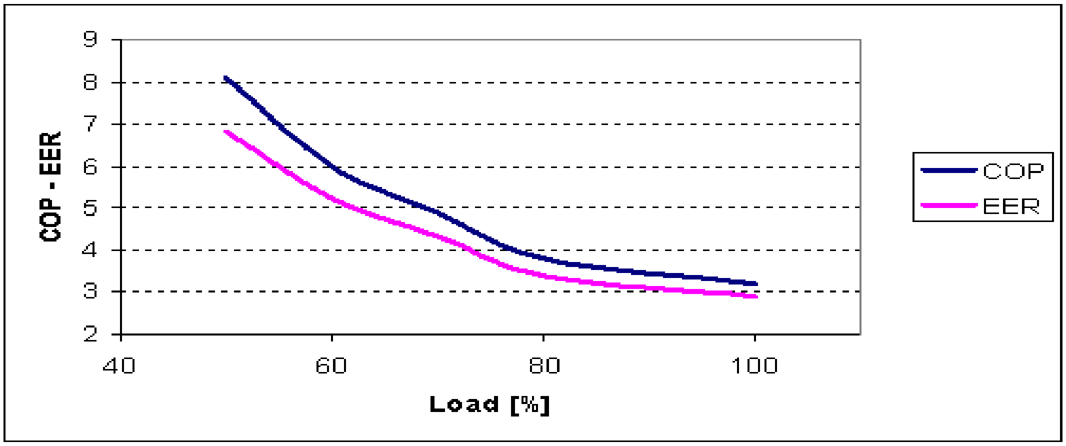

Figure (4.1): COP & EER of chiller

This chart shows the effect of the capacity on the chiller performance and efficiency, the more the load capacity increases the performance and the energy efficiency for the chiller decreases.

4.3 Cost Analysis:

The cost of the operating the chiller is an important factor

4.3.1 Chiller running cost:

compressor1 evaporator 1 :

Table (4.4): data before maintenance

	Before Maintenance								
Period	8:00 AM	10:00 AM	12:00 PM	2:00 PM	4:00 PM	6:00 PM	8:00 PM	10:00 PM	AVERAGE
KW Input	191	187	188	189	190	183	173	184	185.625

For 1 Kw of electricity = 0.56 SDG

The average running cost every (2) hours = (Average KW * KW cost)

The average running cost every (2) hours = 185.625*0.56 = 103.95

Then the average running cost every (2) hours= 103.95 SDG

After maintenance:

Table (4.5): data after maintenance

	After Maintenance								
period	8:00 AM	10:00 AM	12:00 PM	2:00 PM	4:00 PM	6:00 PM	8:00 PM	10:00 PM	AVERAGE
KW Input	143	169	166.1	161	166	154	155	161	159.3875

For 1 Kw of electricity = 0.56 SDG

The average running cost every (2) hours = (Average KW * KW cost)

The average running cost every (2) hours = 159.3875*0.56 = 89.257

Then the average running cost every (2) hours= 89.257 SDG

compressor 2 evaporator 2 :

Table:(4.6) data Before Maintenance

		Before Maintenance							
Period	8:00 AM	10:00 AM	12:00 PM	2:00 PM	4:00 PM	6:00 PM	8:00 PM	10:00 PM	AVERAGE
KW Input	170	178	177	174	178	181	162	175	174.375

For 1 Kw of electricity = 0.56 SDG

The average running cost every (2) hours = (Average KW * KW cost)

The average running cost every (2) hours = 174.375*0.56 = 97.65

Then the average running cost every (2) hours= 97.65 SDG

After maintenance:

Table(4.7) : data after maintenance

		After Maintenance							
period	8:00 AM	10:00 AM	12:00 PM	2:00 PM	4:00 PM	6:00 PM	8:00 PM	10:00 PM	AVERAGE
KW Input	154	126	140	147	145	145	141	131	141.125

For 1 Kw of electricity = 0.56 SDG

The average running cost every (2) hours = (Average KW* KW cost)

The average running cost every (2) hours = 141.125*0.56 = 79.03

Then the average running cost every (2) hours= 79.03 SDG

4.2.1The total cost for the operating hours:

Before maintenance:

Compressor1 evaporator 1running cost = cost of (2) hours * hours

Compressor1 evaporator 1running cost = 103.95 * 8 =831.6 SDG

Compressor2 evaporator2 running cost= cost of (2) hours * hours

Compressor2 evaporator2 running cost = 97.65 * 8 = 781.2 SDG

The total cost of chiller before maintenance = 781.2+831.6 = 1612.8 SDG

After maintenance:

-Compressor1 evaporator 1running cost = cost of (2) hours * hours

Compressor1 evaporator 1running cost = 89.257*8 = 714.056 SDG

-Compressor2 evaporator 2running cost = cost of (2) hours * hours

Compressor2 evaporator 2running cost = 79.03*8 = 632.24 SDG

-The total cost of chiller after maintenance = 714.056+632.24=1346.296 SDG

-The reduced cost = 1612.8-1346.296 = 266.504 SDG for every operating day

Chapter five

5.1 Conclusion:

Research provides the result of implementing and committing to preventive maintenance schedule results in increasing the chances of the system reaching the manufacturer efficiency and reducing the running cost for the system. Filling the daily operating log provides a forecast for the coming problems by comparing the data during time elapses, this resulted for better monitoring and control for the system. Duct system leakage increases the running cost by increase the capacity of the fan by 10%. This effect the system running cost.

Objectives of the research that has been accomplished are:

1-Reduction of the running cost of the system by Operate two chillers for peak efficiency and fixing the duct system leakage.

2- Chiller efficiency is leveled up by implementing the proper preventive maintenance schedule for all of the air conditioning system components and maintaining a daily operating log of the chillers also maintaining refrigerant level in chillers maintains the performance and efficiency.

3- The proper preventive maintenance schedule is developed and the cautions of urgent problems are presented also troubleshooting problems techniques are presented.

5.3 Recommendations:

There are multi recommendations must be taken under consideration in order to seek the highest operation efficiency and the best maintaining methods and techniques, those recommendations are categorized into:

I-Best Practices for Efficient Operation:

Operate multiple chillers for peak efficiency can save energy by matching the building loads to the most efficient combination of one or more chillers.

Raise chilled-water temperature of the chilled water supplied to the building's air handlers will improve its efficiency.

Purge air from refrigerant loop decreases pressure at the compressor discharge, Maintain refrigerant level both low-level and high-level refrigerant reduces a chiller's capacity and efficiency.

II- Best Practices for Maintenance:

Reduce Scale or Fouling of the heat exchanger tubes.

Inspecting and cleaning tubes in the evaporator and condenser.

Inspect for Refrigerant Leaks, Gas analyzers can also be used to identify refrigerant leaks.

Inspect for duct system leakage, manometers can be used.

We recommend that the other air conditioning system components to be studied air Handling Unit, Fan Coil and dual duct.

References:

(1)-Handbook of air conditioning and refrigeration/Shan K.Wang-2nd ed.2000.

(2)-© 2007-2014privicy University of Central Florida. The Florida Solar Energy Center

(3)-1992 ASHRAE HANDBOOK -- HVAC SYSTEMS AND EQUIPMENT, AMERICAN SOCIETY OF
HEATING, REFRIGERATING AND AIR-CONDITIONING ENGINEERS, INC., ATLANTA, GA, 1992.

(4)-HVAC SYSTEMS EVALUATION, R.S. MEANS COMPANY, INC., KINGSTON, MA, 1990

(5) HVAC SYSTEMS DESIGN HANDBOOK, 2ND EDITION, MCGRAWHILL,
INC., NEW YORK, NY, 1994

(6) FEMP.2002. Continuous Commissioning Guide For Federal Energy Managers.

(7)FEMP 2004. O&M Best Practices Guide 2.0.

(8)© 2017 Elite Software Development ,Inc

(9) AFHX , Air Cooled Floolded Chiller, Dunham-Bush .Inc

(10) © 2005 CARRIER CORPORATION

Appendix:

Tables:

Table (3.4) Chiller maintenance table

Maintenance items		Maintenance frequency	Qualify standards (Settlement)	Note
I. General	Noise	Anytime	Judge whether there is abnormal sound by hearing	Watch from one meter away from the center of the Chiller;
	Vibration	Anytime		
	Voltage	Anytime	Rated voltage is within ±10%	
II. Appearance	Clean	Anytime	Keep it clean anytime	
	Rust		using an iron brush to remove rust, besmear again the antirust paint	
	Calm	Anytime	Lock each snail	
	Insulation material flakes		Using adhesives sticky	
	Water leak	Once/Month	Check whether the exhaust water pipe is bloked	
III. Compressor	Noise	Anytime	Whether there is abnormal sound when starts up, runs or stops	
	Insulation Resistance	Once/ Year	Above 5MΩ is required when testing with DV500V high resistance meter	
	Shockproof rubber gets old			
	Medium check			
	Medium check			
IV. Fin heat exchanger	Fan		Normal wind amount, high pressure within the	

			normal range	
	Clean situation			
V. Shell-and-tube heat exchanger	Water flow of the user side	Anytime	Within ±5% of the standard	
	Temperature	Anytime	Within the standard	
	Antifreeze concentration	Once/Month	Make sure it is set above the set concentration	
	Water quality	Once/Month	Within the standard	Refer to water quality furring relations drawing
	Purity	Anytime	The low pressure is within the standard when refrigerating	
	Drainage	Anytime	Drain all the water if it is not used for a long time	Drain water in the distribution pipe
VI. High and low pressure switch	Action	Once/Month	Check according to Protection Devices Action Value	Whether the match point is good
VII. Pressure Gauge	Finger	Once/ Half of a year	Compare with correct pressure gauge	
VIII. Globe valve	Action	Once/Month	Smooth action on globe valve switch	
IX. Refrigeration circle	Refrigeration media leak	Once/Month	Check whether there is refrigeration media leakage inside the Chiller or at the distribution pipe connecting points. Let out all the water inside the shell-and-tube heat exchanger, and check whether there is any leakage at the water inlet or outlet.	Use the electronic leak detector, or blowtorch leak detector, or soap water
	Insulation resistance	Once/Month	Above 5MΩ is required when testing with DV500V high resistance	

X. Electrical machine control			meter.	
	Wire contact	Once/Month	Insulation layer of the wire must be under good contact condition, without damage, bolt uwell fixed.	
	Assistant relay	Once/Month	No abnormal action.	
	Time-limited relay	Once/Month	Act according to the time set.	
XI. Valves	Internal/External Leakage	Once/year	Check the valve components or replace it	
	Galling and sticking	Once/year	Clean the inside of the valve	

Table (3.6)Trouble shooting

Symptom	Possible cause	Remedy
• Unit will not start.	a) power off b) No control power. C) compressor circuit breakers open. d) phase control relay open. e) flow switch open. f) compressor switch open. g) controller shutdown not reset.	a) Check main disconnect switch and main line fuses. b) Check control transformer fusing. c) Close circuit breakers. If trip, check compressor. d) Check for power supply problem (low voltage phase imbalance)when corrected, press reset button. e) Start pumps, check flow switch. f) Turn switch on. Check alarm status. Correct problem g) reset button.
• compressor hums but does not start.	a) low voltage. b) no power on one phase of 3 phase unit. c) Faulty starter or contactor.	a) Check at main entrance and at unit. Consult power company if voltage is low and increase wire size to the unit if voltage is normal at main and low at unit. Voltage must be within

		10% of motor nameplate rating. b) Check fuses and wiring. c) Check the contacts and time delay on part wind start.
• Compressor will not start when reset button is pushed.	a) cooling not required. b) Computer's time delay active. c) Phase control relay open. d) Flow switch open. e) Compressor switch open. f) Burned out single light. g) Wiring problem.	a) Apply load. b) Wait 15 minutes max. c) Check single light bulbs. d) Check wiring against drawing
• Compressor overload	a) Compressor drawing high amps.	a) Check motor mega ohms. Reset overloads; Run compressor an check amps. Do not exceed RL X 1.25 call D/B serviceman.
• High motor temperature	a) motor windings falling.	a) Check mega ohms . Reset by turning compressor switch off and then on.
• Low suction	a) Inadequate feed to evaporator. b) Inadequate refrigerant charge. c) Fouling of waterside of evaporator. d) Inadequate chilled water flow. e) Too much oil in system.	a) Check to see that main expansion valve superheat. b) At high load check evaporator approach , if approach is more than (1.1^{o}c) clean valve. c) If all oil level sight glasses are full at all times; remove oil until oil level shows at top of glass on a compressor.
• High discharge pressure.	a) Inadequate air flow across condenser.	a) Check condenser fan operation and condenser coil for clogging.
• Oil low in sump.	a) Low oil level in compressor.	a) Low oil level in compressor sight glass is acceptable.
• Low oil shutdown.	a) Low oil in compressor.	a) A low oil shutdown switch will turn off the compressor before any damge.
• Freeze warming.	a) Operating setpoint too law. b) Load changing too rapidly.	a) Check leaving water setpoint on controller. b) Load on package must dro b at reasonable rate for automatic control to work properly.
• Improper capacity control.	a) ramp rate incorrect.	

Electricity company:

For 1 Kw of electricity = 0.56 SDG