4.0 Air-Conditioning System

4.1 Introduction of Air-Conditioning System

There are 4 types of air-conditioning system:

1. Room air-conditioner
2. Split unit air-conditioner system
3. Packaged unit air-conditioning system
4. Centralized Air-Conditioning system

4.1.1 Room Air-Conditioner

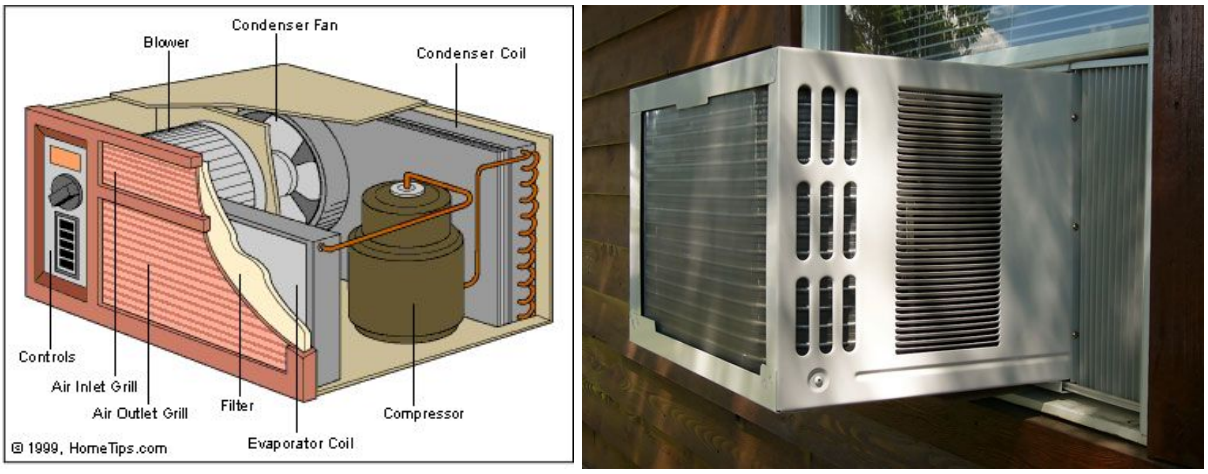

Diagram 4.1 & 4.2 *Room Air-Conditioner.*

Room air-conditioner also known as window air-conditioner. It is the simplest type of an aerating and cooling framework and is mounted on windows or dividers. It is a solitary unit that is amassed in a packaging where every one of the segments are found. This refrigeration unit has a double shaft fan engine with fans mounted on both sides of the engine. One at the evaporator side and the other at the condenser side. The evaporator side is found confronting the space for cooling of the space and the condenser side open air for warmth dismissal. There is a protected segment isolating this two sides inside a similar packaging.

4.1.2 Split unit air-conditioner system

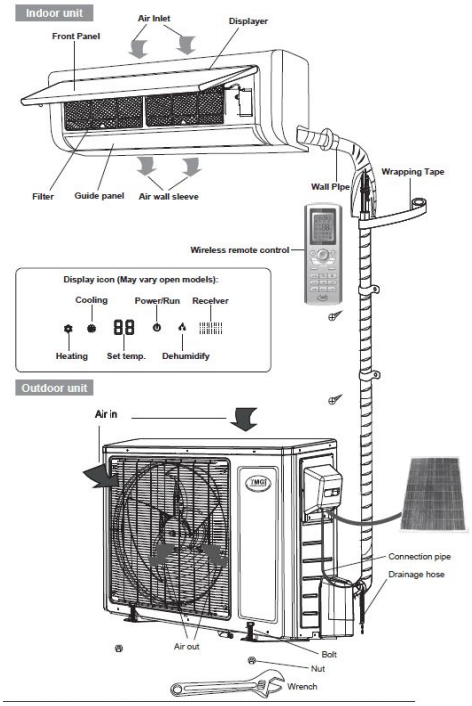

Diagram 4.3 & 4.4 *Split Unit Air-Conditioner System.*

A split unit air-conditioner system comprises of two principle parts: the open air unit and the indoor unit. The open air unit is introduced on or close to the divider outside of the room or space that you wish to cool. The unit houses the compressor, condenser coil and the expansion coil or capillary tubing. The smooth looking indoor unit contains the cooling loop, a long blower and an air filter.

4.1.3 Packaged unit air-conditioning system

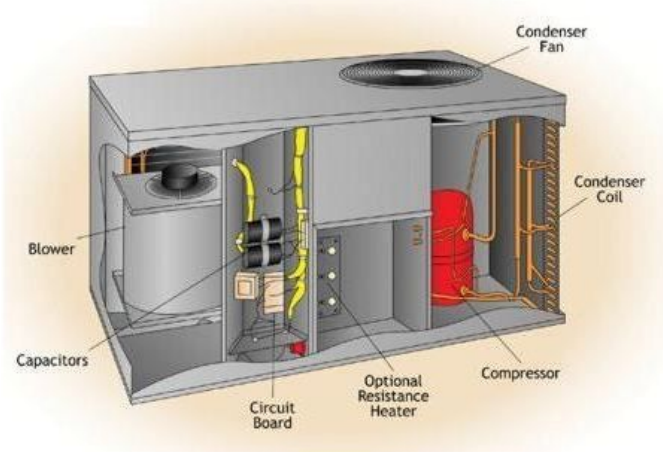

Diagram 4.5 & 4.6 *Packaged Unit Air-Conditioning System.*

A packaged unit is the across the board warming and cooling framework for homes that don't have a great deal of room inside for either a heater and loop, or an air handler. Bundle units will contain the majority of their parts in one open air unit that sits on either the rooftop or to the side of a building. Furthermore, they come in two unique impressions: little or vast. Littler impression bundle units have a tendency to be simpler to introduce while bigger impression bundle units have more noteworthy establishment adaptability. Vast impression units can be introduced on either a housetop or a section while little bundled frameworks must be introduced on a chunk. In Summit USJ, this system is used to provide air-conditioning for extended hours, such as the cinema, bowling centre and entertainment centre.

4.1.4 Centralized air-conditioning system in Summit USJ

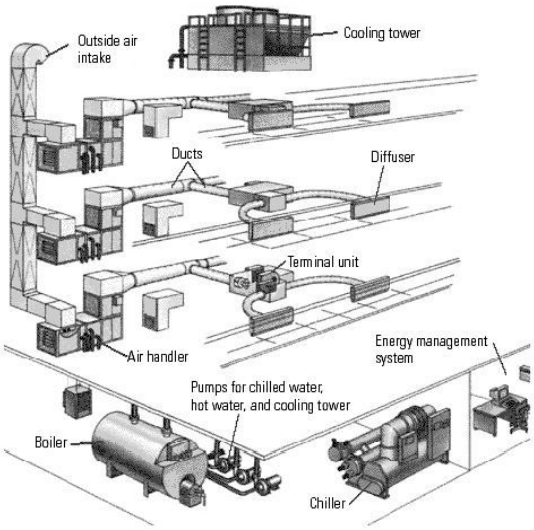

Diagram 4.7 & 4.8 *Centralized Air Conditioning System.*

Centralized Air-Conditioning system is intended for the substantial scale building, for example, doctor's facility, air terminal, shopping center, and so on. Brought together aerating and cooling framework is great at exchanging adapted air from a base area to each zone through the air ducts keeping in mind the end goal to cool each parts of the building. There are 2 sorts of incorporated aerating and cooling framework, Chilled Water Central Air Conditioning Plant and Direct Expansion (DX) Central Air Conditioning Plant. To put it plainly, chilled water focal aerating and cooling plant cools the water first by utilizing refrigerant and transforms the ordinary air into molded air while the refrigerant in DX focal ventilating plant cools the air straightforwardly without utilizing chilled water.

4.2 Benefits of centralized air-conditioning system

1. Indoor comfort during warm weather – Central air conditioning helps keep your home cool and lessens dampness levels.

2. Cleaner air – As the central air conditioning system draws air out of various rooms in the house through return air ducts, the air is pulled through an air filter, which removes airborne particles such as dust and lint. Complex filters may expel infinitesimal toxins too. The sifted air is then directed to air supply ventilation work that conveys it back to rooms.

3. Calmer operation – Because the compressor-bearing unit is situated outside the home, the indoor clamor level from its operation is much lower than that of a detached aerating and cooling unit.

4.3 How chilled water central air-conditioning plant works?

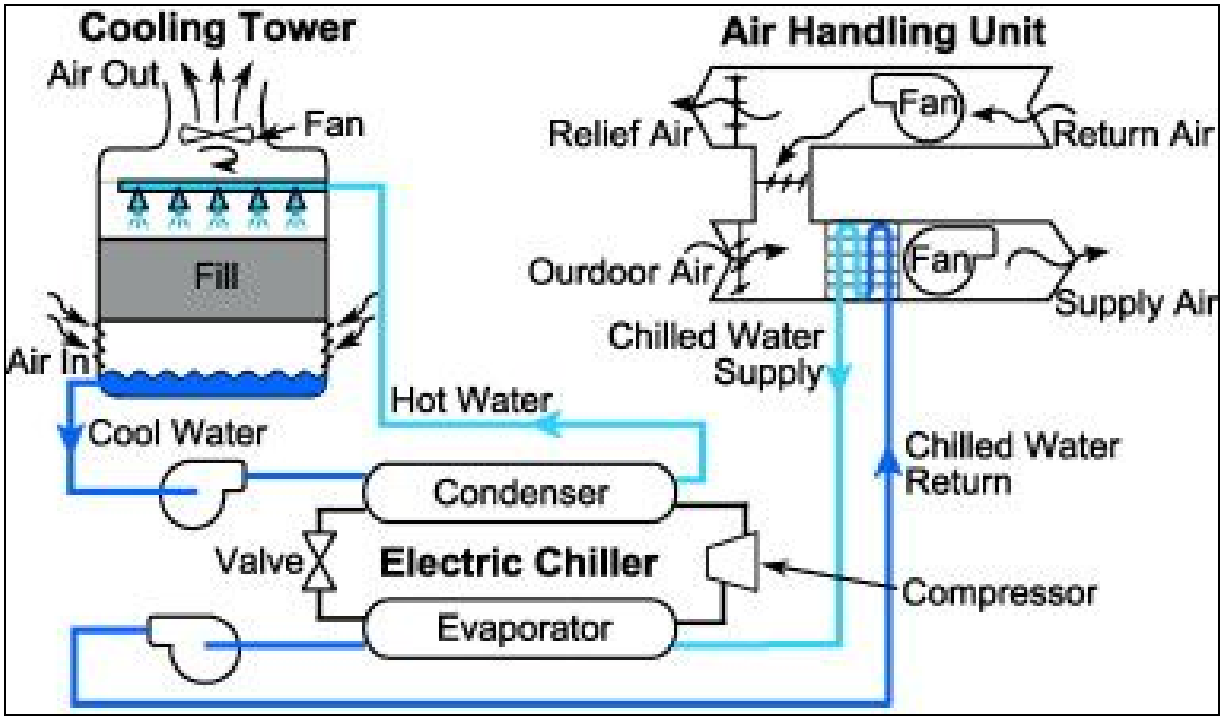

Diagram 4.9 *How Centralized Air Conditioning System works.*

This sort of framework is normally utilized as a part of substantial building particularly the one that contains a few stories to be cooled. In chilled water plant, refrigerant chills answers for a low temperature of around 6 to 8 degree celsius and the chilled water is then pumped to various floors of the building and its individual parts. The Air Handling Unit (AHU) is introduced specifically parts which incorporates ducts, cooling coils and blowers. From that point forward, the chilled water will go through the cooling coil and the arrival air from the chilled air room will be ingested by the blower and cooled by the pipe. Along these lines, the cooled air is separated and aerated and cooled and prepared to cool the specific territory.

4.4 Components of system

4.4.1 Centrifugal chiller

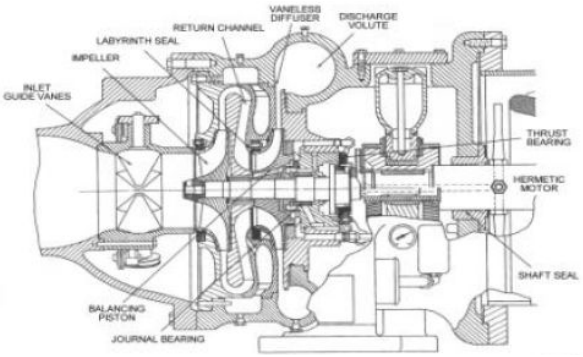

Diagram 4.10 *Overall view in chiller room (left).*

Diagram 4.11 *Components in centrifugal chiller (right).*

The main function of chiller, also known as chilled water plant, is to lower the temperature of the air by using chilled water. Summit Mall chose to use centrifugal chiller as it is the most economical way to cool down spaces in large buildings. In Summit, there are three chillers in total while two chillers are operating at the same time while the other one acts as a standby chiller in case there is any breakdown. However, the three chillers operate based on alternate schedule where they are used alternatively. For example, Chiller 1 and Chiller 2 will be functioning in January while Chiller 1 and Chiller 3 will be functioning in February. Moreover, centrifugal chilled water plant consists of evaporator, compressor, condenser, and thermostatic expansion valve.

Diagram 4.12 & Diagram 4.13 *Condenser motor pump (Green), Chilled water motor pump (Blue).*

There are two motor pumps in chiller; condenser motor pump and chilled water motor pump. The condenser motor pump will exchange consolidated water to the cooling tower. Chilled water will be created by the chilling tower by chilling dense water. The chilled water is then exchanged back to chiller by chilled water motor pump before it is pumped to AHU.

A coveted water temperature of 40°F in the chiller will be aligned by experienced expert. On the off chance that the genuine temperature of water in the chiller does not meet the preset point, it will balanced either to increment or lower the temperature of water to guarantee both setpoint and real temperature is the same. The ideal temperature for Summit Mall is set as 24°C.

Diagram 4.14 *Actual temperature of the water (left).*

Diagram 4.15 *Calibrated temperature of water (right).*

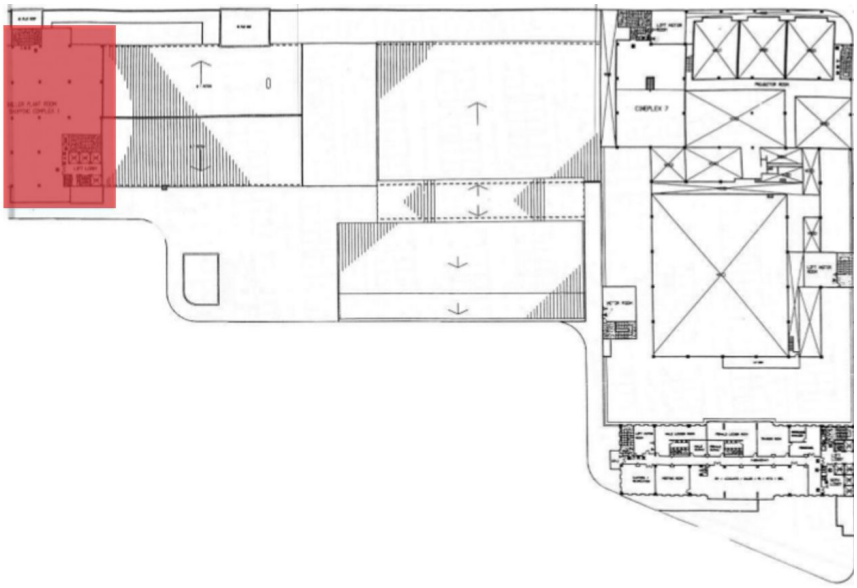

Diagram 4.16 *Indication of where the centrifugal system is located at sixth floor.*

4.4.1.1 Evaporator

Evaporator, known as heat exchanger, serves to extract heat from the chilled water and reduce the water temperature in this cycle. The heat from the warm chilled water is used to boil the refrigerant inside the chiller. After the refrigerant evaporates and turns into vapour, it passes through the compressor before entering the condenser, while chilled water is sent back to AHU to be used again in the air cycle.

4.4.1.2 Compressor

The function of the compressor is to transfer the refrigerant vapour to the condenser. First, the refrigerant vapour with low temperature and pressure will be removed from the evaporator and being compressed to become gas with high temperature and pressure in order to proceed to the condensation process.

4.4.1.3 Condenser

Condenser also act as the same as evaporator, which serves as a heat exchanger in chilled water plant to increase the water temperature thus producing condensed water. Condenser is connected to the cooling tower via condensed water pipe. Condenser turns the refrigerant back to liquid by removing the heat from the refrigerant. Hence, the water becomes condensed water after it absorbs the heat.

4.4.1.4 Thermostatic Expansion Valve

The function of thermostatic expansion valve is to reduce the pressure of the refrigerant liquid before it is transported to the evaporator.

4.4.1.5 Refrigeration Cycle

Centrifugal chillers in Summit Mall utilises vapor compression cycle to lower the temperature of water in which the refrigerant undergoes phases change. Circulation of refrigerant in the cycle helps to absorb and reject heat in the air to the surrounding area. The refrigerant enters the compressor which makes the temperature and pressure of the refrigerant high. High pressure of refrigerant leaves the compressor and enters condenser in chiller unit. Then, condensed water produced from the condenser is transported to cooling tower by using motor pump for further cooling. Pressure of refrigerant remains same level but exits the condenser in a lower temperature since the heat is used to heat up the water. At this stage, expansion valve is used to lower the pressure of refrigerant thus making it undergoes phases changes. Liquid refrigerant evaporates and losses pressure but it can regain the pressure in compressor. Then, gas refrigerant absorbs heat from the water thus creating chilled water in evaporator in chiller unit. Then, the repetition of refrigeration cycle occurs in the chiller unit.

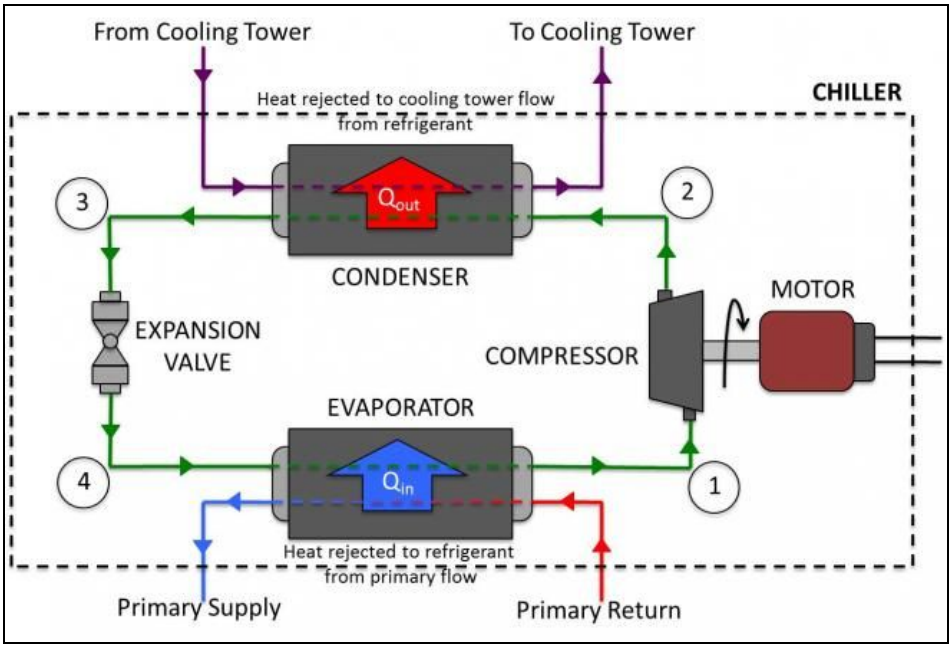

Diagram 4.17 *Basic refrigeration cycle.*

4.4.1.6 Type of Refrigerant Used

The type of refrigerant used in Summit is R-134a which also known as Tetrafluoroethane as a replacement for R-12. It is being widely used in HVAC system nowadays due to its ability to reduce effects of ozone depletion compared to CFC refrigerants. R-134A is a high pressure refrigerant that requires a higher compressor input. Precaution steps need to be taken if R-134A is used as refrigerant in HVAC system due to its high potential in leaking. It is because the it will be more likely to leak out from chiller compared to other type of refrigerants.

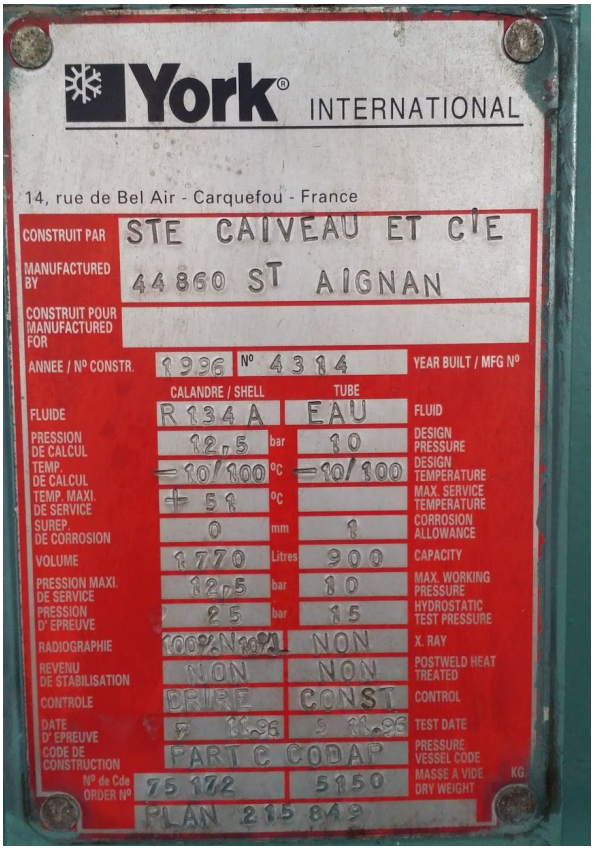

Diagram 4.18 & Diagram 4.19 *Refrigerant R-134A.*

4.4.2 Cooling Tower

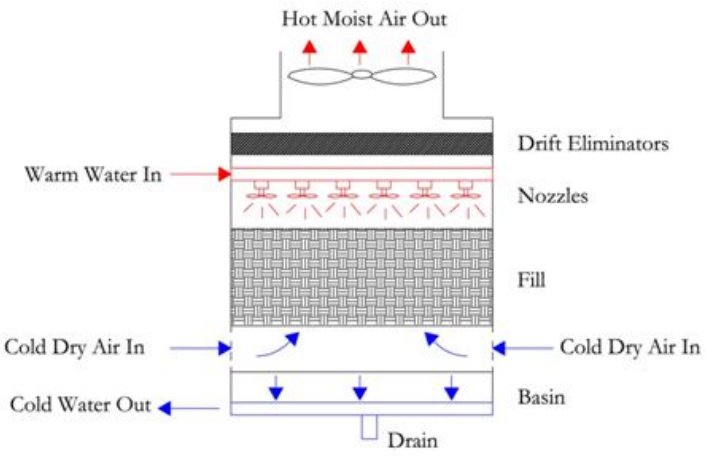

Diagram 4.20 & Diagram 4.21 *Cooling tower located at the roof of Summit Mall.*

Cooling Tower is associated with the condenser in the chiller. The primary capacity of the cooling tower is to evacuate the warmth in the dense water and concentrate the warmth to the climate. The cool chilled water is then disseminated back to the chill water plant to rehash refrigeration cycle. In this way, the vast majority of the cooling tower is put in open air in request to permit the procedure of warmth exchanging runs viably amongst water and environment. In Summit Mall, just a single cooling tower is required for every chiller. Notwithstanding, there are extra cooling towers to be set up in the event that there is any crisis breakdown. Summit Mall picked counterflow water cooling tower in this framework to limit the daylight introduction to the water to avoid overheating and green growth creation. Counterflow water cooling tower is a framework which the dense water will be pumped by consolidated water engine and progresses toward becoming water beads. The fan in the cooling tower will scatter the warmth from the dense water by sucking up the outside air from the air. Along these lines, the cool water streams descending go through the infill and prepared to be pumped back to the chiller.

Malaysian Standard 1525	Analysis
Cooling Tower **Code 8.8 Balancing:** The system design should provide means for balancing the air and water system such as but not limited to dampers, temperature and pressure test connections and balancing valves.	Summit undergoes process which includes balancing air and water distribution systems to ensure proportion flows of air and water in the system according to design specifications.

4.4.3 Fan Coil Unit (FCU)

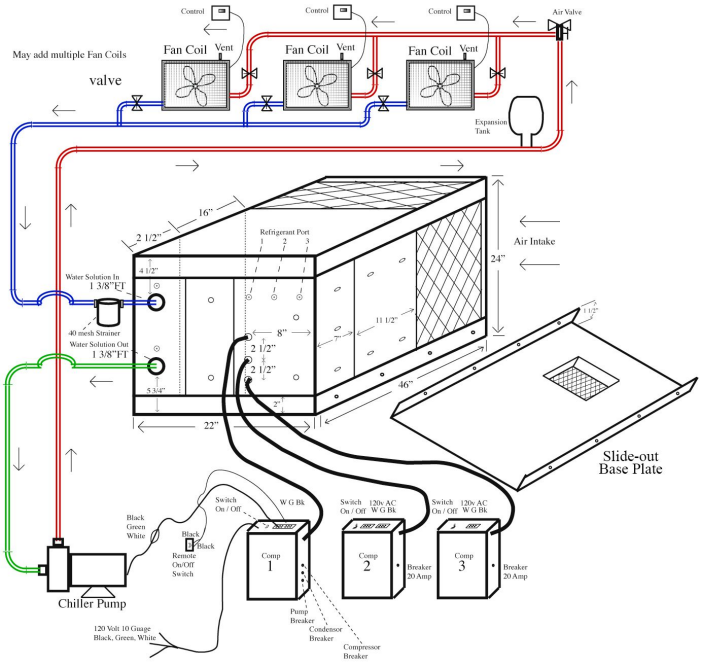

Diagram 4.22 & Diagram 4.23 *FCU at Summit.*

Fundamentally, Fan Coil Unit (FCU) serves an indistinguishable capacity from AHU yet it works in a littler scale. In Summit Mall, FCU used to chill off certain territory of the shopping center, for instance the PC server room. In addition, FCU can control the temperature of the territory. This framework is typically utilized for little zone. The contrasts amongst FCU and AHU is that FCU does not require ventilation work as it is only a basic box formed gadget comprises of diffuser, return pipe, fan and cooling loop. Along these lines, some FCU are introduced at the roof of the shopping center to chill off that specific territory.

4.4.4 Air Handling Unit (AHU)

In Summit Mall, the AHU is utilized to chill off vast range of the shopping center. There are 6 AHU rooms at each floor and one AHU can give cool natural air to 10 shoplots which is around a space of 20m x 20m. To give adequate air to this territory, AHU size is around 1.5m x 3m x 1.5m which alludes to its stature, length and width separately. Summit Mall utilizes mineral fleece sort channel in the AHU in light of the fact that mineral fleece is a decent solid protection and warm protection material. Additionally, the sound protection framework is likewise introduced in dividers and entryways of AHU space to additionally decrease the commotions created. Essentially, AHU comprises of damper, channel, cooling curl, blending chamber, fan and it is associated with the diffuser framework by means of the ducting, which are supply conduit and return pipe. The fan utilized as a part of the AHU in Summit Mall is Centrifugal fan so as to flow the air in the AHU.

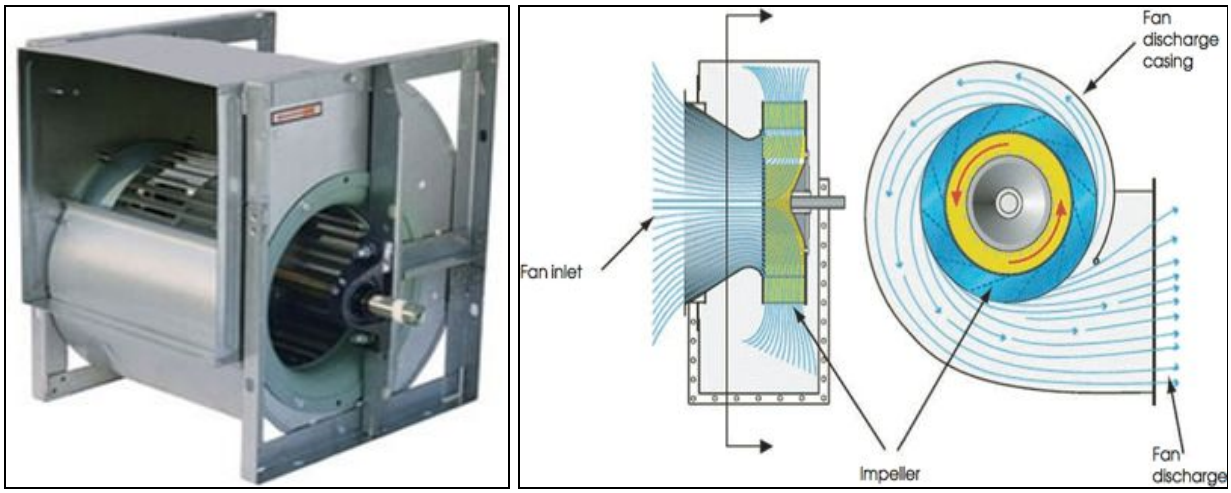

Diagram 4.24 & Diagram 4.25 *Centrifugal Fan in AHU.*

AHU is not just utilized for giving cool air to the inside range of building yet it additionally serves in air dissemination inside the shopping center. The cool chilled water in the chiller will chills off the air hence the cool air will be given to all aspects of shopping center. The more prudential approach to use for cooling the shopping center is by utilizing the air from outside rather than the recycled return air when the open air is cooler than the arrival air. At the point when the open air is hotter than the arrival air, little measure of the outside air will blended by the blending chamber with the arrival air then disseminated to the shopping center through

diffusers. Be that as it may, the air with high debasement will be expelled from the AHU by blower. The warm chilled water will be exchanged back to chilled water plant and the refrigerant in chilled water plant will cools the warm chilled water in refrigeration cycle. After the chilled water being cooled, it exchanged back to AHU and the aerating and cooling cycle is rehashed.

Diagram 4.26 & Diagram 4.27 *Wool Filters of AHU.*

Malaysian Standard 1525	Analysis
<u>Air Handling Unit (AHU)</u> **Code 8.7 Air handling duct system insulation:** All ducts, plenums and enclosures installed in or on buildings shall be adequately insulated to prevent excessive energy losses. Additional insulation with vapour barriers may be required to prevent condensation under some conditions.	Summit protected its ducting system with a layer of insulation material to prevent heat losses and condensation occurs.

4.4.5 Diffuser and Return Air

Diagram 4.28 & Diagram 4.29 *Diffusers at Summit Mall.*

For the most part, there are two sorts of diffusers which are supply air diffuser and return air grilles. Summit Mall has installed circular supply diffusers and return air grilles at the ceiling of the mall. Supply air diffuser goes about as a distributor to supply the cool air to the mall from AHU while return air grilles help to return the warm air back to AHU to repeat the air circulation. The quantity of supply diffuser is more than return air grille, yet return air grille is bigger than supply air diffuser. Be that as it may, there are sure spaces in Summit Mall which have high ceiling, in this Summit Mall utilized non hosted supply air diffuser to chill off the specific areas. It is because ceiling supply air diffuser could not be installed. Maintenance staff will check the diffusers once every month to see whether if there is any dirt accumulated. Removal of the dirt has to be carried out to ensure the high caliber of air distributed to the mall.

4.4.6 Ducting and Piping System


Diagram 4.30 *Ducting system exposed at basement carpark (left).*

Diagram 4.31 *Condenser motor pump (Green) and Chilled Water Motor Pump (Blue) in Chilled Water Plant (right).*

The fundamental capacity of the ducting framework is to connect the AHU, diffuser and return air duct together to help in air dissemination. The duct does not just aides in circulating the fresh air to the building additionally return the air back to AHU. Majority of the ducting systems are concealed by the roof in the mall, yet some ducting systems are uncovered for instance ducting system in basement carpark.

For the piping system, there are 2 type of pipes which are Condenser motor pump and Chilled Water motor pump utilized for the air-conditioning system in Summit Mall. The pipes are set apart by utilizing diverse shading to differentiate them effectively.

Condenser motor pump (Green Color) return the warm condense water from the condenser to cooling and distribute the cool water from the cooling tower to the condenser. On the other hand, the chilled water motor pump (Blue Color) return the warm water from AHU to the evaporator and supply the cool chilled water from evaporator to the AHU. Insulation is applied to the pipes in order to prevent condensation on the pipe and to prevent heat absorption by the cold water in the pipe.

Malaysian Standard 1525	Analysis
Piping System **Code 8.6 piping insulation:** All piping installed to serve buildings and within building should be adequately insulated to prevent excessive energy losses. Additional insulation with vapour barriers may be required to prevent condensation under some conditions.	Summit protected its piping system with a layer of insulation material.

Uniform Building By-Laws 1984	Analysis
Ducting System **Section 123 :** 1. Where ducts or enclosures are provided in any building to accommodate pipes, cables or conduits the dimensions of such ducts or enclosures shall be — **(a)** adequate for the accommodation of the pipes, cables or conduits and for crossings of branches and mains together with supports and fixing; and **(b)** Sufficiently large to permit access to cleaning eyes, stop cocks and other controls there to enable repairs, extensions and modifications to be made to each or all of the services accommodated.	Size of ducts in Summit Mall is huge enough for maintenance as well as sufficient space to place cables, pipes and conduits.

2. The access openings to ducts or enclosures shall be long enough and suitably placed to enable lengths of pipe to be installed and removed.	

4.4.7 Variable Air Volume (VAV)

Diagram 4.32 *Variable air volume box at Summit.*

Variable Air Volume (VAV) framework is normally utilized as a part of shopping buildings. In Summit Mall, it utilizes variable air volume framework to control variable temperature at various regions of the retail platform. For instance, the temperature of the workplace in Summit Mall is distinctive with the shoplots. Variable Air Volume is a container that aides in controlling the temperature of air provided to numerous zones. The fundamental reason of Summit Mall for utilizing this framework is to decrease the vitality utilized as it can back off the speed of the fan and can control the air supply. Essentially, the air will be circulated in a steady temperature to a VAV end unit from focal plant then given to each zones in required cooling level. The indoor regulator goes about as a controller associated with VAV framework which makes it more accommodation for the officer to change the temperature of that specific zone. Capacity of VAV to supply air in various zones that required diverse temperature all the while makes it certainly a helpful application in Summit Mall.

4.4.8 Exhaust Ventilation

Diagram 4.33 *Basic components of exhaust ventilation (left),*

Diagram 4.34 *Kitchen Exhaust in Summit (middle),*

Diagram 4.35 *(Kitchen exhaust system on the left, Fresh air fan on the right).*

An appropriate venting and expulsion of smokes, warmth or gasses that delivered in kitchen, server room and cellar auto stop in Summit. All sustenance and drink eateries inside the shopping center are required which will deliver an expansive volume of smoke to introduce their own particular fumes hood which will be then associated with a brought together fumes fan. The specialists and clients are presented to hurtful smokes as the smokes couldn't be uncovered out if there is no such necessity from Summit. Nearby fumes ventilation comprises of five segments which are hood, conduit, outward fan, engine and fumes as appeared in outline.

Every part plays an imperative and significant part so as to keep the air clean inside these ranges. The hood is dependable to catch vapor and warmth however much as could reasonably be expected from burning exercises, hardware and so forth. It is intended to particular size relies on upon the volume of exhaust that should be encased. Furthermore, pipe is utilized to transport contaminants far from those territories while diffusive fan is utilized to smoothen the development of air all through the framework. At that point, engine works the fan to encourage the wind current. The last part, debilitate expels dirtied air all through the framework.

4.5 MS 1525 Requirements & Regulations of Air-Conditioning

Malaysian Standard 1525	Analysis
Indoor Design Condition **Code 13a:** At normal comfort room temperature (23 to 26°C), the acceptable air velocity would be in the region of 0.15 to 0.5 m/s. The indoor design conditions of an airconditioned space for comfort cooling is recommended to have dry bulb of 23 to 26°c. The recommended design relative humidity is 55-70%. The recommended air movement is 0.15 to 0.5 m/s. According to Department of Malaysian Standards, the maximum air movement is 0.7m/s.	Optimum temperature set by Summit Mall is 24°C and the air velocity is around 0.25m/s.
Code 8.4.4 Off-hour control: **Code 8.4.4.1:** AVMC system should be equipped with automatic controls capable of accomplishing a reduction of energy use for example through equipment shutdown during periods of non-use or alternative use of the spaces served by the system.	In Summit, AVMC system will be switched off automatically after office hours.

Code 8.3 Separate Air Distribution System **Code 8.3.1 :** Zone which are expected to operate non-simultaneously for more than 750 hours per year shall be served by independent air-conditioning system.	A large number of diffusers are used to supply air separately to different zones as Summit operates more than 750 hours per year.
Code 8.4.1 Temperature Control : Each system should be provided with at least one thermostat for the regulation of temperature. Each thermostat should be capable of being set by adjustment or selection of sensor over a minimum range between 22°C to 27°C.	Thermostats are used at management office and tenant areas to adjust its temperature at 24°C.
Code 8.16 Preventive maintenance: The owner should implement preventive maintenance system and schedule periodic maintenance on all the critical items of air-conditioning systems such as compressors, cooling towers, pumps, condensers, air handlers, controls, filters and piping.	Regular maintenance is carried out to ensure all HVAC components are in good condition such as Summit does maintenance job twice a month for cooling tower.
Code 8.4.7 Multi zone systems : These systems, other than those employing variable air volume for temperature control shall be provided with controls that will automatically reset the off -coil air supply to the highest temperature that will satisfy the zone requiring the coolest air.	Summit Mall implements variable air volume system to control variable temperature at different zone of shopping podium.