An Analytical Study of the Maintainability of Academic Building Air Conditioning System

by

Muhammad Nazif Bin Mohd Nasir

Dissertation submitted in partial fulfilment of
the requirements for the
Bachelor of Engineering (Hons)
(Mechanical Engineering)

JANUARY 2010

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CERTIFICATION OF APPROVAL

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A project dissertation submitted to the
Mechanical Engineering Programme
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in partial fulfilment of the requirement for the
BACHELOR OF ENGINEERING (Hons)
(MECHANICAL ENGINEERING)

Approved by,

(Mr. Azman Bin Zainuddin)

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

January 2010

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Muhammad Nazif Bin Mohd Nasir

ABSTRACT

Maintainability is an inherent characteristic of system or product design. It pertains to the ease, accuracy, safety, and economy in the performance of maintenance actions. A system should be designed such that it can be maintained without large investments of time, at the least cost, with a minimum impact on the environment, and with a minimum expenditure of resources. One goal is to maintain a system effectively and efficiently in its intended environment, without adversely affecting the mission of that system. Maintainability is the ability of an item to be maintained, whereas maintenance constitutes a series of actions necessary to restore or retain an item in an effective operational state. Maintainability is a design parameter. Maintenance is required as a consequence of design.

Air conditioning system is often operated and maintained inefficiently due to the knowledge gap between design guidelines and maintenance practices aided with fault detection techniques. To address this issue and to develop a guideline for good practices, this study examined the maintainability parameters for air conditioning system of academic building.

ACKNOWLEDGEMENTS

I would like to thank you my supervisor, Mr. Azman Bin Zainuddin for being so patient to supervise me as his FYP student. Thank you to his guide I am able to finish my Final Year Project as it is.

I would like also to thank you my friends who sometimes help to ti figure out what should I do when I am stuck with my work.

I would like also to thank you the technician, Mr Syed Firdaus that had helped me a lot during my study on the maintenance data at maintenance building.

Last but not least, I would like to thank the Creator, as He had given me the strength to finish my Final Year Project and also finish my study.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

Maintainability refers to the measures taken during the development, design, and installation of a manufactured product that reduce required maintenance, man-hours, tools, logistic cost, skill levels, and facilities, to ensure that the product meets the requirements for its intended use. Many designers do not take into consideration of the maintainability while designing a product, equipment, or system. The importance of maintainability is often realized only after the product has already been made and is being used.

1.2 Problem Statement

The project will involve a study of equipment, which is the air conditioning system for the academic building that already has been made. The maintainability aspect maybe has not been introduced during the development and design stage of the equipment. Thus it is difficult to improve the maintainability.

With regards to the cost aspect, the maintenance cost is normally hidden, not apparent during acquisition stage, might be ignored at these stages but will inflate the operational cost when in use. The buyers or client are not aware or interested of maintenance cost issues. Products or equipment were not designed for easy and low maintenance, the designers are under pressure to reduce cost to attract more sales, and so might select lower quality of materials or components, and more likely less maintainable instead of the more reliable components. Thus, the maintenance cost is not easy to predict or estimate and usually ignored.

1.3 Objective and Scope of Study

The objective of the this study is to make an analytical study of the maintainability of academic building air conditioning system and come out with a proposal to improve its maintainability. The study will cover the analysis in term maintenance activities, repairability of the equipment, and also the availability of the equipment. Besides that, this study will involve data collection for the maintenance work at the academic building.

1.4 Significance of the Project

In one aspect, maintainability seems to be of less significance to the industries as there are many other elements should be considered in producing or designing equipment. Maintenance is an important factor to any organization in the industries to think about, and the maintenance cost is much related to the maintainability of equipment itself. Therefore, the maintainability of equipment is a factor that cannot be taken for granted. As for example, in Singapore, a group has been formed to study the maintainability of buildings in the country. The building and equipment designers and engineers can look into the maintainability aspect at the design stage, and thus can incorporate design features that can minimize the maintenance cost. The output of this project will be useful for designers to improve the life cycle of the equipments, systems, or buildings.

CHAPTER 2

THEORY

2.1 Concept of Maintainability

The concept of maintainability was formally initiated by the military services of the United States in 1954. In the past few decades, researchers had realized the importance of maintainability of buildings in achieving cost savings and better functioning of facilities.[3] The objectives of applying maintainability engineering principles to engineering systems and equipment include to reducing projected maintenance time and costs through gesing modifications directed at maintenance simplification, to determining labor-hours and other related resources required to carry out the projected maintenance, and also to using maintainability data to estimated item availability or unavailability. [1]

From the information above, it is clearly that the maintainability is among the important aspect of early stages in designing an equipment or system. If the maintainability of the equipment is good, it will give benefit to the end user in term of cost saving, less maintenance work required, and many other things that can involve a lot of money.

The maintainability is inter related with reliability and those two element are important design variables. Although good maintenance management and engineering can improve a problematic situation, it is through good design that systems and products can be created that have inherently good maintainability and reliability characteristic.[4] In the first place of producing a product, equipment, or system, designing is the main important part or element to be concern by the producer or the designer. It happened that with low quality of the design of equipment, can cause the equipment to fail and to be worst, it cannot be repair at all. Thus, by concluding all the information that the author gained from various sources, maintainability can become a crucial process from the very first process of designing and make a particular equipment have a lifelong cycle.

With today's complicated designed of air conditioning system, the need the introduced maintainability study while acquisition stage is highly needed to the developers or designers. The equipment should have a plan for how it will be accessed for maintenance and removed and replaced, as necessary [15].

Maintainability requires the consideration of many different factors, involving all aspects of a system, and the measures of maintainability often include a combination of the following:

Mean down time (MDT) is the average time that a system is non-operational. This includes all time associated with repair, corrective and preventive maintenance, self imposed downtime, and any logistics or administrative delays.

Mean time between maintenance (MTBM) will include both preventive (scheduled) and corrective (unscheduled) maintenance requirements. It includes consideration of reliability mean time between failures (MTBF).

Mean time to repair (MTTR) is a basic measure of the maintainability of repairable items. It represents the average time required to repair a failed component or device.

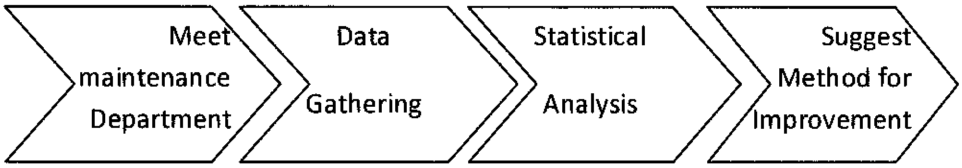
Mean time between failures (MTBF) is the predicted elapsed time between inherent failures of a system during operation. MTBF can be calculated as the arithmetic mean (average) time between failures of a system. The MTBF is typically part of a model that assumes the failed system is immediately repaired (zero elapsed time), as a part of a renewal process.

Availability is the degree to which a system, subsystem, or equipment is operable and in a committable state at the start of a mission, when the mission is called for at an unknown, *i.e.,* a random, time. Simply put, availability is the proportion of time a system is in a functioning condition.

CHAPTER 3

METHODOLOGY

3.1 Research Methodology



1. <u>Meet Maintenance Department</u> - Mr Syed M Firdaus

2. <u>Data Gathering</u>

Collect service maintenance data of maintenance work that have been carried out previously from the maintenance department e.g. maintenance check list, defect summary, etc.

3. <u>Statistical Analysis</u>

There are several measurements or we call it as a model that could be used to analyze the maintainability:

1) Mean time between maintenance(MTBM)

2) Mean time between failure(MTBF)

3) Mean time to repair(MTTR)

4) Maintenance downtime(MDT)

5) Availability(A)

These kinds of models can be interpreted to measure the level of maintainability of the equipment.

3.2 *Gantt Chart*

The project must be completed by the author within 2 semesters. Study, research, collecting data, is allocated to be done in this first semester. Any proposal or outcome of the project will start in the next semester. Gantt chart that shows the milestones of the study of the project: (please refer next page)

No	Detail / Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Study on Air Conditioning System at Academic Building	■	■	■	■	■	■	■								
2	Data gathering for maintenance work	■	■	■	■	■	■	■	Semester Break	■	■	■				
3	Work analysis and finding on Air Conditioning System				■	■	■	■		■	■	■	■	■	■	
4	Preparing for the Final Report									■	■	■	■	■	■	■

Table 1: Gantt chart

3.3 *Process Flow Chart*

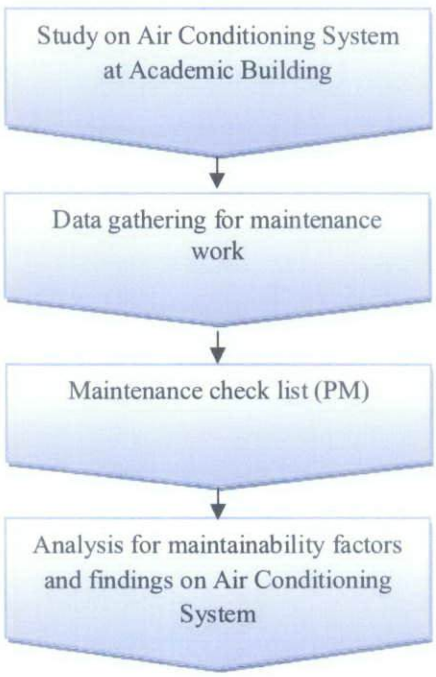


Figure 1: Process Flow Chart

CHAPTER 4

RESULT AND DISCUSSION

4.1 Air Conditioning System

The main equipment in air conditioning system at academic building is the Air Handling Units or AHU. The Air Handling Units are often called AHU. The air-handling unit is box-like equipment with a fan and a cooling coil inside. Some units also contain air filters. The whole fan and motor assembly, comprising shaft, bearings, pulley, and belting are usually put inside the AHU [7].

The basic function of the AHU is to suck air from the rooms, let it pass through chilled water cooling coils and then discharging the cooled air back to the rooms. Normally, letting it pass through panel or bag filters also filters the air. A certain amount of fresh air may be introduced at the suction duct so that air in the rooms may be gradually replaced. AHU's come in many sizes and shapes. Usually, the air conditioning designer will choose a particular AHU based on the air flow requirements and the cooling capacity. If humidity of the air has to be controlled, steam coils, or other heating coils may be installed. If the air has to be much cleaned, special HEPA filters have to be installed at the ducting outlets or at the AHU filter box. Moisture in the air is condensed out when it comes into contact with the chilled water coils. At the bottom of the AHU, a pipe is installed so that water that is collected can be drained out.

The fan and motor assembly is usually mounted on vibration dampers that absorb any vibrations generated. Removable panels are installed so that personnel can enter into the AHU for maintenance. Maintenance is mostly changing or washing of air filters, greasing of bearings, changing of belts, and general inspection and cleaning work. Below is the specification of the AHU and each part of component in the AHU:

- Name of equipment: Air Handling Unit (AHU)
- Manufacturer: Dunham Bush
- Model: AHDAF64 VM (Block 17,3rd floor)

- Motor HP/KW: 10HP/7.5KW

Components that is important in AHU (Air Handling Unit):

1. Fan (FAF/EAF)
2. Damper
3. Air Filter
4. Cooling Coil
5. Blower
6. Supply Duct
7. Suction Duct
8. ERW (Energy Return Wheel)
9. Controller

Below are the details of each of the component in the Air Handling Unit

Figure 2: Air Handling Unit or AHU at Block 17, 3rd floor.

Blower/fan

Air handlers typically employ a large squirrel cage blower driven by an AC induction electric motor to move the air. The blower may operate at a single speed, offer a variety of set speeds, or be driven by a Variable Frequency Drive to allow a wide range of air flow rates. Flow rate may also be controlled by inlet vanes or outlet dampers on the fan. Some residential air handlers (central 'furnaces' or 'air conditioners') use a brushless DC electric motor that has variable speed capabilities.

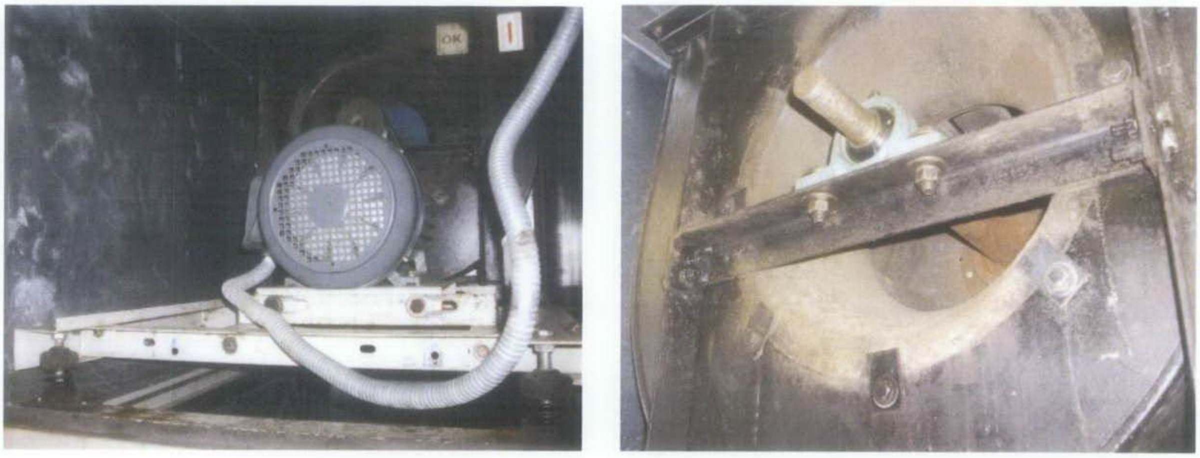


Figure 3: Blower

Filters

Air filtration is almost always present in order to provide clean dust-free air to the building occupants. It may be via simple low-MERV pleated media, HEPA, electrostatic, or a combination of techniques. Gas-phase and ultraviolet air treatments may be employed as well. It is typically placed first in the AHU in order to keep all its components clean.

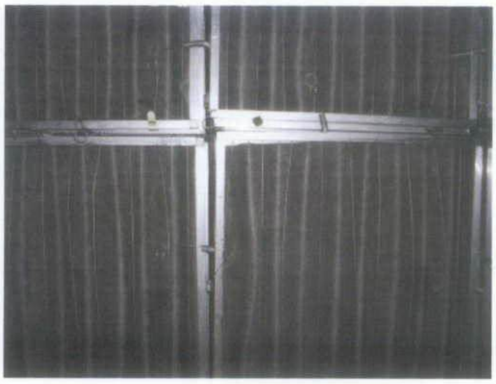


Figure 4: Air Filter in AHU

Temperature Control

Controlling the flow of chilled water through the cooling coils alters the temperature of the discharged air into the rooms. Control valves are used to throttle chilled water through the chilled water coils. A simple temperature control system uses thermostats to control on-off solenoid valves. A better control system uses temperature sensors, controllers, and motorized control valve. More complicating systems may have motor speed control for the fan.

Figure 5: Cooling Coil

Figure 6: Control Valve (2 or 3 way)

Chilled Water

The chilled water, which absorbed heat from the air, is sent via return lines to a cooling tower, which is a heat exchange device used to transfer waste heat to the atmosphere. The extent to which the cooling tower decreases the temperature depends upon the outside temperature, the relative humidity and the atmospheric pressure. The water will be lowered to the Wet-bulb temperature or dry-bulb temperature before proceeding to the water chiller, where it is cooled to between 40° and 45°F and pumped to the air handler, where the cycle is repeated. The equipment required includes chillers, cooling towers, pumps and electrical control equipment.

Figure 7: Chilled Water supply to the AHU

Mixing chamber (ERW – Energy Return Wheel)

In order to maintain indoor air quality, air handlers commonly have provisions to allow the introduction of outside air into, and the exhausting of air from the building. In temperate climates, mixing the right amount of cooler outside air with warmer return air can be used to approach the desired supply air temperature. A mixing chamber is therefore used which has dampers controlling the ratio between the return, outside, and exhaust air.

A heat recovery heat exchanger, of many types, may be fitted to the air handler for energy savings and increasing capacity.

Figure 8: Energy Return Wheel (ERW)

Controls

Controls are necessary to regulate every aspect of an air handler, such as: flow rate of air, supply air temperature, mixed air temperature, humidity, air quality. They may be as simple as an off/on thermostat or as complex as a building automation system using BACnet or LonWorks, for example. Common control components include temperature sensors, humidity sensors, sail switches, actuators, motors, and controllers.

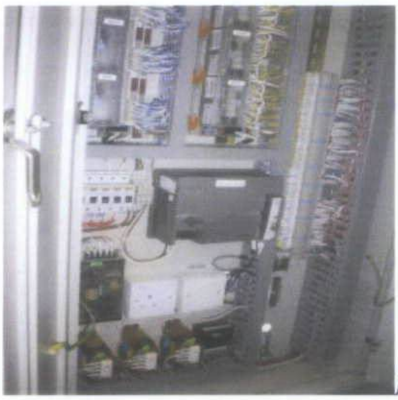


Figure 9: Controller beside the AHU

Damper (flow)

A damper is a valve or plate that stops or regulates the flow of air inside a duct, chimney, VAV box, air handler, or other air handling equipment. A damper may be used to cut off central air conditioning (heating or cooling) to an unused room, or to regulate it for room-by-room temperature and climate control. Its operation can be manual or automatic. Manual dampers are turned by a handle on the outside of a duct. Automatic dampers are used to regulate airflow constantly and are operated by electric or pneumatic motors, in turn controlled by a thermostator building automation system. But in the academic building, the damper that bee used is the manual type of damper.

Figure 10: Damper

Suction and Exhaust Fan

These two fans will suck the fresh air and blow out the used air.

Figure 11: FAF (Fresh Air Fan)

Figure 12: EAF (Exhaust Air Fan)

Figure 13: Fresh Air Suction Zone

Below is the summarize of the Air Flow going through the Air Conditioning System

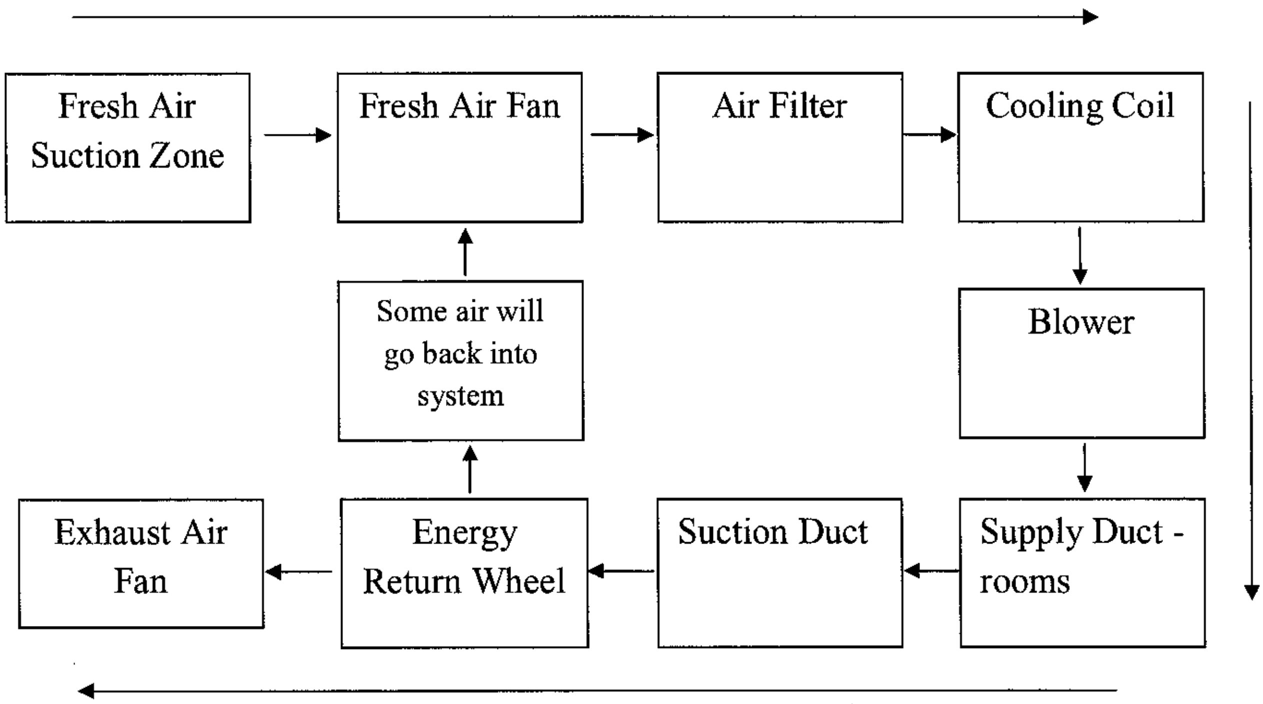
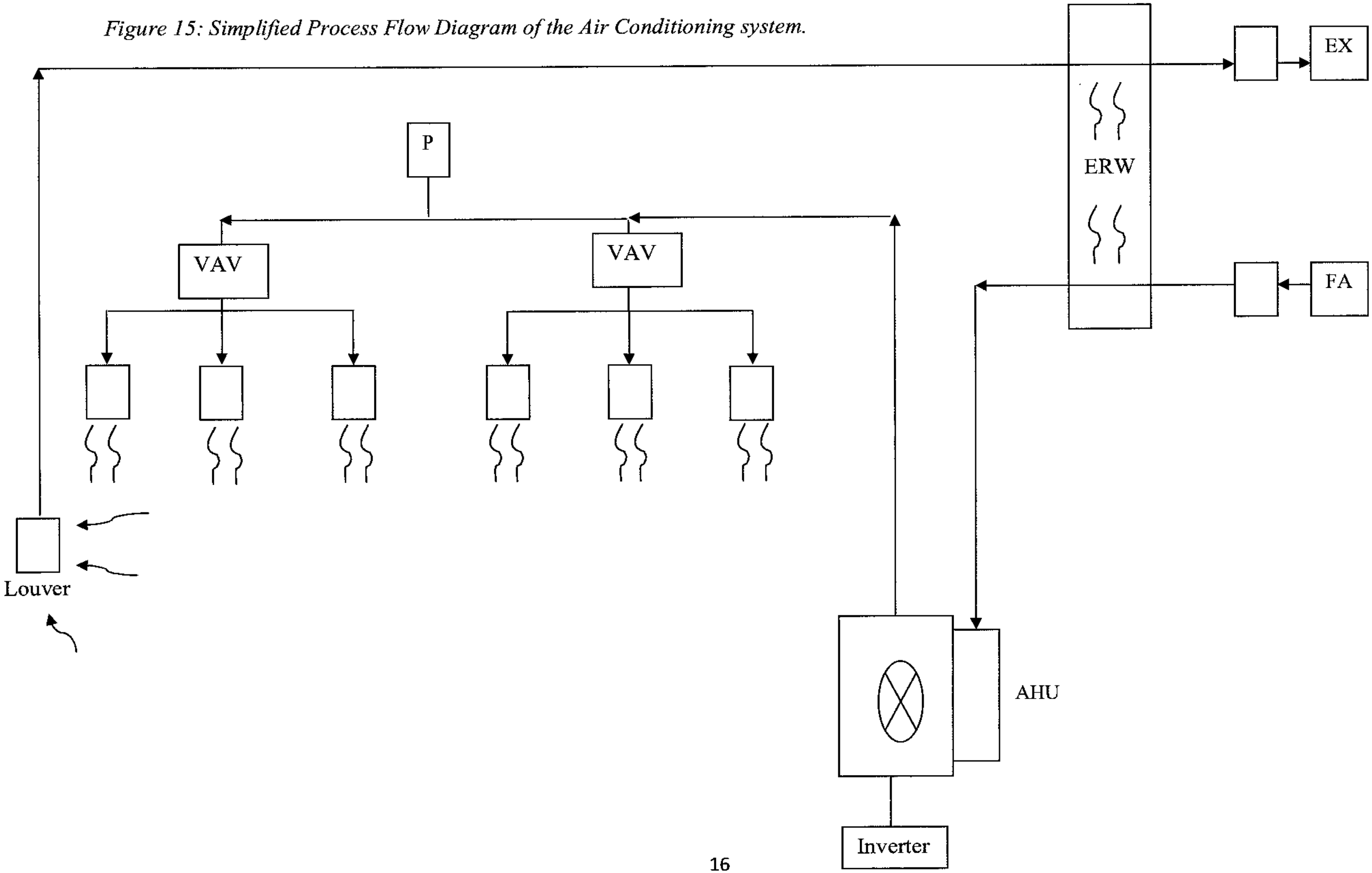


Figure 14: Summarize of Air Flow through the system.

Figure 15: Simplified Process Flow Diagram of the Air Conditioning system.



Description for the simplified process flow diagram:

-Fresh air will be suck by the FAF (fresh air fan) into the system.

-The fresh air will go through the AHU (Air Handling Unit) and cooling process will start there.

-The cooling air will be blow into the duct to distribute it into the room by a blower in AHU.

-The air that had been blow into the room will be suck by a louver, to take it back and flow it to the exhaust.

-Some of the air will be circulating back into the system by ERW (Energy Return Wheel) and the cool heat that already in the air will be use to save the energy to cool down the fresh air from outside.

4.2 Service Maintenance Data (Preventive Maintenance)

The preventive maintenance (PM) of Air Conditioning System was conducted once a month for every Air Handling Units in each block. The author had reviewed the data for the maintenance work for 4 sequent months, which are June, July, August, and September. The summary of the data of each month is shown in the appendixes.

There are 3 main parts in maintaining the AHU, which are Physical Check, Cleaning /Service, and Electrical Control. The maintenance Check list for this document will also be attached with this report. According to the maintenance data sheet [6], the main component that always has problems during the maintenance service is the Air Filter. Out of 4 months of the maintenance data, all of the data shows that the air filter is not ok and need to be wash.

Figure 16: See next page; Example of a maintenance check list that had been used by the contractor to maintain the system

SERVICE MASTER (MALAYSIA) SDN BHD (Co. No. 179804-M)

No. 42, Jalan 13/14, Seksyen 13, 40100 Shah Alam, Selangor Darul Ehsan

Tel: 03-5510 7722 Fax: 03-5510 2772 E-mail: smmsbutp@yahoo.com

MAINTENANCE CHECK LIST REPORT

NO.: 00077

CLIENT

UNIVERSITI ~~PETRONAS~~ TEKNOLOGI PETRONAS

DATE:

14/08/2009

WORK LOCATION

BLOCK 17

TYPE OF EQUIPMENT

AHU

UNIT NO.	AHU 17.00/1	AHU 17.00/2	AHU 17.01/1	AHU 17.01/2
BRAND				
MODEL	AHDAF 120 HM	AHDAF F00 HM	AHDAF 150 HM	AHDAF 120 HM
SERIAL NO.	1A21500152	1A21500128	1A21500135	1A21500133
MOTOR HP/KW	15HP/11KW	15HP/11KW	20HP/15KW	15HP/11KW
MOTOR FULL LOAD AMP	17.7 AMP	19.7 AMP	27.0 AMP	19.7 AMP
RECORD ELECTRICAL VOLTAGE	412V / 414V / 414V	417V / 418V / 420V	415 / 410V / 416V	412V / 412V / 414V
RECORD RUNNING AMP	14.9A / 14.9A / 15.0A	13.5A / 12.8A / 13.7A	12.6A / 12.5A / 12.3A	18.0A / 17.9A / 18.0A
PHYSICAL CHECK:	OK	OK	OK	OK
- Drive Belt	☑	☑	☑	☑
- Pulley Alignment	☑	☑	☑	☑
- Drain Pan	☑	☑	☑	☑
- Blower Wheels	☑	☑	☑	☑
- Fan Bearing	☑	☑	☑	☑
- Motor Bearing	☑	☑	☑	☑
- Greasing (every 3 months)	☑	☑	☑	☑
CLEANING / SERVICE				
- Air Filter	NEED TO CHANGE ☐	NEED TO CHANGE ☐	NEED TO CHANGE ☐	NEED TO CHGNGE ☐
- Cooling Coil	☑	☑	☑	☑
- Drain Pan	☑	☑	☑	☑
- Strainer (every 6 months)	☐	☐	☐	☐
- Unit overall clean	☑	☑	☑	☑
ELECTRICAL CONTROL				
- Check Wiring Termination	☑	☑	☑	☑
- Check Starter Relays	☑	☑	☑	☑
- Check Indicator Bulb	☐	☐	☐	☐
- 2 or 3 way Valve Position	☑	☑	☑	☑
- Temperature Sensor	☐	☐	☐	☐
FREQUENCY INVERTER				
UNIT NO.				
BRAND				
MODEL				
SERIAL NO.				
PHYSICAL CHECK:				
- Cooling Fan	☑	☑	☑	☑
- Check Wiring Termination	☑	☑	☑	☑
OTHER SERVICES PERFORMED				
- On Coil Air Temp. / Relative Humidity	16.5 °C %	12.3 °C %	22.7 °C %	12.9 °C %
- Off Coil Air Temp. / Relative Humidity	23.7 °C %	23 °C %	24.8 °C %	22.8 °C %
- Chilled Water Inlet Temp.	8 °C	10 °C	9 °C	10 °C
- Chilled Water Inlet Press.	4·2 bar	4 bar	3·8 bar	4 bar
- Chilled Water Outlet Temp.	18 °C	14 °C	12 °C	20 °C
- Chilled Water Outlet Press.	4·5 bar	4 bar	3·8 bar	4 bar
REMARKS / COMMENTS				

We hereby accept the above services has been rendered to our complete satisfaction

[illegible] Syed Zaki [illegible]
[illegible] Engineer (Mechanical)
[illegible] Mgmt & Maintenance Dept
[illegible] Teknologi PETRONAS

Authorised Signatory & Chop

Attended by:
1. SYED
2. ELIAS
3. ZAKI
4.
5.

4.3 Important components to the system

After analyzing the data in the maintenance data checklist for several months, it is found that some of the component is considered as important to the system and has to keep track of it conditions every time it is going to be maintain. The components list is as follow:

1. Air Filter
2. Drive Belt
3. Bearing (blower)
4. Fresh air fan
5. Exhaust air fan
6. Temperature sensor(in the room)
7. Pressure sensor
8. Louver

Apparently, the most important component among those is the air filter. The data required for the justification is in the appendixes.

4.4 Maintainability measurements (Calculation)

The author had collected the data for maintenance work for a year which is year 2009. Figure below show the data required for the maintainability calculation.

Subject	Description
Duration of data study	A year / 365 days / 525600 minutes
Total failure per year	12 failures

Figure 17: Data required for Maintainability measurements [6]

4.4.1 Mean Time between Maintenance (MTBM)

MTBM include both preventive (scheduled) and corrective (unscheduled) maintenance requirements. It includes consideration of reliability mean time between failures (MTBF).

No. of Preventive Maintenance (PM) Occurrences	No. of Corrective Maintenance (CM) Occurrences	Total of CM & PM occurrences	Total Time (in minutes)
16 AC x 1 per month x 12 months = 192	10	11192 + 10 = 202	365 x 24 x 60 = 525600 mins

Figure 18: MTBF Data

Based on the data collected above, the MTBM can be calculated:

MTBM = Total time in minutes/Total maintenance work

$$MTBM = \frac{525600 \text{ minutes}}{202 \text{ occurrences}} = 2601.98 \text{ min}$$

4.4.2 Mean Time between Failures (MTBF)

MTBF is the predicted elapsed time between inherent failures of a system during operation. MTBF can be calculated as the arithmetic mean (average) time between failures of a system. The MTBF is typically part of a model that assumes the failed system is immediately repaired (zero elapsed time), as a part of a renewal process.

MTBF = total operating hours / number of failures

So, the MTBF for 2009 can be calculated as:

$$MTBF = \frac{525600 \text{ minutes}}{12 \text{ Failures}} = 43800 \text{ min}$$

4.4.3 Mean Time to Repair (MTTR)

MTTR is total corrective maintenance time divided by the total number of corrective maintenance actions during a given period of time.

$$MTTR = \frac{2160 \text{ minutes}}{12 \text{ Failures}} = 180 \text{ min}$$

4.4.4 Availability

Availability is the degree to which a system, subsystem, or equipment is operable and in a committable state at the start of a mission, when the mission is called for at an unknown, *i.e.,* a random, time. Simply put, availability is the proportion of time a system is in a functioning condition.

Inherent Availability, A_i

$$Ai = \frac{MTBF}{MTBF + MTTR} = \frac{43800 \text{ minutes}}{43800 + 180 \text{ min}} = 0.9959$$

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The main equipment of the academic building air coditioning system is the air handling unit or AHU. AHU is a device used to condition and circulate air as part of a heating, ventilating, and air-conditioning or HVAC system. Air handlers usually connect to ductwork that distributes the conditioned air through the building and returns it to the AHU. The previous data of the maintenance work had shown that there are 2 components that give major problems in the maintenance work. The first one is the Air Filter, the second one is the Drive Belt. Among those two, air filter is the important one.

The measurement of the maintainability factors can be calculated with the given equation. With the data from the calculation, the author can used it for further study or investigation for improving the factors or measurement that had been considered. The factors or measurements that been used are the Mean Time Between Maintenance, Mean Time Between Failure, Mean Time To Repair, and Inherent Availability. The value for each measurements will give an indicator what is the maintainability for the air conditioning system. Further study to improve the measurement is needed in order to propose required actions that should be taken by the maintenance department to enhance the maintainability of the air conditioning system. Time while conducting the maintenance works, repair equipment, failure of equipment is an important thing to get the good result of the study.

5.2 Recommendation

- Further improvement need to be done to enhanced the maintainability of the AC
- There are some components that having no problems for continuous months.
- To review back the maintenance checklist
- Conduct study to reschedule back the preventive maintenance.

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Appendixes

Below is the summarize data from the maintenance data sheet that had been analyze and the result is as in the discussion section whereby we can see the important component is the air filter. The first four table is the summarize table and the rest is the complete data for the whole maintenance data.

June 2009

	Physical Check							Cleaning / Service					Electrical Control		
	Drive Belt	Pulley Allignment	Drain Pan	Blower Wheels	Fan Bearing	Motor Bearing	Greasing (3 month)	Air Filter	Cooling Coil	Drain Pan	Strainer	Unit overall clean	Check wiring termination	Check starter relays	2 or 3 way Valve Position
TOTAL OK	109	113	113	113	113	113	113	0	113	113	113	113	113	113	110
TOTAL KO	4	0	0	0	0	0	0	113	0	0	0	0	0	0	3

July 2009

	Physical Check							Cleaning / Service					Electrical Control		
	Drive Belt	Pulley Allignment	Drain Pan	Blower Wheels	Fan Bearing	Motor Bearing	Greasing (3 month)	Air Filter	Cooling Coil	Drain Pan	Strainer	Unit overall clean	Check wiring termination	Check starter relays	2 or 3 way Valve Position
TOTAL OK	109	113	113	113	113	113	113	0	113	113	113	113	113	113	110
TOTAL KO	4	0	0	0	0	0	0	113	0	0	0	0	0	0	3

August 2009

	Physical Check							Cleaning / Service						Electrical Control		
	Drive Belt	Pulley Allignment	Drain Pan	Blower Wheels	Fan Bearing	Motor Bearing	Greasing (3 month)	Air Filter	Cooling Coil	Drain Pan	Strainer	Unit overall clean	Check wiring termination	Check starter relays	2 or 3 way Valve Position
TOTAL OK	113	118	118	118	117	118	118	0	118	118	118	118	118	118	115
TOTAL KO	5	0	0	0	1	0	0	118	0	0	0	0	0	0	3

September 2009

	Physical Check							Cleaning / Service						Electrical Control		
	Drive Belt	Pulley Allignment	Drain Pan	Blower Wheels	Fan Bearing	Motor Bearing	Greasing (3 month)	Air Filter	Cooling Coil	Drain Pan	Strainer	Unit overall clean	Check wiring termination	Check starter relays	2 or 3 way Valve Position
TOTAL OK	103	118	118	118	117	117	118	0	118	118	118	118	118	118	116
TOTAL KO	15	0	0	0	1	1	0	118	0	0	0	0	0	0	2