Analysis of Maintenance Management Implementation in VAC System

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Abstract

Air Conditioning System or more commonly known as AHU (Air Handling Unit) or VAC (Ventilating and Air Conditioning), plays an important role in various industries. One of the references to the VAC System is the Radioactive Waste Treatment Plant (IPLR), which is a liquid, semi-liquid and solid radioactive waste processing building designed in such a way that it meets the requirements of a nuclear installation and is closed, tight and sturdy.The VAC (Ventilation and Air Conditioning) and exhaust gas (Off-gas) systems have the main function of maintaining the condition of the IPLR room and to achieve optimal operation, it is necessary to minimize various disturbances (trouble) by always carrying out preventive maintenancesuch as replacing loose v-belts, adding grease, tightening bolts, sheave alignment, measuring motor amperage, system measurement, HEPA filter replacement. Maintenance optimization provides a great opportunity for cost savings and increased equipment life in HVAC systems. The purpose of this study is to determine the preventive maintenance characteristic of VAC system in radioactive waste treatment facility.

Keywords
Maintenance Optimization, Preventive Maintenance, Radioactive Waste Treatment Plant and VAC System.

1. Introduction
Air Conditioning System or more commonly known as AHU (Air Handling Unit) or VAC (Ventilating and Air Conditioning), plays an important role in various industries. These include:
1. In order to provide protection to the product manufacturing environment,
2. Ensure quality production,
3. Provide a comfortable working environment for personnel,
4. Provide protection to the environment where there are hazardous materials through the arrangement of an effective and safe air exhaust system from these materials.

One of the references to the VAC System is the Radioactive Waste Treatment Plant (IPLR), which is a liquid, semi-liquid and solid radioactive waste processing building designed in such a way that it meets the requirements of a nuclear installation and is closed, tight and sturdy. This is expected to minimize the risk in case of contamination in the space of the waste treatment system. To support all of this, the process building is equipped with an air conditioning system (VAC & Off-gas).

The VAC (Ventilation and Air Conditioning) and exhaust gas (Off-gas) systems have the main function of maintaining the condition of the IPLR room so that it is always in a state of negative pressure to outside air pressure, limiting the possibility of contamination in the room by blowing fresh air (fresh air)), condition the room air so that it is comfortable for radiation workers and offices are also equipped with filters and evacuate the air that comes out of the IPLR through the chimney. To achieve optimal operation, it is necessary to minimize various disturbances (trouble) by always carrying out preventive maintenance such as replacing loose v-belts, adding grease, tightening bolts, sheave alignment, measuring motor amperage, system measurement, HEPA filter replacement.

The purpose of maintenance is to reduce or even avoid corrective maintenance with proper planning and timely execution of maintenance tasks (Au-Yong et al. 2014). Maintenance of a VAC system like any other facility is usually based on the manufacturer's guidelines and specifications. The interest in building maintenance is that the operation of the building is reviewed by the presence of people in the building. The VAC system can also be stopped because there is no one in the building or part of it (no one in the hotel room or in the office).Therefore, not only planned stops for maintenance tasks can be used (replacement, adjustment, major overhauls, inspection and lubrication, adjustment or calibration, cleaning (Springer and Dakin 2013), but also maintenance stops (building occupancy changes). The last stop can be planned or unplanned and given further space to maintain the system. All these outages are input to the proposed approach based on the remaining life of the system; several outages will be selected to perform maintenance actions on the components of the VAC system.

According to the type of building, the opportunity to perform maintenance on the VAC system is rare. In this case, the grouping maintenance philosophy should be introduced in the maintenance of the VAC System to schedule maintenance activities properly. This will result in saving time and maintenance costs as well as optimizing the VAC system. Mathematical tools known as “probability algorithms” are applied for maintenance purposes (Thomas et al. 2008).

In order to properly plan, organize and execute a maintenance program, it is very important to understand the components and functions of a particular system. The most important HVAC components are the cooler, cooling tower, air handling unit, compressor, and pump. Thus, maintenance of the HVAC system should focus on this critical component to improve system performance and cost-effectiveness. Since the HVAC system is centralized, it can affect the entire building when one of its components fails. For example, condensed water cooling cannot be performed if the cooler is faulty, and therefore the entire system cannot convert hot air into cold air.

Furthermore, the maintenance of a central HVAC system is more complicated and difficult due to the size and complexity of the system. Therefore, to minimize HVAC system downtime, corrective maintenance should be replaced with an appropriate preventive maintenance strategy. Significant maintenance characteristics must be considered in the maintenance of the HVAC system or other building systems. In practice, regression models will help management to predict maintenance performance as evidenced by case studies (Au-Yong et al. 2014).

Maintenance optimization provides a great opportunity for cost savings and increased equipment life in HVAC systems. (Wu et al 2021) proposed an optimization framework to consider the interdependencies among the different parts of the equipment and the interdependencies between the operation, maintenance, and health of the equipment. The framework consists of two stages, parameter generation and optimization. In the parameter generation stage, parameters that capture the system's hourly operating pattern are generated to construct operating-related constraints. At the optimization stage, the optimization model is finalized to obtain a high-quality maintenance schedule.

1.1 Objectives

The objectives of this paper are:

1. To determine the preventive maintenance characteristic of VAC system in several company in Indonesia such ANTAM, BRIN, Cikarang Powerindo, Chandra Asri, Indonesia Power
2. To determine whether those facilities are already applied the preventive maintenance.

2. Literature Review

2.1 Preventive Maintenance

Preventive maintenance (PM) was introduced in the 1950s, after the recognition of the need to prevent failure. As an alternative to CM, PM has been adopted for emerging technologies since such systems are generally more complex than those based on the use of hand tools. The basic principle of a PM system is that it involves predetermined maintenance tasks that are derived from machine or equipment functionalities and component lifetimes. Accordingly, tasks are planned to change components before they fail and are scheduled during machine stoppages or shutdowns (Basri et al. 2016). Preventive maintenance is an effective approach to enhance the reliability and quality of a system and its components. In order to prevent failure from occurring, preventive maintenance practice should be able to indicate when a maintenance work needs to be performed. Maximising component’s reliability and extending the components’ life are the main purpose of preventive maintenance. It also provides a critical service function that minimises interruptions to core business of an organisation (Au Young et al. 2014). Maintenance planning contributes positively in effective maintenance activity (Nurcahyo et al. 2018). Industry accepted that maintenance is a key function in sustaining long-term profitability for organizations. In order to optimize maintenance performance, several aspects of skill and competency maintenance team needed to be concerned in maintenance management. Training is an important element in increasing skills, competency and creating high work performance culture (Nurcahyo and Fatoni. 2018). Equipment maintenance on laboratory services is part of quality management to keep equipment in good condition, safe, reliable, consistent, and accurate. To ensure quality and reduce the loss of machine equipment failure, a maintenance method approach is required. Total Productive Maintenance (TPM) as a maintenance concept that maintains and improves product quality by improving machine working conditions, and reducing failure (Nurcahyo et al. 2018)

2.2 VAC System Preventive Maintenance Characteristic

According to Ahmad and Kamaruddin (2012), Au-Yong et al. (2014), Basriet al. (2017), Chua et al. (2018), and Van Horenbeek et al. (2013), there are several characteristics for VAC system Preventive Maintenance.

Maintenance labour

A skilled worker is one of the important factors in preventive maintenance since the maintenance work is implemented in a fixed time interval. Maintenance management requires a process to allocate and coordinate the resources which include labours in order to further improve the maintenance performance in terms of reliability of the systems. Technically, if maintenance labour in the building has adequate skills and knowledge, an effective maintenance management can be achieved, as error and mistake occurred during maintenance works could be reduced. The important factors from maintenance labour are the satisfaction of fixed salary, the qualification and experience, and the number of maintenance labour provided in the company. Skills and knowledge of the labour can result in an effective maintenance management. Hence, the lack of skill and knowledge of maintenance personnel will be an obstacle to creating effective maintenance management.

Spare parts and materials

Management of spare parts and materials involves the study on the spare part required, the efficiency of spare parts reordering, level of stocks of spare parts and storage of spare parts. Every part or component in a system will need necessary replacement when it reaches the end of its lifetime. Preventive maintenance requires several categories of spare parts which include exchange parts, lubricants and other maintenance materials such as rags, cleaning solvents, etc. Therefore, the availability of spare parts for replacement is necessary in order to ensure a consistent operation system. The availability of spare parts is highly significant in preventive maintenance as it can affect the maintenance performance.

Failure and maintenance downtime

Building systems are subjected to have downtime from the maintenance activities, components failure, inspection, and material shortages. Downtime involves the time required for detection, repair or replacement and restarting the system, where all of them resulted in the unavailability of services and facilities in a building. Generally, there are two types of maintenance activities required for different types of maintenance downtime, which are major and minor activities. For minor activities, there will be fewer maintenance works needed, conducted in shorter durations and may involve some routine operations such as cleaning, lubrication, oil changes, re-alignment, and minor adjustments. On the other hand, for major maintenance activities, the maintenance works may take longer durations. It may also involve system restoration, inspection and replacement.

Maintenance equipment and technique

The efficiencies and effectiveness of the whole of a manufacturing operation are dependent on the sustainable performance of systems or equipment, which can lead to valuable improvements in terms of quality, cost and time. The basic principle of a PM system is that it involves predetermined maintenance tasks that are derived from machine or equipment functionalities and component lifetimes. Accordingly, tasks are planned to change components before they fail and are scheduled during machine stoppages or shutdowns. The important factors are budget allocated for tools and equipment is sufficient, appropriate or advanced maintenance equipment availability, and maintenance tools and technique are fully utilised.

Acquisition of maintenance data

The important aspects of acquisition maintenance data are expenses for documentation and recording of maintenance data are allowed and systems condition is accurately reflected by the maintenance data and record.

Monitoring and inspection

Monitoring is defined as: 'An activity which is intended to observe the actual state of an item'. Typically, periodical monitoring is carried out at certain intervals, such as every hour or every working shift end, with the aid of portable indicators, such as hand-held meters, acoustic emission units, and vibration pens. As for continuous monitoring, as its name suggests, monitoring is performed continuously and automatically based on special measurement devices, such as vibration and acoustic sensors. Two main limitations of continuous monitoring exist: it is expensive because many special devices are required and inaccurate information may be obtained because the continuous flow of data creates increased noise. In contrast, the main limitation of periodic monitoring is the possibility of missing some important information of equipment failure between monitoring intervals.

3. Methods

The methodology of this research consists of the following steps:

1. Literature review
2. Develop questionnaire as showed in Table 1 based on the characteristics of VAC Preventive Maintenance aspect
3. Data collection is based on filling out questionnaires conducted in the VAC system preventive maintenance with data from 30 samples. This questionnaire is addressed to VAC system maintenance employee
4. Data Processing
5. Result and discussion
6. Conclusions

Table 1. Research Questionnaire

No.	Aspect	Questions
1	Maintenance Labour	Is there a dedicated Maintenance workforce in the VAC system?
		How many teams of VAC system maintenance workers?
2	Spare Parts and Materials	Are there spare parts and materials provided in the VAC system?
		How is the replacement of spare parts and materials done?
3	Failure And Maintenance Downtime	Has there ever been a breakdown that caused the VAC system to stop?
		In 1 year how many times does maintenance downtime occur?
4	Maintenance Equipment and Technique	Is there any equipment provided in the maintenance of the VAC system?
		Does the repair technique follow the manual book?
5	Acquisition Of Maintenance Data	Is there a record of VAC system maintenance?
		Is the VAC system maintenance data recorded at your place?
6	Monitoring And Inspection	Is monitoring and inspection of the VAC system carried out?
		What is your action if you found an issue after conducting monitoring and inspection?

4. Data Collection

The data was collected using questionnaires. This study was conducted onVAC system maintenance employee who works at the Radioactive Waste Treatment Plant (IPLR). The proposed question in questionnaire is shown in Table 2.

Table 2. Questionnaire Detailed Question

No	Detailed Question
P1	Company
P2	Division
P3	Is There a Dedicated Maintenance Worker In The VAC System?
P4	How many maintenances worker in VAC system?

P5	Are there spare parts and materials provided in the VAC system?
P6	How is replacement of spare parts and materials done?
P7	Is there any breakdown that caused the VAC system stopped?
P8	How many are times maintenance downtime in one year?
P9	Is there any equipment provided in the VAC maintenance system?
P10	Does the Repair Method Follow the Manual Book?
P11	Is there a VAC System Maintenance Record?
P12	Is the data of VAC System Maintenance in Your Place Recorded?
P13	Is the VAC Monitoring and Inspection System Performed?
P14	What is your action if you found a damage during monitoring and inspection?

5. Results and Discussion
Based on the questionnaires above, the results can be seen in the Table 3.

Table 3. Research Questionnaire Result

P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P1	P12	P13	P14
Chandra Asri	Maintenance Division	yes	3-5 workers	yes	if broken	yes	2-3 times	yes	yes	yes	yes	yes	replaced
ANTAM	Utility Pomalaa UBPN Kolaka	yes	3-5 workers	yes	based on manual	yes	2-3 times	yes	yes	yes	yes	yes	waiting for maintenan ce schedule
PT CikarangListri ndo	Technician	yes	6-10 workers	yes	based on manual	no	never	yes	yes	yes	yes	yes	replaced
PLN Nusantara Power	CNG Plant	yes	1-2 workers	yes	based on manual	no	once	yes	yes	yes	yes	yes	replaced
DPFK-BRIN	Installation for Technology of RadioisotopandRadiofarmaka	yes	6-10 workers	yes	if broken	yes	once	yes	yes	yes	yes	yes	replaced
BRIN	Installation for Radioactive Waste Processing	yes	3-5 workers	yes	if broken	yes	once	yes	no	yes	yes	yes	waiting for maintenan ce schedule
BRIN	Installation for Radioactive Waste Processing	yes	3-5 workers	no	if broken	yes	once	yes	yes	yes	yes	yes	replaced
DPFK - BRIN	Installation for Radioactive Waste Processing	yes	6-10 workers	yes	if broken	yes	> 3 times	yes	yes	yes	yes	yes	replaced
BadanRisetIno vasiNasional	Nuclear Research Reactor 30 MW	yes	6-10 workers	yes	based on manual	yes	never	yes	yes	yes	yes	yes	replaced
DPFK-BRIN	Nuclear Research Reactor 30 MW	yes	6-10 workers	yes	based on manual	no	never	yes	yes	yes	yes	yes	replaced
PT Indonesia Power	Maintenance Service Unit	yes	3-5 workers	yes	if broken	no	once	yes	yes	yes	yes	yes	replaced
ANTAM	Utility Pomalaa UBPN Kolaka	yes	6-10 workers	yes	if broken	yes	once	yes	yes	yes	yes	yes	replaced
BRIN	Installation for Radioactive Waste Processing	yes	6-10 workers	yes	if broken	no	2-3 times	yes	yes	yes	yes	yes	replaced
PT. CikarangListri ndo	TeknisiPerawatan	yes	3-5 workers	yes	based on manual	no	once	yes	yes	yes	yes	yes	replaced
DPFK - BRIN	Installation for Radioactive Waste Processing	yes	6-10 workers	yes	based on manual	no	never	yes	no	yes	yes	yes	waiting for maintenan ce schedule

DPFK - BRIN	Utility Pomalaa UBPN Kolaka	yes	3-5 workers	yes	based on manual	yes	once	yes	yes	yes	yes	yes	waiting for maintenan ce schedule
DPFK-BRIN	Installation for Radioactive Waste Processing	yes	6-10 workers	yes	based on manual	yes	2-3 times	yes	yes	yes	yes	yes	replaced
DPFK - BRIN	Installation for Radioactive Waste Processing	yes	6-10 workers	yes	if broken	yes	once	yes	yes	yes	yes	yes	replaced
PLN Nusantara Power	Maintenance Service Unit	yes	6-10 workers	yes	if broken	no	once	yes	yes	yes	yes	yes	waiting for maintenan ce schedule
ANTAM	Installation for Radioactive Waste Processing	yes	6-10 workers	yes	if broken	no	never	yes	yes	yes	yes	yes	replaced
PT Indonesia Power	Installation for Technology of RadioisotopandRadiofarmaka	yes	3-5 workers	yes	based on manual	yes	once	yes	yes	yes	yes	yes	replaced
ANTAM	Reaktor RSG-GAS	yes	3-5 workers	yes	based on manual	yes	once	yes	yes	yes	yes	yes	replaced
PLN Nusantara Power	Installation for Radioactive Waste Processing	yes	6-10 workers	yes	based on manual	yes	once	yes	no	yes	yes	yes	waiting for maintenan ce schedule
BRIN	Technician	yes	3-5 workers	yes	based on manual	yes	> 3 times	yes	yes	yes	yes	yes	replaced
BRIN	Installation for Technology of RadioisotopandRadiofarmaka	yes	3-5 workers	yes	if broken	yes	once	yes	yes	yes	yes	yes	replaced
BRIN	Installation for Radioactive Waste Processing	yes	3-5 workers	no	based on manual	yes	once	yes	yes	yes	yes	yes	replaced
DPFK-BRIN	Maintenance Division	yes	6-10 workers	no	if broken	yes	never	yes	yes	yes	yes	yes	replaced
PLN Nusantara Power	Maintenance Service Unit	yes	3-5 workers	yes	based on manual	no	once	yes	no	yes	yes	yes	replaced
ANTAM	Installation for Radioactive Waste Processing	yes	6-10 workers	yes	if broken	no	never	yes	yes	yes	yes	yes	replaced
BRIN	Maintenance Division	yes	6-10 workers	yes	if broken	yes	once	yes	yes	yes	yes	yes	replaced

Based on 30 data, for the System HVAC, all plants have dedicated manpower for the maintenance. If you can see, for the material HVAC provided 97% of data. Based on data, for the system HVAC 50% people. The following Table 4 represents the Percentage of Maintenance People in System HVAC in Group.

Table 4. Percentage of Maintenance People in System HVAC in Group

Group People	Maintenance People in System HVAC
1-2	3%
3-5	47%
6-10	50%

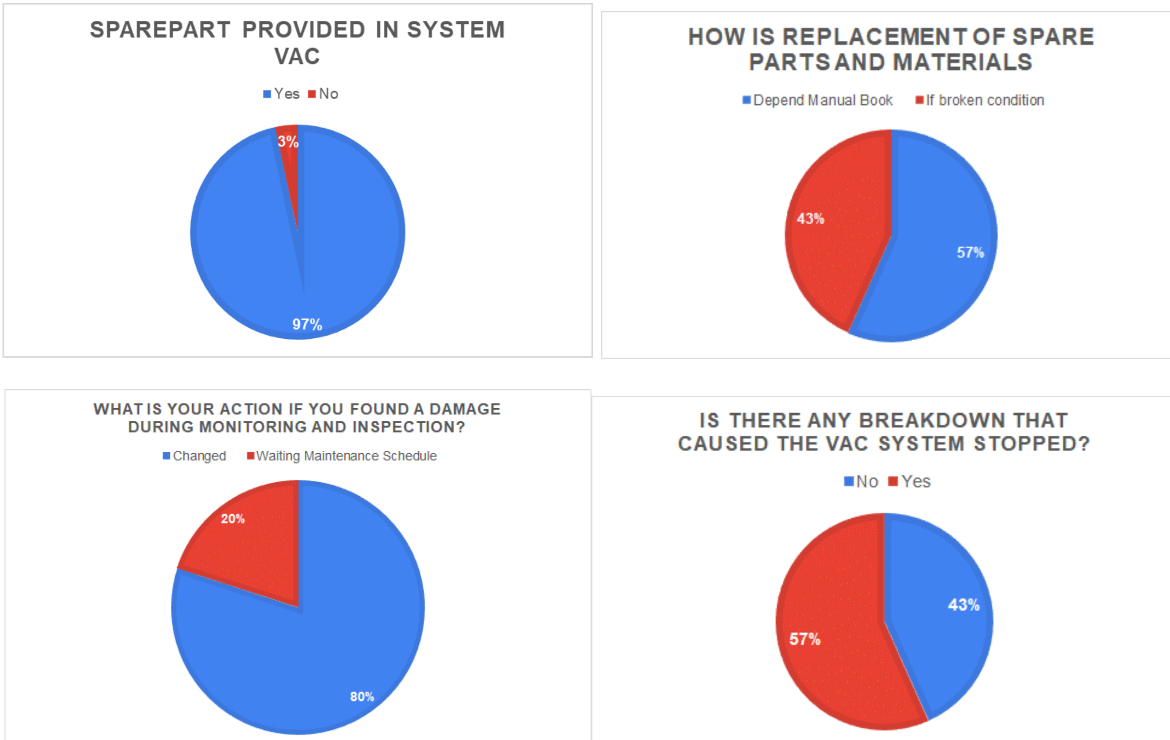

Figure 1. Answer of some Questionaries

6. Conclusions

The conclusion of this paper is regarding the system HVAC, 100% agreed some dedicated team for maintenance the system. And based on data responded all system HVAC have monitoring and Inspection. If any replacement for the change material depend on manual book is 57% and 43% will be changed if broken condition. And 80% responded agreed if any damage during monitoring and inspection will be changed.

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