Schedule maintenance management system for HVAC system in restaurant: A review

B Y Tingginehe1,*, A D Rasasi1 and M Ichsan2

1 Civil Engineering Department, Faculty of Engineering, Universitas Indonesia, Depok, West Java, Indonesia
2 Management Program, Binus Business School, Jakarta, Indonesia

*benedictus.yosia@ui.ac.id

Abstract. Many companies carried out business development to improve the company’s financial. A food and beverage companies need to carry out maintenance of their restaurant to keep all restaurant equipment in good condition. Maintenance have to be carried out with right methods and schedule to assure maintenance of restaurant equipment runs efficiently. One of the important components in restaurant is the Heating, Ventilation, and Air Conditioning (HVAC) system. This system aims to create a comfortable condition in kitchen and dining area of restaurant. Many restaurant’s HVAC systems found in bad condition and many companies do not have adequate scheduling management system. This study aims to find the base in develop scheduling management system for HVAC system maintenance in restaurant by reviewing journal about maintenance. This system expected to assist mechanics in maintaining HVAC system.

1. Introduction

According to PMBOK [1], life cycle of project started from project initiation phase and not stop after execution or construction phase. Project closing phase that include operation and maintenance became an important factor in life cycle. Therefore, after the branch construction finished and started to operate, the maintenance process needed to be done to assure life expectancy of tools and equipment needed for restaurant operation can be maintained properly. A good maintenance plan management needed to increase or meet life expectancy of restaurant asset.

In restaurant asset management process, one of the most important systems have to be concerned about is the HVAC system. On average HVAC system take part 19.1% from all restaurant construction cost. HVAC system is one of the important components in restaurant that needed to assure room temperature and environment in dining room and kitchen in a good condition. In a restaurant’s kitchen, high ventilation level needed to release gas from burning process and contaminant from cooking process [2]. Usage of efficient kitchen hood important to assure a healthy working condition, comfort, and energy efficient [3]. HVAC system assure environment conditions in kitchen area are comfort to workers who work in the kitchen. A hot and uncomfortable kitchen contributes to productivity loss, employee turnover, and eventually profit loss for the restaurant operator [4].

Companies need to develop a good maintenance scheduling management system of restaurant HVAC system to assure HVAC system in restaurant always in excellent condition. This maintenance scheduling
management related to scheduling of temporary downtime, replacing spare parts, and routine inspection of tools and equipment in the HVAC system. According data from Solaria restaurant, there are trends in shutdown of ventilation system in a restaurant a few years back that causing the restaurant to close for a few days [5]. Ventilation system is one of the most important systems to release a gas from burning process and contaminant from cooking process. Some of malls and shopping centers where have a security system that to operate the restaurant and turning the gas system, the ventilation system of restaurant has to be running properly.

Solaria restaurant is a chain restaurant that has branches spreading in 32 provinces all across Indonesia. They have 276 branches that 135 in Greater Jakarta region. Even this restaurant chain has grown bigger, they don’t have a proper management system especially in maintenance management problem. Maintenance system that used in Solaria is corrective maintenance system and maintenance only carried out if there is a breakdown or order by company to contractor. According to data from Solaria’s maintenance contractor, there are backlog in maintenance order that have not done by contractor per December 2019 is 27 branches [5].

![Figure 1. Number of ventilation system breakdown in solaria [5].](image)

Therefore, to improve effectivity of maintenance process, we need to develop a good maintenance scheduling management system to ensure all the equipment used in restaurant were in a good condition. To minimize the maintenance problem, we need to develop a good maintenance management. The old method that used, need to be evaluated to increase the maintenance performance. The corrective maintenance method needs to be evaluated and started to change to preventive maintenance.

According to Kosonen a concern on closed environment increased in years as a result of knowledge about significance of thermal condition and air quality to health, comfort, and productivity of workers [6]. In Indonesia, a research about maintenance in HVAC system is scarce. There is a lot of research that has been conducted on maintenance especially on HVAC. So, we need to look further in restaurant HVAC system maintenance.

This study aims to overview what is the factor and requirement that needed for a maintenance framework. This paper is reviewing available maintenance performance measurement methods in the literature and highlighting the common methods used. The factors and requirements observed in this research used for measuring performance indicator of maintenance method selected.

2. Literature review

2.1. HVAC
In HVAC system, the heating, ventilating, and air conditioning units provide proper thermal comfort and acceptable indoor air quality to inhabitants, within reasonable installation operation, and
maintenance cost. Heating, ventilating, and air conditioning (HVAC) systems have played important role in building energy and comfort management [7]. In restaurant, HVAC systems consist of two main systems. Restaurant have an air conditioning system and ventilation system. These two systems are critical for restaurant operation. Air conditioning system needed to provide a constant and comfortable temperature in the building especially in the dining room.

A typical HVAC system consists of a supply air system and return air system [7]. Air conditioning unit provide an air that have been conditioned in temperature and humidity. The air conditioning system mass used in tropical area that famous for its heat to assure the comfortable room condition. Room comfortability measured from the temperature, humidity, circulation, and cleanliness of the air. The air conditioning unit suck air from the room in return air system. The air conditioning unit then filtered and conditioned the air sucked from the room and then supply the conditioned air to the room by the supply air system. There are many kinds of air conditioning unit type. The choose of air conditioning type depends on budget, room condition, and interior.

As described before, the ventilation system is critical for the kitchen operation in restaurant. The working condition of kitchen affected by the condition of ventilation system. The productivity of kitchen workers affected by the temperature of the kitchen [4]. The heat and the fume from cooking process have to be released from the kitchen to assure the temperature and safety of the kitchen. The fume and the heat from the cooking process have to be released as soon as possible and supplied again by fresh air from outside the kitchen. Ventilation system installed in kitchen consists of exhaust system and fresh air system (make up air or supply air). Exhaust system suck out the air that contain fume of cooking process and heat captured in kitchen hood. The air from the kitchen hood sucked by a fan to outside of the kitchen. After the air in kitchen is sucked up then the air condition in kitchen is in negative volume. It is recommended to keep a negative air balance (under pressure) compared with the surrounding spaces. In practice this means that the exhaust airflow rate should be at least 10% higher than the supply airflow rate in the kitchen [6]. This provide the kitchen with better air condition and balancing the air volume in kitchen so the air that has been conditioned from the dining room is not sucked into kitchen area.

2.2. HVAC system maintenance

Unplanned failure can cause a big cost to fix or replace, production loss, also safety disaster on environment and human [8]. In Pourhosseini said to avoid the negative effect, we need a suitable maintenance strategy for all facility and assets in many industry sectors. A good strategy not just mitigate the chance of equipment failure but also improve working assets condition and impact directly on lowering the maintenance cost and improving product quality. Risk level condition or system reliability and product diversity important in deciding the maintenance strategy. For many types of equipment, reliability depend on time function, equipment age and maintenance level [9]. Selecting of an appropriate maintenance strategy for each piece of equipment or systems is a very complex task due to the difficulties concerning data collection, diversity of components and their functions, and large number of criteria that need to be taken into account and their subjectivity [8].

Traditionally in maintenance systems, the planning and scheduling functions are coupled together. The planning function consists of the following [10]:

- Identification of work to be planned.
- Determination of work complexity and composition.
- Estimation of manpower requirements.
- Identification of spare parts and material requirements and their availability.
- Identification of special tools required.

There are many types of maintenance method that can be considered when managing an asset. Globally we can divide into corrective and preventive maintenance. Corrective maintenance is a maintenance method that all the maintenance is done after breakdown or failure of the asset. Preventive maintenance is a maintenance method that all maintenance is done before breakdown or failure of the asset. Usually preventive maintenance is scheduled based on the wear rate of the parts so the downtime
of the asset could be minimalized. This day, preventive maintenance more popular than corrective maintenance because the corrective maintenance causing an unscheduled downtime that can interrupting the production and causing a significant loss economically. Along with the further research, there are many types of maintenance strategies. There many types of maintenance strategy that have to be chosen. Maintenance strategy used

Tsang states that maintenance performance measurement is needed for the purpose of giving the maintenance manager quantitative information about maintenance goals that can be reached and what actions are needed to be taken in order to improve the operation results to meet the goals [11]. Measurement of maintenance performance is needed to evaluate effectiveness and efficiency of maintenance. Effective maintenance reducing the impact of decreasing equipment performance and efficient maintenance decrease cost needed for maintenance [12]. Result and point from maintenance process have to be measured, controlled, and developed using a good maintenance performance measurement system [13].

It is an important thing for maintenance process to be measured so we can control and supervise to get a proper action and corrective to reduce and mitigate risk in safety, meet social responsibility and improve effectiveness and efficiency of asset under maintenance. Without formal process of performance measurement, it will be difficult to control and develop result from maintenance process [14].

Maintenance has ceased to be considered a tactical subject with relevant repercussion regarding company cost, not profits, and started to be viewed as having a strategic dimension, due to its implication in quality, availability, safety and cost, making it just another requirement for doing business [15,16]. Maintenance is responsible for keeping plants in the state of readiness for operation at the desired level of efficiency [17]. From Desmyter, to evaluate maintenance, we got a factor such as: safety, availability, cost and energy impact, comfort, and environment impact. Many research has try to measure the performance of HVAC system. Au-yong put a survey on building to measure the occupant satisfaction.

3. Method

In attempt of working in this research, a systematic search of the literature related to maintenance management and maintenance performance measurement was conducted. The time frame for this literature review was from 1993 to 2018. This paper is reviewing available maintenance performance measurement methods in the literature and highlighting the common methods used. All of journals obtained from search process, we obtain performance indicator in order to measure performance of HVAC system maintenance.

4. Discussion

The study in standard of HVAC system maintenance in Indonesia is limited. The maintenance management system that applied in some restaurant still have a difficulty in maintaining HVAC system in their restaurant. This study aims to overview what is the factor and requirement that needed for a maintenance framework.

Poor maintenance management has caused several organizations great loss through production unavailability and damage to humans, the environment and physical assets [20]. Maintenance managers are required to control maintenance costs and be in a position to demonstrate the level of performance of their respective organizations [17]. Recent research has identified a growing recognition by business managers that the standard of property and facilities management affects the organization as a whole in terms of cost efficiency, service delivery and performance, as well as protecting this substantial property asset [21]. Many organizations develop an effective method in maintaining their assets to keep their asset condition at top condition. Having an effective maintenance management system in place is critical for maintenance managers of industrial facilities to ensure that maintenance expenditure are kept to a minimum [22].

As mentioned before, the maintenance process performance need to measured. We review various journal in maintenance to see the performance indicator proposed. As we review from [23-33], there are
a few indicators that always mentioned. Cost, availability, HSE, efficiency, and equipment are the indicators always mentioned. We use these indicators as performance indicator in measuring maintenance performance of HVAC system. There is also another performance indicator that can be used but need further research.

There are few performance indicators that always mentioned but need adjustment in the way we use it. As example some journal mention customer satisfaction as the performance indicator. From the field we can see that customer is not enter the kitchen area. We cannot put customer satisfaction as performance indicator for kitchen ventilation system in restaurant. Customer satisfaction only used in AC system performance indicator in dining area. From this example we need more further research to determine another performance indicator that suit with all HVAC system in restaurant.

The factors and requirements observed in this research used for measuring performance indicator of the maintenance method selected. After we understand the factors and requirements, the maintenance framework is developed. The maintenance framework and standard will be used by restaurant to maintaining their HVAC system. The outdated corrective maintenance method will be left and developed into preventive maintenance method. With this development organization may increase the condition of their HVAC equipment. Further research can be done with more effective and specific method that fit for HVAC system maintenance to increase the effectiveness and condition of HVAC system in restaurant.

5. Conclusion
From this review we can conclude that we need a performance indicator to measure the performance of maintenance. Cost, availability, HSE, efficiency, and equipment have to be in performance indicator. A further research needs to be done to evaluate another performance indicator that fit to measure maintenance of restaurant’s HVAC system. Concept introduced in this study is to find the maintenance performance indicator of HVAC system that will be used with another data and requirement in developing schedule maintenance management system for HVAC system in restaurant. The purpose of this management system is helping the company to maintain the HVAC system in restaurant always in good condition and working properly. A good maintenance management increase the efficiency of maintenance, reduce cost, and assure availability of HVAC system. The performance indicators can be used as the base in developing a maintenance management framework and SOP for HVAC system in restaurant.

References
[1] Project Management Institute 2017 Project Management Body of Knowledge (Chicago: Independent Publisher Group)
[2] Zhao Y, Tao P and Gao R 2013 The Impact of Various Hood Shapes, and Side Panel and Exhaust Duct Arrangements, on the Performance of Typical Chinese Style Cooking Hoods 139–49
[3] Kotani H, Yamanaka T, Sagara K and Momoi Y 2014 Prediction of Plume above Residential Cooking Range by Means of CFD analysis
[4] Livchak A and Schrock D 2015 The Effect of Supply Air Systems on Kitchen Thermal Environment ASHRAE Trans. 111 748–54
[5] Solaria 2019 Solaria Company Report 2019
[6] Kosonen R 2013 Ventilation of Commercial Kitchen: How to Guarantee Operation and Improve Energy Efficiency REVHA Eur. HVAC J. 34–8
[7] Yang R and Wang L 2012 Optimal Control Strategy for HVAC System in Building Energy Management
[8] Pourhosseini O and Nasiri F 2018 Availability-Based Reliability-Centered Maintenance Scheduling: Case Study of Domestic (Building-Integrated) Hot Water Systems ASCE-ASME J. Risk Uncertain. Eng. Syst. Part A Civ. Eng. 4 1–13
[9] Shafiee M 2015 Maintenance strategy selection problem : An MCDM overview
[10] Duffuaa S O and Al-Sultan K S 1997 Mathematical programming approaches for the management
of maintenance planning and scheduling. J. Qual. Maint. Eng. 3 163–76

[11] Tsang A H C, Jardine A K S and Kolodny H 1999 Measuring maintenance performance: a holistic approach. Int. J. Oper. Prod. Manag.

[12] Thompson C C, Gao D Y and Hale P S 2018 An evaluation of HVAC failure and maintenance equipment data for facility resiliency and reliability ASHRAE Trans. 124 116–27

[13] Fokkens D-J 2015 A Practical Approach to Maintenance Performance Measurement (University of Twente)

[14] Sari E, Mohamed A, Ma A and Yazid A M 2015 Sustainable Maintenance Performance Measures: a pilot survey in Malaysian Automotive Companies Procedia CIRP 26 443–8

[15] Tsang A H C 1998 A strategic approach to managing maintenance J. Qual. Maint. Eng.

[16] Andijani A and Duffuaa S 2002 Critical Evaluation of Simulation Studies in Maintenance Systems Prod. Plan. Control 13 336–41

[17] Raouf A 1993 On Evaluating Maintenance Performance Int. J. Qual. Reliab. Manag. 10 33–6

[18] Desmyter J and Huovila P 2011 Performance Indicators for Health, Comfort and Safety of the Indoor Environment 39–50

[19] Au-yong C P, Ali A S and Ahmad F 2014 Automation in Construction Improving occupants’ satisfaction with effective maintenance management of HVAC system in office buildings Autom. Constr. 43 31–7

[20] Okoh P, Schjolberg P and Wilson A 2015 AMMP: a new maintenance management model based on ISO 55000

[21] Housley J 1997 Managing the estate in higher education establishments Proc. Cobra 1996 Res. Conf. 15 72–83

[22] Oseghale G E 2014 Impact of Maintenance Strategies on the Performance Of Industrial Facilities In Selected Industrial Estates In Lagos State, Nigeria Am. J. Eng. Res. 03 171–9

[23] Simões J M, Gomes C F and Yasin M M 2011 A Literature Review of Maintenance Performance Measurement: A Conceptual Framework and Directions for Future Research J. Qual. Maint. Eng. 17 116–37

[24] Samat H A, Kamaruddin S and Azid I A 2011 Maintenance Performance Measurement: A Review 19 199–211

[25] Vaisnys P, Contri P and Bieth M 2007 Benchmarking study of maintenance performance monitoring practices Summary Report Eur. Comm. Dir. Gen. Jt. Reserach Cent.

[26] Peach R, Ellis H and Visser J K 2016 A Maintenance Performance Measurement Framework That Includes Maintenance Human Factors: A Case Study From the Electricity Transmission Industry South African J. Ind. Eng. 27 177–89

[27] Horenbeek A Van and Pintelon L 2014 Development of a maintenance performance measurement framework — using the analytic network process (ANP) for maintenance performance indicator selection Omega 42 33–46

[28] Aditya P 2006 Development of a Multi-criteria Hierarchical Framework for Maintenance Performance Measurement Concepts, Issues and Challenges

[29] Róka-madarász L 2011 Performance Measurement for Maintenance Management of Real Estate 8 161–72

[30] Oliveira M, Lopes I and Rodrigues C 2016 Use of maintenance performance indicators by companies of the industrial hub of Manaus Procedia CIRP 52 157–60

[31] Kumar U, Galar D, Parida A, Stenström C and Berges L 2003 Maintenance Performance Metrics: A State of the Art Review 3–34

[32] Weber A and Thomas R 2005 Key Performance: Measuring and Managing the Maintenance

[33] Omar M F, Ibrahim F A, Mohd W and Wan S 2017 Key Performance Indicators for Maintenance Management Effectiveness of Public Hospital Building MATEC Web Conf. 97