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Research Article

Risk Assessment of Fire Protection Pumps at The Faculty of Applied Science Building

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ABSTRACT

Thailand has many large buildings. The fire protection systems in high buildings must be inspected and maintained so that they are ready to use in the event of a fire. The Hazard and Operability Study (HAZOP) was used for the pumps risk assessment of the fire protection systems of the Faculty of Applied Science building, King Mongkut's University of Technology North Bangkok (KMUTNB). From examining the fire pump and jockey pump of the fire protection systems, it was found that both pumps have never been damaged and need not be replaced. The pumps of the fire protection system are ready to use in the event of the fire and will provide safety to the people who use the building as well.

Keywords: Building, Fire Pump, Jockey Pump, Risk Assessment

INTRODUCTION

A fire inside a building may cause damage or loss to property or life, including a loss of the reputation of an organization. In 2019-2022, there were more than 1,660 incidents of fire in Thailand, an average of 415 fires per year. Fires of this sort are most often caused by negligence, a short circuit, an explosion, cooking, or arson [1, 2]. An example of such a fire incident occurred in August 2022 in the tenant area of a tall building in Bangkok. The emergency team of the building management center and firefighters from the fire station were at first able to urgently halt and then control the situation within one hour. There were no injuries or deaths in this incident. Later, it was discovered that the fire was caused by a rubbish heap inside the building [3].

Risk assessment by a Hazard and Operability Study (HAZOP) is a systematic technique for identifying hazards and processing problems. It is a technique used to study process safety by studying the possibility of the origin of the error [4, 5]. The cause may be produced by a process error or a device within the system. HAZOP is a systematic study with clear procedures. HAZOP operations not only identify hazards but also identify abnormalities that are dangerous to normal operating conditions. Therefore, HAZOP is applied to the identification of transportation hazards and problems to bring forth road safety measures, hazard analysis in the installation of solar cells, the pump and maintenance in piping systems, and the change of equipment according to the specified service life so that there is no problem in the future [6, 7]. HAZOP is also an easy-to-learn method. The work process of maintenance staff experienced in the research of studies related to HAZOP will be much more effective in the event of problems within a system. It can be applied to the petrochemical industry and the polymerization reactor industry [8]. Industrial plants with production processes involving machines, equipment, and exact procedures are particularly appropriate for HAZOP studies.

The staffs of the Faculty of Applied Sciences building, King Mongkut's University of Technology North Bangkok (KMUTNB) have not yet rated the risk and hazards that could possibly occur if there is a failure in the fire protection system. Therefore, to help prevent damage that may occur to the lives and property of personnel within the Faculty of Applied Sciences building, this research aims to study flaws and assess the fire safety of high-building fire protection systems using the HAZOP method for hazard assessment within normal operating procedures to identify problems and maintenance.

FIRE ROOM INSPECTION

The fire room of the Faculty of Applied Science building is located on the 1stfloor of the 78th building. It is about two meters above the ground level as shown in Fig. 1 (a). The inspection fire room is a rectangular room. Its dimensions are 3.60 meters by 6.00 meters by 4 meters in width, length, and height, respectively. Then, the area and volume of the fire pump room is 21.6 square meters and 86.4 cubic meters, respectively. The main equipment in the fire room of the Faculty of Applied Science building consists of several components. First, the automatic fire alarm control panel serves to notify staff automatically when there is a fire or water is used within the fire protection system. Then, the jockey pump maintains the pressure in the fire protection system pipes when water is used in the fire protection system so that the pressure in the pipe system is not lower than the value given. Next, the fire pump utilizes a diesel engine to fill the water instead of the jockey pump when there is continuous use of the water in the fire protection system or the pressure in the piping system has continuously dropped, or the jockey pump cannot put the water into the piping system because the pressure in the piping system drops to the point where the pressure switch is set to the main controller commands for fire pump operation and pumping water into the piping systems. Finally, the tank oil serves as fuel storage for the fire pump. The plan of the fire room is drawn in Fig. 1.

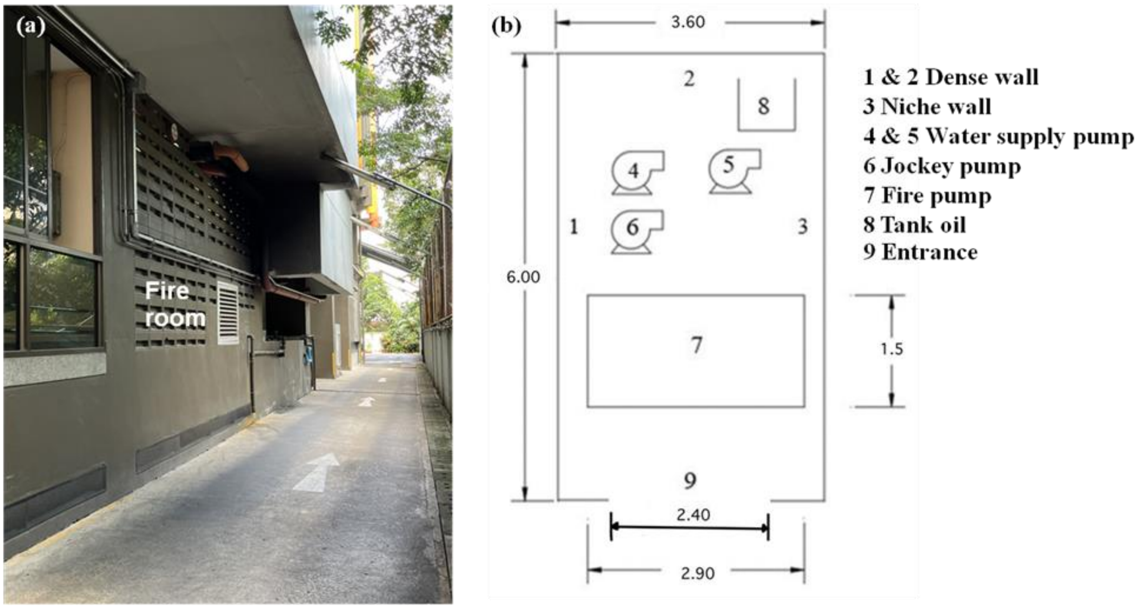

Fig. 1 Location of the fire room of Faculty of Applied Science Building at KMUTNB (a) photograph of fire room and (b) structure diagram

PROCESS FLOW DIAGRAM OF FIRE PROTECTION SYSTEM

The schematic process flow diagram of the equipment in the fire protection system room is shown in Fig. 2. The fire protection system in the Faculty of Applied Sciences building is a wet pipe system that has water in the pipe all the time. In the event of a fire in the building, sprinklers installed throughout the building are activated and immediately spray water to extinguish the fire. This makes it possible to quickly control the fire. The working principle of the fire protection system in the building starts at the jockey pump, where the jockey pump and fire pump suck water from the water tank to store in the pipe systems with check valves to keep the water in the piping system and prevent it from flowing back to the water tank. The fire protection system of the Applied Science building automatically keeps the pressure in the pipeline ready for use at all times. In normal conditions with no fire, both pumps are inactive. On the other hand, if a fire occurs, the pressure in the piping system drops below 150 PSI, and the jockey pump activates to maintain the pressure at 165 PSI. When the water is used continuously or the pressure in the piping system drops continuously to below 130 PSI, the jockey pump cannot pump water into the piping system in time. The fire pump runs and pumps water into the piping system and keeps the water pressure in the system constant because fire pump has more power than the jockey pump.

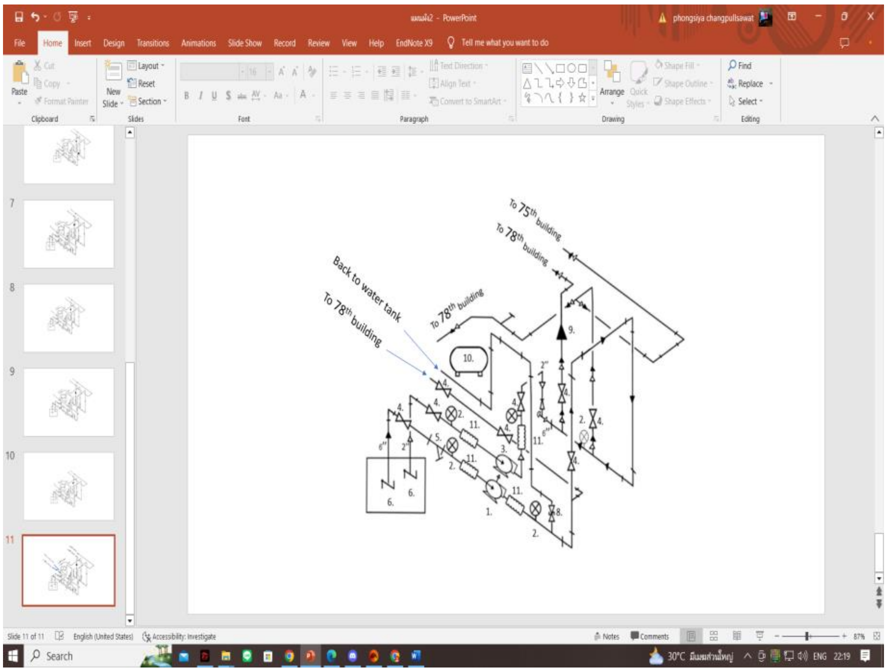

Fig. 2 Process flow diagram of fire protection system of Faculty of Applied Science Building

Remark: 1 Fire pump; 2 Pressure gauge; 3 Jockey pump; 4 Gate valve; 5 Strainer; 6 Check valve; 7 Automatic air vent; 8 Pressure relief valve; 9 Alarm check valve; 10 Oil tank; 11 Flexible joint

RISK MATRIX

The risk matrix is the level of risk when a parameter changes. It can be divided into two situations that include fire and no fire. Table I shows the 5x5 risk matrix of the fire protection system room of the Faculty of Applied Science building. The risk assessment from the risk matrix table is used in the last step. Hazard identification is based on the probability and the impact.

Probability

The probability is represented by the letters A – E, which are sorted by the frequency of the occurrence of the hazard as follows: A means that this event has never occurred; B means that it has been known to occur; C means that it has occurred once in a high-risk condition; D means that it has occurred every few years; and E means that it has occurred several times a year.

Impact

The impact considers both the cost of damage to equipment and the safety of people. The specification is a number from 1 to 5 as follows: 1 indicates that property damage was worth more than $30 or there was minor injury to one person; 2 indicates that property damage was worth more than $300 or there was minor injury to more than one person; 3 indicates that property damage exceeded $3,000 or there was one serious injury; 4 indicates that property damage exceeded $30,000 or there were multiple people seriously injured; and 5 indicates that property damage exceeded $300,000 or there was one fatality.

In addition, the order of risk can be explained from the colors together with letters and numbers as follows: the white background means that it is an acceptable risk and the control is not required; the blue color refers to the level of risk that is acceptable, but it must be controlled so that the risk does not move to an unacceptable level; the yellow color indicates an unacceptable level of risk, and the risks must be managed to keep them within acceptable levels; and the red background indicates the unacceptable level of risk, and it is necessary to immediately manage the risk to an acceptable level [9, 10].

Table I Risk Matrix of fire protection system room

Criticality rate		Impact				
		1	2	3	4	5
Probability	E	E1	E2	E3	E4	E5
	D	D1	D2	D3	D4	D5
	C	C1	C2	C3	C4	C5
	B	B1	B2	B3	B4	B5
	A	A1	A2	A3	A4	A5

RISK ASSESSMENT OF FIRE PUMP

The fire pump under normal conditions never has failed even once. The damage can cost up to $9,000 to replace and has a criticality rate of Level 3. In the event of a fire, the failure of the fire pump can lead to death due to lack of water to help extinguish it. The criticality rate increases to Level 5. The risks arising from the inoperability of the fire pump are as follows.

No Flow and Vacuum Pressure

No flow and vacuum pressure occur for many reasons as follows: a broken pipe connected to the check valve, a chapped pump gasket, or a closed gate valve. Without the water supply to the fire pump, water cannot be supplied to the fire hoses and sprinklers. What should be done in normal conditions includes repairing the leaks, changing the new suction line, checking the vacuum level or whether the seals or gaskets may need to be replaced. In these cases, the risk assessment is Level 2, which means that it is an acceptable level of risk, but controls must be taken so that the risk does not move to unacceptable levels. In the event of a fire, the risk assessment increases to Level 3, which means it is an unacceptable level of risk. Leaks in the pipe need to be repaired or changes need to be made to the suction pipe.

Less Flow and Low Pressure

Less flow and low pressure are caused by a broken pipe, the erosion or clogging of the impeller or internal parts of the fire pump, a leaking fire pump or ripped gasket seal, or a clogged or leaking filter. In these cases, the fire pump must expend too much energy, resulting in damage. These events can be resolved by repairing the leak, changing the suction pipe, removing any debris from the impeller, and checking and cleaning the strainer. In normal conditions, the risk assessment is Level 2, but in the event of a fire, the risk assessment will increase to Level 3.

More Flow and High Pressure

More flow and high pressure are produced by the impeller inside the fire pump turning too fast and setting the motor speed incorrectly. These issues result in the fire pump working harder but producing less water flow in the discharge direction, which may damage the fire pump. In normal conditions the risk assessment is Level 2, but in the event of a fire, the risk assessment is Level 3. The above information can be written in the HAZOP table as shown in Table II, consistent with the research of Marhavilas [11].

Table II Risk assessment of fire pump

Deviation	Causes	Consequences	Action required	Criticality rate	Frequency	Ranking
No flow/ Vacuum pressure	- Broken, leaking, or torn pipe or gasket - Closed valve	- Water cannot enter fire protection system	- Repair or change pipe or gasket	3/5	B	2/3
Less flow/ Low pressure	- Eroded, broken, or clogged pump or impeller - Pump at low speed - Clogged strainer - Broken, leaking, or torn gasket	- Pump over works, resulting in damage	-Repair or change pipe - Remove debris from pump, impeller, or strainer	3/5	B	2/3

More flow/ High pressure	- Pump impeller at high speed - Motor speed setting incorrect	- Pump over works with less water output, resulting in damage	-Check motor -Adjust inlet valve	3/5	B	2/3

RISK ASSESSMENT OF JOCKEY PUMP

The jockey pump under normal conditions has never failed even once. The damage can cost up to $2,000 to replace and has a criticality rate of Level 2. In the event of a fire, the failure of the jockey pump can lead to death due to lack of water to help extinguish it. The criticality rate increases to Level 5. The risks arising from the inoperability of jockey pump are as follows.

A. No Flow and Vacuum Pressure

No flow and vacuum pressure occur for many causes such as a broken pipe connected to the check valve, a chapped pump gasket, or a closed gate valve. Without the water supply to the jockey pump, water cannot be supplied to the fire hoses and sprinklers. What should be done in normal conditions includes repairing the leaks, changing the new suction line, checking the vacuum level or whether the seals or gaskets may need to be replaced. For these reasons, the risk assessment is Level 2. In the event of a fire, the risk assessment increases to Level 3.

B. Less Flow and Low Pressure

Less flow and low pressure are caused by a broken pipe, eroded or clogged internal parts of the jockey pump or impeller, leaking jockey pump or ripped gasket seal, or leaking or clogged filter. In these cases, the jockey pump overworks, resulting in damage. These events can be resolved by repairing the leak, changing the suction pipe, removing any debris from the impeller, and checking and cleaning the strainer. In normal conditions, the risk assessment is Level 2, but in the event of a fire, the risk assessment will increase to Level 3.

C. More Flow and High Pressure

More flow and high pressure are produced by the impeller inside the jockey pump turning too fast and setting the motor speed incorrectly. In these cases, the jockey pump must work harder with less water flowing out in the discharge direction, which may damage the jockey pump. In normal conditions the risk assessment is Level 2, but in the event of a fire, the risk assessment is Level 3. The HAZOP risk assessment of the jockey pump is shown in Table III.

Table III Risk assessment of jockey pump

Deviation	Causes	Consequences	Action required	Criticality rate	Frequency	Ranking
No flow/ Vacuum pressure	- Broken, leaking, or torn pipe or gasket - Closed valve	Water cannot enter fire protection system	- Repair or change pipe or gasket	2/5	B	2/3
Less flow/ Low pressure	- Eroded, broken, or clogged pump or impeller - Pump at low speed -Clogged strainer - Broken, leaking, or torn gasket	Pump overworks, resulting in damage	-Repair or Change pipe - Remove debris from pump, impeller, or strainer	2/5	B	2/3
More flow/ High pressure	-Pump impeller at high speed - Low pressure at discharge	Pump overworks with less water output, resulting in damage	- Check motor -Adjust inlet valve	2/5	B	2/3

CONCLUSION

The risk assessment of the fire protection systems at the Faculty of Applied Sciences building of KMUTNB used the HAZOP technique to examine the availability of the fire pump and jockey pump. It was found that the average risk assessments were Level 2 and 3 in normal and fire situations, respectively, because both pumps have never been damaged. Therefore, the water pumps in the fire protection systems of the Faculty of Applied Sciences building are ready to use when there is an emergency situation from a fire.

REFERENCES

[1] M. Karemaker, G.A. Ten Hoor, R.R. Hagen, C.H.M. Van Schie, and R.A.C. Ruiter, “Social cognitive determinants of fire safe behaviour in older adults,” Fire Safety Journal, vol. 134, pp. 103667, 2022.

[2] S.G. Arce, C. Jeanneret, J. Gales, D. Antonellis, and S. Vaiciulyte, “Human behaviour in informal settlement fires in Costa Rica,” Safety Science, vol. 142, pp. 105384, 2021.

[3] Information https://www.thaipbs.or.th/news/content/318224.

[4] J.I. Single, J. Schmidt, and J. Denecke, “State of research on the automation of HAZOP studies”, Journal of Loss Prevention in the Process Industries, Vol. 62, pp. 103952, 2019.

[5] J.M. Kościelny, M. Syfert, B. Fajdek, and A. Kozak, “The application of a graph of a process in HAZOP analysis in accident prevention system,” Journal of Loss Prevention in the Process Industries, vol. 50, pp. 55-66, 2017.

[6] E. Ayyildiz, and A.T. Gumus, “Pythagorean fuzzy AHP based risk assessment methodology for hazardous material transportation: an application in Istanbul,” Environmental Science and Pollution Research, vol.28, pp. 35798, 2021.

[7] J. Ahn, and D. Chang, “Fuzzy-based HAZOP study for process industry,” Journal of Hazardous Materials, vol. 317, pp. 303-311, 2016.

[8] M. Cheraghi, A.E. Baladeh, and N. Khakzad, “A fuzzy multi-attribute HAZOP technique (FMA-HAZOP): Application to gas wellhead facilities,” Safety Science, vol. 114, pp. 12-22, 2019.

[9] R. Alaei, S.A.A. Mansoori, A.H. Moghaddam, S.M. Mansoori, and N. Mansoori, “Safety assessment approach of hazard and operability (HAZOP) for sulfur recovery unit Claus reaction furnace package; blower; heat exchanger equipment in South Pars gas processing plant,” Journal of Natural Gas Science and Engineering, vol. 20, pp. 271-284, 2014.

[10] P.K. Marhavilas, M. Filippidis, G.K. Koulinas, and D.E. Koulouriotis, “The integration of HAZOP study with risk-matrix and the analytical-hierarchy process for identifying critical control-points and prioritizing risks in industry – A case study,” Journal of Loss Prevention in the Process Industries, vol. 62, pp. 103981, 2019.

[11] P.K. Marhavilas, M. Filippidis, G.K. Koulinas, and D.E. Koulouriotis, “Safety-assessment by hybridizing the MCDM/AHP & HAZOP-DMRA techniques through safety’s level colored maps: Implementation in a petrochemical industry,” Alexandria Engineering Journal, vol. 61, pp. 6959-6977, 2022.