NFPA 14-Based Hydrant Pillar Installation at PT. XYZ Sales Office

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The Sales Area Manager Bandung office, which is located in the city of Bandung, is one of the work locations that covers the working area of Bandung and its surroundings. This Sales Area Office was built in the 90s, but originally functioned as a TNI office. In 2017, the new office was moved to PT. XYZ. However, when I made field observations. The fire protection conditions installed in the building are only Light Fire Extinguishers. Even though SNI and NFPA explain that a building with an area of more than 500 m2 must have a hydrant pillar installation, while a sales office with an area of 1,827 m^2 only has active fire protection in the form of a Light Fire Extinguisher or APAR. Therefore, this report contains planning and analysis of the pillar hydrant system and water requirements for extinguishing the hydrant used in the Sales Area Manager's Office Building located in the city of Bandung. With planning referring to the NFPA 14 standard, this research was conducted by observing the Market in the Office of PT. XYZ, which is located in Bandung City, in April-March 2022. Observation data processing was carried out at the Fire Safety Engineering Study Program, Faculty of Engineering, Jakarta State University, in June-August 2022. From the design results, pillar hydrants have been installed. It can be written that the capacity of the extinguishing media needed to overcome the fire in the sales area management building is 85,171 liters of water. Based on NFPA 14 for building sales area management, the number of pillars needed to protect the building from fire hazards is 5. The pump power required for the installation of a hydrant pillar is 12.54 hp. Installation of pipes used above the ground and around the building.

Keywords: Hydrant, NFPA, Pipe, Pump

INTRODUCTION

The Bandung Sales Area Manager Office, located on Jalan Wirayuda Timur, Lebakgede, Cilongok District, Bandung City, serves as one of the operational centers responsible for managing marketing activities in the Bandung region and its surrounding areas. Due to its strategic role in supporting the company's marketing operations, the building is categorized as a critical asset that must be protected from various potential risks. Among these, fire hazards represent one of the most significant threats, as they could cause not only operational disruptions and financial losses but also pose safety risks to employees and nearby residents [1], [3], [7].

In order to mitigate such risks, an effective fire protection system is essential, especially considering that the office building houses administrative and managerial activities involving electronic equipment, documents, and employees on a daily basis. The importance of implementing a reliable hydrant system becomes increasingly crucial as part of a comprehensive fire protection plan, ensuring that both active and passive fire protection systems meet regulatory and safety standards [2], [5], [9], [14].

This research refers to the previous study titled "Perancangan Sistem Perpipaan Hidran dan Sprinkler di Sejahtera Family Hotel and Apartment" conducted by Andreas Kurniawan (2007). The methodology from that study serves as a comparative reference, particularly in the aspects of head loss calculation and hydrant unit determination, which are based on the Darcy–Weisbach equation [1], [4], [6], [11]. Adopting this approach provides a scientifically grounded framework to determine accurate water pressure, flow rate, and system efficiency for the hydrant pillar installation [13], [15].

Historically, the Bandung Sales Area Office building was constructed in the 1990s and initially functioned as a TNI (Indonesian National Armed Forces) office. In 2017, the building was officially transferred to PT. XYZ to serve as its Sales Area Manager Office. However, during field observations conducted as part of this study, it was found that the existing fire protection system was limited only to portable fire extinguishers (APAR). This condition is inadequate, considering the building area of 1,827 m^2, which, according to both SNI and NFPA 14 standards, should be equipped with a hydrant pillar system for proper fire protection coverage [8], [9], [10].

The absence of a hydrant system highlights a significant gap in fire safety compliance that needs immediate attention. Without an integrated hydrant network, fire response time would depend solely on portable extinguishers, which are insufficient for large-scale or rapidly spreading fires [4], [7], [12]. Therefore, this study seeks to provide a comprehensive planning and technical analysis of hydrant pillar installation tailored to the site's characteristics, ensuring that water flow, pipe sizing, and system components align with internationally recognized standards [14], [15].

The outcomes of this research are expected to serve as a design reference and implementation guideline for PT. XYZ and similar organizations in developing a safe and standardized fire protection system. The planning process adheres to NFPA 14: Standard for the Installation of Standpipe and Hose Systems, which specifies the minimum requirements for system design, water supply, and installation procedures [9]. By aligning the proposed hydrant pillar system with NFPA 14, this project aims to enhance the safety, compliance, and resilience of the Bandung Sales Area Manager Office against potential fire incidents [10], [16].

MATERIALS AND METHODS

Materials

This study was conducted at the Marketing Office of PT. XYZ, located in Lebakgede, Coblong District, Bandung City, from April to March 2022. Data observation and analysis were performed at the Fire Safety Engineering Laboratory, Faculty of Engineering, Jakarta State University, between June and August 2022.

The research methodology adopted in this study consisted of field observation, data collection, system design, and hydraulic analysis. The goal was to design and evaluate a hydrant pillar system that complies with the NFPA 14 and SNI 03-1745-2000 standards for buildings exceeding 500 m² in area.

The materials used in this research consisted of both primary and secondary data relevant to the analysis and design of a hydrant pillar system at the PT. XYZ Sales Area Manager Office. The primary materials included architectural drawings of the 1,827 m² office building, on-site measurements of water pressure and flow rate, as well as environmental data related to fire load, ignition sources, and existing fire protection facilities. Field observations were conducted to identify the type, capacity, and layout of existing firefighting equipment, which currently consisted only of portable fire extinguishers. These findings served as the foundation for hydraulic calculations and fire risk assessments necessary for system design.

The secondary materials comprised national and international standards, technical references, and modeling tools that supported the analytical process. The main design references used were NFPA 14 (2023 Edition) and SNI 03-1745-2000, which establish guidelines for the installation and performance requirements of standpipe and hydrant systems. Additional resources included technical datasheets of hydrant components, previous academic studies on fire protection system design. These materials collectively ensured that the proposed hydrant pillar system met safety, reliability, and performance standards suitable for the operational environment of PT. XYZ.

Methods

This study was conducted at the Marketing Office of PT. XYZ, located in Lebakgede, Coblong District, Bandung City, from April to March 2022. Data observation and analysis were performed at the Fire Safety Engineering Laboratory, Faculty of Engineering, Jakarta State University.

The research methodology adopted in this study consisted of field observation, data collection, system design, and hydraulic analysis. The goal was to design and evaluate a hydrant pillar system that complies with the NFPA 14 and SNI 03-1745-2000 standards for buildings exceeding 500 m² in area. In the research flow, it is presented in the form of a research diagram that explains the steps to be taken in the research. In this study, the flow used is shown in Figure 1:

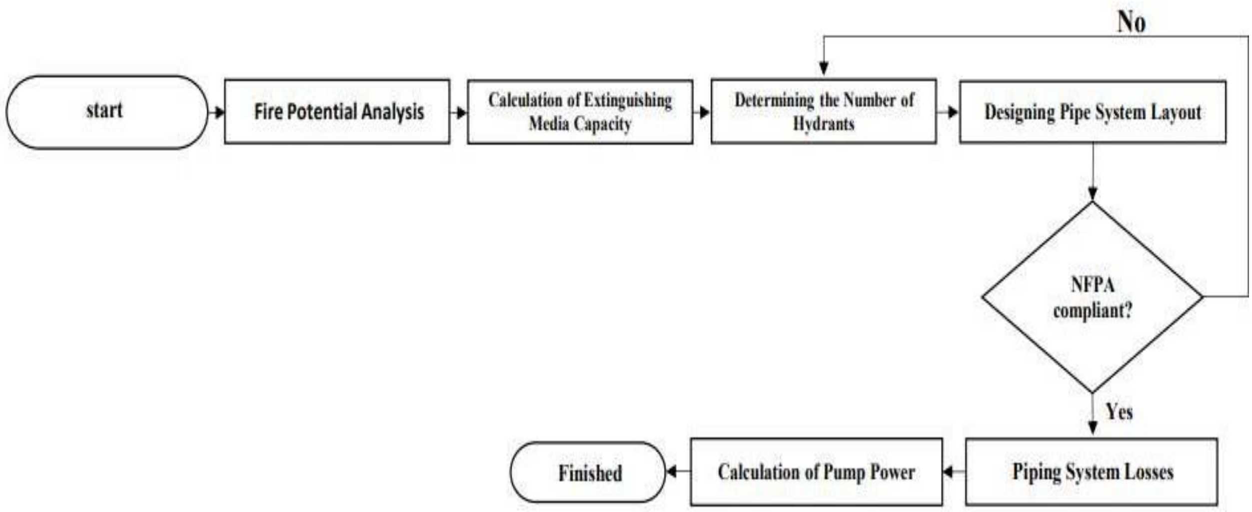

Figure 1. Flow Chart

RESULTS AND DISCUSSION

Fire Potential Analysis

The analysis of fire potential constitutes the initial phase of this research and serves as the foundation for developing an effective fire protection strategy. At this stage, a pre-fire planning process was conducted to identify potential ignition sources, combustible materials, and fire propagation pathways within the building. Pre-fire planning refers to a systematic approach for anticipating and preparing response strategies prior to the occurrence of a fire, including training, communication protocols, and coordination among emergency personnel. This stage enables the identification of high-risk zones and the formulation of operational response measures to minimize damage and ensure personnel safety.

In this study, a fire scenario was simulated in the administration room located on the first floor of the PT. XYZ Sales Area Manager Office. This room was selected due to its high concentration of electrical equipment such as computers and office devices, which present a considerable risk of ignition through short circuits. Additionally, the presence of combustible materials—including paper, wooden furniture, and plastic components—was identified as a factor contributing to rapid fire growth. Based on the scenario, it was assumed that the fire spread uncontrollably within the room and exceeded the extinguishing capability of portable fire extinguishers (APAR). Consequently, the response scenario involved the activation of three hydrant outlets, two of which were designated for direct fire suppression and one for cooling operations, to evaluate system performance and water demand under realistic fire conditions.

Calculation of Hydrant Output Speed

The distance of the hydrant beam is generated from the pressure that occurs on each floor, which flows from the pipe system, and the hose is then emitted by the nozzle. The hose used is 2.5" (63.5 mm) in diameter according to NFPA 14. As for the input diameter nozzle, adjust the hose to 2.5" with an outlet hole of 0.75" (19.05 mm). To simplify the speed calculation, the jet, in the calculation of the nozzle, is directed flat, with negligible frictional losses at the nozzle.

Calculation of Hydrant Discharge

The hydrant discharge is obtained by multiplying the velocity at the nozzle outlet and the nozzle outlet area. The amount of water supply for yard hydrants needed during a blackout, according to NFPA 14, is as follows:

- With 3 active hydrants
- Maximum limit of auxiliary hydrants up to a total of 750gpm(2839.058 liters/minute)
- Minimum volume of water required:

$$
\begin{aligned}
V &= Q \times t \\
&= 2839.058 \times 30 \\
&= 85{,}171.74 \text{ liters} \\
&= 85.171 \text{ m}^3
\end{aligned}
$$

Determine the number of hydrants

After calculating the need for extinguishing media, the next step is to determine the number and placement of hydrants. In this study, a fire hydrant was used to spray water into the combustion chamber and the surrounding rooms, which were exposed to radiation. The steps taken in determining the number and placement of hydrants. In NFPA 14, it is explained that the distance between hydrants is calculated based on the length of the hose from one hydrant to another. In other words, the distance between the hydrant pillars is 30m.

Mapping the position of the fire hydrant from the coverage area

The coverage area of the hydrant is 30m; this distance can be seen from the length of the hydrant hose, which is 30m. In the final project has been tested, a hydrant with a 10 bar nozzle has a beam length of 47.82m.

To calculate the coverage area, the following formula is used:
Coverage Area = π (Hose length + Jet length)^2

Given:
Hose length = 30 m
Jet length = 47.82 m

Then:
Coverage Area = 3.14 $(30 + 47.82)^2$
Coverage Area = 3.14 $(77.82)^2$
Coverage Area = 19,015.69 m^2
Therefore, the total coverage area is 19,015.69 m^2.

Piping system head loss calculation

After determining the location of the hydrant, the next step is to calculate the pipe head loss. Headloss in the design of this piping system consists of 2 types of headloss, namely Major Loss and Minor Loss. The large head loss is caused by frictional losses in the pipe. To calculate the friction loss between the pipe wall and the fluid flow.

Major loses

Header pipe

Pipe diameter = 6 in = 150 mm
Pipe inside diameter = 6.065 in = 154.05 mm = 0.15405 m Pipe inside diameter

$$A = \frac{3,14}{4} \times (0.15405)^2$$
$$= \frac{3,14}{4} \times (0.15405)^2$$
$$= 0.0186292$$

The average velocity of flow in the pipe, with known:

Q =750 gpm= 2839.0588 lpm
= 0.0473176 m^3

So,

$$V = \frac{Q}{A}$$
$$= \frac{0.0473176}{0.0186292} = 2.254$$

Reynolds number (Re)
Knowing:
The water temperature is 30oC, then μ=0.801× 〖10〗 ^(-6)m2/s So,
Re = (V×D)/μ
= (2.254×0.15405)/(0.801× 〖10〗 ^(-6))
= 433,494
Re > 4000, then the flow is turbulent

Friction losses in the pipe (major losses)
The average height of the Galvanized pipe roughness Re

$$= \frac{V \times D}{\mu}$$
$$= \frac{2.254 \times 0.15405}{0.801 \times 10^{-6}} = 433.494$$

Re > 4000 maka aliran bersifat turbulen Friction losses in the pipe (major losses)
The average height of the Galvanized pipe roughness ε=0.15mm
Pipe diameter (D) = 6 inches = 150 mm

Relative Roughness $= \frac{\varepsilon}{D}$

$$= \frac{0.15}{150} = 0.001$$

Friction Factor (f) = 0.021
(Based on previously known Reynolds Number and Relative Roughness) The following is the calculation of the standpipe friction loss (hf): Longest Vertical Pipe Length (L) = 7 m
Acceleration of Gravity = 9.8 $m/s2$ So,

$$hf_{mayor} = f \frac{L \times V^2}{2 \times D \times g}$$
$$= 0.021 \frac{7 \times (2.254)^2}{2 \times 0.15405 \times 9.8}$$

Standpipe

Pipe diameter = 4 in = 101.6 mm
Pipe inside diameter = 4.026 in = 102.2604 mm = 0.1022604 m Pipe inside diameter

$$A = \frac{\pi}{4} \times (D)^2$$
$$= \frac{3,14}{4} \times (0.15405)^2$$
$$= 0.0186292$$

The average velocity of flow in the pipe, with known:
Q = 750 gpm = 2839.0588 lpm
= 0.0473176 m^3

So,

$$v = \frac{Q}{A}$$
$$= \frac{0.0473176}{0.0186292}$$

= 2,254

Reynolds number (Re)
Knowing:
The water temperature is 30oC, then μ= 0.801× 〖10〗 ^(-6)m2/s So,

$$Re = \frac{v \times D}{\mu}$$
$$= \frac{2.254 \times 0.15405}{0.801 \times 10^{-6}}$$
$$= 433.494$$

Re > 4000, then the flow is turbulent

Friction losses in the pipe (major losses)
The average height of the Galvanized pipe roughness ε=0.15mm
Pipe diameter (D) =4 inch = 101.6 mm

$$Relative\ Roughness = \frac{\varepsilon}{D}$$
$$= \frac{0.15}{101.6}$$
$$= 0.001$$

Friction Factor (f) = 0.021
(Based on previously known Reynolds Number and Relative Roughness)

The following is the calculation of the standpipe friction loss (hf): Longest dividing pipe length (L) = 1.5 m
Acceleration of Gravity = 9.8 $m/s2$ So,

$$hf_{mayor} = f\,\frac{L \times V^2}{2 \times D \times g}$$
$$= 0.021\,\frac{1.5 \times (2.254)^2}{2 \times 0.1022604 \times 9.8}$$
$$= 0.0798463 \text{ m}$$

Dividing pipe
Pipe diameter = 6 in = 150 mm
Pipe inside diameter = 6.065 in = 154.05 mm = 0.15405 m Pipe inside diameter

$$A = \frac{\pi}{4} \times (D)^2$$
$$= \frac{3,14}{4} \times (0.15405)^2$$
$$= 0.0186292$$

The average velocity of flow in the pipe, with known:
Q = 750 gpm = 2839.0588 lpm
= 0.0473176 m3
So,

$$v = \frac{Q}{A}$$
$$= \frac{0.0473176}{0.0186292}$$
$$= 2.254$$

Reynolds number (Re)
Knowing:
The water temperature is 30 °C, then μ= $\mu = 0.801 \times 10^{-6}$ m^2/s So,

$$Re = \frac{v \times D}{\mu}$$
$$= \frac{2.254 \times 0.15405}{0.801 \times 10^{-6}}$$
$$= 433.494$$

Friction losses in the pipe (major losses)
The average height of the Galvanized pipe roughness ε=0.15mm
Rellative Roughness

$$= \frac{\varepsilon}{D}$$
$$= \frac{0.15}{150}$$
$$= 0.001$$

Friction Factor (f) $= 0.021$

(Based on previously known Reynolds Number and Relative Roughness)

The following is the calculation of the standpipe friction loss (hf): Longest dividing pipe length (L) = 212.5 m
Acceleration of Gravity = 9.8 $m/s2$ So,

$$hf_{mayor} = f\,\frac{L \times V^2}{2 \times D \times g}$$
$$= 0.021\,\frac{212.5 \times (2.254)^2}{2 \times 0.15405 \times 9.8}$$
$$= 7.508 \text{ m}$$

Minor losses
With known:
Pipe Diameter (D) = 6 inches = 150 mm
Pipe inside diameter = 6.065 in = 154.05 mm = 0.15405 m The loss coefficient at the gate valve(fv) = 0.45

$$hf_{minor_1} = f_v\,\frac{v^2}{2 \times g} \times jumlah\ katup$$
$$= 0{,}12\,\frac{2.254^2}{2 \times 9.8} \times 3$$
$$= 0.0933156 \text{ m}$$

Next is the calculation of the pipe bend loss. There are thirteen 90 ° turns on the dividing pipe, so to get the value of minor losses, you can use the following formula:

So,

$$hf_{minor_2} = f_v \frac{v^2}{2 \times g} \times jumlah\ katup$$
$$= 0.45 \frac{2.254^2}{2 \times 9.8} \times 13$$
$$= 1.51638 \text{ m}$$

Next is the calculation of the pipe bend loss. There are two 45 ° turns on the dividing pipe, so to get the value of minor losses, you can use the following formula:

$$hf_{minor_3} = f_v \frac{v^2}{2 \times g} \times jumlah\ katup$$
$$= 0.24 \frac{2.254^2}{2 \times 9.8} \times 2$$
$$= 0.124421 \text{ m}$$

So, the total loss of minor losses is as follows.

$$hf_{minor} = hf_{minor_1} + hf_{minor_2} + hf_{minor_3}$$
$$= 0.0933156 + 1.51638 + 0.124421$$
$$= 1.7341166 \text{ m}$$

Static Heads

Static head (Ha) is the height difference between the outside water level/nozzle ($Z2$) and the suction side ($Z1$). The static head of this hydrant installation is 2 m

Pressure Heads

Suction Pressure ($P1$) $P1 = \rho \times g \times Ha$

Where:

ρ = 995.65 $kg/m3$ (density or specific gravity of water at 30 °C)

g = 9.8 $m/s2$ (gravitational acceleration) So,

$P1$ = $\rho \times g \times Ha$

= 995.65 × 9.8 × 2

= 19,514.74 kg/m2

Pressure on the pipe installation

$P2$	= pressure for hydrants – air pressure Where :
Pressure for hydrants	= 10 bar
Air pressure = 1 atm	= 1.01325 bar
$P2$	= pressure for hydrants – air pressure
	= 10 bars – 1.01325 bars
	= 8.9865 bars
	= 91636.80 kg/m2

So,

$$\Delta hp = \frac{P_2 - P_1}{\rho \times g}$$
$$= \frac{91636{,}80 - 19.514{,}74}{995{,}65 \times 9{,}8}$$

=7,39 m

Total Head (HLT)

The total head is the sum of the total loss head, static head, and pressure head calculations. Then the calculation of the total head is as follows:

$$\text{Head total} = \sum hf_{mayor} + hf_{minor} + h_{statis} + h_{tekanan}$$
$$= 7{,}89 + 1{,}73 + 2 + 7{,}39$$

= 19,01 m

Hydrant Pump Capacity

Judging from the fire scenario, the number of standpipes that are planned to be active when a fire occurs is 3 units. Based on this plan, the calculation of the total discharsystem ise hydrant pump systemis as follows:

Total flow rate = 3 standpipes

= 500 + 250 gpm= 750 gpm

Based on the calculation of flow rate in the hydrant pump system, the fire pump capacity that can be selected is 750 gpm

Pump Power Calculation

After calculating the losses from the piping system, the next step is to calculate the pump. The first step is to calculate the NPSHA. Can be calculated by the following formula:

hydrant pressure = 10 bar = 101,9 m Hs
= 1 m
Hd = 1,5 m
Hf = 19,01 m
Hi = 0,35 m

HA = NPSH + Loses
HA = Hs + Hd + hydrant pressure + Hf + Hi
HA = 1 + 1,5 + 101,9 + 19,01 + 0,35 = 123,76 m

Maximum Pump Power (Pw)

Pw = 0,163 × γ × Q × HA

γ = determining the specific gravity of water per unit volume = 9,765 $kN/m3$
Q = 0,0473176 $m3/s$ HA =
123,76 m
Maka,
Pw = 0,163 × γ × Q × HA
= 0,163 × 9,765 $kN/m3$×0,0473176 $m3/s$ × 123,76 m
= 9,32 kW = 12,5 hp

$$P = \frac{P_w}{np}$$

Maximum shaftpower (P)

When:
np = centrifugal pump standard efficiency = 80%
P = Maximum shaft power
P_w = maximum pump power

$$P = \frac{P_w}{np}$$

$$P = \frac{12{,}5}{80\%}$$

$$P = 15{,}6\ hp$$

CONCLUSION

From the results of the design of the hydrant pillar installation that has been carried out, conclusions can be drawn. The capacity of the extinguishing media needed to tackle fires in the sales area manager building is 85,171 liters of water. Based on NFPA 14 for the sales area manager building, the number of hydrant pillars needed to protect the building from fire hazards is 5. The required pump power for pillar hydrant installation is 12.54 hp. The pipe installation used is above the ground and surrounds the building.

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