International Journal of
Innovation in Mechanical Engineering & Advanced Materials (IJIMEAM)
https://publikasi.mercubuana.ac.id/index.php/ijimeam

Vol.5 (No.2). 2023. pp. 49-55
Published online: December 26, 2023
ISSN: 2477-541X

ANALYSIS OF FIRE FIGHTING PUMP PERFORMANCE USING SNI 03-6570-2001 STANDARD ON SELF-CONTAINED HYDRANTS

A. Auf[1], A. W. Biantoro[2], D. Romahadi[1,3], and A. Chaeroni[4]*

[1]Department of Mechanical Engineering, Universitas Mercu Buana, Kembangan, Jakarta 11650, INDONESIA
[2]Department of Civil Engineering, Universitas Mercu Buana, Kembangan, Jakarta 11650, INDONESIA
[3]School of Mechanical Engineering, Beijing Institute of Technology, Beijing 100811, CHINA
[4]Department of Aeronautical Engineering, Universitas Dirgantara Marsekal Suryadarma, Komp. Bandara Halim Perdana Kusuma, Jakarta 13610, INDONESIA

Abstract

Self-controlled hydrants are fire protection systems located in residential areas that function for early fire extinguishing. In a fire protection system, the pump plays an important role in supplying water from the reservoir to the end point of the installation. Fire pumps must always be in optimum condition and accordance with applicable standards. This study aims to analyze pump performance at current conditions in self-contained hydrants in the Palmerah District and then compare it with the performance that pumps should have in ideal conditions according to SNI 03-6570-2001 standards. The method used is a quantitative descriptive analysis method by comparing the current condition of the pump with applicable standards and conducting a direct survey of the location of the installed fire pump. The measuring instruments used in the study were a pressure gauge, control box, and pitot gauge. The results obtained through testing and calculating pump performance The pump installed on the self-contained hydrant in actual conditions with a total head of 86.62 m produces a flowrate of 0.0189 m^3/s at 2800 RPM and can flow a maximum flowrate of 0.0284 m^3/s with a head of 66.94 m while in ideal conditions with approximately the same speed and total pump head of 88.83 m, The pump produces a flow rate of 0.0473 m^3/s and can produce a maximum flowrate of 0.0710 m^3/s with a head of 71.81 m and when shut-off (Q = 0) at actual and ideal conditions produces a same total pump head 94.10 m. However, the pump in actual conditions can flow a minimum flowrate required of 0.040 m^3/s with a pressure required of 350 kPa at 3000 RPM with a total pump head of 108.52 m. Thus, the pump must operate heavier due to the higher total head to deliver the required minimum flow rate and pressure.

Keywords: Flowrate, Head, Hydrants, Pump

*Corresponding author: Tel. +62 21 5840815 Ext. 5200
E-mail address: abdurrahmanauf08@gmail.com

DOI: 10.22441/ijimeam.v5i2.20898

1. Introduction

Fire is a disaster that can cause large losses, both casualties and material losses and cannot be predicted when it comes. Fires can occur anywhere and anytime, including densely populated areas. DKI Jakarta Regional Regulation No. 8 of 2008, supported by DKI Jakarta Governor Regulation No. 143 of 2016 concerning Prevention and Control and Fire Safety Management, has regulated residential buildings, whether organized or not, must be equipped with fire prevention and suppression facilities and infrastructure. Based on research [1], the West Jakarta area, especially Palmerah, has a fairly high level of fire risk with a heavy classification (66.2%) with 59 cases throughout 2021[2]; this occurs due to high population density with inappropriate building separation distances and difficult access. All equipment and facilities in the fire protection system must be by applicable standards. Standard orientation is crucial, especially regarding Security, Health, Safety and Environmental Conservation [3]. As in [4], the fire protection system fails to extinguish the fire due to equipment and equipment not complying with applicable standards. The existence of self-contained hydrants in densely populated settlements is very important so that early extinguishing can be carried out when a fire occurs [5]. In addition, the reliability of the pump, which is an important factor in distributing water, must always be maintained in the best condition by applicable standards. If the pump does not operate in its best condition, it can cause pump malfunction [6].

An analysis related to the performance of the fire pump must be tested with flow condition annually [7]

International Journal of
Innovation in Mechanical Engineering & Advanced Materials (IJIMEAM)
https://publikasi.mercubuana.ac.id/index.php/ijimeam
Vol.5 (No.2). 2023. pp. 49-55
Published online: December 26, 2023
ISSN: 2477-541X

so that the pump is always in the best condition and existing problems such as rust, pipe leaks, and so on can be detected so that earlier and faster countermeasures can be taken.

Similar research that has been done on [5] the self-contained hydrant in North Kedoya, it was found that some leaks and blockages reduce performance. This paper aims to analyze the performance of centrifugal pumps installed in the self-contained hydrants at Palmerah District using SNI 03-6570-2001 standards by considering the headloss that occurs and variations in different speeds. Centrifugal pumps are pumps that use rotation speed to increase pressure in the fluid [8]. The final results obtained are expected to be a reference for the fire management service tribe in determining the right action before the failure of the self-contained hydrant function. They can ensure that the pumps used today are still in accordance or not with applicable standards. An analysis related to the performance of the fire pump must be tested with flow condition annually [7] so that the pump is always in the best condition and existing problems such as rust, pipe leaks, and so on can be detected so that earlier and faster countermeasures can be taken.

A decline in the operational efficiency of a fire pump, attributed to issues within the hydrant installation, has the potential to impede the requisite flow rate and pressure essential for effective firefighting. Addressing this concern necessitates a comprehensive analysis in accordance with the SNI 03-6570-2001 standards. Evaluating the actual performance of a fire pump under realistic conditions involves testing parameters such as flow rate and minimum head. This empirical data is subsequently juxtaposed with the benchmark pump performance outlined in the SNI 03-6570-2001 standards, establishing a basis for comparison.

The identification of disparities between the observed performance and the ideal parameters stipulated by standards enables the formulation of targeted solutions. Analyzing the discrepancies facilitates a nuanced understanding of the root causes behind the diminished performance of fire pumps. Consequently, tailored interventions can be devised to rectify issues within the hydrant installation, ensuring the restoration of optimal flow rates and pressures as per the stipulated standards. This methodical approach aligns with the imperative of SNI 03-6570-2001, providing a systematic framework to enhance the functionality and reliability of fire pumps in critical scenarios.

2. Experimental and Procedures

The method used in this study is a quantitative descriptive analysis method by comparing pump performance in actual conditions with pump performance at ideal conditions; actual conditions are defined as conditions at the time of testing with data obtained from testing, while ideal conditions are defined as conditions that should be owned by pumps by SNI-03-6570-2001 standards.

2.1 Data Experiment Process

The data collection process will be carried out with water working fluid assuming a water temperature of 30 degrees Celsius and a driving

Fig. 1. RPM indicator in Control Box

Fig. 3. Pressure Indicator on Pressure gauge

Fig. 4. Output pressure indicator on pitot

Vol.5 (No.2). 2023. pp. 49-55
Published online: December 26, 2023
ISSN: 2477-541X

Table 1. Pump Test Results

Speed	**Pressure**	**Flowrate**	**Static Head (hs)**
RPM	Kpa	m^3/s	m
2400	350	0.0284	2
2600	550	0.0227	2
2800	750	0.0189	2
2900	850	0.0142	2
3200	1000	0.0002	2

engine temperature of 75 ^{O}C with a 2400-3200 RPM drive engine speed. Adjustment of the pump's rotational speed was chosen because it is the most efficient method of controlling the flow rate [9]. In data retrieval, all values obtained are recorded to facilitate analysis. The process at this stage includes:

a. Checking the engine speed and temperature through the control box when the pump works (Fig.1.)
b. Checking water pressure on a pressure gauge (Fig.2.)
c. Checking flow rate using a flowmeter.
d. Checking the pressure coming out of the tip of the nozzle using a pitot (Fig.3.)

2.2 Data Analysis Process

In the next process, data analysis, the data obtained from the pump test results will be compared with the ideal data that should be owned by the pump as explained in the SNI 03-6570-2001 standard, namely the pump must be equipped with at least 150% of the nominal pump capacity at least 65% of the total nominal head and the head at closing time must not exceed 140% of the nominal head [10]. So, whether the pump is still in ideal condition can be known.

2.3 Technical Specification

Water
Water source : Groundwater
Capacity : 30 m^3

Pump
Model : EBARA 125 x 100 FS JCA
Type : Centrifugal End Suction
Capacity : 0.0473 m^3/s
Head rated : 85 m
Rated speed : 2.900 RPM
Pipe Installation Length : ± 900 m
Furthest Installation pipe length : 310 m
Suction Pipe Diameter : 0.1016 m
Discharge Pipe Diameter : 0.1016 m

Drive engine:
Model : Isuzu 4BD-Z
Types of machines : 4 stroke
Fuel : Solar (diesel)
Cooling system : Radiator
Power : 2 Accu 24 Volt, 80 amp
Cylinder : 4
Starter : Electric
Fuel Volume : 0.1 m^3
Power : 90 Kw

3. Results and Discussion

3.1 Test Result

After testing the pump at self-contained hydrant, the data will be obtained to calculate the total head presented in Table 1.

3.2. Total Head Pump Calculation at Actual Conditions

In determining the total pump head in actual conditions, it is necessary to calculate the pressure head, velocity head, and head loss using data obtained in actual conditions [11]. The following is an example of calculating the total pump head with a flow rate of 0.0189 m^3/s.

A. Pressure Head

Head pressure is the pressure difference on the suction and compressive sides and can be determined using equation 1 [12].

$$\frac{P}{\rho g} = \frac{P_s}{\rho g} \pm \frac{P_d}{\rho g} \tag{1}$$

Assuming the pressure on the suction side is equal to atmospheric pressure, thus the pressure head is:

$$h_p = \frac{750\ Kpa - 101.32\ Kpa}{998\ {kg}/_{m^3} \times 9.8\ {m}/_{s^2}} = 66.48\ m$$

B. Velocity Head

Head velocity is caused by the velocity fluids in pipe at discharge and is formulated with [13];

$$h_v = \frac{{v_d}^2}{2g} \tag{2}$$

With the value velocity obtained through the calculation of capacity divided by the cross-sectional area [14] then the velocity head is;

Vol.5 (No.2). 2023. pp. 49-55
Published online: December 26, 2023
ISSN: 2477-541X

$$h_v = \frac{2.18^{2} m/_{s}}{2 \cdot 9.8 m/_{s^2}} = 0.243\ m$$

C. Head loss

Head loss is an energy loss that occurs due to friction along the installation pipe and pipe fittings [15]; the calculation of total head loss in actual conditions with RPM 2400-3200 will be shown in Table 2.

Table 2. Total Head Loss on Actual Conditions

Speed	Flowrate	Major losses	Minor Losses	Total Head Loss (hl)
RPM	m^3/s	m	m	m
2400	0.0284	23.793	15.115	38.908
2600	0.0227	15.731	9.674	25.405
2800	0.0189	11.183	6.718	17.901
2900	0.0142	6.540	3.779	10.318
3200	0.0002	0	0	0

D. Total Head Pump

The total pump head is the sum of the static head, pressure head, velocity head and head loss [16]; the calculation of the total pump head can be seen in Table 3 below;

Table 3. Actual Total Head Pump

Speed	Head				
	hs	hv	hp	hl	Total
RPM	m				
2400	2	0.5471	25.487	38.908	66.943
2600	2	0.3502	45.985	25.405	73.741
2800	2	0.2432	66.484	17.901	86.628
2900	2	0.1368	76.733	10.318	89.188
3200	2	0	92.107	0	94.107

3.4. *Total Head Pump Calculation at Ideal Condition*

The calculation of the total head pump at ideal conditions has the same stages as the calculation of the pump at actual conditions; the difference is in ideal conditions, rated capacity, piping diameter and rated head will be based on SNI standard 03-6570-2001 and factory data, it is known that pumps with a capacity of 0.0473 m^3/s must use pipes with a diameter of 0.1524 m [10]; if referring to factory data, The pump has a rated head of 85 m with a rated capacity of 0.0473 m^3/s. So that the data to be used with the same speed and pressure as the actual conditions of 2400-3200 RPM will be shown in Table 4.

Table 4. Data at Ideal Conditions

Speed	Pressure	Flowrate	hs
RPM	Kpa	m^3/s	m
2400	350	0.0710	2
2600	550	0.0568	2
2800	750	0.0473	2
2900	850	0.0355	2
3200	1000	0.0005	2

With the data obtained from standard and factory, there will be different data from the resulting velocity head and total head loss; this will affect the total head of the pump. The total head pump at ideal conditions will be shown in Table 5 and Fig. 5.

From the calculation of the pump at ideal conditions, it can be seen that a very significant difference when compared to actual conditions, with head 85 m that flowrate produced by the pump at ideal

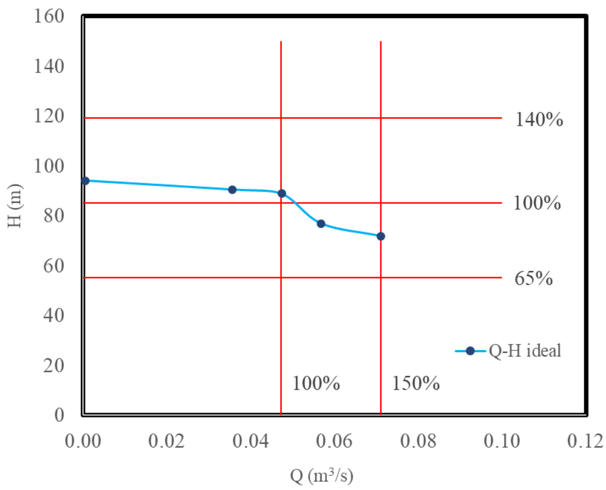

Fig. 5. Performance Graph (Q vs H) of Pump at Ideal Conditions

Table 5. Ideal Total Head Pump

Speed	Head				
	hs	hv	hp	hl	Total
RPM	m				
2400	2	0.7283	25.487	43.602	71.818
2600	2	0.4661	45.985	28.411	76.863
2800	2	0.3237	66.484	20.028	88.836
2900	2	0.1822	76.733	11.571	90.486
3200	2	0	92.107	0	94.107

Vol.5 (No.2). 2023. pp. 49-55
Published online: December 26, 2023
ISSN: 2477-541X

conditions is much greater than in actual conditions.

In testing the performance of fire pumps for all types of pumps, there are general requirements that fire pumps must own. The fire pump must meet these three requirements so that the pump can extinguish the fire in the event of a fire. In the Indonesian National Standard or SNI with number 03-6570-2001 and then strengthened by the National Fire Protection Association or NFPA 20 2019 edition three requirements must be met for every fire pump performance test. The three requirements are as follows:

- Each pump used in a fire protection system must deliver a capacity greater than or at least equal to 150% of its nominal capacity.
- The pump head value at a flow rate of 150 percent must be 65% greater than the nominal pump head.
- The value of the pump head when the flow capacity = 0 must not exceed 140% of the nominal pump head

3.5 Pump Performance at Actual and Ideal Conditions

Based on the test results and calculations of pump performance installed at ideal conditions, a pump performance graph is obtained to compare pump performance at actual conditions. Here is a graph of pump performance that should be owned by the pump at ideal conditions.

From the test results and calculation of pump performance at ideal conditions shown in Fig.6, it can be seen that at ideal conditions, the pump with head 88.83 m should be able to flow a flowrate of 0.0473 m^3/s with maximum flowrate 0.0710 m^3/s with head of 71.81 m and when shut-off (Q = 0) head at ideal conditions is 94.10 m. At the same time, the fire pump performance in actual conditions has obtained flowrate data at head 86.62 m(rated), which is 0.0189 m^3/s, the graph of fire pump performance in actual conditions.

Based on test data and calculation of pump performance in actual conditions shown in Fig. 7., it can be seen that the fire pump is only able to flow a maximum flow rate of 0.0284 m^3/s with a head of 66.94 m. When shut off (Q = 0), the pump has a head of 94.10 m because the pressure used in ideal and actual conditions is the same.

3.6. Comparison of Pump Performance on Actual and Ideal Conditions

The performance of fire pumps in actual conditions and ideal conditions must be compared to see a decrease in performance that occurs, with differences in flowrates and total pump heads in two different conditions causing significant differences in pump performance.

The graph in Fig. 5 shows a very significant difference between pump performance in actual conditions and pump performance in ideal conditions; the most significant difference between the two conditions is the flow rate. It is because the author wants to see the difference that occurs in the pump at the same pressure or head; in actual conditions, the fire pump is unable to deliver water more than or equal to 150% of the nominal capacity of the pump at ideal conditions, even fire pumps are unable to drain water according to the nominal capacity of the pump.

Based on the author's analysis, the reason the pump is not able to produce a flowrate by the standard is because of the use of inappropriate pipes; if referring to the SNI 03-6570-2001 standard, pumps with a capacity of 0.0473 m^3/s must use a pipe diameter of 0.1524 m, while the pipe installed in the installation with a diameter of 0.1016 m, it will affect the head loss that occurs along the piping installation if the pump is

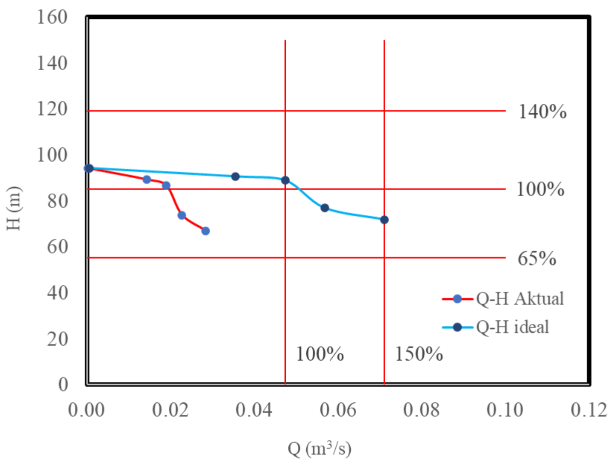

Fig. 6. Performance comparison Q vs H of pump at actual and ideal conditions

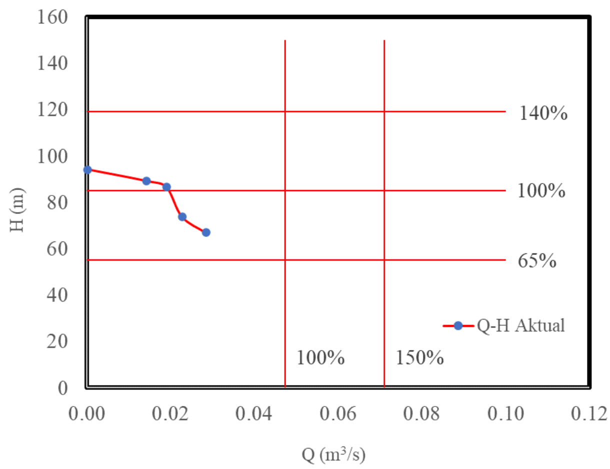

Fig. 7. Performance Graph (Q vs H) of Pumps at Actual Conditions

forced to flow a flowrate of 0.0473 m^3/s, what happens is that the total pump head will be higher due to the head loss that occurs.

However, if analyzed further, the reason for using a 0.1016 m pipe in a Hydrant is that a hydrant requires adequate pressure and an appropriate flow rate. If you look at the pump performance graph under actual conditions in Fig. 7, it can be seen that the pump can reach the required pressure by the applicable standards; this is indicated by the head still falling within the standard criteria of SNI 03-6570-2001. If the pump is forced to deliver a minimum flowrate of 0.040 m^3/s with a pressure of 350 kPa by the SNI 03-1735-2000 standard regarding outdoor hydrants located in residential areas, then with the same calculation stages, the resulting total pump head is 108.52 m at 3000 RPM, the total head is dominated by the head loss that occurs along the pipe. Thus, the pump installed in actual conditions can deliver the minimum flow rate with the required pressure, but due to the high total head, a high speed is also required. More frequent and intense care and maintenance of the pump is required so that the pump is always at its optimum condition. Another reason for using a 0.1016 m pipe is because the pipe is more economical than a 0.1524 m.

When compared with previous research conducted with the same pump specifications on North Kedoya self-contained hydrants, it was found that the pump produced a flow rate of 0.0475 m^3/s with an output pressure of 3 bar [5]. Still, the calculation did not consider the head loss that occurred due to the length of the pipe; in another study conducted in the South Processing Unit field, a fire pump with a nominal flowrate of 672.18 m3 / hour at a nominal head of 110 m is only able to flow a flowrate of 450.5 m^3/hour at the same head, this is due to the high silting of the water surface so that dredging with the airlift technique is needed.

4. Conclusion

The fire pump that is installed on a self-contained hydrant is capable of delivering the required pressure and flow rate, but the performance of the pump can be improved if using a pipe diameter according to predetermined recommendations; in order for the pump to remain optimal, more intense maintenance is needed.

The outcomes derived from the process of testing and calculating the efficiency of the pump. The pump, when operating under real conditions, achieves a flowrate of 0.0189 m3/s at 2800 RPM and a total head of 86.62 m. It has the capacity to reach a maximum flowrate of 0.0284 m3/s at a head of 66.94 m. Under ideal conditions, with a similar speed and total pump head of 88.83 m, the pump performs similarly. The pump has a flowrate of 0.0473 m3/s and can reach a maximum flowrate of 0.0710 m3/s. It operates with a head of 71.81 m and when shut-off (Q = 0), it produces a total pump head of 94.10 m under both actual and ideal conditions. Nevertheless, the pump is capable of maintaining a minimum flowrate of 0.040 m3/s under real operating conditions. This requires a pressure of 350 kPa, a rotational speed of 3000 RPM, and a total pump head of 108.52 m. Therefore, the pump needs to work with more force because of the increased total head, in order to achieve the necessary flowrate and pressure.

References

[1] Cahyadi, A., Lestari, F., & Kadir, A. (2022). Analisis tingkat risiko bencana kebakaran wilayah Jakarta Barat, Provinsi DKI Jakarta. *Prepotif: Jurnal Kesehatan Masyarakat*, *6*(1), 468-477.

[2] BPS Kota Jakarta Barat (2020). *Jumlah peristiwa kebakaran menurut Kecamatan 2017-2019*. (accessed Mar. 03, 2023). jakbarkota.bps.go.id, 2022. https://jakbarkota.bps.go.id/indicator/34/245/1/jumlah-peristiwa-kebakaran-menurut-kecamatan.html

[3] Badan Standarisasi Nasional (2022). *Waspada bahaya kebakaran, ini pentingnya alat pemadam api ber-SNI*. (accessed Nov. 02, 2022). https://www.bsn.go.id/main/berita/detail/13112/waspada-bahaya-kebakaran-ini-pentingnya-alat-pemadam-api-ber-sni

[4] CNN Indonesia (2020). *Pakar: Kebakaran kejagung, kegagalan fatal sistem keselamatan*. (accessed Nov. 02, 2022). https://www.cnnindonesia.com/nasional/20200823133834-20-538332/pakar-kebakaran-kejagung-kegagalan-fatal-sistem-keselamatan

[5] Wijayanto, E. (2022). *Analisis kinerja pompa pada jaringan hidran mandiri di Kedoya Utara Jakarta Barat* [Thesis]. Universitas Mercu Buana.

[6] Biantoro, A. W., Darmono, B., & Pranoto, H. (2022). Performance analysis of DN1750 and DN1800 electric submersible pump for production optimization on the oil well. *International Journal of Advanced Technology in Mechanical, Mechatronics and Materials*, *3*(1), 39-52.

[7] National Fire Protection Association (2022). *NFPA 25: Standard for the inspection, testing,*

Vol.5 (No.2). 2023. pp. 49-55
Published online: December 26, 2023
ISSN: 2477-541X

and maintenance of water-based fire protection systems.

[8] Fitri, M., & Rizqiansyah, F. (2022). Design of frame for the pump performance test equipment using VDI 2221 method. *Int. J. Innov. Mech. Eng. Adv. Mater*, *4*(1), 17.

[9] Zisopoulos, A., & Razis, D. (2017). The pipe-pump integration in the “Airborne pipeline docked to an earth reservoir to deliver water over long distance for aerial firefighting and irrigation” system. *American Journal of Environmental and Resource Economics*, *2*(2), 56-61.

[10] Badan Standarisasi Nasional (2001). *SNI 03-6570-2001: Instalasi Pompa Yang Dipasang Tetap Untuk Proteksi Kebakaran.*

[11] Sularso, & Tahara, H. (2000*). Pompa & kompresor: Pemilihan, pemakaian dan pemeliharaan.* PT Pradnya Paramita.

[12] Caisasworo, I. (2020). *Analisis sistem hydrant kebakaran pada kawasan industrial* [Thesis]. Universitas Mercu Buana.

[13] Gunawan, G. (2018). Analisa performansi fire pump DEP-0131-A dengan standar NFPA 20 pada lapangan south processing unit. *Transmisi*, *14*(1), 237-243.

[14] Arifin, A. S., Sahupala, P., & Parenden, D. (2014). Analisis Instalasi Pompa Pemadam Kebakaran Pada Kompleks Terminal Bahan Bakar Minyak Merauke. *Mustek Anim Ha*, *3*(3), 267-284.

[15] Wibowo, A. S., Mahendra, T. S. S. I., Fitri, M., & Romahadi, D. (2022). Tinjauan Penelitian Tentang Simulasi Penurunan Tekanan Akibat Rugi–Rugi Aliran Pada Instalasi Pipa. *Jurnal Teknik Mesin*, *11*(3), 216.

[16] ART, R. (2009). *Perancangan ulang instalasi pipa sistem pemadam kebakaran pd gedung CCV dan perkantoran PT Sumi Indo Kabel Tbk Tangerang* [Thesis]. Universitas Mercu Buana.