20898 Rev. 20230902

by Abdurrahman Auf

Submission date: 03-Sep-2023 05:45PM (UTC+0700)
Submission ID: 2156690610
File name: 20898-65929-1-ED.docx (398.13K)
Word count: 3025
Character count: 14532

Self Contained Hydrants are fire protection systems located in residential areas that function for early extinguishing of a fire. 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 in accordance with applicable standards. This study aims to analyze pump performance at current conditions in self contained hydrants in the Palmerah sector 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 to the location of the installed fire pump. The measuring instruments used in the study were pressure gauge, control box and pitot gauge. The results obtained through testing and calculating pump performance The pump installed on the selfcontained 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 is able to 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 flowrate of 0.0473 m^3/s and is able to 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, 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 in order to deliver the minimum flowrate and pressure required.

Keywords: Flowrate, Head, Hydrants, Pump

*Corresponding author: +6281808389214
E-mail address: abdurrahmanauf08@gmail.com

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 in accordance with applicable standards. Standard orientation is very important, especially when it comes to Security, Health, Safety and Environmental Conservation [3]. As in [4], the fire protection system fails to extinguish the fire due to equipment and equipment that does not comply 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 in accordance with applicable standards. If the pump does not operate at its best condition it can cause pump malfunction [6].

basically an analysis related to the performance of the fire pump must be tested with flow condition annualy [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

like research that has been done on [5] the self contained hydrant in north kedoya, it was found that there are leaks and blockages that reduce performance. This paper aims to analyze the performance of centrifugal pumps installed in the self contained hydrants at palmerah 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 and can ensure that the pumps used today are still in accordance or not with applicable standards.

1.1 Problem

- A decrease in the performance of the fire pump due to problems that occur on installation hydrants can disrupt the flowrate and pressure required during a fire so that it needs to be analyzed according to SNI 03-6570-2001 standards.

1.2. Purpose

- Knowing the performance of a fire pump under actual conditions during testing which consists of flowrate and minimum head then comparing it with the ideal pump performance that should be owned by a pump based on SNI 03-6570-2001 standards and provide solutions to problems that occur when performance fire pumps are decreased.

2. Methodology

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 in accordance with SNI-03-6570-2001 standards. The flow this Research will be shown in the flow chart in *Fig. 1.* Below

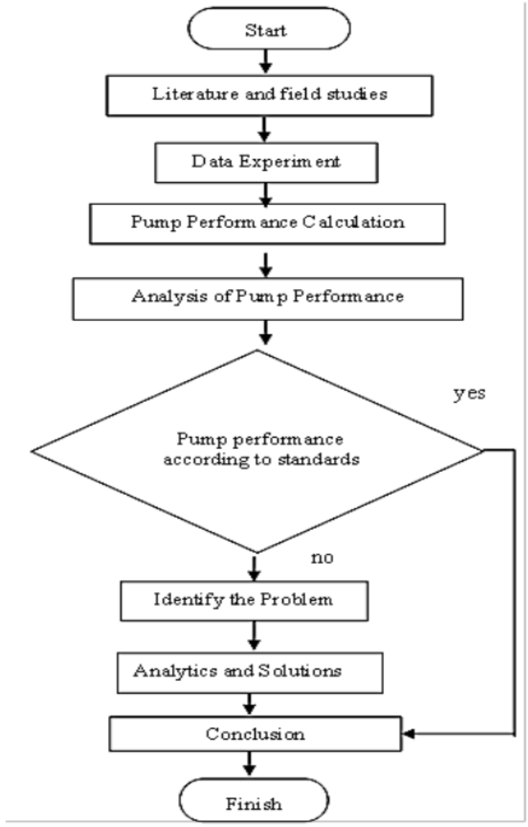

Fig. 1. Flow Chart

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

A. Checking the engine speed and engine temperature through the control box when the pump is working (*Fig.2.*)

Fig. 2. RPM indicator in Control Box

B. Checking water pressure on a pressure gauge (*Fig.3.*)

Fig. 3. Pressure Indicator on Pressure gauge

C. Checking Flowrate using a flowmeter.

D. Checking the pressure coming out of the tip of the nozzle using a pitot (*Fig.4.*)

Fig. 4. Output pressure indicator on pitot

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 it can be known whether the pump is still in ideal condition or not ideal

2.3 Technical Installation Data

A. Water
Water source : Groundwater
Capacity : 30 m^3

B. 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 specifications:
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. Result and Discussion

3.1 Test Results

After testing the pump at Palmerah self contained hydrant, the data will be obtained to be used for the calculation of the total head presented in *Table 1*:

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

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 headloss [11] using data obtained in actual conditions. The following is an example of calculating the total pump head with a flowrate of 0.0189 m^3/s.

A. Pressure Head

Head pressure is the pressure difference on the suction side and compressive side and can be found using equation 1 [12]

$$\frac{P}{\rho g} = \frac{P_s}{\rho g} \pm \frac{P_d}{\rho g} \quad (1)$$

Assuming the pressure on the suction side is equal to atmospheric pressure so 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]

$$h_v = \frac{{v_d}^2}{2g} \quad (2)$$

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

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

C. Headloss

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

Table 2. Total Headloss on Actual Conditions

Speed	Flowrate	Major losses	Minor Losses	Total Headloss (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 static head, pressure head, velocity head and headloss [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 Conditions

In the calculation of the total head pump at ideal conditions have 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 5*.

Table 5. 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, so that there will be different data from the resulting velocity head and total headloss, this will affect the total head of the pump. Total head pump at ideal conditions will be shown in *Table 6*

Table 6. 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

From the calculation of the pump at ideal conditions, it can be seen that a very significant difference when compared to actual conditions, with a more or less head (85 m) that flowrate produced by the pump at ideal 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 must be owned by fire pumps. These three requirements must be met by the fire pump so that the pump is able to 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 there are three requirements that must be met for every fire pump performance test. The three requirements are as follows:

- Each pump used in a fire protection system must be capable of delivering a capacity greater than or at least equal to 150% of its nominal capacity.
- The pump head value at a flowrate 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 so that it can be a comparison for pump performance at actual conditions. Here is a graph of pump performance that should be owned by the pump at ideal conditions

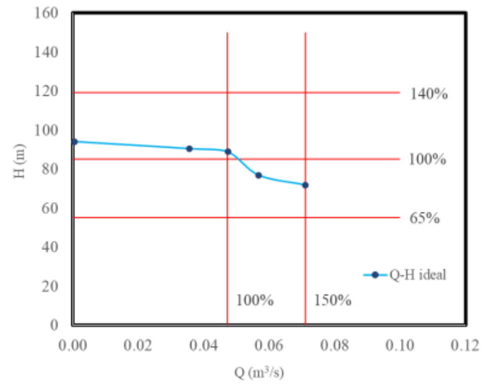

Fig. 6. Performance Graph (Q vs H) of Pump at Ideal Conditions

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. While the performance of the fire pump 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 is as follows:

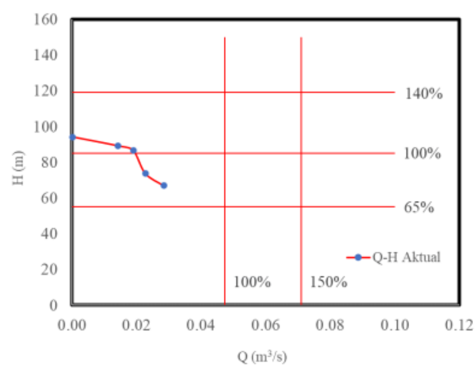

Fig. 7. Performance Graph (Q vs H) of Pumps at Actual Conditions

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 flowrate of 0.0284 m^3/s with a head of 66.94 m and 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, here is a comparison of fire pump performance graphs at actual and ideal conditions;

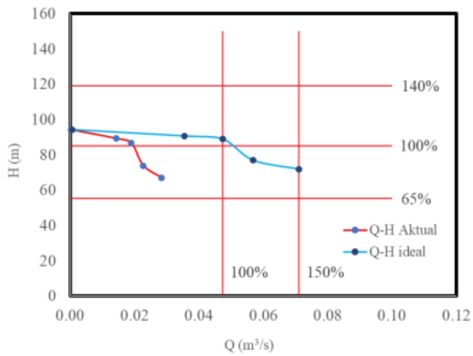

Fig. 8. Comparison of Pump Performance at Actual and Ideal Conditions

In the graph in *Fig. 8* you can see 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 flowrate,its 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 in accordance with 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 headloss that occurs along the piping installation, if the pump is 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 headloss that occurs.

However, if analyzed further, the reason for using a 0.1016 m pipe in Hydrant is because basically a hydrant requires adequate pressure and of course with an appropriate flowrate. If you see at the pump performance graph under actual conditions in *Fig. 7* it can be seen that the pump is able to reach the required pressure in accordance with 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 in accordance with 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 headloss that occurs along the pipe, thus the pump installed in actual conditions is actually capable of delivering the minimum flowrate with the required pressure, but due to the high total head, a high speed is also required. about more frequent and more 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 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 was able to produce a flowrate of 0.0475 m^3 / s with an output pressure of 3 bar, but the calculation did not consider the headloss 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 m^3 / 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 installed on an self contained hydrant is capable of delivering the required pressure and flowrate, 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.

20898 Rev. 20230902

ORIGINALITY REPORT

0%	0%	0%	0%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

Exclude quotes	Off	Exclude matches	< 17 words
Exclude bibliography	Off		