

## Study of Pump Driving Motors at PERUMDA Tirta Taman in Bontang City

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**ABSTRACT:** A pump driving motor is an electric motor utilized to operate water pumps. At PERUMDA Tirta Taman, Bontang City, six motors and three pumps are employed, where the submersible pump motor functions to extract raw water from wells, the feed pump transfers water to the clarifier tank, the dosing pump supplies chemical reagents, the backwash pump and root blower are used for cleaning the filtration tank, and the distribution pump delivers treated water to consumers.

Field measurements show that the main protection for the submersible pump motor is a 160 A MCCB, whereas the calculated rating is 290 A. The main protection for the feed pump and backwash pump (1 and 2) in the field uses a 100 A MCCB, while calculations show 73.5 A and 72.5 A. The dosing pump motor uses a 6 A MCB in the field, with a calculated value of 3.6 A. The root blower motor utilizes a 20 A MCB in the field, while its calculated rating is 30.75 A. The distribution pumps (1 and 2) use a 125 A MCCB, whereas the calculated protection rating is 202.5 A.

For the conductor sizing, a  $4 \times 35 \text{ mm}^2$  NYY cable is installed for the submersible motor, while its calculated ampacity is 145 A. The dosing motor uses a  $3 \times 2.5 \text{ mm}^2$  NYY cable with a calculated capacity of 1.8 A. The feed pump and backwash pump use a  $4 \times 6 \text{ mm}^2$  NYY cable, with calculated ampacities of 36.75 A and 36.25 A, respectively. The root blower uses a  $4 \times 2.5 \text{ mm}^2$  NYY cable with a calculated rating of 15.37 A, and the distribution pump (1 and 2) uses a  $4 \times 25 \text{ mm}^2$  NYY cable with a calculated rating of 101.25 A.

**KEYWORDS:** Backwash Pump, Distribution Pump, Dosing Pump, Feed Pump, Induction Motor, Pump Driving Motor, Submersible Pump, Water Treatment Process.

### I. INTRODUCTION

Clean water is an essential requirement for sustaining life, and therefore, its utilization must be managed properly to ensure public welfare. One of the efforts to optimize the use of water resources is conducted by PERUMDA Tirta Taman Bontang, a regional water utility company responsible for supplying clean water to local communities. The management of clean water distribution plays a crucial role in maintaining quality standards and requires reliable infrastructure to guarantee a continuous and safe water supply to consumers [1].

With technological advancements in modern industrial practices, there has been significant development in various sectors, including water supply systems. Motor efficiency, component failures, and pump leakage are among the technical issues that frequently occur in water treatment operations. As a regional water supplier, PERUMDA Tirta Taman Bontang encounters challenges in optimizing the performance of pump driving motors used for raw water treatment and distribution [2].

In the clean water treatment process, multiple pump driving motors support each stage of operation. The submersible pump extracts raw water from the well, the feed pump transfers water to the clarifier tank, the dosing pump injects chemical reagents, the backwash pump and root blower are utilized for cleaning filtration systems, and the distribution pump delivers treated water to consumers [2][3][4].

To support public demand, clean water facilities must be equipped with adequate motor-driven pumping systems to ensure effective processing and distribution. As water demand increases, the pumping system at the Water Treatment Plant (WTP) must be upgraded according to operational requirements [5]. Therefore, PERUMDA Tirta Taman Bontang serves as a suitable research location to study the operational principles, protection devices, and performance of pump driving motors.

Based on the aforementioned conditions, this research is entitled:

“Study of Pump Driving Motors at PERUMDA Tirta Taman in Bontang City.”.

**II. RESEARCH METHODOLOGY**

**A. Research Location and Schedule**

This study was conducted at PERUMDA Tirta Taman, Water Treatment Plant (WTP) 1 Lhoktuan, located on Slamet Riyadi Street, Lok Tuan District, North Bontang, East Kalimantan, Indonesia. The research activities were carried out from February 2024 to June 2024.

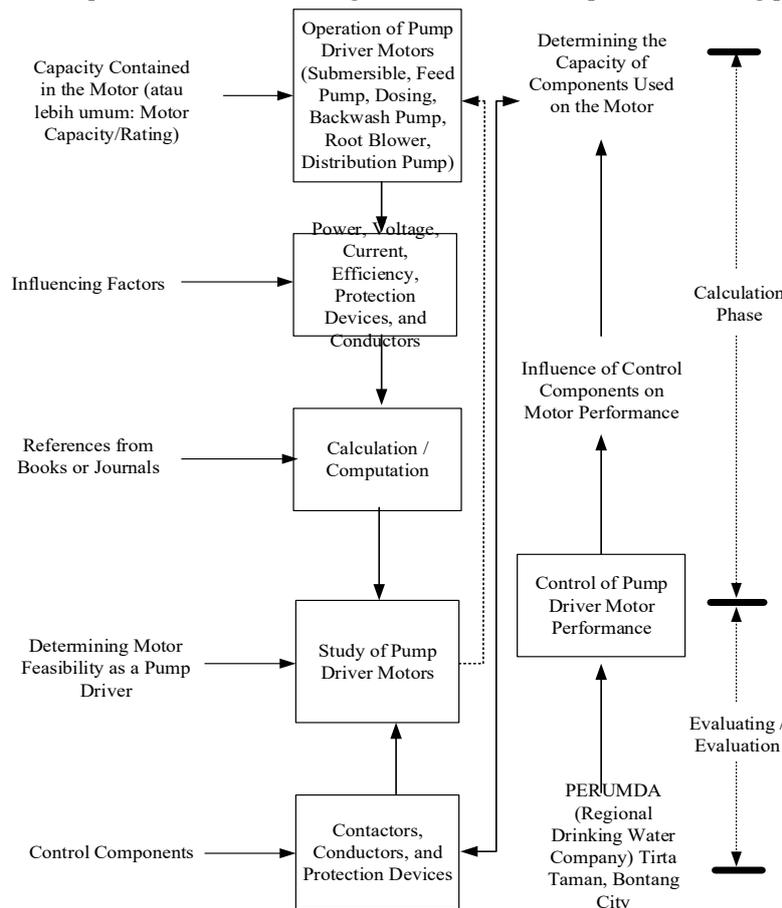
**B. Types and Sources of Data**

The data collected in this research were related to centrifugal pump driving motors installed in the booster pump system at PERUMDA Tirta Taman, WTP 1 Lhoktuan, including:

1. Literature studies from textbooks and scientific journals related to motor-driven pumping systems.
2. Technical specifications of pump motors.
3. Documentation and field observations of pump driving motors at PERUMDA Tirta Taman, Bontang City.

**C. Conceptual Diagram**

The conceptual diagram illustrates the research framework and explanation regarding the scope, limitations, and expected outcomes of the study. The conceptual flow is presented as a visual diagram that outlines the problem-solving process.



**Figure 1 Conceptual Diagram**

The Research Operational Framework serves as a graphical representation of the steps or processes within an algorithm. This flowchart is utilized to visually explain the actions or decisions involved in solving a problem. It employs specific symbols to represent various elements such as operations, inputs, outputs, and decisions as illustrated in Figure 2 Research Operational Framework.

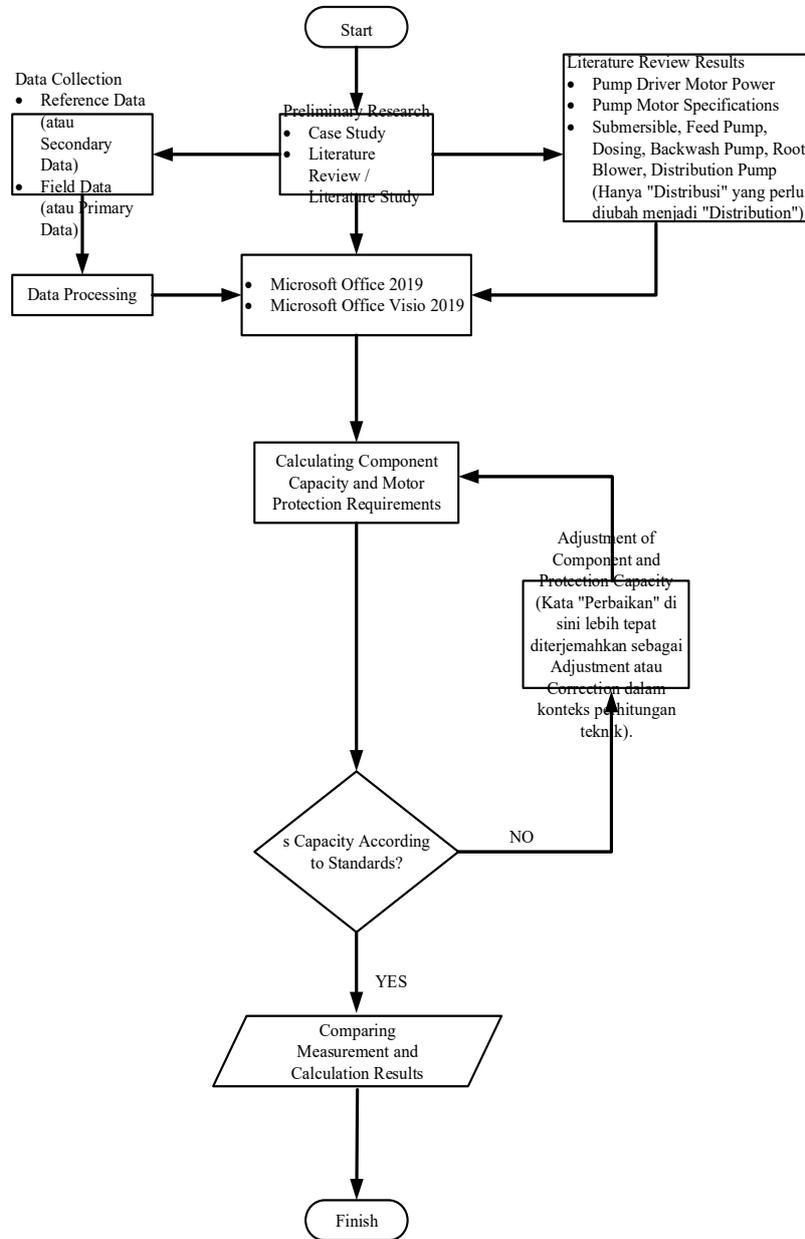


Figure 2 Research Operational Framework

III. RESULT AND DISCUSSION

A. Operational Description of the Clean Water Treatment Process

Raw water treatment at PERUMDA Tirta Taman Bontang begins with a submersible pump used to extract raw water from the well. The raw water treatment facility utilizes 7 electric motors serving as pump drivers and 1 electric motor serving as a blower driver. First, a submersible pump transfers water from the well to the cascade aerator. This process aims to eliminate gas content in the water by flowing it through a series of steps, generating air bubbles. Subsequently, these air bubbles meet the flowing water surface and release dissolved gases into the air, thereby reducing gas levels.

Next, the water proceeds to the coagulation tank for the mixing of coagulants (chemicals) such as PAC, Soda Ash, and Chlorine. The purpose of this process is clarification and binding impurities contained in the water so they flocculate (clump together), making them easier to settle or discard later. A dosing pump is used to distribute these chemicals.

Afterward, the water is pumped by a feed pump to the clarifier tank to separate the treated water from the flocculated impurities. This is achieved by flowing water continuously so that the clumped impurities, having a heavier mass, fall and settle at the bottom of the tank. During this stage, a drainage process occurs to remove sediment accumulation; every hour, an actuator opens a valve for 2 minutes to drain the settled sludge toward the sludge drying bed. The treated water, separated from the impurities, then flows by gravity to the filtration tank for filtering. After filtration, the water flows into the reservoir holding tank. Finally, there are 2 distribution pumps used to pump water from the reservoir and distribute clean water to the community.

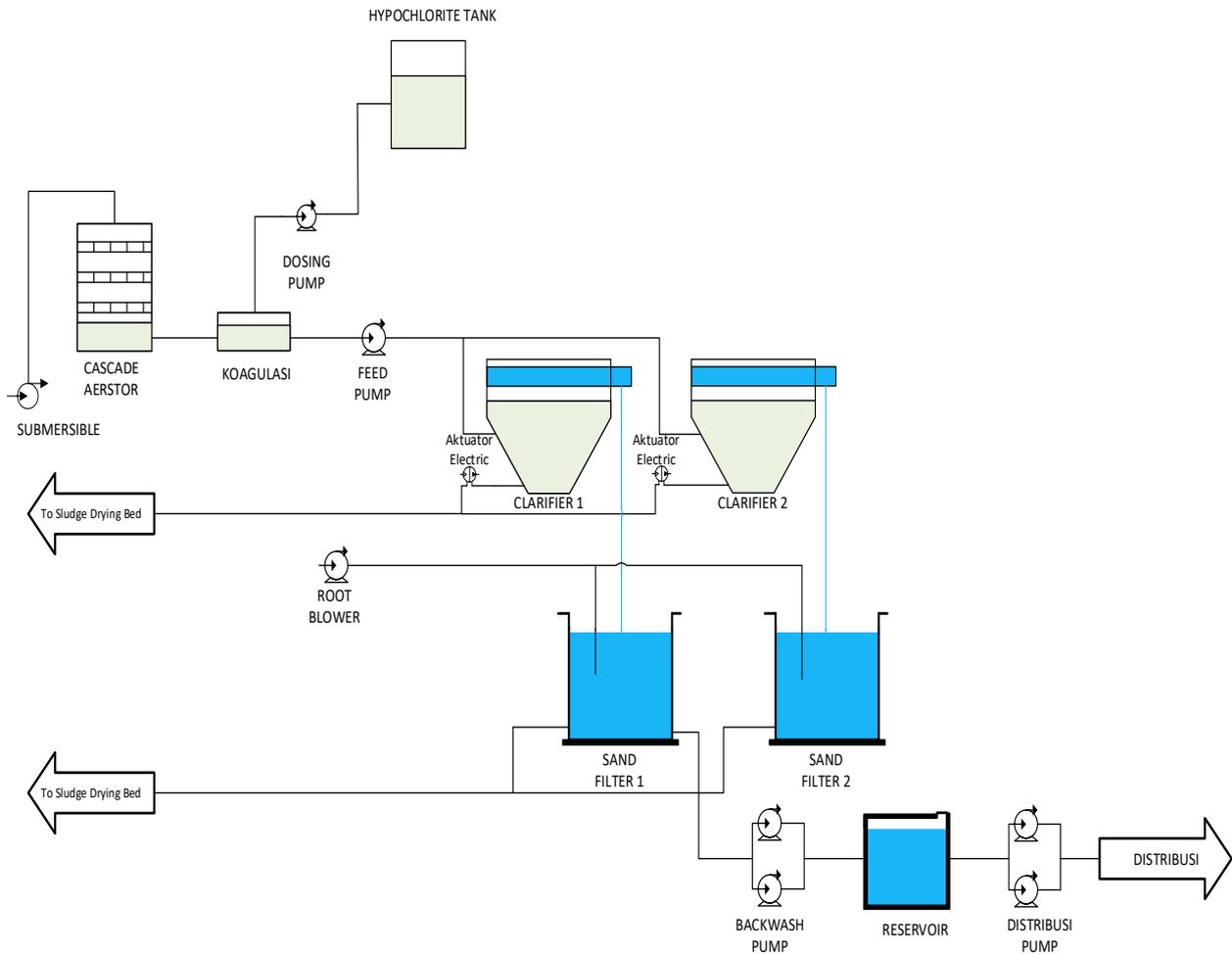


Figure 3. Clean Water Treatment Design Layout

**B. Operational Description During Preventive State**

Preventive measures are implemented to maintain the quality of water produced by PERUMDA Tirta Taman Bontang and to ensure that the water is safe and suitable for use. Consequently, a preventive process is conducted to maintain the cleanliness of the sand filter tank and prevent damage to the filter media.

This preventive maintenance is executed using two backwash pumps and one blower through a process known as backwashing. The procedure begins with the operator closing the valve from the clarifier tank and opening the valve leading to the sludge drying bed. Next, the blower is activated for 35 minutes to dislodge impurities adhering to the tank and filter media using air pressure.

After 35 minutes, the backwash pump is activated for another 35 minutes to flow water from the reservoir (from the bottom) upwards through the filter media, thereby detaching dirt particles from the media. During this backwash process, the dirty water carrying the debris is flushed out of the filter into the drainage channel towards the sludge drying bed.

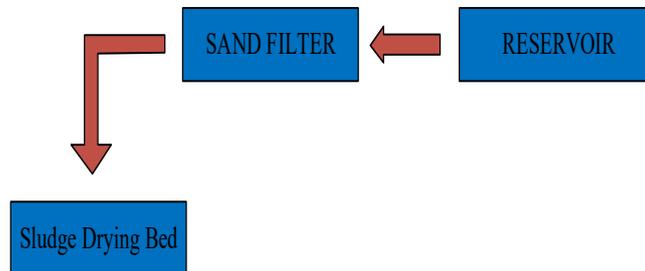


Figure 4. Preventive Process Diagram

### C. Working Principles of Pump Driver Motors

The following are the working principles of the driver motors for the submersible pump, dosing pump, feed pump, root blower, backwash pump, and distribution pump:

Berikut adalah terjemahan teks tersebut ke dalam bahasa Inggris dengan gaya bahasa teknis yang formal.

#### 1) Submersible Pump

This submersible pump utilizes a 3-phase Grundfos MMS8000 motor with a capacity of 55 kW, a maximum speed range of 2890-2900-2910 rpm, and a frequency of 50 Hz.

The motor is submerged in a well at a depth of 80 meters below ground level and is capable of pumping 25 liters of water per second. This pump motor operates continuously (non-stop) for a period of 3 months, after which scheduled maintenance is performed. The function of this pump motor is to transfer water from the well to the coagulation holding tank located at PERUMDA Tirta Taman Bontang City, WTP 1 Lhoktuan Branch. The water is conveyed through an 8-inch iron pipe spanning a distance of 40 meters from the well. This process ensures the water undergoes several treatment stages to become suitable for distribution and daily use by the community of Bontang City.

#### 2) Dosing Pump

The dosing pump utilizes a 3-phase Milton Roy YSJ7114 motor with a capacity of 0.25 kW, a maximum speed of 1400 rpm, and a frequency of 50 Hz. The motor is capable of delivering a flow rate of 7 liters per hour. This pump motor operates continuously for 24 hours and undergoes maintenance only in the event of a breakdown. The function of this pump motor is to transfer chemical solutions to the coagulation area before the water enters the clarifier holding tank at PERUMDA Tirta Taman Bontang City, WTP 1 Lhoktuan Branch. The solution is conveyed through a 3-inch PVC pipe spanning a distance of 10 meters from the coagulation point.

#### 3) Feed Pump

The feed pump utilizes a 3-phase TITAN TM-160M2-2 motor with a capacity of 15 kW, a maximum speed of 2930 rpm, and a frequency of 50 Hz. This motor is employed to pump water from the coagulation unit to the clarifier, transferring water from the initial treatment stages to the subsequent stages of the clean water treatment process. The pump motor operates continuously for 24 hours, delivering a flow rate of 30 liters per second through an 8-inch iron pipe. Maintenance is performed only when a leak is detected in the pump area.

#### 4) Backwash Pump and Root Blower

The Root Blower utilizes a 3-phase TECO AEEBKB motor with a capacity of 5.5 kW, a maximum speed of 1450 rpm, and a frequency of 50 Hz. Similarly, the Backwash Pump utilizes a 3-phase TECO AEEBKB motor with a capacity of 15 kW, a maximum speed of 1450 rpm, and a frequency of 50 Hz. Function and Operation: The Root Blower motor functions to generate the pressurized air required to clean impurities from the filter media during preventive maintenance. Meanwhile, the Backwash Pump is employed during preventive maintenance to deliver high-pressure water into the filtration media for the backwashing process. Preventive maintenance is performed using the backwash pump and blower through a procedure known as "backwashing." The process begins by rotating the water distribution valve until it is fully closed. Next, the blower is activated for 35 minutes to dislodge impurities adhering to the tank and filter media using air pressure. Following this, the backwash pump is activated for 35 minutes to flow water from the reservoir upwards (from bottom to top) through the filter media, effectively detaching dirt particles. During this backwash process, the dirty water containing debris is flushed out of the filter into the drainage channel leading to the sludge drying bed.



## 5) Distribution Pump

The **Distribution Pump** utilizes a **3-phase Elektrim motor** with a capacity of **45 kW**, a maximum speed of **2968 rpm**, and a frequency of **50 Hz**. This motor operates by generating mechanical energy, which is then used to rotate the pump impeller, creating the flow and pressure necessary for water distribution. The pump motor operates **continuously for 24 hours**, distributing a daily water volume of **2,416 m<sup>3</sup>**. Maintenance is performed only when a leak is detected in the pump area. The function of this motor is to drive the water distribution pump, transferring water from the reservoir to consumers through a **12-inch HDPE pipe**, ensuring smooth distribution and providing water suitable for the daily needs of the Bontang City community.

### D. Calculation of Electric Motor Protection

The calculation of the electric motor protection capacity is based on Equations (2.13) and (2.14)

Protection for squirrel cage motor = 250% times  $I_n$  or 2.5 times  $I_n$

Overload protection =  $I_n$  times (110% - 115%)

#### 1) Submersible Pump Motor Protection

Given an induction motor with a power capacity of 55 kW operating at a voltage of 380 V and a nominal current of 116 A, the calculation to determine the capacity of the main protection device is as follows:

$$\begin{aligned} \text{Circuit breaker} &= 250\% \times I_n \\ &= 250\% \times 116 \text{ A} \\ &= 290 \text{ A} \end{aligned}$$

For a circuit breaker requirement of 290 A, a 250 A MCCB can be selected. However, according to field data, a 160 A MCCB is currently utilized. Next, to determine the Thermal Overload Relay (TOR), Equation (2.16) is utilized as follows:

$$\begin{aligned} \text{TOR} &= I_n \times (110\% - 115\%) \\ \text{TOR} &= 116 \text{ A} \times (1,10 - 1,15) \\ \text{TOR} &= 127,6 \text{ A} - 133,4 \text{ A} \end{aligned}$$

The overload protection (TOR) can be set within the range of 127.6 – 133.4 A, whereas the unit installed on-site has a range of 110 – 140 A.

#### 2) Protection motor feed pump

Given an induction motor with a power capacity of 15 kW operating at a voltage of 380 V and a nominal current of 29.4 A, the calculation to determine the capacity of the main protection device is as follows:

$$\begin{aligned} \text{Circuit breaker} &= 250\% \times I_n \\ &= 250\% \times 29,4 \text{ A} \\ &= 73,5 \text{ A} \end{aligned}$$

For a circuit breaker requirement of 73.5 A, a 63 A MCB can be selected, whereas according to field data, a 100 A MCCB is utilized. Next, to determine the TOR, Equation (2.16) is utilized as follows

$$\begin{aligned} \text{TOR} &= I_n \times (110\% - 115\%) \\ \text{TOR} &= 29,4 \text{ A} \times (1,10 - 1,15\%) \\ \text{TOR} &= 32,34 \text{ A} - 33,81 \text{ A} \end{aligned}$$

The overload protection (TOR) can be set within the range of 32.34 – 33.81 A, whereas the unit installed on-site has a range of 30 – 38 A.

#### 3) Protection motor dosing pump

Given an induction motor with a power capacity of 0.25 kW operating at a voltage of 380 V and a nominal current of 1.44 A, the calculation to determine the capacity of the main protection device is as follows:

$$\begin{aligned} \text{Circuit Breaker} &= 250\% \times I_n \\ &= 250\% \times 1,44 \text{ A} \\ &= 3,6 \text{ A} \end{aligned}$$

For a circuit breaker requirement of 3.6 A, a 6 A MCB can be selected; according to field data, a 6 A MCB is also utilized. Next, to determine the TOR, Equation (2.16) is utilized as follows:

$$\begin{aligned} \text{TOR} &= I_n \times (110\% - 115\%) \\ \text{TOR} &= 1,44 \text{ A} \times (1,10 - 1,15\%) \end{aligned}$$



TOR = 1,58 A – 1,65 A

The overload protection (TOR) can be set within the range of 1.58 – 1.65 A, whereas the unit installed on-site has a range of 1 – 1.7 A.

4) Backwash motor pump 1 and 2

Given an induction motor with a power capacity of 15 kW operating at a voltage of 380 V and a nominal current of 29.0 A, the calculation to determine the capacity of the main protection device is as follows:

$$\begin{aligned} \text{Circuit Breaker} &= 250\% \times I_n \\ &= 250\% \times 29,0 \text{ A} \\ &= 72,5 \text{ A} \end{aligned}$$

For a circuit breaker requirement of 72.5 A, a 63 A MCB can be selected, whereas according to field data, a 100 A MCCB is utilized. Next, to determine the TOR, Equation (2.16) is utilized as follows:

$$\begin{aligned} \text{TOR} &= I_n \times (110\% - 115\%) \\ \text{TOR} &= 29,0 \text{ A} \times (1,10 - 1,15\%) \\ \text{TOR} &= 31,9 \text{ A} - 33,35 \text{ A} \end{aligned}$$

The overload protection (TOR) can be set within the range of 31.9 – 33.35 A, whereas the unit installed on-site has a range of 30 – 38 A.

5) Root blower motor

Given an induction motor with a power capacity of 5.5 kW operating at a voltage of 380 V and a nominal current of 12.3 A, the calculation to determine the capacity of the main protection device is as follows:

$$\begin{aligned} \text{Circuit Breaker} &= 250\% \times I_n \\ &= 250\% \times 12,3 \text{ A} \\ &= 30,75 \text{ A} \end{aligned}$$

For a circuit breaker requirement of 30.75 A, a 25 A MCB can be selected, whereas according to field data, a 20 A MCB is utilized. Next, to determine the TOR, Equation (2.16) is utilized as follows:

$$\begin{aligned} \text{TOR} &= I_n \times (110\% - 115\%) \\ \text{TOR} &= 12,3 \text{ A} \times (1,10 - 1,15\%) \\ \text{TOR} &= 13,53 \text{ A} - 14,14 \text{ A} \end{aligned}$$

The overload protection (TOR) can be set within the range of 13.53 – 14.14 A, whereas the unit installed on-site has a range of 12 – 18 A.

6) Distribution motor pump 1

Given an induction motor with a power capacity of 45 kW operating at a voltage of 380 V and a nominal current of 81.0 A, the calculation to determine the capacity of the main protection device is as follows:

$$\begin{aligned} \text{Circuit Breaker} &= 250\% \times I_n \\ &= 250\% \times 81,0 \text{ A} \\ &= 202,5 \text{ A} \end{aligned}$$

For a circuit breaker requirement of 202.5 A, a 200 A MCCB can be selected, whereas according to field data, a 125 A MCCB is utilized. Next, to determine the TOR, Equation (2.16) is utilized as follows:

$$\begin{aligned} \text{TOR} &= I_n \times (110\% - 115\%) \\ \text{TOR} &= 81,0 \text{ A} \times (1,10 - 1,15\%) \\ \text{TOR} &= 89,1 \text{ A} - 93,15 \text{ A} \end{aligned}$$

The overload protection (TOR) can be set within the range of 89.1 – 93.15 A, whereas the unit installed on-site has a range of 80 – 104 A.

**E. Determining Contactor Capacity**

To calculate the capacity of the contactor used, Equation (2.15) is utilized.

$$K = 115\% \times I_n$$

1) Submersible Pump Motor Contactor

The following is the calculation for the contactor capacity of the Submersible Pump Motor:



$$\begin{aligned} I_n &= 116 \text{ A} \\ K &= 115\% \times 116 \text{ A} \\ &= 133,4 \text{ A} \end{aligned}$$

From the calculation results, a contactor current capacity of 133.4 A is obtained; therefore, a capacity of 150 A can be selected, whereas according to field data, the contactor capacity utilized is 150 A.

## 2) Feed Pump Motor Contactor

The following is the calculation for the contactor capacity of the Feed Pump Motor:

$$\begin{aligned} I_n &= 29,4 \text{ A} \\ K &= 115\% \times 29,4 \text{ A} \\ &= 33,81 \text{ A} \end{aligned}$$

From the calculation results, a contactor current capacity of 33.81 A is obtained; therefore, a capacity of 40 A can be selected, whereas according to field data, the contactor capacity utilized is 40 A.

## 3) Dosing Pump Motor Contactor

The following is the calculation for the contactor capacity of the Dosing Pump Motor:

$$\begin{aligned} I_n &= 1,44 \text{ A} \\ K &= 115\% \times 1,44 \text{ A} \\ &= 1,65 \text{ A} \end{aligned}$$

From the calculation results, a contactor current capacity of 1.65 A is obtained; therefore, a capacity of 9 A can be selected, whereas according to field data, the contactor capacity utilized is 9 A.

## 4) Backwash Pump Motor Contactor 1 and 2

The following is the calculation for the contactor capacity of Backwash Pump Motors 1 and 2:

$$\begin{aligned} I_n &= 29,0 \text{ A} \\ K &= 115\% \times 29,0 \text{ A} \\ &= 33,35 \text{ A} \end{aligned}$$

From the calculation results, a contactor current capacity of 33.35 A is obtained; therefore, a capacity of 40 A can be selected, whereas according to field data, the contactor capacity utilized is 40 A.

## 5) Root Blower Motor Contactor

The following is the calculation for the contactor capacity of the Root Blower Motor:

$$\begin{aligned} I_n &= 12,3 \text{ A} \\ K &= 115\% \times 12,3 \text{ A} \\ &= 14,14 \text{ A} \end{aligned}$$

From the calculation results, a contactor current capacity of 14.14 A is obtained; therefore, a capacity of 18 A can be selected, whereas according to field data, the contactor capacity utilized is 18 A.

## 6) Distribution Pump Motor Contactor 1 and 2

The following is the calculation for the contactor capacity of Distribution Pump Motors 1 and 2:

$$\begin{aligned} I_n &= 81,0 \text{ A} \\ K &= 115\% \times 81,0 \text{ A} \\ &= 93,15 \text{ A} \end{aligned}$$

From the calculation results, a contactor current capacity of 93.15 A is obtained; therefore, a capacity of 115 A can be selected, whereas according to field data, the contactor capacity utilized is 115 A.

## F. Calculation of Electric Motor Conductors

To calculate the electric motor conductor size based on Equation (2.12).

Current Carrying Capacity = 125% x  $I_n$

### 1) Submersible Pump Motor Conductor

The following is the calculation for the Submersible Pump Motor conductor size:

$$\begin{aligned} I_n &= 116 \text{ A} \\ KHA &= 125\% \times 116 \text{ A} \end{aligned}$$



$$= 145 \text{ A}$$

After obtaining the conductor's Current Carrying Capacity value based on the calculation from Equation (2.14), the conductor selected according to Table 2.2 is the NYY 4 x 35 mm<sup>2</sup> cable. Whereas the conductor utilized on-site is the NYY 4 x 35 mm<sup>2</sup> cable.

2) Feed Pump Motor Conductor

The following is the calculation for the Feed Pump Motor conductor size:

$$I_n = 29,4 \text{ A}$$

$$KHA = 125\% \times 29,4 \text{ A}$$

$$= 36,75 \text{ A}$$

After obtaining the conductor's Current Carrying Capacity value based on the calculation from Equation (2.14), the conductor selected according to Table 2.2 is the NYY 4 x 6 mm<sup>2</sup> cable. Whereas the conductor utilized on-site is the NYY 4 x 6 mm<sup>2</sup> cable

3) Dosing Pump Motor Conductor

The following is the calculation for the Dosing Pump Motor conductor size:

$$I_n = 1,44 \text{ A}$$

$$KHA = 125\% \times 1,44 \text{ A}$$

$$= 1,8 \text{ A}$$

After obtaining the conductor's Current Carrying Capacity value based on the calculation from Equation (2.14), the conductor selected according to Table 2.2 is the NYY 3 x 2.5 mm<sup>2</sup> cable. Whereas the conductor utilized on-site is the NYY 3 x 2.5 mm<sup>2</sup> cable.

4) Backwash Pump Motor Conductor 1 and 2

The following is the calculation for the conductor size of Backwash Pump Motors 1 and 2:

$$I_n = 29,0 \text{ A}$$

$$KHA = 125\% \times 29,0 \text{ A}$$

$$= 36,25 \text{ A}$$

After obtaining the conductor's Current Carrying Capacity value based on the calculation from Equation (2.14), the conductor selected according to Table 2.2 is the NYY 4 x 6 mm<sup>2</sup> cable. Whereas the conductor utilized on-site is the NYY 4 x 6 mm<sup>2</sup> cable.

5) Root Blower Motor Conductor

The following is the calculation for the Root Blower Motor conductor size:

$$I_n = 12,3 \text{ A}$$

$$KHA = 125\% \times 12,3 \text{ A}$$

$$= 15,37 \text{ A}$$

After obtaining the conductor's Current Carrying Capacity value based on the calculation from Equation (2.14), the conductor selected according to Table 2.2 is the NYY 4 x 2.5 mm<sup>2</sup> cable. Whereas the conductor utilized on-site is the NYY 4 x 2.5 mm<sup>2</sup> cable.

6) Distribution Pump Motor Conductor 1 and 2

The following is the calculation for the conductor size of Distribution Pump Motors 1 and 2:

$$I_n = 81,0 \text{ A}$$

$$KHA = 125\% \times 81,0 \text{ A}$$

$$= 101,25 \text{ A}$$

After obtaining the conductor's Current Carrying Capacity value based on the calculation from Equation (2.14), the conductor selected according to Table 2.2 is the NYY 4 x 25 mm<sup>2</sup> cable. Whereas the conductor utilized on-site is the NYY 4 x 25 mm<sup>2</sup> cable.

**G. Calculation of Pump Capacity and Water Discharge**

The following is the calculation of the Submersible Water Pump capacity:

1) Submersible Pump

Given a submersible pump with a flow rate capacity of 25 L/s and a pipe size of 8 inches (PDAM standard), the determination of the pipe cross-sectional area is as follows:

$$\text{Pipe Cross-Sectional Area} = A = \frac{\pi}{4} D^2$$

$$A = \frac{3,14}{4} (0,2032)^2$$

$$A = 0,032 \text{ m}^2$$



Then, to determine the pump capacity (velocity), Equation (2.12) is utilized as follows:

$$\text{Pump Capacity} = \text{Volume air} = \frac{Q}{A} = \frac{0,25}{0,032}$$
$$\text{Volume air} = 7,81 \text{ m/s}$$

To determine the water discharge, Equation (2.13) is utilized as follows:

$$\text{Therefore, the water discharge} = Q = A \times V$$
$$Q = 0,032 \times 7,81$$
$$Q = 0,250 \text{ m}^3/\text{s}$$
$$Q = 250 \text{ L/s}$$

From the calculation results, the pipe cross-sectional area obtained is 0.032 m<sup>2</sup>, the pump capacity is 7.81 m/s, and the water discharge is 250 L/s.

### 2) Dosing Pump

Given a submersible pump with a flow rate capacity of 7 L/s and a pipe size of 3 inches (PDAM standard), the determination of the pipe cross-sectional area is as follows:

$$\text{Pipe Cross-Sectional Area} = A = \frac{\pi}{4} D^2$$
$$A = \frac{3,14}{4} (0,0058)^2$$
$$A = 0,004 \text{ m}^2$$

Then, to determine the pump capacity (velocity), Equation (2.12) is utilized as follows:

$$\text{Pump Capacity} = \text{Volume air} = \frac{Q}{A} = \frac{0,07}{0,004}$$
$$\text{Volume air} = 17,5 \text{ m/s}$$

To determine the water discharge, Equation (2.13) is utilized as follows:

$$\text{Therefore, the water discharge} = Q = A \times V$$
$$Q = 0,004 \times 17,5$$
$$Q = 0,07 \text{ m}^3/\text{s}$$
$$Q = 70 \text{ L/s}$$

From the calculation results, the pipe cross-sectional area obtained is 0.004 m<sup>2</sup>, the pump capacity is 17.5 m/s, and the water discharge is 70 L/s.

### 3) Feed Pump

Given a submersible pump with a flow rate capacity of 30 L/s and a pipe size of 8 inches (PDAM standard), the determination of the pipe cross-sectional area is as follows:

$$\text{Pipe Cross-Sectional Area} = A = \frac{\pi}{4} D^2$$
$$A = \frac{3,14}{4} (0,2032)^2$$
$$A = 0,032 \text{ m}^2$$

Then, to determine the pump capacity (velocity), Equation (2.12) is utilized as follows:

$$\text{Pump Capacity} = \text{Volume air} = \frac{Q}{A} = \frac{0,30}{0,032}$$
$$\text{Volume air} = 9,37 \text{ m/s}$$

To determine the water discharge, Equation (2.13) is utilized as follows:

$$\text{Therefore, the water discharge} = Q = A \times V$$
$$Q = 0,032 \times 9,37$$
$$Q = 0,3 \text{ m}^3/\text{s}$$
$$Q = 300 \text{ L/s}$$

From the calculation results, the pipe cross-sectional area obtained is 0.032 m<sup>2</sup>, the pump capacity is 9.37 m/s, and the water discharge is 300 L/s.



#### 4) Root Blower Pump

From the calculation results, the pipe cross-sectional area obtained is 0.032 m<sup>2</sup>, the pump capacity is 9.37 m/s, and the water discharge is 300 L/s.

$$\begin{aligned}\text{Pipe Cross-Sectional Area} = A &= \frac{\pi}{4} D^2 \\ A &= \frac{3,14}{4} (0,0058)^2 \\ A &= 0,004 \text{ m}^2\end{aligned}$$

Then, to determine the pump capacity (velocity), Equation (2.12) is utilized as follows:

$$\begin{aligned}\text{Pump Capacity} = \text{Volume air} &= \frac{Q}{A} = \frac{0,06}{0,004} \\ \text{Volume air} &= 15 \text{ m/s}\end{aligned}$$

To determine the water discharge, Equation (2.13) is utilized as follows:

$$\begin{aligned}\text{Therefore, the water discharge} = Q &= A \times V \\ Q &= 0,004 \times 15 \\ Q &= 0,06 \text{ m}^3/\text{s} \\ Q &= 60 \text{ L/s}\end{aligned}$$

From the calculation results, the pipe cross-sectional area obtained is 0.004 m<sup>2</sup>, the pump capacity is 15 m/s, and the water discharge is 60 L/s.

#### 5) Backwash Pump

Given a submersible pump with a flow rate capacity of 14 L/s and a pipe size of 8 inches (PDAM standard), the determination of the pipe cross-sectional area is as follows:

$$\begin{aligned}\text{Pipe Cross-Sectional Area} = A &= \frac{\pi}{4} D^2 \\ A &= \frac{3,14}{4} (0,2032)^2 \\ A &= 0,032 \text{ m}^2\end{aligned}$$

Then, to determine the pump capacity (velocity), Equation (2.12) is utilized as follows:

$$\begin{aligned}\text{Pump Capacity} = \text{Volume air} &= \frac{Q}{A} = \frac{0,14}{0,032} \\ \text{Volume air} &= 4,37 \text{ m/s}\end{aligned}$$

To determine the water discharge, Equation (2.13) is utilized as follows:

$$\begin{aligned}\text{Therefore, the water discharge} = Q &= A \times V \\ Q &= 0,032 \times 4,37 \\ Q &= 0,140 \text{ m}^3/\text{s} \\ Q &= 140 \text{ L/s}\end{aligned}$$

From the calculation results, the pipe cross-sectional area obtained is 0.032 m<sup>2</sup>, the pump capacity is 4.37 m/s, and the water discharge is 140 L/s.

#### 6) Distribution Pump

Given a submersible pump with a flow rate capacity of 32 L/s and a pipe size of 12 inches (PDAM standard), the determination of the pipe cross-sectional area is as follows:

$$\begin{aligned}\text{Pipe Cross-Sectional Area} = A &= \frac{\pi}{4} D^2 \\ A &= \frac{3,14}{4} (0,3048)^2 \\ A &= 0,073 \text{ m}^2\end{aligned}$$

To determine the water discharge, Equation (2.13) is utilized as follows:

$$\begin{aligned}\text{Pump Capacity} = \text{Volume air} &= \frac{Q}{A} = \frac{0,25}{0,073} \\ \text{Volume air} &= 4,38 \text{ m/s}\end{aligned}$$

$$\begin{aligned}\text{Therefore, the water discharge} = Q &= A \times V \\ Q &= 0,073 \times 4,38\end{aligned}$$

$$Q = 0,319 \text{ m}^3/\text{s}$$

$$Q = 319 \text{ L/s}$$

From the calculation results, the pipe cross-sectional area obtained is 0.073 m<sup>2</sup>, the pump capacity is 4.38 m/s, and the water discharge is 319 L/s.

**H. Comparison of Main Protection: Calculated Data vs. Field Data**

To facilitate the comparison between the calculated results and the existing field data for the main protection devices specifically regarding the main protection (Circuit Breaker) and TOR—the details are presented in Table 1 below:

**Table 1. Comparison of Main Protection**

Motor	Nominal Current (In)	Calculation Result (A)	Field Data (A)
Motor Pompa <i>Submersible</i>	116	290	160
Motor <i>Feed Pump</i>	29,4	73,5	100
Motor Pompa <i>Dosing</i>	1,44	3,6	6
Motor <i>Backwash Pump 1</i>	29,0	72,5	100
Motor <i>Backwash Pump 2</i>	29,0	72,5	100
Motor <i>Root Blower</i>	12,3	30,75	20
Motor <i>Distribusi Pump 1</i>	81,0	202,5	125
Motor <i>Distribusi Pump 2</i>	81,0	202,5	125

Based on Table 1, a comparison of the protection ratings between the calculated results and the field data is presented. For the Submersible Pump Motor, the calculation indicates the use of a 250 A MCCB, whereas the field data shows the use of a 160 A MCCB. For the Feed Pump Motor, the calculation yields a 63 A MCB, while the field data utilizes a 100 A MCCB. Regarding the Dosing Pump Motor, the calculation requires a 6 A MCB, which corresponds to the field data also using a 6 A MCB. Next, for Backwash Pump Motors 1 & 2, the calculation results suggest a 63 A MCCB, whereas the field data employs a 100 A MCCB. For the Root Blower Motor, the calculation indicates a 25 A MCB, while the field data uses a 20 A MCB. Finally, for Distribution Pump Motors 1 & 2, the calculation results in a 202.5 A MCCB, whereas the field installation uses a 125 A MCCB.

**Table 2. Comparison of Thermal Overload Relays (TOR)**

Motor	Current Nominal (In)	Calculation Result (A)	Field Data (A)
Motor Pompa <i>Submersible</i>	116	127,6 – 133,4	110 – 140
Motor <i>Feed Pump</i>	29,4	32,34 – 33,81	30 – 38
Motor Pompa <i>Dosing</i>	1,44	1,58 – 1,65	1 – 1,7
Motor <i>Backwash Pump 1</i>	29,0	31,9 – 33,35	32 – 38
Motor <i>Backwash Pump 2</i>	29,0	31,9 – 33,35	32 – 38
Motor <i>Root Blower</i>	12,3	13,53 – 14,14	12 – 18
Motor <i>Distribusi Pump 1</i>	81,0	89,1 – 93,15	80 – 104
Motor <i>Distribusi Pump 2</i>	81,0	89,1 – 93,15	80 – 104

Based on Table 2, a comparison is presented regarding the usage of Thermal Overload Relays (TOR) between the calculated results and the field data. For the Submersible Pump Motor, the calculated range is 127.6 – 133.4 A, whereas the TOR installed on-site has a range of 110 – 140 A. For the Feed Pump Motor, the calculation yields 32.34 – 33.81 A, while the field TOR is set at 32 – 38 A. Regarding the Dosing Pump Motor, the calculated result is 1.58 – 1.65 A, compared to the field TOR range of 1 – 1.7 A. Next, for



Backwash Pump Motors 1 & 2, the calculated range is 31.9 – 33.35 A, whereas the field TOR range is 32 – 38 A. For the Root Blower Motor, the calculation indicates 13.53 – 14.14 A, while the field data shows a range of 12 – 18 A. Finally, for Distribution Pump Motors 1 & 2, the calculated result is 89.1 – 93.15 A, whereas the TOR utilized on-site has a range of 80 – 104 A.

**I. Comparison of Contactors: Calculated Data vs. Field Data**

To facilitate the comparison between the calculated contactor results and the existing field data, the details are presented in Table 4.3 below:

**Table 3. Comparison of Contactors (Calculated and Field Data)**

Motor	Nominal Current (In)	Calculation Result (A)	Field Data (A)
Motor Pompa <i>Submersible</i>	116	133,4	150
Motor <i>Feed Pump</i>	29,4	33,81	40
Motor Pompa <i>Dosing</i>	1,44	1,65	9
Motor <i>Backwash Pump 1</i>	29,0	33,35	40
Motor <i>Backwash Pump 2</i>	29,0	33,35	40
Motor <i>Root Blower</i>	12,3	14,14	18
Motor <i>Distribusi Pump 1</i>	81,0	93,15	115
Motor <i>Distribusi Pump 1</i>	81,0	93,15	115

**J. Comparison of Conductors: Calculated Data vs. Field Data**

To facilitate the comparison of conductors between the calculation results and the existing field data, the details are presented in Table 4.4 below:

**Table 4. Comparison of Conductors: Calculated Data Vs. Field Data**

No.	Motor	Calculation Data	Field Data
1.	Motor Pompa <i>Submersible</i>	NYY 4 x 35 mm <sup>2</sup>	NYY 4 x 35 mm <sup>2</sup>
2.	Motor <i>Feed Pump</i>	NYY 4 x 6 mm <sup>2</sup>	NYY 4 x 6 mm <sup>2</sup>
3.	Motor Pompa <i>Dosing</i>	NYY 3 x 2,5 mm <sup>2</sup>	NYY 3 x 2,5 mm <sup>2</sup>
4.	Motor <i>Backwash Pump 1</i>	NYY 4 x 6 mm <sup>2</sup>	NYY 4 x 6 mm <sup>2</sup>
5.	Motor <i>Backwash Pump 2</i>	NYY 4 x 6 mm <sup>2</sup>	NYY 4 x 6 mm <sup>2</sup>
6.	Motor <i>Root Blower</i>	NYY 4 x 2,5 mm <sup>2</sup>	NYY 4 x 2,5 mm <sup>2</sup>
7.	Motor <i>Distribusi Pump 1</i>	NYY 4 x 25 mm <sup>2</sup>	NYY 4 x 25 mm <sup>2</sup>
8.	Motor <i>Distribusi Pump 2</i>	NYY 4 x 25 mm <sup>2</sup>	NYY 4 x 25 mm <sup>2</sup>

Based on Table 4, a comparison is presented regarding the conductor types used in the field versus the calculation results. For the Submersible Pump Motor conductor, the calculated size is NYY 4 x 35 mm<sup>2</sup>, which matches the field installation. Similarly, for the Feed Pump Motor, the calculated conductor size is NYY 4 x 6 mm<sup>2</sup>, identical to the field data. Next, regarding the Dosing Pump Motor, the calculated result is NYY 3 x 2.5 mm<sup>2</sup>, which corresponds to the field installation. For Backwash Pump Motors 1 & 2, the calculated conductor is NYY 4 x 6 mm<sup>2</sup>, which is consistent with the field data. For the Root Blower Motor, the calculation yields an NYY 4 x 2.5 mm<sup>2</sup> cable, matching the field installation. Finally, for Distribution Pump Motors 1 & 2, the calculated conductor size is NYY 4 x 25 mm<sup>2</sup>, which is also identical to the field data.



**Table 5. Comparison of Conductors: Calculated Data Vs. Field Data**

No.	Motor	Calculation Data	Field Data
1.	Motor Pompa <i>Submersible</i>	NYAF 1,5 mm <sup>2</sup>	NYAF 1,5 mm <sup>2</sup>
2.	Motor <i>Feed Pump</i>	NYAF 1,5 mm <sup>2</sup>	NYAF 1,5 mm <sup>2</sup>
3.	Motor Pompa <i>Dosing</i>	NYAF 1,5 mm <sup>2</sup>	NYAF 1,5 mm <sup>2</sup>
4.	Motor <i>Backwash Pump 1</i>	NYAF 1,5 mm <sup>2</sup>	NYAF 1,5 mm <sup>2</sup>
5.	Motor <i>Backwash Pump 2</i>	NYAF 1,5 mm <sup>2</sup>	NYAF 1,5 mm <sup>2</sup>
5.	Motor <i>Root Blower</i>	NYAF 1,5 mm <sup>2</sup>	NYAF 1,5 mm <sup>2</sup>
6.	Motor <i>Distribusi Pump 1</i>	NYAF 1,5 mm <sup>2</sup>	NYAF 1,5 mm <sup>2</sup>
7.	Motor <i>Distribusi Pump 2</i>	NYAF 1,5 mm <sup>2</sup>	NYAF 1,5 mm <sup>2</sup>

The installed motor control circuit conductors are consistent in size with the field data, as PUIL 2020 stipulates that cables used for control devices must have a minimum cross-sectional area of 1.0 mm<sup>2</sup>.

**K. Comparison of Pump Capacity and Water Discharge: Calculated Data vs. Field Data**

To facilitate the comparison of pump capacity and water discharge between the calculation results and the existing field data, the details are presented in Table 4.6 below.

**Table 5. Calculation and Field Results of Pump Capacity And Water Discharge**

No	Pompa	Field Water Discharge (L/s)	Calculated Water Discharge (L/s)	Calculation Results (m3/s)
1	<i>Submersible</i>	25	250	7,81
2	<i>Dosing</i>	7	70	17,5
3	<i>Feed Pump</i>	30	300	9,37
4	<i>Backwash</i>	14	140	4,37
5	<i>Root Blower</i>	6	60	15
6	<i>Distribusi</i>	32	319	4,38

**IV. CLOSING**

**A. Conclusions**

- 1) The submersible pump driver motor functions to pump raw water from the well at a rate of 160 m<sup>3</sup>/hour from a depth of 80 meters through an 8-inch iron pipe.
- 2) The root blower driver motor functions to agitate and clean the sand filter media for a duration of 35 minutes using air assistance. Once the root blower process is complete, the subsequent process operates the backwash pump driver motor, which aims to clean the filtration media of the sand filter tank for a duration of 35 minutes. The impurities dislodged within the sand filter are then transported to the sludge drying bed via the waste disposal system. After the backwash process concludes, the cleaned sand filter tank can resume water flow into the distribution tank or reservoir.
- 3) The protection devices for the respective pump driver motors used in the clean water treatment at PERUMDA Tirta Taman, Bontang City, are as follows: the submersible pump utilizes a 160 A 3-pole MCCB; the feed pump utilizes a 100 A 3-pole MCCB; the dosing pump utilizes a 6 A 1-pole MCB; the root blower utilizes a 20 A 3-pole MCB; backwash pumps 1 and 2 utilize 100 A 3-pole MCCBs; and distribution pumps 1 and 2 utilize 125 A 3-pole MCCBs.



- 4) The contactor capacities for the respective pumps used in the clean water treatment at PERUMDA Tirta Taman, Bontang City, are as follows: submersible pump 150 A, feed pump 40 A, dosing pump 9 A, root blower 18 A, backwash pumps 1 and 2 115 A, and distribution pumps 1 and 2 115 A.
- 5) The conductors utilized for the respective pumps in the clean water treatment at PERUMDA Tirta Taman, Bontang City, are as follows: the submersible pump uses NYY 4 × 35 mm<sup>2</sup> cable; the feed pump uses NYY 4 × 6 mm<sup>2</sup> cable; the dosing pump uses NYY 3 × 2.5 mm<sup>2</sup> cable; the root blower uses NYY 4 × 2.5 mm<sup>2</sup> cable; backwash pumps 1 and 2 use NYY 4 × 6 mm<sup>2</sup> cable; and distribution pumps 1 and 2 use NYY 4 × 25 mm<sup>2</sup> cable.

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