# Preventive Analysis of Maintenance On Centrifugal Pumps Using The Mean Method Time Between Failure (MTBF) and Mean Time To Repair (MTTR)

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***Abstract.***
*Centrifugal pumps are essential equipment in fluid distribution systems that operate continuously, so they have the potential to suffer damage that can reduce the reliability of the system. This study aims to analyze the damage and effectiveness of centrifugal pump maintenance using the* ***Preventive Maintenance Analysis method*** *on centrifugal pumps using the Mean Time Betwwn Failure (MTBF) and Mean Time To Repair (MTTR) methods. The MTBF value is used to determine the reliability level of the pump, while the MTTR is used to evaluate the efficiency of the repair time. The results of the analysis show that a high MTBF value indicates good pump reliability, while a low MTTR value indicates an efficient repair process. Based on the results of the study, it can be concluded that the implementation of planned and reliability-based maintenance is able to reduce* ***downtime*** *and improve the performance and service life of centrifugal pumps. This research is expected to be a reference in the preparation of a more effective and optimal pump maintenance strategy.*
***Keywords:*** *Centrifugal pump, maintenance, breakdown and MTBF, MTTR..*

## 1. INTRODUCTION

Centrifugal pumps are one of the mechanical equipment that has a very important role in various fluid transfer systems, both in the industrial, utilities, water treatment, agriculture, energy, and public service sectors. These pumps are used to flow fluids from one place to another by utilizing the kinetic energy generated by the rotation of the impeller and converted into pressure energy. Due to their vital function, centrifugal pumps are required to be able to operate continuously, stably, and have a high level of reliability so as not to interfere with the system as a whole. In field operational practice, centrifugal pumps are generally operated over long periods of time with variations in loads and working conditions. Factors such as fluid quality, operating temperature, working pressure, shaft alignment, vibration, and lubrication system greatly affect the life and performance of the pump. Over time, pump components such as bearings, mechanical seals, impellers, shafts, casings, and drive motors will experience wear and degradation in performance. If this condition is not monitored and handled properly, it can cause damage that leads to the cessation of pump operations.[1].

Damage to centrifugal pumps not only has an impact on the technical side, but also has an impact on operational and economic aspects. Pump disruptions can lead to increased downtime, fluid flow disruption, decreased system productivity, and increased costs of repairs and component replacements. In addition, damage that occurs suddenly without proper maintenance planning can pose greater occupational safety risks and operational losses [2].

To improve the effectiveness of the treatment system, a data-driven approach and reliability analysis are required. Reliability analysis aims to measure the ability of an equipment to perform its functions without experiencing failure within a certain period of time. By conducting a reliability analysis, it can be known the pattern of damage, the frequency of failures, and the performance of the repair system applied. One of the methods that is widely used in the analysis of equipment reliability is the Mean Time Between Failures (MTBF) and Mean Time To Repair (MTTR) parameters. MTBF is a statistical measure that states the average operating time of an appliance between two consecutive failure events. The MTBF value is used as an indicator of the reliability level of the equipment, where the greater the MTBF value, the less likely the equipment is damaged. By knowing the MTBF value, the management can estimate the damage interval and plan preventive maintenance schedules more accurately [3].

Meanwhile, MTTR is a parameter that shows the average time needed to make repairs until the equipment can return to normal operation. MTTR reflects the effectiveness of the maintenance system, the readiness of technicians, the availability of spare parts, and the repair procedures applied. A low MTTR value indicates that the repair process can be carried out quickly and efficiently. A combination of MTBF and MTTR values can also be used to assess availability

Based on this background, the author is interested in conducting a research entitled "Preventive Maintenance Analysis on *Centrifugal* Pumps Using the *Mean Time Between Failure* (Mtbf) and *Mean Time To Repair* (Mttr) Methods". This study is focused on analyzing the types of damage that often occur, especially in the bearings and impellers of Torishima brand centrifugal pumps with a capacity of 50 liters per second, as well as examining the treatment methods applied. The results of this study are expected to be evaluation and recommendations for PDAM in improving the reliability and efficiency of the water distribution pump system.

## II. METHODS

This study uses a quantitative method with a reliability analysis approach to centrifugal pumps used in the water distribution system of PDAM Bengkalis. The research data was obtained through field observations, interviews with technicians and operators, documentation of historical damage data, and data collection of operating time and pump repair time. All data obtained are then analyzed to determine the level of reliability of the pump and the effectiveness of the treatment system applied.

### A. Tools and Materials

The object of the research is a centrifugal pump that operates continuously in the water distribution system. The data used includes pump operating time, frequency of damage, repair time, and the type of damage that occurs to the main components, especially bearings and impellers. The data was obtained from historical records of maintenance and operational documentation of pumps

**Table 1. Research Tools and Materials**

| NO | RESEARCH MATERIALS | Quantity |
|---|---|---|
| 1 | Centrifugal Pump | 1 piece of toshiba brand pump |
| 2 | Pump operating time data. | 1 pump operation data |
| 3 | Data Damage and Distractions pump. | 1 pump damage data |
| 4 | Data Time Repairs and downtime. | 1 pump repair time data |
| 5 | Maintenance support materials such as lubricants, seals, bearings, and gaskets. | 1 piece of supporting material per item |

### B. Research Variables

The variables used in this study consist of independent variables, bound variables, and control variables, which are as follows.

#### 1. Independent Variable

The independent variable in this study is the centrifugal pump components that have been damaged based on historical data during the period June 2025 to June 2026.

#### 2. Dependent Variable

The bound variables in this study include:

- Mean Time Between Failure (MTBF).
- Mean Time To Repair (MTTR) value.
- Value Availability of centrifugal pumps.
- The frequency of damage to each pump component.
- Proposed preventive maintenance schedule based on the results of reliability analysis.

#### 3. Controlled Variable

Control variables maintained during the study included:

- The object of the research is in the form of value the same centrifugal pump.
- The historical data period used is June 2025–June 2026.
- The analysis methods used were Mean Time Between Failure (MTBF) and Mean Time To Repair (MTTR).
- The data source comes from the damage record, the time of operation, and the time of the pump repair.
- The calculation is carried out using the same procedures and formulas on all research data so that the results of the analysis can be compared objectively.

**C. Research Procedure**

This research stage is systematically arranged so that the process of analyzing preventive maintenance on centrifugal pumps can be carried out in a directed manner. The stages of research carried out are as follows.

1. **Literature Studies**

The initial stage of the research was carried out by studying various references related to maintenance systems, reliability, Mean Time Between Failure (MTBF), Mean Time To Repair (MTTR), and preventive maintenance. References are obtained from books, scientific journals, theses, and other scientific sources relevant to the research.

2. **Problem Identification**

At this stage, the problems that occur in centrifugal pumps are identified, especially regarding the high frequency of component damage that causes disruption of the water distribution process. The results of the identification are used as a basis for determining the focus of the research.

3. **Data Collection**

Research data was obtained through direct observation in the field, interviews with technicians and operators, and documentation of historical data on pump failures. The data collected included the pump's operating time, the number of breakdowns, the repair time, and the type of damage that occurred during the study period.

4. **Data Processing**

The data that has been obtained is then processed using the Mean Time Between Failure (MTBF) method to find out the average operating time before damage occurs and Mean Time To Repair (MTTR) to find out the average time required in the repair process. In addition, the Availability value is calculated as an indicator of the level of operational readiness of the pump.

5. **Results Analysis**

The results of MTBF, MTTR, and Availability calculations were analyzed to determine the reliability level of the centrifugal pump. Furthermore, the identification of components that have the highest level of damage is carried out as a basis for the preparation of a proposed preventive maintenance schedule so that it can minimize the occurrence of repeated damage.

6. **Conclusion**

The last stage is to draw conclusions based on the results of the analysis that has been carried out. The conclusion contains the level of reliability of the centrifugal pump as well as recommendations for the implementation of preventive maintenance to improve the reliability and continuity of pump operation.

**D. Data Analysis**

This research was carried out on centrifugal pumps used in the clean water distribution system of the Regional Drinking Water Company (PDAM). Data were obtained through three methods, namely direct field observation of pump operational conditions, interviews with technicians and operators responsible for pump maintenance, and record tracing (*Log book*) pump maintenance and repair during the period June 2025 - June 2026.

## III. RESULT AND DISCUSSION

## A. Cumulative calculation results from MTBF and MTTR in each event

Preliminary analysis showed porous bearings, impellers, clutches, and casings as the dominant components that suffered damage. Maintenance priorities are determined based on the frequency of damage and the length of downtime caused. As an initial overview of the recording pattern, the repair data snippet in the first quarter while the compilation of damage data for the full year (June 2025- June 2026) is presented in full in Table 4.

**Table 3.** Centrifugal Pump Damage Data for the Period of June 2025-June 2026

| Yes | Date of Damage | Damaged Components | Repair time | | Repair Time (Hours) | Downtime (minutes) |
|---|---|---|---|---|---|---|
| | | | Start | Finish | | |
| 1 | 12/06/2025 | bearings | 08.00 | 10.30 | 2,5 | 150 |
| 2 | 05/07/ 2025 | impeller | 09.00 | 13.30 | 4,5 | 270 |
| 3 | 28/07/ 2025 | bearings | 08.30 | 11.00 | 2,5 | 150 |
| 4 | 19/08/2025 | Clutch | 08.00 | 10.00 | 2 | 120 |
| 5 | 11/09/ 2025 | bearings | 09.00 | 12.00 | 3 | 180 |
| 6 | 30/09/2025 | impeller | 08.00 | 12.30 | 4,5 | 270 |
| 7 | 18/10/ 2025 | bearings | 08.30 | 11.30 | 3 | 280 |
| 8 | 10/11/ 2025 | Porous casing | 08.00 | 14.00 | 6 | 360 |
| 9 | 2/12/2025 | bearings | 09.00 | 11.30 | 2,5 | 150 |
| 10 | 24/12/2025 | Clutch | 08.00 | 10.00 | 2 | 120 |
| 11 | 16/01/2026 | impeller | 08.00 | 12.00 | 4 | 240 |
| 12 | 8/02/ 2026 | bearings | 08.30 | 11.00 | 2,5 | 150 |
| 13 | 5/03/2026 | Clutch | 09.00 | 11.00 | 2 | 120 |
| 14 | 1/04/ 2026 | impeller | 08.00 | 12.30 | 4,5 | 270 |
| 15 | 27/05/2026 | Porous casing | 08.00 | 14.30 | 6,5 | 390 |
| 16 | 15/06/2026 | bearings | 08.00 | 11.00 | 3 | 180 |

Based on the Pareto Diagram in Figure 4.2, it is known that *bearing* components are the most frequently damaged components with a frequency of 7 times or 43.75% of all damage events. It was followed by *impellers* 4 times (25.00%), clutches 3 times (18.75%), and porous *casing* 2 times (12.50%). The cumulative percentage shows that the bearings and impellers together have accounted for 68.75% of the total damage, making the two components the top priority group according to the Pareto principle. Based on this principle, *preventive maintenance* efforts should be focused first on *bearings* and *impellers* because they contribute the largest to the total damage of centrifugal pumps.

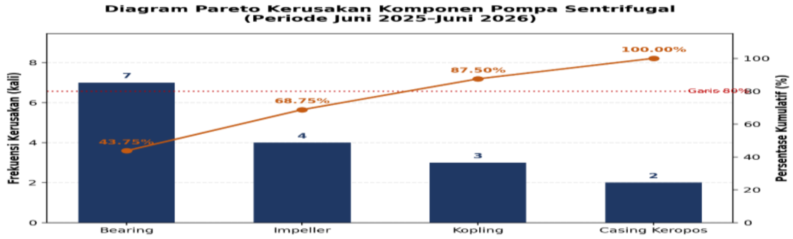
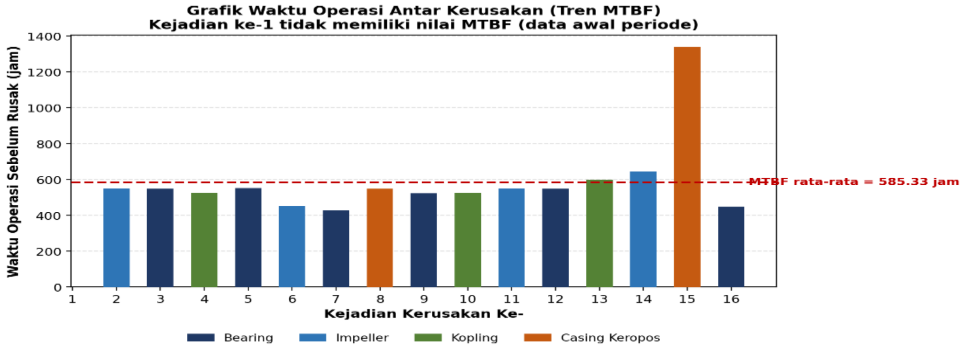


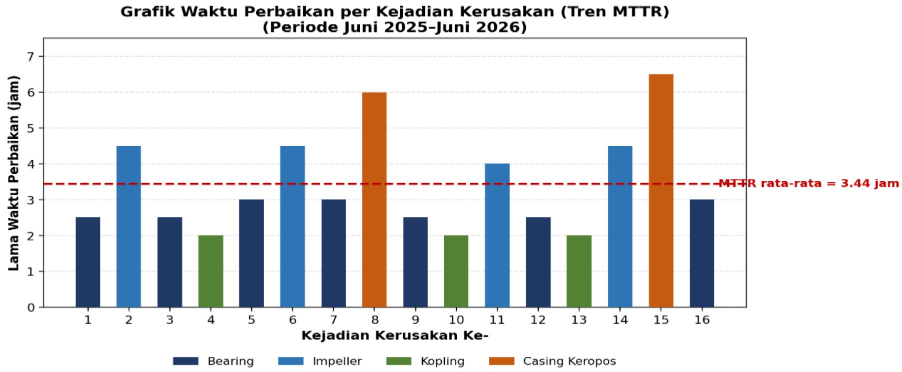

**Fig. 4.2 Pareto Diagram of Centrifugal Pump Component Breakdowns**

## B. MTBF and MTTR Trend Charts and Analysis

| Parameters | Value |
|---|---|
| MTBF | 548.75 hours |
| MTTR | 3.28 hours |
| Availability | 99,41% |

The average MTBF value of 548.75 hours indicates that the centrifugal pump is capable of operating for an average of 548.75 hours before suffering the next breakdown, which indicates that the pump's reliability level is relatively good. As seen in Figure 4.3, the MTBF value in the 16th event (*porous casing*) reached 1,339.50 hours, much higher than other events, so it was an *outlier* value that increased the overall average MTBF. This value is in line with the progressive nature of the casing damage due to long-term corrosion, so the pump can operate for a much longer time before the casing actually leaks. In Figure 4.4 showing the enlarged scale without the 15th event, it is more evident that events involving bearing components (3rd, 7th, 9th, 16th events) were consistently below the occurrence of other components, with the lowest MTBF value at the 7th event being 428.00 hours. This condition indicates that bearings tend to be damaged earlier than other components, so the bearing inspection interval needs to be set more tightly than other components, which is under 428 hours of operation.




## C. Pump Treatment System Analysis

Before the analysis was carried out using *the Mean Time Between Failure* (MTBF) and *Mean Time To Repair* (MTTR) methods, the centrifugal pump maintenance system in PDAM was still a combination of preventive maintenance and *corrective maintenance*. *Preventive maintenance* is carried out through periodic checks of the condition of the bearing, impeller, clutch, lubrication, and condition of the pump casing. However, based on the results of interviews with technicians, maintenance activities are more often carried out after the pump shows symptoms of damage such as the appearance of excessive vibration, abnormal noise, decreased water discharge, and leaks in the pump casing.

## D. MTBF Analysis

obtained an average MTBF value of 548.75 hours. This value shows that the average pump is able to operate for 548.75 hours before suffering the next breakdown. However, this value was also influenced by one *outlier* value in the 15th incident of 1,339.50 hours. If the deviation value is excluded from the calculation, the average MTBF of the remaining 14 intervals is approximately 7,440.50/14 = 531.46 hours, which is more representative of the general operating conditions of the pump.

## E. MTTR Analysis

The average MTTR value obtained of 3.28 hours shows that the average time required by technicians to complete one repair job is relatively short. A low MTTR value indicates that:

- The technician has sufficient experience and competence in handling pump repairs,
- The repair procedure has gone well and is quite standardized, especially on the consistent clutch repair which takes 2.00 hours throughout the incident,
- The availability of the main parts is sufficient so that there is no delay in repairs.

**F. Availability Analysis**

The calculation results show an Availability value of 99.41%. An availability value above 95% indicates that the pump has an excellent level of operational readiness. This indicates that the operating time is much greater than the downtime due to damage. However, increasing availability can still be done through:

- periodic inspection of the bearing at the interval proposed in Table 4.13,
- Periodic Monitoring of Vibrations.
- Bearing temperature monitoring to detect indications of early wear,
- regular clutch alignment checks,
- Regular lubricant changes according to the manufacturer's recommendations.

**G. Pareto Diagram Analysis**

The results of the Pareto Diagram in Figure 4.2 show that the bearing component accounts for 43.75% of the total pump failure. Based on the Pareto principle (80/20), the focus of maintenance should be directed to the components that are most frequently damaged because it will have the greatest impact on reducing downtime. Thus, the priority order of recommended preventive maintenance is as follows:

1. Bearings
2. Impeller
3. Coupling
4. Porous Casing

**H. Preventive Maintenance Proposal**

Based on all the results of the analysis of MTBF, MTTR, Availability, and Pareto Diagrams, a proposed preventive maintenance schedule was obtained. The implementation of the schedule is expected to be able to reduce the frequency of damage and increase the service life of centrifugal pumps, especially in bearing components that are the biggest contributor to damage.

## IV. CONCLUSION

Based on the results of data collection, data processing, as well as analysis and discussion of preventive maintenance of centrifugal pumps in PDAM's clean water distribution system using the Mean Time Between Failure (MTBF) and Mean Time To Repair (MTTR) methods that have been described in Chapter IV, several conclusions can be drawn as follows.

1. During the period June 2025-June 2026, there were 16 incidents of damage to centrifugal pumps, with bearing components as the largest contributor to damage, namely 7 times (43.75%), followed by impellers 4 times (25.00%), clutches 3 times (18.75%), and porous casings 2 times (12.50%). Based on the results of the Pareto Diagram analysis, bearings and impellers are two critical components that together account for 66.67% of all damages, making them a top priority in the implementation of preventive maintenance.
2. The Mean Time Between Failure (MTBF) value obtained was 548.75 hours, which indicates that on average the centrifugal pump is able to operate for 548.75 hours before experiencing the next breakdown. This value is relatively good, but damage to bearing components tends to occur at operating times below the average MTBF, so bearing inspection intervals need to be set more tightly than other components.

3. The Mean Time To Repair (MTTR) value obtained was 3.28 hours, which shows that the centrifugal pump repair process has been carried out effectively and relatively quickly. The longest repair time occurs in porous casing damage (6.0–6.5 hours) because it requires disassembly and welding processes, while the fastest repair time occurs in clutch damage (2.0 hours).
4. The system availability value obtained from the MTBF and MTTR calculations is 99.41%, which is well above the 95% threshold commonly used as a reference for the reliability of industrial equipment. This shows that centrifugal pumps have an excellent level of operational readiness in supporting the continuity of clean water distribution to customers.
5. Overall, the MTBF and MTTR methods have proven to be effective in being used as a quantitative basis in determining more planned preventive maintenance intervals on centrifugal pumps, so that they can be a reference for clean water supply companies in improving equipment reliability and reducing operational downtime.

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