Jurnal Penelitian Politeknik Penerbangan Surabaya
Vol 10, No 4, Month December, Year 2025
p-ISSN: 1978-6832
e-ISSN: 2622-5948

ANALYSIS OF RELIABILITY & AVAILABILITY OF GENERATOR SET MACHINE (GENSET) OF POLYTECHNIC AVIATION SURABAYA

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DOI: https://doi.org/10.46491/jp.v19i4.2031

Abstrak

Generator sets (generators) are backup power sources that have an important role in maintaining operational and service continuity at the Surabaya Aviation Polytechnic when there is a disruption of electricity supply from PLN. The reliability and availability of generators are the main factors that determine the sustainability of educational activities, practicums, and campus facility operations. This study aims to analyze the reliability and availability of the Cummins Silent 500 KVA Generator Set engine based on operational and maintenance data during the January-December 2024 period. The study used a descriptive quantitative approach by utilizing data on operating hours, scheduled maintenance times, repair times due to damage, and number of component failures. The analysis was carried out using the indicators of Specified Operating Time (SOT), Actual Operating Time (AOT), Mean Time Between Failures (MTBF), Reliability, and Availability. The results showed that the average reliability level of Generator Set 1 was 98.90%, while Generator Set 2 was 99.15%. The largest decrease in reliability occurred in Generator Set 1 in June with a value of 94.47%, which was caused by damage to several components thus increasing repair time. Meanwhile, the average availability rate of Generator Set 1 and Generator Set 2 reached 95.10% and 95.24%, respectively, indicating that both units still have a good level of operational readiness. The results of this study can be the basis for the preparation of preventive maintenance strategies and equipment performance evaluations to improve the reliability and continuity of electrical power supply at the Surabaya Aviation Polytechnic.
Keywords : Generator Set, Reliability, MTBF, Preventive Maintenance

INTRODUCTION

Generator set (genset) is a backup power generation system that maintains continuity of power supply when the main grid is disrupted. Its presence is especially important in facilities that require a continuous supply of electricity, such as hospitals, airports, industries, data centers, and educational institutions.

Generator failure can hamper operations, reduce service quality, and increase the risk of equipment damage. Therefore, an effective maintenance system is needed so that the generator is always ready to operate (O'Connor & Kleyner, 2012).

Maintenance is an activity to maintain or restore the condition of equipment so that it can function according to its specifications, which includes systematic inspection, maintenance, repair, and replacement of components (Muhtadi, 2009). Maintenance aims to minimize failures, increase reliability, extend asset life, and reduce the cost of unplanned breakdowns (Mobley, 2002). A good maintenance system can also increase the effectiveness of operations and reduce the frequency of failures (Dhillon, 2006). Of the various strategies available, preventive maintenance is widely applied because it can reduce the risk of sudden damage and increase the reliability of equipment (Mobley, 2002; Dhillon, 2006).

In reliability engineering, equipment performance can be evaluated through reliability and availability. Reliability indicates the probability that the system can operate without failure within a certain period, while availability indicates the readiness of the equipment when needed. Both indicators are important for evaluating the effectiveness of maintenance and supporting decision-making in asset management (Ebeling, 1997; O'Connor & Kleyner, 2012; Smith, 2017).

The Surabaya Aviation Polytechnic is a vocational university under the Ministry of Transportation whose education, practicum, research, and administrative activities depend on the continuity of electricity supply. To support these activities, the institution uses two units of Cummins Silent 500 KVA Generator Set as a backup power source when PLN's supply is disrupted.

Based on operational data and maintenance records for the January-December 2024 period, component damage was still found that increased downtime and reduced the actual operating time of the generator. This condition shows the need to evaluate the effectiveness of the maintenance system using the indicators of Specified Operating Time (SOT), Actual Operating Time (AOT), Mean Time Between Failures (MTBF), Reliability, and Availability (Ebeling, 1997; O'Connor & Kleyner, 2012).

Several studies have shown that Reliability Centered Maintenance (RCM) can improve maintenance effectiveness by determining appropriate maintenance intervals (Zein et al., 2019). Regular maintenance has also been shown to improve the reliability and availability of generator sets (Manihuruk & Samosir, 2022). In addition, the combination of RCM and Maintenance Value Stream Mapping (MVSM) can improve maintenance process efficiency (Pratama Putra & Endih Nurhidayat, 2022). The RCM approach has also been applied to the Cummins Silent 500 kVA Generator Set to optimize backup electrical power availability (Widdana & Lukmandono, 2023).

However, previous research has generally focused on the formulation of RCM strategies and the analysis of failure modes. Studies that evaluate reliability and availability based on actual operational data through SOT, AOT, MTBF, Reliability, and Availability indicators are still limited, especially in vocational college environments. The novelty of this study lies in a comprehensive analysis of two units of the Cummins Silent 500 KVA Generator Set using actual operational and maintenance data during January–December 2024.

This study aims to analyze the reliability and availability level of Cummins Silent 500 KVA Generator Set at the Surabaya Aviation Polytechnic. The results of the research are expected to contribute to the development of reliability engineering and maintenance management, become the basis for evaluating the effectiveness of maintenance, and support the development of preventive maintenance strategies to improve the reliability and availability of generators in a sustainable manner.

METHODS

This study used a descriptive quantitative approach to analyze the reliability and availability of two units of Cummins Silent 500 KVA Generator Set at the Surabaya Aviation Polytechnic. The analysis was carried out using numerical operational and maintenance data during January-December 2024 with the indicators of Specified Operating Time (SOT), Actual Operating Time (AOT), Mean Time Between Failures (MTBF), Reliability, and Availability.

The object of the research is in the form of two units of Cummins Silent 500 KVA Generator Set which functions as a backup power source. The research data consists of primary data and secondary data. Primary data is obtained through interviews with technicians and direct observation, while secondary data comes from operational logbooks, operating hours data, breakdown records, maintenance reports, downtime times, number of failures, and other supporting documents.

The data collection techniques in this study include:

1. Interview

Interviews are conducted with the technicians responsible for the operation and maintenance of the generator set. This activity aims to obtain information about operational procedures, maintenance activities, causes of damage, and repair actions.

2. Observations

   Observations are carried out directly on the condition of the generator set, operational activities, and maintenance processes. The results of the observations are used to match actual conditions with available operational data.

3. Documentation

   Documentation is carried out by collecting operational logbooks, operating hours data, breakdown records, periodic maintenance reports, activity documentation, and other technical documents that support the analysis process.

4. Literature Study

   Literature studies were carried out through the review of books, standards, scientific articles, and journals related to reliability engineering, maintenance management, Reliability Centered Maintenance (RCM), as well as analysis of reliability and availability of generator sets.

Data analysis was carried out by calculating the values of SOT, AOT, MTBF, Reliability, and Availability. The indicators are used to evaluate the maintenance effectiveness, failure rate, and operational readiness of the generator set during the study period.

The accuracy of the data is guaranteed through a validation process by matching operational data, maintenance data, maintenance logbooks, and the results of technician interviews. Validation is performed to ensure the consistency of operating time, maintenance time, number of failures, and downtime data.

The research stages include operational and maintenance data collection, data pre-processing, calculation of reliability and availability indicators, analysis of results, and drawing conclusions. The complete flow of the research is shown in Figure 1.

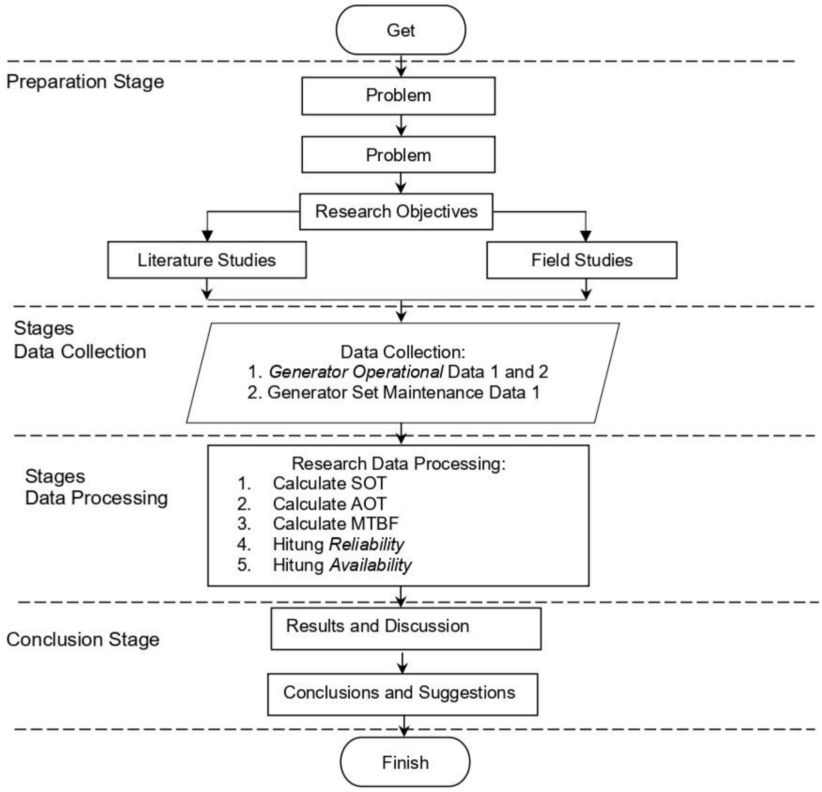

Figure 1. ***Flowchart*** **Penelitian**

RESULTS AND DISCUSSION

The results of the study were obtained based on the analysis of operational data and maintenance data of two units of the Cummins Silent 500 KVA Generator Set at the Surabaya Aviation Polytechnic during the January-December 2024 period. The analysis was carried out using the indicators of Specified Operating Time (SOT), Actual Operating Time (AOT), Mean Time Between Failures (MTBF), Reliability, and Availability to evaluate the level of reliability and availability of the generator set as a backup power provider system.

Spesified Operating Time (SOT)

Specified Operating Time (SOT) is the planned or set operating time as the basis for evaluating the performance of the generator set during the observation period. The SOT value is obtained from the total operating time of the generator set each month which is used as a reference in the calculation of Actual Operating Time (AOT), Reliability, and Availability.

Table 1 shows the operating hours of the Cummins Silent 500 KVA Generator Set 1 and 2 during January–December 2024.

Table 1. Generator Operating Hours (SOT)

Moon	Generator Operating Time 1 (Minutes)	Generator Operating Time 2 (Minutes)	TODAY (Minutes)
1	281	278	559
2	255	245	500
3	253	214	467
4	219	236	455
5	223	219	442
6	177	270	447
7	210	206	416
8	190	154	344
9	190	190	380
10	230	227	457
11	250	235	485
12	400	400	800

(Source: Surabaya Aviation Polytechnic)

Based on Table 1, the operating time of the generator set fluctuates following the disruption of PLN's electricity supply. The highest operating time occurred in December at 800 minutes, while the lowest in August was 344 minutes.

During the research period, Generator Set 1 took 7 damages, while Generator Set 2 took 5 damages. Higher frequency of Set 1 Generator failures indicates a lower level of operational reliability and requires more attention in preventive maintenance. The more often equipment fails, the more likely it is that the reliability value will decrease (O'Connor & Kleyner, 2012).

Treatment Period Time(s)

The Cummins Silent 500 KVA Set Generator at the Surabaya Aviation Polytechnic is used as a backup power source so that it only operates when there is a disruption of electricity supply from PLN. Nevertheless, preventive maintenance activities are still carried out routinely twice every week with an average duration of 20 minutes per activity, or about 2.7 hours every month.

The implementation of periodic maintenance aims to maintain the condition of the generator set so that it remains in a ready to operate condition. These activities include checking the lubrication system, cooling system, battery condition, starter system, fuel level, pressure indicator, and generator function testing. A preventive maintenance program that is carried out periodically is expected to be able to reduce the possibility of sudden damage so that the reliability and availability value of the generator set can be maintained at a high level.

Total Operating Time (T) and Amount of Damage

Total unscheduled operating time (T) is the accumulation of time the generator set cannot operate due to damage or corrective maintenance activities. In addition, the number of damage events during the study period was also used as the basis for calculating the Mean Time Between Failures (MTBF).

Table 2. Data on Operating Time and Number of Generator Damage 1 and 2

Nama Kegiatan	Bulan												T Rusak
	1	2	3	4	5	6	7	8	9	10	11	12	(Menit)
Genset 1			5	5		7			5				22
Jumlah Kerusakan			1	2		3			1				7
Genset 2			7					4		5			16
Jumlah Kerusakan			2					2		1			5

Based on Table 2, it can be seen that Generator Set 1 has a higher amount of damage and downtime than Generator Set 2. This causes the actual operating time of Generator Set 1 to be lower, which affects the decrease in MTBF value, reliability, and availability. Increased downtime is generally caused by component damage that requires corrective maintenance before the generator can be operated again. The greater the downtime that occurs, the smaller the actual operating time that the generator set can achieve.

Actual Operating Time (AOT)

Actual Operating Time (AOT) is the actual operating time of the generator set after deducting the time used for scheduled and unscheduled maintenance activities. The AOT value indicates the length of time the generator set was actually in a ready state for operation during the observation period.

Table 3. AOT Calculation Results of Generator 1 and 2

Nama Operation	Bulan											
	1	2	3	4	5	6	7	8	9	10	11	12
Genset 1	539	480	441	428	422	417	396	324	354	437	465	780
Genset 2	539	480	438	435	422	427	396	318	360	431	465	780

The calculation results show that the AOT value of Generator Set 2 is generally higher than that of Generator Set 1. This shows that Generator Set 2 has better effective uptime because it experiences relatively less downtime. The difference in AOT values between the two generators shows that the effectiveness of maintenance implementation affects the operational readiness of the generator set. The smaller the downtime, the greater the Actual Operating Time value.

Mean Time Between Failures (MTBF)

Calculation of the average time between failure (MTBF) of Cummins silent 500 KVA generator sets 1 and 2 in January – December 2024 in table 4. Below:

Table 4. MTBF Calculation Results of Generator Set 1 and 2

Nama Operation	Bulan												Rata-rata
	1	2	3	4	5	6	7	8	9	10	11	12	
Genset 1	0	0	441	214	0	139	0	0	354	0	0	0	96
Genset 2	0	0	219	0	0	0	0	159	0	431	0	0	67

Graph of Mean Time Between Failures (MTBF) of Cummins silent 500 KVA generator sets 1 and 2 for January – December 2024 in figure 2. Below:

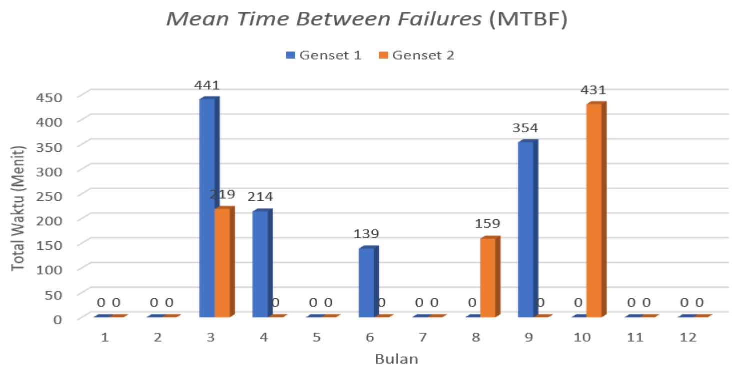

Figure 2. MTBF Calculation Results of Generator Set 1 and 2

Based on the calculation results, Generator Set 2 has an MTBF value that tends to be higher than Generator Set 1. This shows that the Set 2 Generator is able to operate longer before it fails. In contrast, the decrease in MTBF values in Generator Set 1 mainly occurred in June which coincided with an increase in the number of component damages. These conditions show that the frequency of failures has a direct relationship with the decline in the value of MTBF. These results are consistent with Manihuruk and Samosir (2022), who found that an increase in failure frequency can reduce the MTBF value and subsequently affect the reliability level of the generator set.

Reliability

The results of the calculation of the reliability level of each generator set (Genset) 1 and 2 cummins silent 500 KVA in January – December 2024 in table 5. Below:

Table 5. Reliability Calculation Results of Generator Sets 1 and 2

Nama Operation	Bulan												Rata-rata
	1	2	3	4	5	6	7	8	9	10	11	12	
G1 (%)	100,00	100,00	98,22	96,37	100,00	94,47	100,00	100,00	97,79	100,00	100,00	100,00	98,90
G2(%)	100,00	100,00	96,45	100,00	100,00	100,00	100,00	95,15	100,00	98,18	100,00	100,00	99,15

Remarks :

< 70% : Very frequent disturbances

70% ≤ R < 95%: Frequent disturbances

≥ 95% : Rarely disturbed

Graph of the reliability level of cummins silent 500 KVA 1 and 2 genset engines for January – December 2024 in figure 3. below :

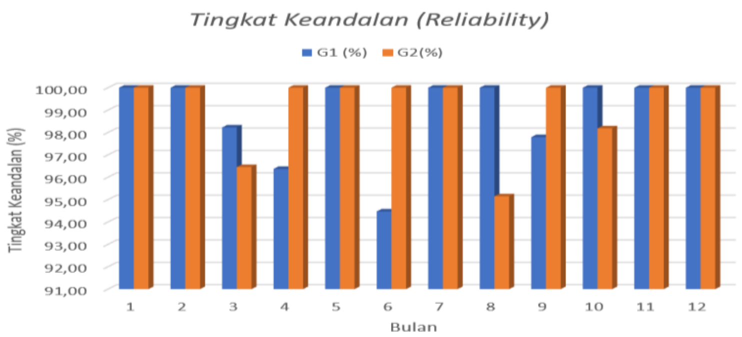

Figure 3. Generator Reliability Level Graph 1 and 2

Availability Rate

The results of the calculation of the availability level (availability) of each generator set (Genset) 1 and 2 cummins silent 500 KVA in January – December 2024 in table 6. Below:

Table 6. Results of Calculation of Availability Level *(Availabilty)* of Generator Set 1 and 2

Nama Operation	Bulan												Rata-rata
	1	2	3	4	5	6	7	8	9	10	11	12	
G1 (%)	96,42	96,00	94,43	94,07	95,48	93,29	95,19	94,19	93,16	95,62	95,88	97,50	95,10
G2(%)	96,42	96,00	93,79	95,60	95,48	95,53	95,19	92,44	94,74	94,31	95,88	97,50	95,24

Remarks :
< 70% : Very frequent disturbances
70% ≤ R < 95%: Frequent disturbances
≥ 95% : Rarely disturbed

Graph of availability of 1 and 2 cummins silent 500 KVA generator sets for January – December 2024 in figure 4. Below:

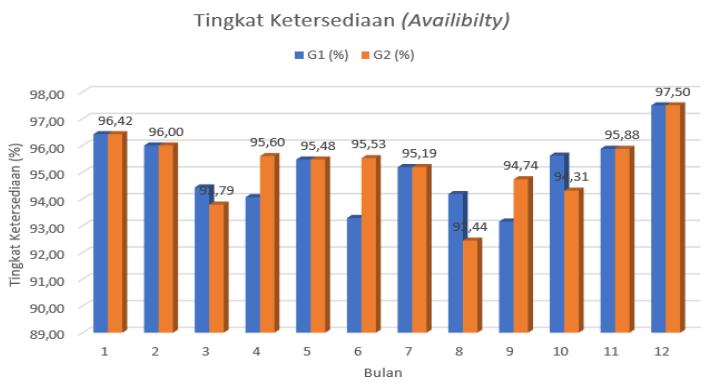

Figure 4. Results of Calculation of Generator Availability Level 1 and 2

CONCLUSION

Based on the analysis that has been carried out, it can be concluded that the performance results of the 500 KVA silent cummins generator set (genset) at the Surabaya Aviation Polytechnic can be concluded as follows:

1. The average reliability level from January to December 2024 for generator set 1 engine is 98.90% and generator set engine (Genset) 2 is 99.15%, there is a considerable decrease in generator set 1 engine in June of 94.47% due to component damage and requires maintenance and component maintenance time.
2. The average availability rate from January – December 2024 for generator set 1 engine is 95.10% and generator set engine (Genset) 2 is 95.24%

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