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Temperature and Vibration Monitoring System on Electric Motors From Wireless Remote Control Using Blynk App

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Abstract

The purpose of this research is to create a device that can track the temperature and vibration of an electric motor. It has two sensors: a thermocouple sensor and a piezoelectric sensor. When the electric motor is operating, the device displays digital data in the form of numbers on the monitor screen wirelessly. This research shows that the electric motor can be effectively monitored remotely. The Blynk app can connect with the unit within 0-200 meters without any obstacles. However, if the unit is blocked by a barrier, the distance that can be covered by the Blynk application is 0-160 meters. The test results show that the average electric motor temperature measured is 31.7°C, and the percentage of error value obtained is -1.01%.

Keywords: Thermocouple sensor, Piezoelectric sensor, Blynk, Temperature and Vibration

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1. Pendahuluan

Electric motors are classified into two main types: Direct Current (DC) motors and Alternating Current (AC) motors. Both types are widely used on ships due to their indispensable role in supporting various operations. These motors are critical for ship functionality, performing essential tasks across different operational stages. Because of their significant role, electric motors are used continuously on a daily basis. However, this constant operation exposes them to wear and tear, increasing the likelihood of malfunctions and breakdowns over time. Consequently, ensuring the proper functioning and maintenance of electric motors on ships is of paramount importance.

One of the most frequent and serious issues encountered with electric motors is the burning of the windings. This failure typically results from prolonged exposure to high temperatures, leading to insulation breakdown and potential short circuits. Several factors contribute to the overheating of electric motors, including continuous operation under heavy loads, inadequate ventilation, and improper lubrication. Overheating can escalate into a critical situation, potentially leading to catastrophic events

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such as fires. Fires caused by motor overheating not only damage the motors themselves but also jeopardize the safety of the entire vessel and its crew.

In addition to overheating, another critical factor affecting the performance and longevity of electric motors is vibration. Abnormal motor vibrations are often caused by a range of issues, such as unbalanced rotors, loose or improperly secured mounting, and misaligned bearings. These vibrations can lead to excessive wear on motor components, reducing operational efficiency and increasing the likelihood of breakdowns. Furthermore, prolonged exposure to vibrations can cause fatigue in surrounding structures, leading to mechanical failures and compromising the overall stability of the motor.

The impact of motor malfunctions on ship operations cannot be overstated. For example, during loading and unloading activities, any disruption caused by a malfunctioning motor can lead to significant delays. Such delays not only result in financial losses due to idle time and missed deadlines but also impact the operational schedule of the entire shipping process. Furthermore, when critical motors fail unexpectedly, the risk of collateral damage increases, potentially leading to even more extensive repairs and replacements.

Given the potential severity of motor malfunctions, proactive measures must be taken to monitor and mitigate these risks. One effective approach is the implementation of a remote monitoring system that tracks the temperature and vibration levels of electric motors in real-time. This system can provide early warning signs of abnormal conditions, enabling timely interventions to prevent catastrophic failures. By detecting signs of overheating or excessive vibration at an early stage, maintenance teams can address the root causes before they escalate into more serious issues.

The need for a reliable and efficient monitoring system has led to the development of various technological solutions. One such solution involves the use of wireless communication and mobile applications to provide real-time data monitoring and alerts. Among the available options, the Blynk application stands out as a versatile and user-friendly platform for creating remote monitoring systems. Blynk enables users to design custom dashboards for displaying sensor data, set up automated alerts, and access real-time information from anywhere with an internet connection.

To address the challenges associated with motor overheating and vibration on ships, this project proposes the development of a KIT titled “Design and Development of a Remote Wireless Temperature and Vibration Monitoring System for Electric Motors Using the Blynk Application.” This system will be equipped with sensors to measure temperature and vibration levels, and it will transmit the collected data to a central monitoring dashboard via a wireless network. The dashboard, accessible through the Blynk application, will allow operators to monitor motor conditions in real-time and receive alerts when predefined thresholds are exceeded.

The proposed system offers several advantages over traditional manual monitoring methods. Firstly, it provides continuous, real-time monitoring of motor conditions, ensuring that any deviations from normal operating parameters are detected promptly. This early detection capability can significantly reduce the likelihood of unexpected breakdowns and associated downtime. Secondly, the use of wireless communication eliminates the need for complex wiring installations, making the system more flexible and easier to deploy. Lastly, the remote accessibility feature enables maintenance teams to stay informed about motor conditions even when they are not physically present on the ship.

In addition to preventing motor failures, the proposed monitoring system can contribute to improved overall maintenance practices. By analyzing historical temperature and vibration data, operators can identify patterns and trends that may indicate potential issues. This data-driven approach allows for the implementation of predictive maintenance strategies, which can further enhance the reliability and performance of electric motors. Predictive maintenance not only minimizes unplanned downtime but also extends the lifespan of motor components, leading to long-term cost savings.

Safety is another critical aspect that this project aims to address. By mitigating the risk of motor-related fires and mechanical failures, the monitoring system can help ensure a safer working environment for the crew. Early detection of abnormal conditions provides valuable time for operators to take corrective actions, such as reducing motor loads or shutting down the motor to prevent further damage. This proactive approach reduces the likelihood of accidents and minimizes the potential for injuries or property damage.

Moreover, the implementation of the proposed monitoring system aligns with industry best practices and regulatory requirements for maritime safety. Many shipping companies and regulatory bodies emphasize the importance of adopting advanced technologies to enhance operational efficiency and safety. By incorporating a state-of-the-art monitoring system, ship operators can demonstrate their commitment to continuous improvement and compliance with industry standards.

In conclusion, electric motors play a vital role in the daily operations of ships, making their reliability and performance essential for overall operational success. However, the risks associated with motor overheating and abnormal vibrations necessitate the adoption of advanced monitoring solutions. The proposed “Design and Development of a Remote Wireless Temperature and Vibration Monitoring System for Electric Motors Using the Blynk Application” aims to provide an effective and efficient solution for real-time motor condition monitoring. Through continuous data collection, early warning alerts, and remote accessibility, this system can help prevent motor failures, enhance safety, and improve maintenance practices on ships. By leveraging modern technology, this project seeks to contribute to the advancement of maritime operations and ensure the smooth functioning of electric motors in critical applications.

2. Research Method

The research method used in this study is the *Research and Development* (R&D) method. This research and development method is employed to produce a specific product and test its effectiveness. In this study, the product developed is a remote wireless monitoring tool for the temperature and vibration of electric motors, utilizing the Blynk application. This tool is designed to be an effective and beneficial solution for monitoring the condition of electric motors, whether they are operating normally or showing signs of malfunction. Thus, it helps prevent motor damage caused by insufficient monitoring. Additionally, testing can be conducted from any location since the tool supports remote monitoring.

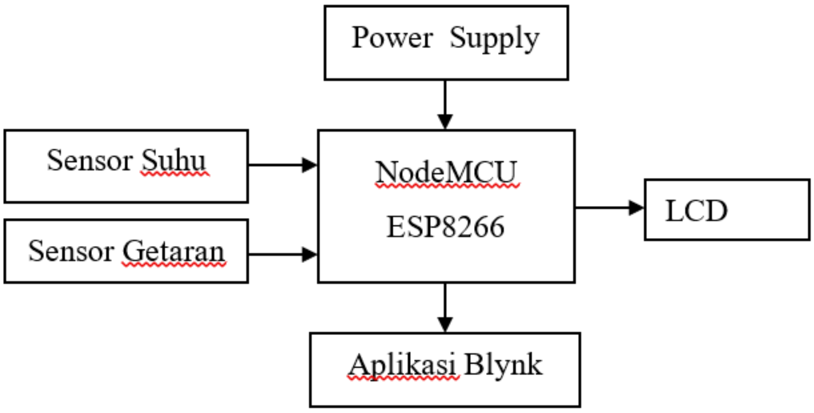

Figure 1. Blok Diagram

Component Descriptions in the Block Diagram:

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1. NodeMCU ESP8266 is a microcontroller that acts as the central control unit, containing all the programming needed by other components in the system.
2. Temperature sensor is used to detect the temperature of the object. It is directly connected to the NodeMCU ESP8266, and the temperature data is sent to the Blynk application.
3. Vibration sensor functions to measure vibrations occurring on the observed object. The detected vibration data is analyzed and sent to the Blynk application.
4. 16x2 LCD is used to display the measurement results from the sensors. The data received by the sensors is processed by the NodeMCU ESP8266 and shown on the LCD screen.
5. Power supply provides the main power source for all components to ensure the system operates properly.
6. Blynk application is a software tool used to remotely monitor temperature and vibrations in this study.

3. Results and Discussion

The tool testing was conducted to determine whether the system functions properly, with the goal of ensuring that the tool operates in accordance with the design of the wireless temperature and vibration monitoring system for electric motors using the Blynk application. The test results for this system design utilized a NodeMCU ESP8266 microcontroller, a piezoelectric sensor, a thermocouple sensor, and were monitored using an LCD display and the Blynk application.

3.1. NodeMCU ESP8266 Test

The method for testing the microcontroller is to connect the microcontroller using a USB cable to the USB port on the NodeMCU ESP8266. Then, the cable is connected to a laptop or computer. If the microcontroller lights up with a blue indicator, it indicates that the microcontroller is functioning properly.

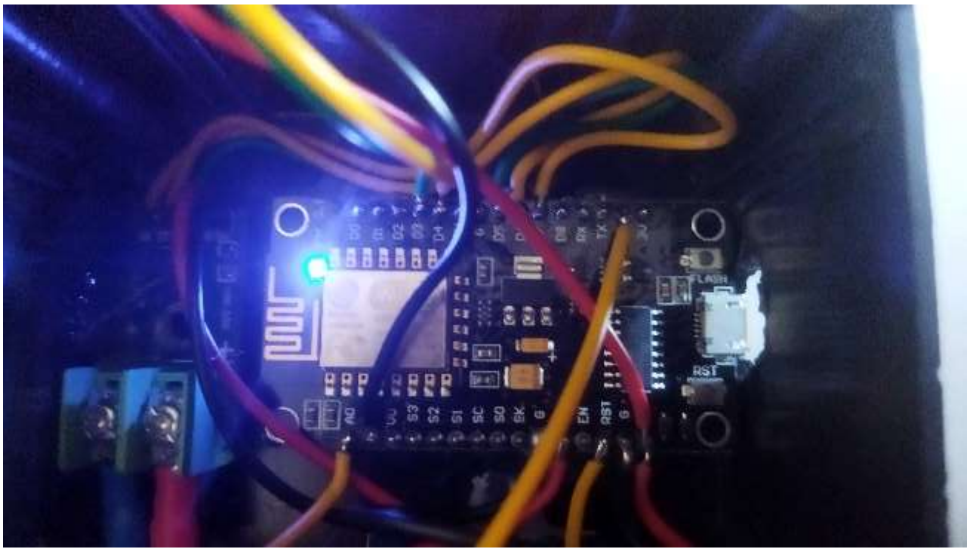

Figure 2. NodeMCU ESP8266 Test

3.2. Piezzoelectric Test

The sensor testing is carried out to ensure that the sensor functions properly during the assembly and testing process. The piezoelectric sensor is tested by connecting it to the microcontroller on pins A0 and GND. Programming is then performed using the Arduino software. The display of sensor values on the LCD confirms that the sensor is functioning properly.

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Figure 3. *Piezzoelectric* Test

3.3. Thermocouple Test

The method for testing the thermocouple sensor involves connecting the sensor to the MAX6675 driver, which is then connected to the NodeMCU ESP8266 microcontroller on pins D7, D6, D5, Vin, and GND. The test used a Type K thermocouple sensor, which was tested using heat from a lighter. The test was successful, as confirmed by the sensor values being displayed on the LCD screen.

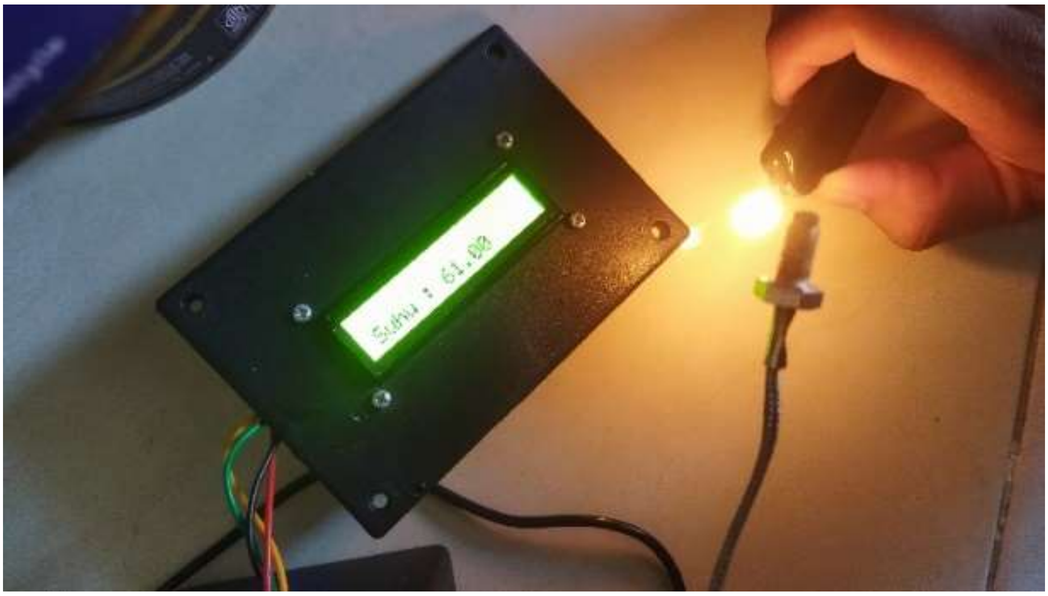

Figure 4. Thermocouple Test

To test whether the Type K thermocouple sensor matches the measured temperature, a comparison is made using a thermogun, and the error value of the sensor is calculated. If the sensor's error value is too high, calibration will be performed. However, if the error value is low, the sensor is deemed good and ready for use without calibration. The comparison of temperature readings on the LCD and Blynk application with the thermogun, conducted 30 times, showed that the sensor operates properly and matches the measured temperature. Therefore, additional calibration of the thermocouple

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sensor is not necessary. However, a small error still exists between the thermocouple sensor and the thermogun readings. The error value can be calculated using the following formula: Error value = (Sensor temperature value / Thermogun temperature value) × 100. Using this formula, the thermocouple sensor's error values can be seen in Table 1.

Tabel 1. Comparison of Thermocouple Sensor Values with Thermogun

No	*Thermogun*	*Thermocouple*	Eror
1	40,5°C	40,0°C	-1,23%
2	39,5°C	39,1°C	-1,01%
3	37,5°C	37,2°C	-0,8%
4	37,5°C	37,3°C	-0,5%
5	32,6°C	32,1°C	-1,53%
6	32,3°C	32,0°C	-0,92%
7	32,9°C	32,7°C	-0,60%
8	40,3°C	40,0°C	-0,74%
9	40,1°C	40,5°C	0,99%
10	40,2°C	40,3°C	0,24%
11	38,7°C	38,6°C	-0,25%
12	38,4°C	38,0°C	-1,04%
13	38,0°C	37,8°C	-0,52%
14	37,7°C	37,4°C	-0,79%
15	37,4°C	37,2°C	-0,53%
16	37,0°C	36,8°C	-0,54%
17	36,6°C	36,4°C	-0,54%
18	36,3°C	36,2°C	-0,27%
19	36,0°C	36,0°C	0%
20	35,8°C	35,6°C	-0,55%
21	35,3°C	35,0°C	-0,84%
22	34,9°C	34,7°C	-0,57%
23	34,5°C	34,2°C	-0,86%
24	34,2°C	33,9°C	-0,87%
25	33,8°C	33,5°C	-0,88%
26	33,5°C	33,2°C	-0,89%
27	33,1°C	32,9°C	-0,60%
28	32,7°C	32,5°C	-0,61%
29	32,4°C	32,0°C	-1,23%
30	32,1°C	31,7°C	-1,24%
	eror rate *thermocouple*		-0,73%

Based on Table 3.1, which presents the comparison between the thermocouple sensor and the thermogun conducted 30 times, the average percentage error was found to be -0.73%.

3.4. Application Blynk

The first test was conducted in an open room with no barriers between the two devices. The second test was carried out with an obstacle in the form of a wall, where the device was placed in a

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closed room. This test measured the connection from the closest range until disconnection, at which point the NodeMCU ESP8266 module could no longer read the sensor values. The purpose of this test was to assess the NodeMCU ESP8266 module's ability to receive signals from an Android smartphone hotspot under conditions with obstacles or barriers. This ensures that the device can function properly when applied to monitor the temperature and vibration of electric motors from a distance using the Blynk application. During the test without obstacles, conducted on a 300-meter road in front of the house, the connection remained stable from 0 to 200 meters. However, from 200 to 250 meters, the connection was lost. The test results are shown in Table 3.2 below.

Table 2. NodeMCU ESP8266 Module Testing Data Without Barrier

No.	Distance (m)	Without Barrier Transmitter and Receiver Communication
1	0	Connect
2	25	Connect
3	50	Connect
4	75	Connect
5	100	Connect
6	125	Connect
7	150	Connect
8	175	Connect
9	200	Connect
10	250	Disconnect

The obstacle test was conducted indoors, where the device was placed in a partitioned room with brick walls and the door closed. The test results showed that the connection remained stable from 0 to 160 meters, while from 160 to 170 meters, the connection was lost. Partitioned rooms in houses and on ships differ significantly. On ships, steel-partitioned rooms can affect the connection range of the Blynk application. The test results are shown in Table 3.3 below.

Table 3. NodeMCU ESP8266 Module Test Data with Obstacles

No.	Distance (m)	With Barrier Transmitter and Receiver Communication
1	0	Connect
2	2	Connect
3	4	Connect
4	10	Connect
5	15	Connect
6	25	Connect
7	50	Connect
8	70	Connect

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9	100	Connect
10	130	Connect
11	160	Connect
12	170	Disconnect

3.5. Data Analysis

The test was conducted by monitoring the temperature and vibration of the electric motor and observing whether the sensors functioned properly. If the sensors function correctly, they will send signals to the Blynk application as expected. This test aims to determine whether all components are working properly, indicated by the consistency of data between the LCD monitor and the Blynk application. Additionally, the test aims to evaluate the sensors' performance in monitoring temperature and vibration and transmitting the data to the Blynk application. In this test, the electric motor was operated for 30 minutes, and the test results are presented in Table 4.

Tabel 4. Thermocouple Sensor and Piezzoelctric Sensor Value Data

No.	Time (minutes)	Thermocouple Sensor	Piezoelectric Sensor (m/s^2)
1	1	30,3°C	20
2	5	30,8°C	24
3	10	30,7 °C	21
4	15	31°C	23
5	20	31,7°C	24
6	25	33,6°C	24
7	30	34,2°C	23

Based on the sensor tests conducted and presented in Table 4.1, it can be determined that the sensors are functioning properly. From the collected data, it can be concluded that the electric motor is in poor condition due to the average vibration value of 22 m/s^2. Since the unit of the piezoelectric sensor used is m/s^2, this value needs to be converted to mm/s for comparison with the standards in the ISO 10816 table. The conversion is performed using the following formula:

$$\textit{Piezzoelectric}\ \text{(mm/s)} = \frac{\sqrt{Nilai}Piezzoelectric\ \ x\ \ 1000}{Rpm\ Motor}$$

With the formula above and with a sensor value of 22 m/s^2 and the rpm of the electric motor tested this time is 978rpm, the following values can be taken:

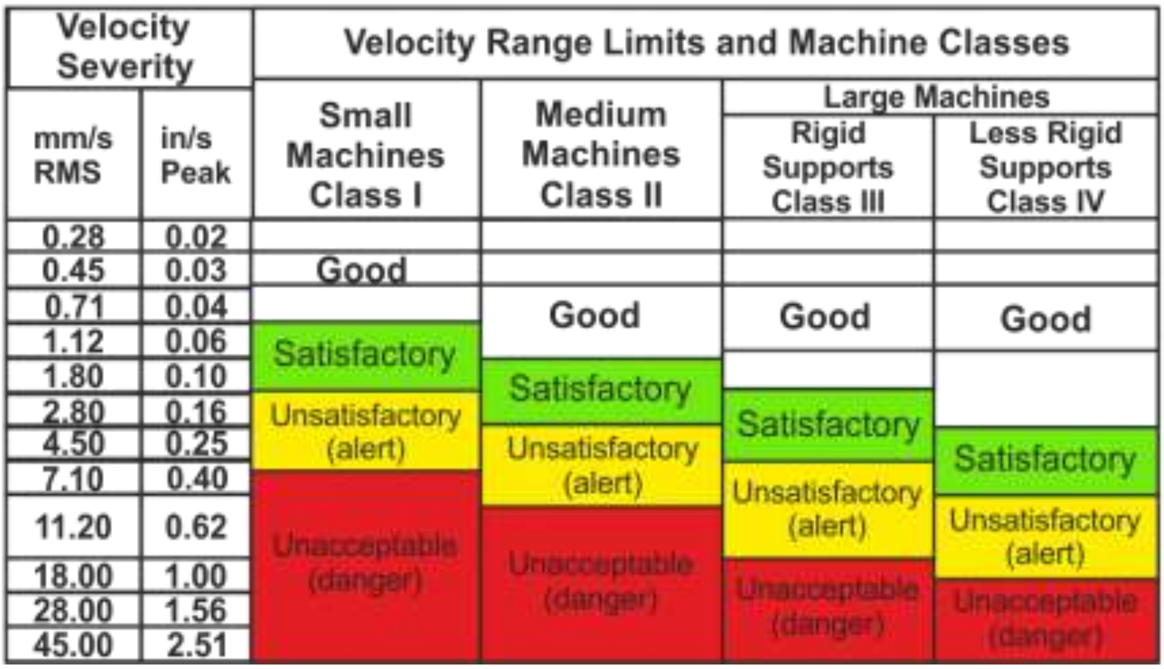
$$\textit{Piezzoelectric}\ \text{(mm/s)} = \frac{\sqrt{Nilai}\ Piezzoelectric\ \ x\ \ 1000}{Rpm\ Motor}$$

$$= \frac{\sqrt{22}\ \ x\ \ 1000}{978}$$

$$= \frac{4{,}69\ \ x\ \ 1000}{978}$$

$$= 4{,}8 \text{ mm/s}$$

When compared to the ISO 10816 table, the vibration value of 4.8 mm/s tested on the motor in Figure 4.1 with the Small Machines Class 1 motor specification is worth ‘Unsatisfactory (alert)’ or means not good.



Velocity Severity		Velocity Range Limits and Machine Classes			
				Large Machines	
mm/s RMS	in/s Peak	Small Machines Class I	Medium Machines Class II	Rigid Supports Class III	Less Rigid Supports Class IV
0.28	0.02	Good	Good	Good	Good
0.45	0.03				
0.71	0.04				
1.12	0.06	Satisfactory			
1.80	0.10		Satisfactory		
2.80	0.16	Unsatisfactory (alert)		Satisfactory	
4.50	0.25		Unsatisfactory (alert)		Satisfactory
7.10	0.40	Unacceptable (danger)		Unsatisfactory (alert)	
11.20	0.62		Unacceptable (danger)		Unsatisfactory (alert)
18.00	1.00			Unacceptable (danger)	
28.00	1.56				Unacceptable (danger)
45.00	2.51				

Figure 5. ISO10816-1

4. Conclussion

Based on the design process and test results conducted, it can be concluded that the wireless temperature and vibration monitoring system for electric motors using the Blynk application and the NodeMCU ESP8266 microcontroller has been successfully designed and tested. This system utilizes two sensors: a piezoelectric sensor for vibration measurement and a thermocouple sensor for temperature measurement, with output displayed on a 16x2 LCD and the Blynk application. The sensors are connected to the NodeMCU ESP8266, which is linked via Wi-Fi or a smartphone hotspot. The transmitted data can be monitored in real-time using the Blynk application, enabling remote monitoring of motor temperature and vibration, particularly for motors on ships, especially in engine rooms. The test results demonstrate that the thermocouple sensor functions well without requiring additional calibration, as verified by comparisons with a thermogun measuring device. Furthermore, based on the performance data obtained and comparison with the ISO 10816 table, a vibration value of 4.8 mm/s indicates that the electric motor is in poor condition and requires immediate repair to prevent further potential damage.

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