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Research/Review

Evaluation of Level Transmitter Performance Through Calibration Data in the Instrument Maintenance Unit of PLTGU Cilego

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Abstract: This study evaluates the consistency of transmitter level performance through calibration data obtained from the Instrumentation Maintenance Unit of the Cilegon PLTGU. The purpose of this study is to determine the accuracy, linearity, and stability of transmitter output against standard reference values. Qualitative methods were used, including direct observation, interviews, and literature studies to support the analysis of calibration procedures. Calibration data from the Masoneilan 12420-51 and Yokogawa EJA210E transmitters were analyzed using a comparative approach between normal and abnormal calibration results. Classification was based on the difference between the actual output and the 4–20 mA standard signal, with a tolerance limit of ±0.25% in accordance with ISA and IEC calibration standards. The results of the study show that the Level-3 Deaerator Storage Tank transmitter operates within the normal range, with excellent linearity and accuracy, while the Flash ST Tank Level transmitter shows minor deviations outside the tolerance limit, categorized as abnormal. These deviations suggest the potential for drift or zero shift influenced by environmental factors and aging. This study concludes that periodic calibration is necessary to maintain tranmitter performance reliability and ensure accurate signal transmission in the automatic control system at the Cilegon PLTGU facility.

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1. Introduction

Gas and Steam Power Plants (PLTGU) are types of power generation facilities that convert heat energy from burning fuel and air into electricity. Essentially, the PLTGU system combines the functions of a Gas Power Plant (PLTG) and a Steam Power Plant (PLTU). The heat produced from the exhaust gases of the gas turbine in the PLTG system is used to create steam, which acts as the working fluid in the steam turbine within the PLTU system. Therefore, the operational mechanism of the PLTGU represents a combination of the Gas Turbine Generator (GTG) and the Steam Turbine Generator (STG), with the STG deriving heat energy from the GTG exhaust through the water heating process in the Heat Recovery Steam Generator (HRSG) (Antariksa & Sinaga, 2023).

Gas and Steam Power Plants are facilities that utilize gas and steam as working fluids to move turbines in the electricity generation process. This system relies on compressors and internal combustion engines to produce heat energy. In its operation, a gas and steam power plant involves several stages, including a desalination unit. The desalination process converts seawater into steam through heating with a specialized boiler, and then the steam is condensed back into distilled water. This distilled water is subsequently used as a pure water source within the generation cycle to efficiently produce electrical energy (Dimas Bagas Wicaksono, 2023).

To ensure smooth operations of the Gas and Steam Power Plant (PLTGU), various support equipment is essential, one of which is the water purification unit (Desalination Plant). Currently, several methods for seawater desalination are being developed, each with its own advantages and limitations. The primary aim of the desalination process is to remove salt and mineral content from seawater to prevent corrosion and the buildup of salt deposits on the equipment within the PLTGU system (Prasetio et al., 2021).

Level transmitter is a process instrumentation tool that measures and transmits fluid height data in various industrial systems, such as steam drums, condensers, feedwater tanks, and fuel storage in gas-fired power plants. This device is essential for maintaining the stability of thermodynamic operations by ensuring that the fluid levels remain within safe limits, Accurate measurement of liquid levels in storage tanks is vital so that gas and steam turbines can operate optimally and efficiently(Singh & Raghuwanshi, 2019). According to Darmawan & Yuwono (2019), controlling the water levels in the condenser unit and steam drum of a gas-fired power plant is crucial since it impacts heat transfer efficiency and operational safety. Instruments like level transmitters are utilized to continuously monitor fluid level changes and send signals to the main control system to keep the cooling process and water circulation stable.

Calibration is a crucial procedure for ensuring the accuracy, precision, and reliability of measuring instruments so that measurement results align with established standards. This procedure involves comparing the readings from the device to known reference values with established precision to identify any deviations and make adjustments when necessary. Calibration also plays a significant role in maintaining the consistency of measurement outcomes and is an integral part of the quality assurance system in laboratories and industries. Through regular calibration activities, data quality can be upheld, the likelihood of measurement errors can be reduced, and operational efficiency can be notably improved. Therefore, calibration is an essential component in ensuring quality standards and reliability of measurement results across various engineering and research fields (Budi Purwaka et al., 2022).

2. Preliminaries or Related Work or Literature Review

Transmiter

Transmitter is an instrument device that converts physical changes detected by the sensing element into standard electrical signals that the controller system can comprehend. This device operates by transforming process variables such as pressure, temperature, level, or flow into either analog or digital signals. The primary role of the transmitter is to ensure that the data from the sensor can be accurately and reliably transmitted to the control unit for further processing (Ayu Komalasari & Yuliarman Saragih, 2024).

Level Transmitter

This is a type of transmitter that functions to measure the height or level of a fluid, such as water, oil, and other liquids. This measurement is performed to determine how high the surface of the liquid is inside a tank or container, whether it is a liquid or other material with fluid properties. The device used in the level measurement process is generally a Differential Pressure Transmitter, which works by detecting the pressure difference between two points to accurately determine the height of the liquid surface (Pamor Gunoto, 2021).

Figure 1. Level transmitter.

The image above shows the level transmitter installed in the desalination system, whose function is to measure the water level in the desalination process tank. This device plays an important role in monitoring the volume of water produced, so that the tank filling and emptying processes can be controlled automatically. In addition, the data generated by the level transmitter is used as feedback for the control system to maintain the stability of the desalination unit's operation. With accurate level measurements, risks such as overflow, water shortage, or pressure imbalance in the system can be minimized. Therefore, the use of level transmitters in desalination systems is a crucial aspect in maintaining the efficiency and reliability of the clean water production process.

Calibration

Calibration is a process carried out to ensure the accuracy of a device's measurements by comparing the values obtained by the measuring device with reference values that use national and international standards. The purpose of this activity is to ensure that the measuring device is still functioning properly and is suitable for use in measurements that require high precision (Jesse et al., 2020). Based on ISA standards in document ISA-50.00.01-1975 (R2012), the calibration process is carried out using an electric current of 4–20 mA, which is stretched into standard instrumentation values of 4 mA, 8 mA, 12 mA, 16 mA, and 20 mA. Calibration is very important so that measuring instruments can provide measurement results that comply with standards and ensure the accuracy and consistency of these instruments in every measurement(Fatimah & Hidayat, 2024).

3. Proposed Method

Literature study

Literature study is an activity of searching and collecting various theoretical sources that are related to the topic or issue being researched. These reference sources can be obtained from various media such as books, scientific journals, research articles, and credible online sources (Pilendia, 2020). The selection of written materials related to a theme, which includes information, ideas, data, and evidence presented from a particular perspective to achieve a specific goal or to express a particular view of the characteristics of the theme and how it will be implemented, analyzed, and evaluated effectively in the context of the planned research (Waruwu, 2024).

Direct Observation

The observation method is a data collection technique that involves systematically observing the research object. In this method, researchers not only directly observe the behavior or condition of the object being studied (Hasibuan et al., 2023). but also keep detailed records of every phenomenon that arises during the observation process. The aim is to obtain data that is objective, accurate, and relevant to the focus of the research, so that the results obtained can describe the real conditions of the situation being studied.

Interview

The interview method is a data collection technique used by researchers to interact directly through a question and answer process with parties who have a connection to or knowledge of the research subject. Through this method, researchers can obtain more in-depth, clear, and contextual information about the facts, experiences, and views of respondents that are relevant to the research topic (Noor & Sari, 2020).

Calibration Procedure

Calibration of control level transmitters requires systematic procedures and adequate preparation. The initial stages include collecting relevant level datasheets and compiling a list of calibration equipment requirements. In addition, a complete calibration plant must be provided, including control devices and supporting measuring instruments such as digital multimeters and other instruments necessary to ensure that calibration is carried out accurately and consistently (Syahputra Arief, Muhaimin, 2022). Calibration is performed by simulating signals at five standard points, namely 0%, 25%, 50%, 75%, and 100% of the transmitter's measuring range. Each input point is then compared with the transmitter's output to assess its accuracy.

Research Flowchart

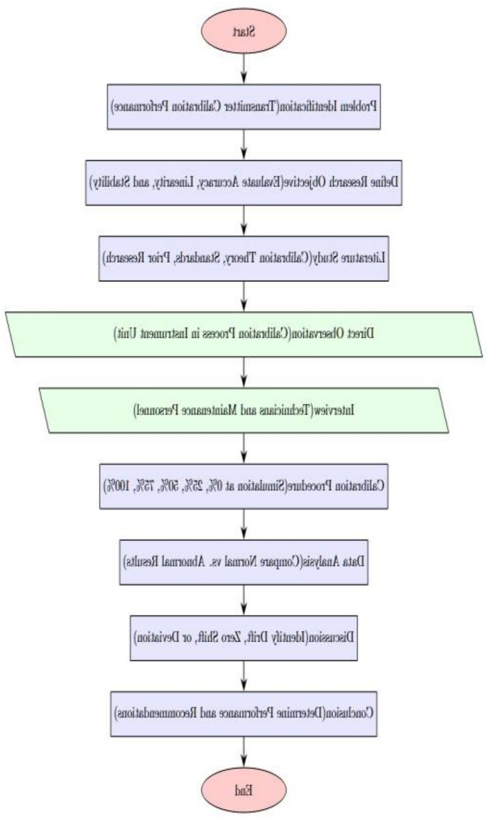

Figure 2. Research flowchart.

The flowchart illustrates the research process aimed at evaluating transmitter level performance through calibration data at the Cilegon PLTGU Instrument Maintenance Unit. The research began with the identification of problems regarding transmitter calibration performance, followed by the formulation of objectives to assess the accuracy, linearity, and stability of the device's output. A literature study was conducted to strengthen the theoretical basis related to ISA and IEC calibration standards and previous research. Next, direct observation of the calibration process and interviews with technicians were conducted to obtain empirical and contextual data in the field. The calibration procedure was carried out through a five-point measurement simulation (0%, 25%, 50%, 75%, and 100%) to compare the actual results with the standard values. The data obtained was then analyzed to determine whether the transmitter was functioning normally or experiencing abnormalities, which could be caused by drift, zero shift, or environmental factors. The final results of the study were used to conclude the transmitter's performance level and provide recommendations for periodic recalibration to maintain the reliability and accuracy of the measurement system at the Cilegon PLTGU.

4. Results and Discussion

Data Classification: Normal and Abnormal Calibration

To assess the consistency and reliability of transmitter performance, calibration data is grouped into two main categories: normal and abnormal. This grouping aims to facilitate the analysis of the stability of the output signal generated by the transmitter during the measurement process.

Table 1. Normal Deaerator Storage Tank Level-3 Calibration Data.

INPUT LEVEL		OUTPUT (mA)		
% Level	**Input (mm)**	**Standard Output (mA)**	**Test Results / Loop Check (mA)**	**Current Level**
0%	–2200	4.000	4.000	-2200
25%	–1450	8.000	8.000	-1450
50%	–700	12.000	12.000	-700
75%	50	16.000	16.000	50
100%	800	20.000	20.000	800
75%	50	16.000	16.000	50
50%	-700	12.000	12.000	-700
25%	-1450	8.000	8.000	-1450
0%	-2200	4.000	4.000	-2200

Table 1 shows the results of the level transmitter calibration process on the Deaerator Storage Tank Level-3, categorized under normal conditions. Based on this data, the relationship between the level input value and the current output (mA) shows excellent conformity with the 4–20 mA calibration standard. At the 0% level position (–2200 mm), the transmitter produces an output of 4,000 mA, which is in accordance with the standard value. A gradual increase in the level input to the 25%, 50%, 75%, and 100% positions also shows a linear increase in current output to 8,000 mA, 12,000 mA, 16,000 mA, and 20,000 mA, respectively. The consistency between the standard value and the test result (loop check) indicates that the transmitter is functioning properly without any significant deviation from the reference value. This indicates that the device has stable accuracy and linearity and is capable of transmitting signals in accordance with actual level changes in the tank.

Table 2. ST Flash Tank Level Calibration Data Abnormal.

INPUT LEVEL		OUTPUT (mA)		
%	**Input (mm)**	**Standard Output (mA**	**Test Results / Loop Check (mA)**	**Level Aktual (mm)**
0%	–1500	4.000	4.057	–1491
25%	–875	8.000	8.033	–869
50%	–250	12.000	12.067	–235
75%	375	16.000	15.942	365
100%	1000	20.000	20.056	1005
75%	375	16.000	15.942	365
50%	-250	12.000	12.067	-235
25%	-875	8.000	8.033	-869
0%	-1500	4.000	4.057	-1491

The table above shows the level transmitter calibration results, which indicate a small deviation between the standard output value and the actual test results (loop check). Based on the data, at a 0% level with an input of –1500 mm, the transmitter should produce a current output of 4.000 mA, but the test results show 4.057 mA, or a deviation of +0.057 mA. The same pattern is also seen at the 25%, 50%, 75%, and 100% points, where the loop check results show variations between +0.033 mA and +0.067 mA compared to the standard values.

Although the detected deviation is still relatively small, this difference indicates the potential for drift or zero shift in the transmitter measurement system. This condition can be caused by factors such as changes in ambient temperature, the age of electronic components, or imperfections in the previous calibration process. Thus, although in general the transmitter is still functioning properly and producing a response that is close to linear to level changes, these calibration results are categorized as abnormal because they have exceeded the specified accuracy tolerance limit of ±0.25%.

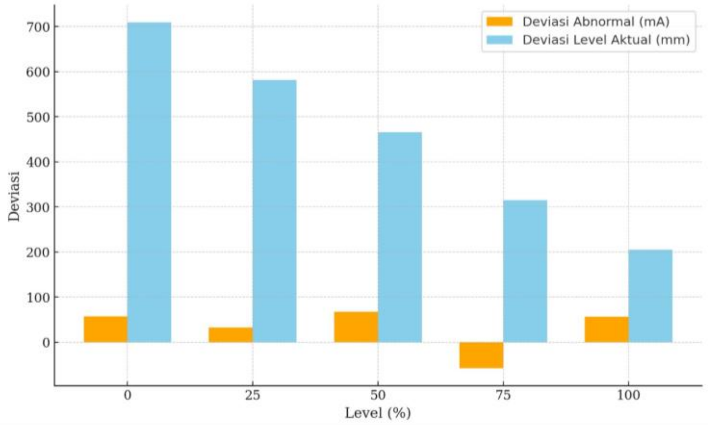

Figure 2. abnormal ST deviation graph Flash Tank Level.

The figure above shows the abnormal deviation graph generated from the ST Flash Tank Level calibration data as listed in Table 2. This graph displays two types of deviations, namely abnormal deviation (mA) and actual level deviation (mm) at each measurement point with a level percentage of 0%, 25%, 50%, 75%, and 100%. This deviation decrease pattern indicates that the transmitter still responds proportionally to level changes, but there are accuracy deviations in certain areas within the measurement range. This condition is generally caused by drift (zero point shift due to sensor aging or temperature changes), zero shift (zero reference shift due to electrical interference or atmospheric pressure), and non-linearity (misalignment between input and output changes due to electronic component degradation). Even a small current deviation of ±0.05 mA in a 4–20 mA signal system can have a significant effect on level readings, as this signal represents the transmitter's full measurement range (full scale). Thus, any small error in current will be translated into a considerable difference in fluid level. This indicates that the ST Flash Tank Level transmitter has experienced a decrease in accuracy.

Meanwhile, normal calibration data on the Deaerator Storage Tank Level-3 (Table 1) cannot be visualized in the form of a deviation graph. This is because the calibration results show perfect conformity between the standard output and the inspection results (loop check). Each measurement point at 0%, 25%, 50%, 75%, and 100% has an identical output value, namely 4,000, 8,000, 12,000, 16,000, and 20,000 mA. With no difference between the actual and standard values, the resulting deviation is zero (0) at all measurement points. As a result, if a graph is created, all points will be on a horizontal zero line, showing no data variation. Therefore, a deviation graph can only be created for abnormal data that has a difference between the actual calibration results and the reference values.

Comparative Analysis Between Normal and Abnormal Data

The comparison between normal and abnormal calibration data shows a significant difference in the linearity pattern between the input level value and the current output (mA) generated by the transmitter. Based on the calibration results on the Deaerator Storage Tank Level-3 transmitter, the actual output values read perfectly matched the 4–20 mA calibration standard values at each measurement point. At 0% level (–2200 mm), the transmitter produced an output of 4,000 mA, and as the input increased to 25%, 50%, 75%, and 100%, the current produced increased proportionally to 8,000 mA, 12,000 mA, 16,000 mA, and 20,000 mA. No deviation was found.

The deviation between the test results and the standard values indicates that the transmitter is operating stably, accurately, and has good linearity characteristics. This condition indicates that the device is functioning within the permitted tolerance limits, namely ±0.25%, in accordance with ISA and IEC calibration standards. Thus, the transmitter can be categorized as normal because it is capable of consistently transmitting fluid level changes and is reliable for routine operations in the Cilegon PLTGU deaerator system.

Meanwhile, the calibration results on the ST Flash Tank Level transmitter show a small difference between the standard value and the actual value obtained during the inspection process. At the 0% level measurement point (-1500 mm), the standard value should be 4.000 mA, but the loop check results show 4.057 mA, a deviation of +0.057 mA. A similar pattern also appeared at the 25%, 50%, 75%, and 100% points, where the current value difference ranged from +0.033 mA to +0.067 mA from the standard value. Although these deviations are relatively small, this condition indicates a zero shift or drift in the transmitter measurement system. Possible factors behind these deviations include the influence of changes in ambient temperature, aging of electronic components, or imperfections in the previous calibration process. As a result, the transmitter exhibits slightly disturbed linear characteristics and does not fully follow the ideal current increase pattern.

Deviations in transmitter calibration results, even if minor, can have a significant impact on the accuracy of measurement and process control systems in the field. Discrepancies between actual and standard values cause the control system to receive signals that do not fully represent the actual conditions inside the tank or process pipe. In the context of the Cilegon PLTGU, deviations in level readings have the potential to disrupt the balance of fluid supply and circulation, especially in de-aerator and flash tank units that are directly connected to high-pressure steam systems. Repeated measurement errors can cause the level transmitter to not function optimally, thereby impacting thermal efficiency and operational pressure stability. In addition, if these deviations are not immediately corrected through periodic recalibration, the automation system may experience data interpretation errors (signal misreading), which ultimately reduces process reliability and accelerates the degradation of other instrument components. Therefore, consistency and accuracy in maintaining transmitter calibration results are crucial aspects to ensure measurement data integrity and the efficient and safe operation of power plants.

Based on the analysis results, the Deaerator Storage Tank Level-3 transmitter is classified as normal because there is no deviation from the standard, while the ST Flash Tank Level transmitter is categorized as abnormal because its deviation value has exceeded the accuracy tolerance limit of ±0.25%. This condition indicates that although the transmitter is still functional, its performance is declining and could potentially cause level reading errors if left without corrective action. Overall, a comparison of these two data sets shows that transmitters with normal calibration results produce a linear and stable input-output relationship pattern, while abnormal transmitters display a slight deviation from the ideal line. Therefore, to maintain the accuracy and reliability of the level measurement system at the Cilegon PLTGU, it is recommended that transmitters with abnormal calibration results be recalibrated or have their sensitive components replaced in order to restore the performance of the device to the applicable standards.

5. Conclusions

Based on the results of calibration analysis conducted on several transmitter levels at the Cilegon PLTGU Instrument Maintenance Unit, it can be concluded that transmitter performance shows two main conditions, namely normal and abnormal. The Deaerator Storage Tank Level-3 transmitter has calibration results that are fully compliant with the 4–20 mA standard without any deviation, indicating a high level of linearity, stability, and accuracy. Meanwhile, the ST Flash Tank Level transmitter shows a small deviation above the tolerance limit of ±0.25%, indicating symptoms of drift or zero shift due to environmental factors or component aging.

These findings demonstrate the importance of regular calibration to ensure that each transmitter operates within the tolerance limits permitted by ISA and IEC standards. A regular calibration process can improve the reliability of the measurement system, reduce the potential for signal reading errors, and maintain the efficiency and operational safety of the desalination system at the Cilegon PLTGU. Therefore, the implementation of structured and continuous instrument maintenance management is essential to support data accuracy and process stability in modern power plant industrial environments.

References

Antariksa, A. A., & Sinaga, N. (2023). *Optimasi performa gas turbine generator (GTG) unit PLTGU Cilegon PGU melalui analisis performa pada variabel beban berbeda dan strategi peningkatan efisiensi PT. PLN Indonesia Power Cilegon PGU*. Jurnal Teknik Mesin S-1, 11(2), 39–48.

Budi Purwaka, P., Taufik, M., Lahtiani, S., & Jamaludin, J. (2022). Uji banding laboratorium kalibrasi: Kalibrasi sound level meter dengan artefak Rion NL-10A. *Jurnal Ecolab*, 16(1), 13–22. https://doi.org/10.20886/jklh.2022.16.1.13-22

Darmawan, N., & Yuwono, T. (2019). Effect of increasing sea water temperature on performance of steam turbine of Muara Tawar Power Plant. *IPTEK: The Journal for Technology and Science*, 30(2), 60–67. https://doi.org/10.12962/j20882033.v30i2.4994

Fatimah, L. A., & Hidayat, R. (2024). Analisis hasil studi kasus kalibrasi pressure transmitter dengan metode zero calibration. *ELECTRON: Jurnal Ilmiah Teknik Elektro*, 5(1), 21–29. https://doi.org/10.33019/electron.v5i1.109

Hasibuan, M. P., Azmi, R., Arjuna, D. B., & Rahayu, S. U. (2023). Analisis pengukuran temperatur udara dengan metode observasi. *Jurnal Garuda Pengabdian Kepada Masyarakat*, 1(1), 8–15. https://doi.org/10.55537/gabdimas.v1i1.582

Jesse, A., Firdaus, A., Pramono, D., Purnomo, W., Studi, P., Informasi, S., Komputer, F. I., & Universitas Brawijaya. (2020). Pengembangan sistem informasi UPT kalibrasi Dinas Kesehatan Kabupaten Malang berbasis web. *Jurnal Sistem dan Teknologi Informasi (JUSTSI)*, 1(1), 23–34. https://doi.org/10.25126/justsi.v1i1.3

Komalasar, A., & Saragih, Y. (2024). Sistem kontrol temperature transmitter pada reaktor AP-545 di PT Sintas Kurama Perdana. *Aisyah Journal of Informatics and Electrical Engineering*, 6(1), 27–34. https://doi.org/10.30604/jti.v6i1.161

Noor, N., & Sari, K. (2020). Rancang bangun media pengenalan huruf. *Jurnal Teknologi Informasi*, 14(2), 161–170. https://doi.org/10.47111/jti.v14i2.1214

Pamor, G. (2021). Pengukuran adalah kegiatan membandingkan suatu besaran yang diukur dengan alat ukur., 4(2), 187–198.

Pilendia, D. (2020). Pemanfaatan Adobe Flash sebagai dasar pengembangan bahan ajar fisika: Studi literatur. *Jurnal Tunas Pendidikan*, 2(2), 1–10. https://doi.org/10.52060/pgsd.v2i2.255

Prasetio, D., Sahbana, M. A., & Hermawan, D. (2021). Optimasi LP (low pressure) auxiliary steam pada desalination plant untuk meningkatkan produksi steam turbine PLTGU Grati. *Journal Mechanical and Manufacture Technology (JMMT)*, 2(2), 52–64. https://doi.org/10.35891/jmmt.v2i2.2701

Singh, Y., & Raghuwanshi, S. K. (2019). Design and development of a novel level transmitter utilizing lithium niobate (LiNbO3) Mach–Zehnder modulator for hazardous regions. *Optik*, 181, 748–759. https://doi.org/10.1016/j.ijleo.2018.12.086

Syahputra, A., & Muhaimin, A. (2022). Analisa kalibrasi level transmitter dengan metode uji lineritas arus pada plant kontrol level. *Jurnal Tektro*, 6(1), 5–12.

Waruwu, M. (2024). Pendekatan penelitian kualitatif: Konsep, prosedur, kelebihan dan peran di bidang pendidikan. *Afeksi: Jurnal Penelitian dan Evaluasi Pendidikan*, 5(2), 198–211. https://doi.org/10.59698/afeksi.v5i2.236

Wicaksono, D. B. (2023). Rancang bangun sistem kendali nilai klorin pada kandungan air laut menggunakan metode fuzzy logic. *Journal of Computer Electronic and Telecommunication*, 4(1). https://doi.org/10.52435/complete.v4i1.217