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## Supervision of Metrology in Ensuring the Accuracy of the Volume Measurement of Fuel Pumps at Gas Stations in Baubau City

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### ABSTRACT

This study aims to analyze the implementation of metrological supervision at Baubau City petrol stations. The research uses a qualitative approach with a descriptive method, where data is collected through field observations, documentation, and interviews with supervisory officers and petrol station managers. The results of the study show that supervision is carried out with an integrative approach, including technical examinations in accordance with regulations, education to business actors, and proportionate law enforcement. Officers are present in team formations with standardized tools and administrative documentation, and actively involve petrol station managers in the process of testing and clarifying results. This practice reflects transparent, educational, and participatory supervision. The recommendations given include strengthening the capacity of officers, digitizing documentation, increasing the participation of business actors and the community, and periodic evaluation of the supervision system. The researcher is then advised to conduct a comparative study between regions and measure the impact of supervision on business actors' compliance in order to produce a more measurable and applicable supervision policy

## INTRODUCTION

Metrology as part of the national standardization system plays a strategic role in ensuring the accuracy of measurements used in trade transactions. One form of measurement that directly intersects with consumer interests is the volume of fuel oil (BBM) dispensed through measuring pumps at gas stations (SPBU). In Indonesia, metrology supervision is carried out by government agencies to ensure that every measuring, weighing, and measuring instrument, along with its accessories (UTTP), operates according to standards and does not harm any party, especially consumers.

Fuel stations as public service entities and commercial businesses are required to use measurement pumps that have been calibrated and re-calibrated periodically. However, in practice, there are still indications of fuel measurement deviations in several areas, including the potential for discrepancies between the volume paid by consumers and what is actually received. This creates public unrest and undermines the principle of fairness in transactions. In Indonesia, the role of legal metrology is regulated by Law Number 2 of 1981 on Legal Metrology, which requires every measuring device used in trade to be calibrated and re-calibrated. One of its implementations is the supervision of fuel measuring pumps at public fuel filling stations to ensure that the amount of fuel paid for by consumers aligns with what is actually provided.

The accuracy of fuel volume measurements is very important because it relates to daily transactions on a large scale and directly impacts people's lives. Any inaccuracies in measurements, no matter how small, can potentially harm consumers and diminish public trust in regulatory agencies and energy service providers. Therefore, metrology oversight should not only be viewed as a technical measurement aspect but also as part of consumer protection and public service responsibility.

The metrological supervision of fuel measuring pumps at gas stations is a crucial legal and technical instrument in ensuring the accuracy of the volume received by consumers. Variations in volume, even

if small (<0.5%), if they occur systematically can have significant economic impacts and diminish public trust (Syahwir et al., 2022). Furthermore, the discovery of fraud cases such as illegal jerrycan filling or deviations in recalibration emphasizes the importance of implementing effective supervision. Various previous studies have discussed the technical aspects and calibration of fuel measuring pumps in various countries with advanced supervision systems (L. V. Kolomiets, O. V. Grabovsky, V. F. Kuznetsov, 2024); (Batista et al., 2025). However, there has yet to be a study that specifically reviews the implementation of metrological supervision at gas stations in regions with geographical, technical, and regulatory limitations, such as the city of Baubau. Meanwhile, Trebuna et al. (2021) and Batista et al. (2025) have discussed oversight in the context of legal metrology and national comparisons, but have not examined the roles and challenges faced by local inspectors in island regions with limited facilities and technical resources. In the regulatory aspect, John T. McGuire et al. (2023) introduced a revision of the law and guidelines for monitoring fuel measurement through the publication of "Uniform Laws and Regulations" that includes calibration standards and limits on pump measurement error tolerance. This provides an important basis for strengthening legal metrology governance across various jurisdictions. Interestingly, a cross-disciplinary approach is also evident in the study by Kim et al. (2024) that investigates cross-validation of metrology for hydrogen filling stations. Although the context is different, the metrology evaluation methodology used can be adapted to enhance the accuracy of fuel measurement in conventional pumps.

In addition, although advanced technological approaches such as the utilization of IoT and blockchain have been proposed to enhance the transparency and accuracy of fuel pump measurement supervision (Melo et al., 2021), the implementation of these technologies has not been widely explored in the context of small gas stations in Indonesia, especially outside urban areas. Furthermore, there has yet to be any research

specifically depicting the synergy between national metrology regulations and local government policies in ensuring the accuracy of fuel measurements in the field. It is evident that there is an urgent need to conduct more contextual and empirical studies on the metrology supervision mechanisms in regions like Baubau City, which combine the regulatory, technical, and social aspects of fuel pump accuracy. Therefore, this research is important to fill this gap and provide an empirical description of the effectiveness of metrology supervision in the regional context.

This research is expected to fill the gap in the literature and provide policy contributions to the improvement of consumer protection and fair metrology-based energy distribution governance. This study aims to analyze the implementation of metrological supervision at the Public Fuel Filling Station (SPBU) in Baubau City, focusing on the integration of technical inspection aspects, educational approaches to business actors, and the enforcement mechanisms applied.

## **METHODS**

This research uses a descriptive qualitative design with a juridical-empirical approach. This design was chosen because it is suitable to deeply describe the practice of metrological supervision of fuel measuring pumps at gas stations in Baubau City, while also examining the effectiveness of the implementation of regulations such as Law Number 2 of 1981 concerning Legal Metrology and Minister of Trade Regulation Number 26 of 2017. This approach allows researchers to contextually understand the processes of calibration and re-calibration, the implementation of supervision, as well as the perceptions of field actors regarding the accuracy of fuel measurements (J W Creswell & Poth, 2016). The informants in this study were purposively selected, namely individuals deemed relevant and who have in-depth information about the phenomenon under study, such as officials from the Legal Metrology UPTD, gas station managers and operators, as well as gas station consumers.

The data collection techniques in this research include semi-structured in-depth interviews, participatory observation, and document studies.

Interviews are used to explore information about procedures, constraints, and perceptions regarding metrology supervision. Observations are conducted directly at the gas station to see the calibration practices and monitoring of fuel dispensers. Documentation is obtained from calibration reports, monitoring minutes, and technical regulations used as legal references (Sugiyono, 2019). The collected data is analyzed using thematic analysis, starting with the transcription of interview results and observation notes, followed by an open coding process to identify main issues such as inaccuracy of measurements, manipulation of tools, and effectiveness of regulations. The data is then categorized into main themes such as compliance with regulations, resource constraints, and consumer protection. The final results are presented in the form of a descriptive narrative to illustrate the findings describing the phenomenon comprehensively (J W Creswell & Poth, 2016).

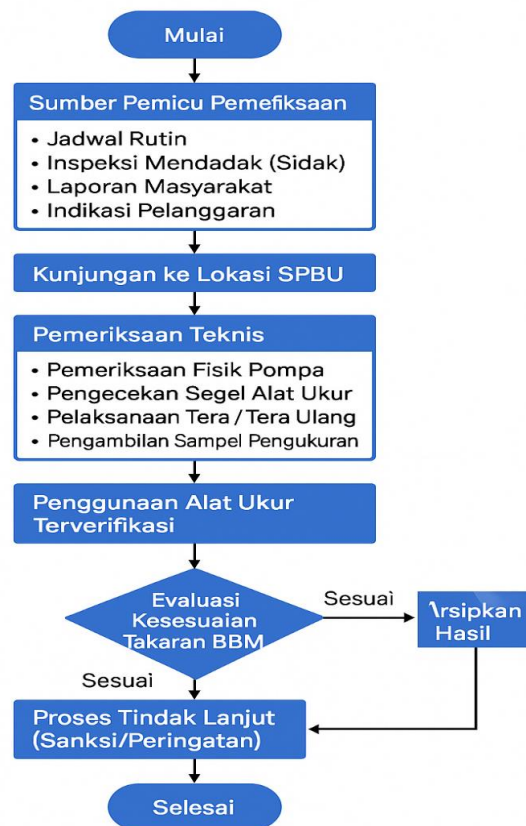
To ensure the validity of the data, source and technique triangulation methods were used, which involved comparing the results of interviews, observations, and documentation from various types of informants. The researcher also conducted prolonged observation and increased diligence in data collection to avoid perception bias and ensure consistency of findings. Additionally, member checking was performed, which involved asking informants to confirm the analyzed interview results to ensure the validity of data interpretation. These techniques were employed to guarantee the quality of data in terms of credibility, dependability, confirmability, and transferability, in accordance with standards in qualitative research (Denzin & Lincoln, 1994); (Sugiyono, 2019) & (John W. Creswell, 2007).

## **RESULTS AND DISCUSSION**

The research results indicate that the metrological supervision of fuel measurement pumps in the study area has been carried out through a systematic and structured approach. This approach can be analyzed based on the framework of four dimensions of supervision, namely: setting standards, measuring performance, comparing results, and taking corrective actions. In the dimension of standard setting, the supervision process refers to the applicable legal framework and

regulations, particularly Law No. 2 of 1981 concerning Legal Metrology, as well as the technical implementation regulations issued by the Ministry of Trade. These regulations serve as a normative

reference in establishing permissible measurement error limits and the procedures for initial and subsequent calibrations, as shown in Figure 1 below;



At the measurement stage, verification activities are carried out through periodic verification and recalibration procedures by authorized metrology officials. The measuring tools used are standards that have been calibrated and verified according to legal metrology principles. This reflects an effort to ensure the reliability of measurement data and reduce the potential for deviation in the volume of fuel distributed to consumers. This method is technically applied in the field by testing all nozzles on each fuel pump to ensure that the volume of fuel dispensed meets the allowed error tolerance. Each test result is recorded

in minutes as part of the administrative documentation. Pumps that meet standards are marked with a special seal in the form of an official calibration sticker. This process is carried out routinely, transparently, and accountably, reflecting a concrete form of the implementation of legal metrology supervision.

In the process, the officers used an official measuring tool in the form of a 20-liter calibrated measuring vessel that has been verified according to the provisions of the Minister of Trade Regulation Number 26 of 2017 concerning Legal Metrology Supervision.



Figure 1 Standard Testing Tool in the Form of a Measuring Vessel Furthermore, in the dimension of comparing results, supervision is conducted by matching actual measurement results against the error tolerance set in technical regulations. This process is complemented by a formal documentation system, in the form of minutes of calibration results and digital data storage, to support the principles of transparency and accountability in supervision implementation. Finally, in the dimension of

corrective actions, if deviations or non-compliance with applicable measurement standards are found, follow-up actions are taken gradually. These actions may include issuing warnings, re-monitoring, and recommendations for temporarily halting the operational of measuring pumps that do not meet legal metrology requirements. Table 1. Matrix of aspects, findings, and supervisory indicators.

Aspect	Meet	Indicators	Description
Monitoring Method	Carried out directly, orderly, and systematically	Direct observation, the officers are present as a team	There are standard testing devices and administrative documents.
Examination Object	All technical components of the pump are re-calibrated	Seal, nozzle, metering unit	Focus on the accuracy of the measurements and the physical completeness of the tools..
Recalibration Procedure	accompanied by the recording of results and the submission of monitoring documents	Calibration result form, minutes of Result	Documentation evidence is submitted to the gas station manager.
Involvement of Business Actors	The gas station is actively involved in the inspection process.	Preparation of results and handover of supervision documents Gas stations are actively involved in the inspection process.	Direct education during the inspection if non-compliance is found.
Follow-Up and Correction	Corrective action instructions are given	Technical instructions	delivered directly on-site by the officers.

	when violations are found.		
Supervision	Using an integrative approach	Technical, educational, and law enforcement combination	In accordance with the principles of consumer protection and fostering business actors
Approach Effects on Society	Enhancing public confidence in the protection of consumer rights	Transparency of processes, involvement of business actors	social support for the accuracy of fuel measurements in the distribution sector.

Overall, the findings of this study indicate that the implementation of metrological supervision at fuel stations in Baubau City has been carried out within a systematic and integrative normative framework. The supervision is conducted by a competent team using verified measuring instruments, supported by administrative documentation and the active involvement of business actors. This reflects the government's efforts to apply the principles of good governance in guaranteeing measurement accuracy and consumer protection. However, the effectiveness of the supervision implementation still has room for improvement, particularly through optimizing the technical resources of field officers, updating digital-based supervision instruments, and strengthening coordination between supervisory agencies and fuel station operators. These steps are expected to enhance the quality of supervision that is more adaptive, responsive, and sustainable in facing the dynamics of fuel distribution at the local level.

### Discussion

This research found that metrological oversight at the Baubau City gas stations is carried out with an integrative approach, which includes technical inspections in accordance with regulations, education for business actors, and proportional law enforcement. Supervisory officers are present in complete teams with standardized testing equipment and administrative documentation. Activities such as the physical inspection of pumps, seals, nozzles, and meters are conducted meticulously. The test results are recorded and submitted to the gas station management, accompanied by explanations and

corrective guidance if non-compliance is found. This practice demonstrates transparent, educational, and participatory oversight.

This finding is in accordance with the research conducted by (Mubarak, 2019), which examined the performance of metrological supervision in Padang City. They stated that the effectiveness of supervision is greatly influenced by stakeholder involvement, good documentation, and the presence of competent officers in the field. However, they noted that supervision in Padang is not yet optimal due to weak coordination and participation of business actors (Mubarak, 2019). In contrast, in Baubau, the involvement of gas stations in the checking process as well as transparency in reporting results indicates better practices.

Furthermore, (Sri Guntoro & Rukmini, 2020) highlight the importance of law enforcement in metrology supervision, particularly against the manipulation of fuel measuring pumps. They state that violations of fuel measurement can systematically harm consumers if not responded to decisively (Sri Guntoro & Rukmini, 2020). Findings in Baubau indicate that the law enforcement process is carried out proportionally and educationally. Direct corrections in the field and the provision of technical guidance are forms of legal application that are not only repressive but also educational. From a theoretical perspective, the supervisory approach taken in Baubau is in line with the regulatory enforcement theory developed by (Ayres & Braithwaite, 1992) in the Responsive Regulation theory. According to them, effective supervision is one that is responsive to the context of the actors,

using an escalatory approach: starting from education, warnings, to legal sanctions when necessary. This strategy appears to be implemented in a tangible way. The strategy appears to be implemented in practice in the supervision model in Baubau, where education and correction are prioritized, and only in the case of serious violations, legal action is enforced. Additionally, the implementation of supervision that involves businesses and the community reflects the principles of good governance as developed by UNDP, namely transparency, participation, and accountability (Pérez-Durán, 2024). These three aspects are essential elements in the governance of the public sector (Didi, 2021). The metrology supervision found at the gas stations in Baubau City shows the characteristics of adaptive and participatory government governance, where the function of supervision is conducted not only to ensure technical compliance with regulations but also to build transparency and trust between regulators and businesses. According to recent findings, governance in the legal metrology sector must ensure fairness in trade transactions and protect consumers from measurement fraud, especially in the distribution of fuel oil (BBM) that directly impacts the wider community (Salohiddin, 2025). The implementation of an effective legal metrology system at fuel filling stations requires close coordination between government metrology bodies and business actors, within a framework that allows for collaborative governance and trust-based oversight. (Salohiddin, 2025).

A study by (Ramley, 2025) also shows that the effectiveness of legal metrology oversight is determined by the integration of technical measurement standards and the clarity of institutional responsibilities. They reveal that the governance of fuel oversight requires a measurement audit system, validation of measurement instruments, and social control mechanisms from the community to prevent manipulation of measurements. The implementation of oversight in Baubau, which records recalibration results, involves gas stations, and submits testing documents

according to procedures reflects a measurable and accountable form of legal governance. (Ramley, 2025).

This finding is in line with the research by (Khosravi et al., 2023) which shows that the accuracy of measurement systems in the energy sector is greatly influenced by the consistency of oversight and public involvement. The oversight practices in Baubau that implement recalibration procedures, involve gas stations, and formal reporting are concrete examples of measurable and accountable legal governance.

## **CONCLUSION**

This research concludes that metrology supervision at the Baubau City gas stations has been carried out in an integrated and effective manner, combining three main approaches: technical inspections, educational approaches, and proportional law enforcement. Supervision is conducted by officers in a complete and competent team, using verified measuring devices and accompanied by administrative documentation. The implementation of inspections covers all important components of the fuel dispensers, including seals, nozzles, and meters, conducted meticulously and objectively. The test results are communicated transparently to the gas station management, accompanied by corrective guidance in case of discrepancies, reflecting supervision that is not only oriented towards legal compliance but also fosters honest and responsible business behavior.

It is recommended that metrology supervision be strengthened through increased capacity of officers, documentation digitization, and active participation of business actors and the community in the supervision process. Periodic evaluation is also important to maintain the effectiveness of governance. Future researchers are advised to study the comparison of the effectiveness of supervision between regions and its impact on compliance among business actors.

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