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Literature Study and Field Observation of the Coal Conveyor Instrumentation System at PT Paiton Operation & Maintenance Indonesia (POMI)

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ABSTRACT

The instrumentation system for coal conveyors plays an important role in supporting measurement accuracy and operational safety in coal handling systems at coal-fired power plants. This study examines the measurement system, protection devices, and preventive maintenance practices implemented on conveyors E4 and E5 at PT Paiton Operation & Maintenance Indonesia (PT POMI). The research employed a descriptive qualitative approach through literature review, field observation, technical documentation, and discussions with instrumentation personnel. The results show that the Thermo Scientific Ramsey™ Flex Belt Scale Integrator underwent routine weekly zero calibration, with observed calibration deviation values ranging from ±0.00% to ±0.09%. Furthermore, the conveyor protection system incorporates five types of safety devices: pull-cord switches, belt sway switches, speed sensors, heat detectors, and emergency stop devices. Each device serves a specific protective function, including detecting belt misalignment, abnormal conveyor movement, excessive temperature, and emergency conditions, thereby enabling appropriate protective responses through the conveyor interlock system. Preventive maintenance activities support the inspection and operational condition of these instruments. These findings provide an overview of the implementation and functional contribution of measurement and protection instrumentation in supporting the operational safety of coal conveyor systems.

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1. INTRODUCTION

Steam power plants (PLTUs) require a continuous and reliable coal supply to maintain the electricity generation process. This requirement is supported by a coal handling system that transports coal from storage areas to the bunkers and pulverizers before combustion. Belt conveyors are commonly used in this system because of their ability to transport large quantities of bulk materials continuously and efficiently. However, conveyor operations are susceptible to various disturbances, including belt misalignment, slippage, abnormal speed, and potential fire hazards (Zhu & Liu, 2023; Wu et al., 2024).

To monitor operating conditions and maintain operational safety, coal conveyor systems are equipped with industrial instrumentation consisting of measurement instruments

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and protective devices. One of the primary measurement instruments is the belt scale, which determines coal mass flow rate and accumulated mass through the integration of load cell and belt speed measurements. Meanwhile, protection devices, including pull-cord switches, belt sway switches, speed sensors, and heat detectors, detect abnormal operating conditions and initiate protective responses to prevent potential equipment damage and workplace hazards (Thermo Fisher Scientific, 2022; Fitriana et al., 2025; Bandri et al., 2022).

The performance of these instruments is supported by preventive maintenance activities, such as inspection, cleaning, testing, and periodic calibration. These activities help maintain measurement consistency and ensure that protective devices remain in suitable operating condition. Therefore, the integration of measurement instrumentation, protection devices, and preventive maintenance is an important aspect of managing coal conveyor operations (Mobley, 2002; Moubray, 1997).

Previous studies have investigated various aspects of coal handling systems and conveyor instrumentation. Gupta et al. (2009) examined the performance of coal handling units in thermal power plants, highlighting their relationship with power generation continuity. Tri Wahyuni et al. (2022) investigated a PLC-based conveyor protection system designed to improve operational safety through sensor integration and interlock mechanisms. Meanwhile, Warfield et al. (2023) discussed technical specifications and tolerances for weighing instruments, emphasizing the importance of measurement accuracy.

Although these studies provide important insights into conveyor performance, protection systems, and measurement requirements, they primarily address these aspects from different perspectives. An integrated field-based examination of belt scale calibration, conveyor protection devices, and preventive maintenance practices within an actual coal handling environment remains an important area of investigation.

Therefore, this study focuses on the implementation of coal conveyor instrumentation at PT Paiton Operation & Maintenance Indonesia (PT POMI), particularly on conveyors E4 and E5. Unlike studies that examine individual instrumentation aspects, this research combines the observation of belt scale zero calibration, the identification and functional analysis of conveyor protection devices, and the examination of preventive maintenance practices. The contribution of this study lies in presenting an integrated description of these instrumentation aspects based on actual industrial field observations.

This study aims to examine the working principles, functions, and roles of coal conveyor instrumentation systems in supporting the reliability and operational safety of coal handling systems. Furthermore, it seeks to evaluate how preventive maintenance activities contribute to belt scale measurement accuracy and the effectiveness of protection devices in preventing operational disruptions. The findings are expected to provide a technical overview of conveyor instrumentation system implementation in the power generation industry and serve as a reference for developing future maintenance strategies and enhancing the reliability of coal handling systems.

2. METHOD

2.1 Research Design

This study employs a qualitative descriptive method using a case study approach, combined with a literature review and field observations. The qualitative descriptive approach was selected for its ability to provide a comprehensive understanding of the actual state of industrial instrumentation systems through the interpretation of phenomena based on empirical data and theoretical analysis. The case study approach enables an in-depth analysis of the research subject within a real-world operational context, allowing for a holistic

understanding of the relationships between measurement systems, protection systems, and maintenance activities (Creswell, 2009; Yin, 2018).

2.2 Research Location and Subject

The research was conducted at the Instrumentation Division of PT Paiton Operation & Maintenance Indonesia (PT POMI) during an industrial internship. The research was conducted at the Instrumentation Division of PT Paiton Operation & Maintenance Indonesia (PT POMI) during an industrial internship from January 2026 to May 2026. During this period, field observations were carried out on the instrumentation systems of coal conveyors E4 and E5, focusing on belt scale calibration, protection devices, and preventive maintenance activities. The study focused on the instrumentation systems of coal conveyors E4 and E5, which are components of the coal handling system. These conveyors were selected due to their role as primary routes for coal distribution to the power generation units and their implementation of comprehensive measurement and protection systems.

The instruments examined included the Thermo Scientific Ramsey™ Flex Belt Scale Integrator (for coal mass flow measurement) and various operational safety and protection devices, such as pull-cord switches, belt sway switches, speed sensors, heat detectors, and emergency stop buttons.

2.3 Data collection technique

Data collection was conducted using four primary techniques: literature review, field observation, technical documentation review, and technical discussions with instrumentation personnel.

The literature review involved examining Thermo Scientific manuals, PT POMI's maintenance standard operating procedures (SOPs), industry maintenance standards, and scientific articles regarding coal handling systems, belt conveyors, industrial instrumentation, reliability, and preventive maintenance. This stage aimed to establish a theoretical foundation concerning instrument operating principles and maintenance strategies applied to conveyor systems (Mobley, 2002; Moubray, 1997).

Field observations were conducted directly within the coal handling system area during weekly preventive maintenance activities. Observations focused on the belt scale zero-calibration process, safety device inspections, sensor operating mechanisms, and device interactions within the interlock system. This observational approach enabled the identification of actual system conditions that could not always be ascertained through technical documentation alone (Yin, 2018).

During the observation period, a total of 5 field observation activities were conducted, covering belt scale zero calibration procedures, inspection of conveyor protection devices, and preventive maintenance activities on conveyors E4 and E5. In addition, 3 belt scale calibration records were examined to identify the observed deviation values. These records were used as supporting data to describe the measurement performance of the belt scale during the observation period.

Technical documentation review involved gathering operational data, instrument specifications, equipment photographs, calibration results, and routine maintenance records available from PT POMI's Instrumentation Division. These data were used to verify field observations and enhance the validity of the research findings.

2.4 Research Parameters

The parameters observed in this study encompass aspects of measurement, safety, and maintenance of the coal conveyor system, as presented in Table 1.

Table 1. *Research Observation Parameters*

Parameters	Unit	Method of collecting data

Zero calibration error value	%	Integrator panel observation
Calibration duration	Second	Direct measurement
Conveyor path length	meter	PT POMI Data Engineering
Number of safety devices	unit	Field inventory
Types of protection devices	-	Visual identification
Preventive maintenance activities	activity	Observations and SOPs

These parameters were selected because they represent key indicators of measurement system reliability, the effectiveness of safety protection, and the success of the preventive maintenance program implemented for the coal conveyor.

2.5 Data Analysis Techniques

Data analysis was conducted using a descriptive-qualitative approach involving the stages of data reduction, categorization, interpretation, and conclusion drawing, as outlined by Miles et al. (2014). Observational data were first classified based on measurement functions, protection functions, and maintenance activities. Subsequently, the actual field conditions were compared against industrial instrumentation theory, the concept of reliability-centered maintenance, and findings from previous studies.

The validity of the research findings was reinforced through source triangulation—specifically, by comparing field observations with the company's technical documentation, instrument manuals, standard operating procedures, and relevant scientific literature. This approach was employed to enhance the consistency and credibility of data interpretation, ensuring that the resulting conclusions accurately reflect actual operational conditions.

The overall research process comprised five stages: literature review, identification of the research object, field observation, data analysis, and formulation of conclusions. The research flowchart is presented in Figure 1.

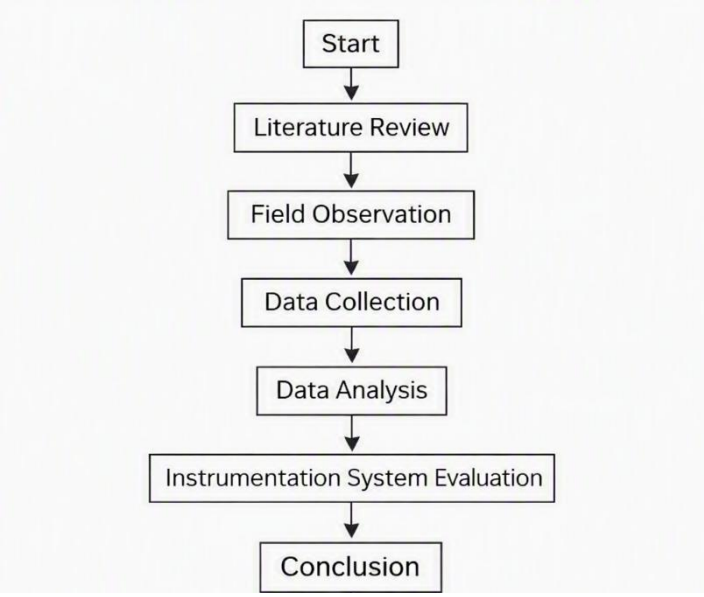


***Figure 1**. Research Flowchart*

3. RESULTS AND DISCUSSION

3.1 Coal Mass Flow Measurement System (Belt Scale)

A belt scale is a critical instrument installed on a conveyor structure to measure the mass flow rate and the total accumulated mass of coal being transported, expressed in tons per hour. At PT POMI, the measurement instrumentation system utilizes the Thermo Scientific Ramsey™ Flex Belt Scale Integrator.

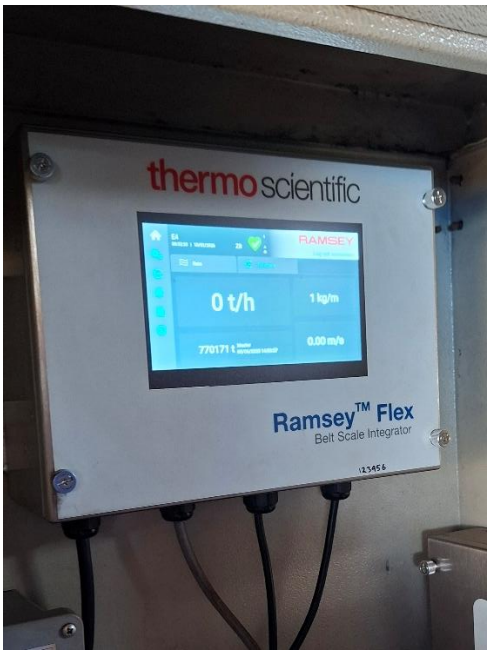


***Figure 2**. Thermo Scientific Ramsey™ Flex Belt Scale Integrator*

Physically, this system integrates two key parameters: the weight of the material detected by a load cell (utilizing the strain gauge principle) and the belt speed, detected by a speed sensor. Signals from both sensors are continuously processed by an integrator unit.

To ensure optimal reading precision, the instrumentation division has established a preventive maintenance schedule that includes routine zero calibration once a week. Zero calibration is crucial for compensating for the empty weight of the conveyor belt, which often varies due to residual coal dust or mechanical wear.

Observations of the conveyor system which spans a total length of 790 meters indicate that a single zero calibration cycle takes exactly 600 seconds (10 minutes). This 600-second duration was not chosen arbitrarily; it corresponds to the time required for the conveyor belt to complete two full revolutions at normal operating speed. Testing over two full revolutions minimizes instantaneous reading fluctuations, thereby yielding the most stable average value for the empty belt mass. The observed zero calibration deviation values ranged from ±0.00% to ±0.09%. These results indicate that the recorded zero calibration deviations were relatively small during the observation period. However, the evaluation was limited to zero calibration observations and does not independently establish the overall measurement accuracy of the belt scale under loaded operating conditions.

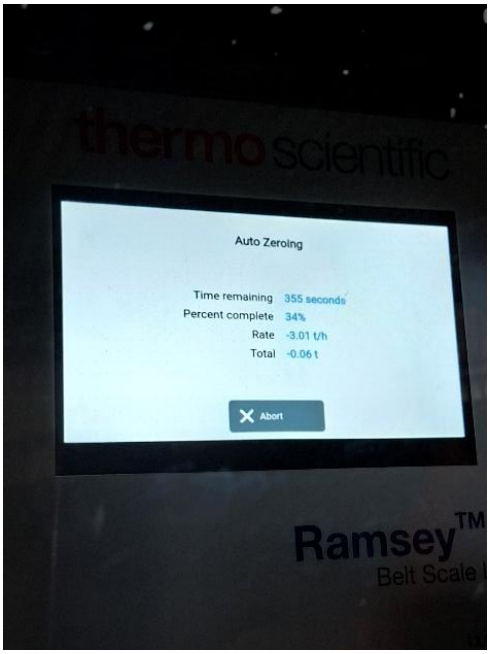


***Figure 3**. Belt scale calibration display.*

The calibration procedure (sequence) for Thermo Scientific belt scales generally includes the following systematic steps:

1. Ensure the conveyor operates in an empty state (without a coal load) at normal running speed.
2. Accessing the calibration menu (Zero Calibration) on the Thermo Scientific integrator panel.
3. Initiate the automatic calculation process by the integrator, where the system will record data from the load cell and speed sensor for exactly 600 seconds (2 laps of the 790 meter track).
4. Evaluating the calibration results displayed on the integrator screen.
5. Save data (Save/Accept) if the deviation (error) value shows a range of ± 0.00% to ± 0.09%.

The deviation values ranging from ±0.00% to ±0.09% indicate that the belt scale zero calibration results were within a relatively narrow range during the observed calibration activities. This condition suggests that the zero reference of the measurement system was maintained during the observation period. Nevertheless, further testing using a reference load or material test would be required to evaluate the overall measurement accuracy of the belt scale. These results indicate that the implemented weekly calibration process effectively maintains the stability of load cell and speed sensor readings during operation. The accuracy of coal mass flow measurement is a critical aspect of the coal handling system, as it impacts fuel consumption calculations, boiler combustion control, and coal inventory records. Consequently, successfully maintaining low error levels contributes directly to the power plant's operational efficiency.

3.2 Conveyor Protection System (Safety Devices)

The belt conveyor protection system consists of a set of safety devices interlocked with the drive motor. Its function is to instantly detect abnormal operating conditions and prevent fire hazards or asset damage. Based on the instrumentation layout, five primary safety instruments are installed, including those implemented in the E4 and E5 conveyor areas. The characteristics of each instrument are outlined in Table 2.

***Table 2**. Conveyor Protection System*

Figure	Safety Device Name	Functions and Operating Principles
 *Figure 1. Pull Cord Conveyor*	Pull Cord Conveyor	A pull-cord switch is a safety device used on conveyors to minimize the risk of workplace accidents (Fitriana et al., 2025). It is a manually operated emergency switch; a cable (or cord) runs along the side of the conveyor. In an emergency, workers can pull this cord from any point to instantly stop the motor. Six pull-cord units are strategically installed across the E4 and E5 conveyor areas.
 *Fogure 2. Belt Sway Switch*	Belt Sway Switch	A conveyor protection device designed to prevent the belt from drifting off-track and to trigger an alarm or stop the system (Fitriana et al., 2025). A sensor for detecting belt misalignment.
 *Figure 3. Speed Sensor*	Speed Sensor	A zero-speed switch monitors conveyor rotation via a sensor on the pulley, and when the rotation drops drastically or stops, the system can issue a safety signal to halt conveyor operations (Bandri et al., 2022).
 *Figure 4. Heat Detector*	Heat Detector (Glass Bulb Sprinkler)	A thermal sensor designed to monitor temperature rises along the conveyor path. It is crucial for preventing spontaneous combustion, a phenomenon that frequently occurs with coal.

 *Figure 8. Emergency Stop*	Emergency Stop	An emergency stop button is a manually operated safety device designed to stop conveyor operation immediately when an emergency condition occurs. Unlike a pull-cord switch, which uses a cable installed along the conveyor to allow emergency activation from multiple positions, an emergency stop button is activated by pressing a dedicated button at a specific installation point. Both devices serve emergency stopping functions but differ in their physical configuration and activation mechanisms.

Based on field observations, each safety device is designed to address a specific type of fault, thereby creating a layered protection system. Belt sway switches focus on the mechanical aspects of the belt, speed sensors detect anomalies in conveyor movement, and heat detectors serve to mitigate fire risks.

The presence of these multiple protection layers is crucial, given the harsh and high-risk environment of coal handling areas. Through an integrated interlock system, the potential for equipment damage and operational shutdowns caused by conveyor faults can be minimized.

The observed protection system is consistent with the layered protection concept commonly applied in industrial conveyor systems. Each protection device addresses a different operational hazard, allowing abnormal conditions to be detected through multiple monitoring mechanisms. Belt sway switches are used to detect belt misalignment, while speed sensors monitor abnormal conveyor movement, as discussed by Bandri et al. (2022). Heat detection devices provide an additional protective function against potential fire hazards in coal handling areas. Furthermore, the implementation of pull-cord switches and emergency stop buttons provides manual emergency stopping mechanisms for personnel. These observations demonstrate that the protection devices installed on conveyors E4 and E5 serve complementary functions in supporting operational safety.

3.3 System Reliability and Maintenance Analysis

The effectiveness of these five safety devices and the accuracy of the Thermo Scientific instruments depend heavily on adherence to preventive maintenance protocols. Coal handling environments present rigorous physical challenges, including heavy coal dust accumulation, high humidity, and constant mechanical vibration. Without routine inspections, mechanical sensors—such as belt sway arms or pull-cord levers—can seize up due to corrosion or the buildup of material residue.

By implementing weekly preventive maintenance (such as zero calibration), the instrumentation team can simultaneously perform visual inspections and cleaning of the safety sensors along the 790-meter conveyor line. The integration of routine preventive maintenance activities, including zero calibration, visual inspection, and cleaning, helps maintain the operating condition of measurement and protection instruments along the conveyor system. These activities support the early identification of potential instrument abnormalities and help maintain the functional condition of the conveyor instrumentation system. However, the direct impact of these activities on system reliability and availability cannot be quantitatively established within the scope of this observational study.

Integration of Instrumentation Systems to Support Coal Distribution Reliability

Based on the observations and analysis conducted, the reliability of coal distribution at PT POMI depends not on a single specific instrument, but rather on the integration of the entire implemented instrumentation system. Belt scales provide quantitative data on the volume of

coal being transported, safety devices offer protection against various potential operational disruptions, and preventive maintenance ensures that all equipment continues to operate according to established specifications.

The interplay between these three components creates a mutually supportive system. When belt scale accuracy is maintained through periodic calibration, coal distribution data can serve as a reliable basis for more precise operational decision-making. Simultaneously, safety devices ensure that the distribution process proceeds without disruptions that could endanger personnel or equipment. Finally, the preventive maintenance program plays a crucial role in sustaining the optimal long-term performance of both systems.

The results of this study illustrate how measurement instrumentation, protection devices, and preventive maintenance activities are implemented together within the coal conveyor system at PT POMI. The belt scale provides information regarding coal mass flow, while protection devices detect abnormal operating conditions and provide appropriate protective responses. Preventive maintenance activities support the inspection and maintenance of these instruments to ensure that they remain in suitable operating condition. Therefore, the integration of these instrumentation aspects represents an important operational support for coal conveyor safety and measurement monitoring. Nevertheless, its quantitative contribution to overall system reliability and availability requires further investigation using operational failure and downtime data.

4. CONCLUSION

This study examined the implementation of the coal conveyor instrumentation system at PT Paiton Operation & Maintenance Indonesia (PT POMI), focusing on measurement instrumentation, protection devices, and preventive maintenance activities on conveyors E4 and E5. The observations showed that the Thermo Scientific Ramsey™ Flex Belt Scale Integrator underwent routine weekly zero calibration, with recorded deviation values ranging from ±0.00% to ±0.09%. These results indicate relatively small zero calibration deviations during the observed activities, although further testing is required to evaluate the overall measurement accuracy under loaded operating conditions.

The conveyor protection system incorporates five types of safety devices: pull-cord switches, belt sway switches, speed sensors, heat detectors, and emergency stop buttons. Each device provides a specific protective function to detect abnormal operating conditions and support appropriate safety responses. Furthermore, preventive maintenance activities, including periodic calibration, inspection, and cleaning, contribute to maintaining the operating condition of the conveyor instrumentation system.

Overall, this study provides a descriptive overview of the integration of measurement and protection instrumentation with preventive maintenance practices in an industrial coal handling environment. However, the study was limited to field observations and qualitative analysis of conveyors E4 and E5. Therefore, the quantitative impact of these instrumentation and maintenance practices on system reliability and availability remains to be evaluated through further studies involving equipment failure records, downtime measurements, and operational performance indicators.

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