**Hydro Pumping Ltd. - Sensor Data Analysis**

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**1. Introduction**

This report delves into an in-depth examination of sensor data from Hydro Pumping Ltd.'s water pump systems. By pinpointing outliers, evaluating the variation in sensor readings via standard deviation, and computing the Mean Absolute Deviation (MAD) for each sensor, this analysis aims to uncover unusual patterns and understand the consistency of the sensor measurements. This is especially significant in light of the seven system failures in the past year, which have impacted service reliability and community trust.

**2. Agenda**

2.1 Objective  
The primary objective of this project is to analyze sensor data to identify patterns, anomalies, and potential predictors of system failures. By understanding these aspects, the company aims to move towards predictive maintenance, reducing downtime and enhancing service reliability.

2.2 Methodology  
We utilized a comprehensive data analysis approach using Python and Excel, focusing on 52 sensors. The analysis involves data cleaning and preparation, followed by a statistical examination of sensor readings. Outliers are identified and interpreted to understand their impact on the system, with graphical representations used to visualize patterns and anomalies in the data.

2.3 Data Overview  
The dataset consists of raw values from 52 sensors over a specified period. Data integrity was ensured through rigorous cleaning processes, addressing missing values and anomalies before analysis.

**3. Findings**

3.1 Standard Deviation  
Varied standard deviations were observed across sensors, highlighting different levels of variability:

* High Standard Deviation: Sensors like sensor\_23, sensor\_28, and sensor\_21 indicate significant variability, suggesting potential sensitivity to environmental changes or operational anomalies.
* Low Standard Deviation: Sensors such as sensor\_00, sensor\_06, and sensor\_07 show more consistent readings, indicating stable operations.

3.2 Mean Absolute Deviation (MAD)  
MAD values also varied, reflecting the typical deviation in sensor readings:

* Higher MAD Values: Notably in sensors like sensor\_21, sensor\_23, sensor\_28, and sensor\_31, which may require more frequent monitoring.
* Lower MAD Values: Observed in sensors like sensor\_00, sensor\_06, and sensor\_07, suggesting reliable operations under normal conditions.

**4. Insights**

4.1 Variability in Sensor Readings  
Observation: There is a notable variation in sensor readings across different sensors. Some sensors exhibit more stable readings (lower standard deviation), while others show significant fluctuations. Implication: Sensors with high variability might be more sensitive to environmental changes or could be indicative of potential malfunctions. These should be monitored closely for maintenance or calibration.

4.2 Outliers in Sensor Data  
Observation: A substantial number of outliers were detected in several sensors. These outliers are data points that significantly deviate from the majority of readings.

Implication: Outliers could indicate transient or abrupt changes in the system, sensor malfunctions, or environmental anomalies. Identifying the causes of these outliers is crucial for maintaining system reliability.

4.3 Mean Absolute Deviation in Sensor Data  
Observation: The MAD values varied across sensors, indicating differences in the consistency of readings.

Implication: Sensors with high MAD values might require more frequent monitoring or maintenance to ensure accurate readings.

**5. Recommendations**

* Close Monitoring of High-Variability Sensors: Sensors with high variability and MAD should be prioritized for regular checks and calibration.
* Investigation of Outliers: Conduct a thorough investigation into the causes of outliers to ensure they are not indicative of underlying system issues.
* Regular System Audits: Implement a schedule for regular system audits and sensor calibration to proactively manage and mitigate operational risks.

**6. Conclusions**

The comprehensive analysis of the sensor data from Hydro Pumping Ltd reveals crucial insights into the functioning and health of the water pump system. Key observations include variability in sensor readings, the presence of outliers, and identifiable trends in sensor performance. These findings are instrumental in understanding the system's current state and predicting potential issues. Further discussions and actions based on these findings could significantly enhance operational reliability and predictive maintenance capabilities.