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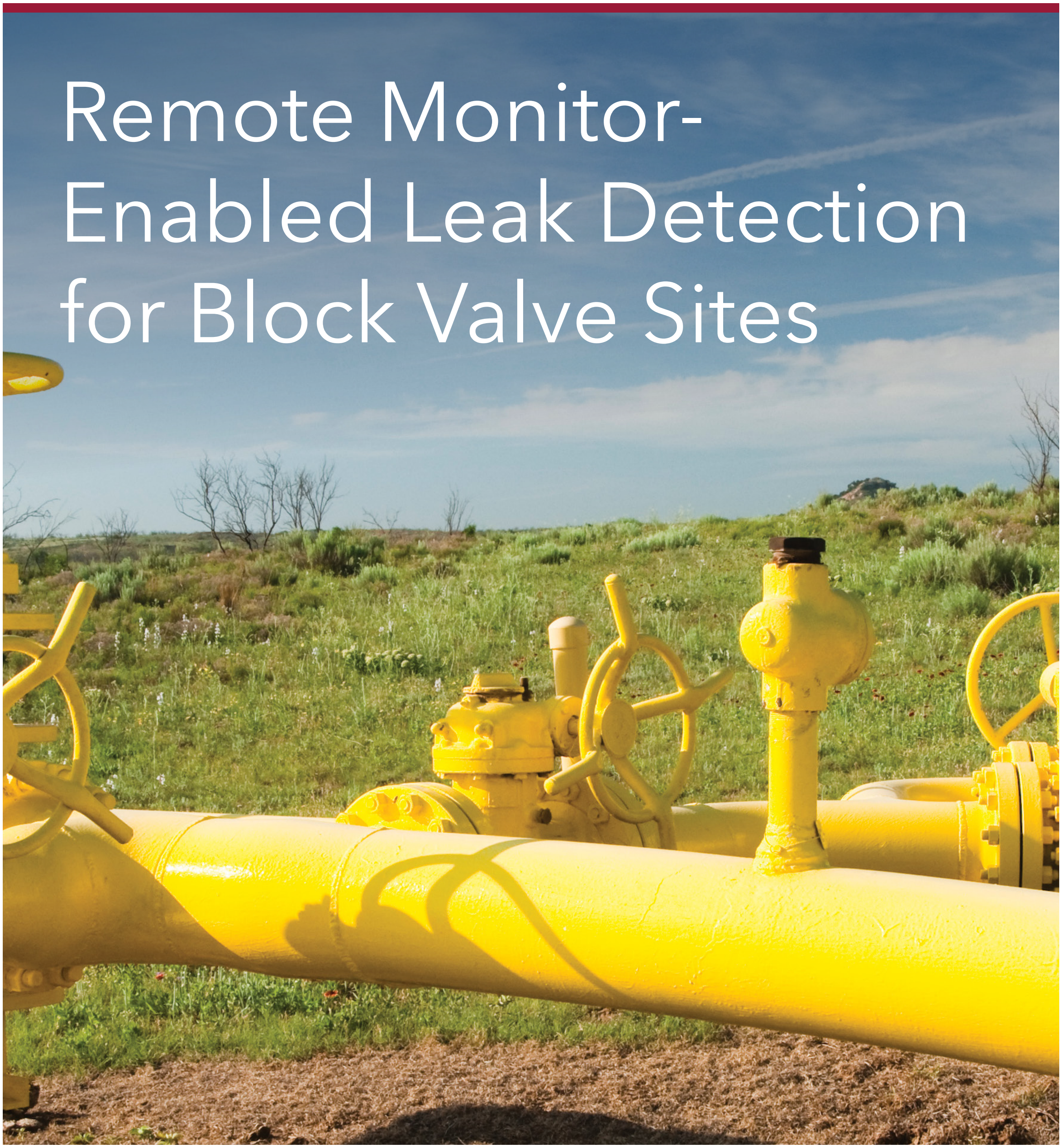
August 2025

Remote Monitor-Enabled Leak Detection for Block Valve Sites



INTRODUCTION

Pipeline leak detection is emerging as a prime focus of PHMSA and other regulatory agencies in the United States as well as jurisdictions all over the world. The immense volume of buried pipelines and the fact that much of this buried infrastructure is over forty years old[1] combines to present increasing risk of leaks with potentially catastrophic results. During the twenty-year timespan from 2005 through 2024, in the United States alone, the Pipeline and Hazardous Materials Safety Administration (PHMSA) recorded 40 hazardous liquids incidents resulting in 28 fatalities, 64 injuries, and over 185,932 barrels spilled (Figure 1).[2] In many cases the environmental and human health and safety costs could have been reduced if the leaks were detected much earlier.

Figure 1: PHMSA hazardous liquids pipeline incidents: 2005 - 2024

Calendar Year	Number	Fatalities	Injuries	Barrels Spilled	Net Barrels Lost
2005	4	2	2	4,048	3,518
2006	1	0	2	4,513	4,513
2007	5	4	10	12,176	11,961
2008	3	2	2	6,755	5,755
2009	3	4	4	364	364
2010	3	1	3	3,105	3,105
2011	1	0	1	0	0
2012	2	3	4	1,500	1,245
2013	4	1	6	23,703	23,702
2014					
2015	1	1	0	976	976
2016	3	3	9	7,032	5,349
2017	1	1	1	13,465	13,465
2018	1	0	2	48,400	48,400
2019					
2020	3	5	10	21,103	21,102
2021	1	0	1	0	0
2022					
2023	2	0	5	0	0
2024	4	1	2	38,794	38,794
Grand Total	**40**	**28**	**64**	**185,932**	**182,248**

Monitoring and communication technology has evolved significantly over the past thirty years, particularly through relatively inexpensive low-bandwidth satellite communication and increasingly robust and reliable cellular communication. The expansion of these communication networks has resulted in nearly complete global coverage, greatly facilitating data acquisition from even the most remote pipeline locations. Additionally, monitoring systems, sensors, and field asset control devices have evolved as well, taking advantage of the data communication options currently available. These advances in communication and monitoring technology have enabled the hazardous materials pipeline industry, along with most other industries, to transmit ever-increasing volumes of data from an ever-increasing number of field locations. Many field sites that were typically inaccessible except in case of emergency are now able to both transmit and receive data in near real-time with consistent reliability.

Along with these advances in monitoring and data communication technology has come expectations that pipeline operators can and should have much greater visibility into field assets essential to pipeline integrity, environmental health and safety, and the pipeline assets themselves. This paper presents an ongoing proof-of-concept that combines sensor and communication technologies to develop a reliable and cost-effective system for continuous leak detection monitoring.

Application for the product is to monitor key locations along the pipelines, tanks, block valve sites and other locations where having visibility on the asset integrity is critical and elevated risk of leaks and contamination exists.

EQUIPMENT USED

The systems used in the laboratory system development and testing as well as in the field installations consist of a hydrocarbon sensor, an RTD sensor control box, and a cellular communication enabled monitoring device. The monitoring device communicates data to a web-based data portal providing authorized users access to the data from the field device. The web interface also serves as the data conduit for configuring the monitoring frequency, data reporting frequency, setting sensor alarm recognition thresholds, and generating notification of alarm condition events to the user.

Sensor and Sensor Control Interface

The sensor type used in these systems use "Polymer Absorption Sensor" (PAS) technology, forms of which have been in use since the 1950s. The current technology in the specific sensors used in this study are a variant of PAS termed "Elastomer Absorption Sensor" (EAS) technology. Though the basic principles behind this sensor technology have been in use for decades the current sensor system elevates the technology using a "smart" data acquisition module enabling progressive leak detection options. The data acquisition module is a "Class1, Div1" rated device providing connection to the sensor via a multi-pin cable connection and the data output via a 2-conductor cable transmitting the sensor value in volts to the monitoring system. The range of the signal is 0-5V. The module is powered by an extended life 3.6V lithium non-rechargeable battery providing voltage to the sensor. Estimated battery life is >10 years.

The sensors are available in lengths up to 80 feet (24.38 meters), with a recommended maximum length of 50 feet (15.24 meters) for "horizontal" applications, as would be the case in most pipeline applications. This sensor technology is reactive to liquid hydrocarbons and heavier gases such as propane but is not effective for lighter gases such as methane. The sensor is unaffected by the presence of water, maintaining reliability in any application environment (Figure 2).

The electronic components in the data acquisition module are epoxy enclosed (potted), facilitating both the electrical isolation necessary for the Class1, Div1 rating as well as providing exceptional protection against water, dust, and chemical ingress that could damage the internal components.

Figure 2: Control Module

Figure 3: Sensor section

Monitoring Device and Web Interface

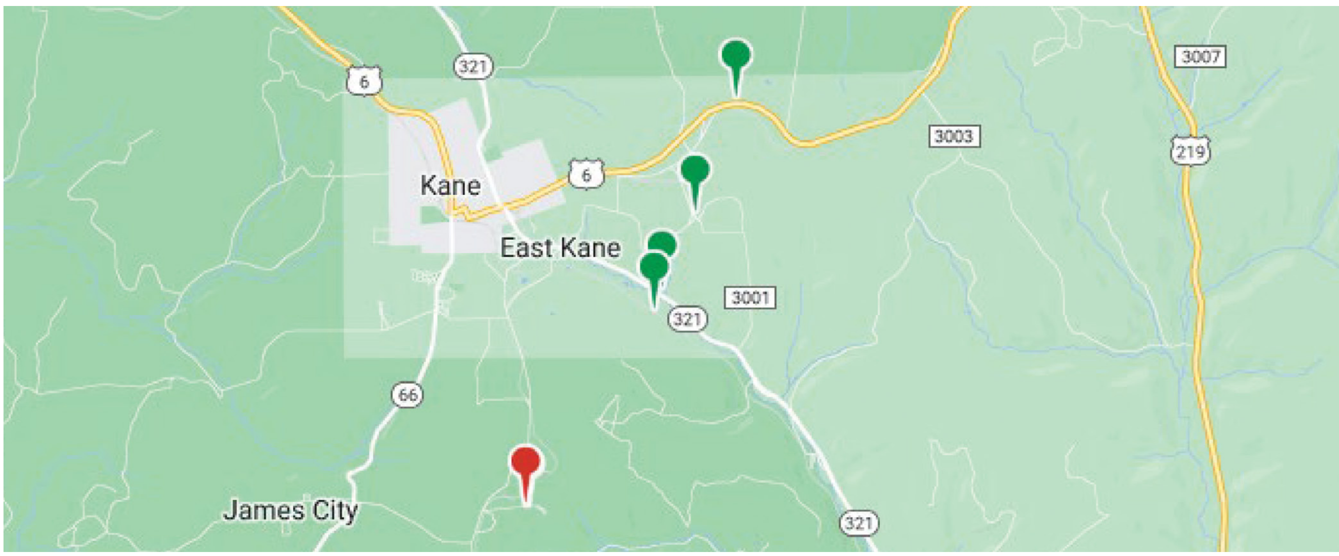
Many of the applications targeted for this system will not have external power available, therefore there is a need for a portable battery-operated unit. The Lindsay SentraLink™ LD system was designed specifically for the application in remote areas. The system includes a cellular based remote monitor, and a sensor control module designed for use with liquid hydrocarbon detection sensors. The final inhouse lab testing, and field installations used the 2-channel battery operated devices (Figure 4).

Figure 4: SL-LD Monitoring device

Web-based Data Interface

The field monitoring device communicates via cellular communication to a secure web portal enabling authorized users to access monitor data, configure the alarm thresholds, configure the sampling and reporting frequency, and receive alarm notifications in the event a leak condition is detected. Alarm notifications are delivered immediately from the web portal to authorized users via email and/or text messaging. The interface includes an interactive asset mapping feature displaying the locations and alarm status of sensors in the field enabling swift recognition of areas requiring attention (Figure 5).

Figure 5: "Map View" of field sites showing status pins



There are different levels of alarm conditions based on the signal value. If the sensor output ranges between 0.01V-0.89V it is indicative of "Sensor Issue" condition and reflected on the data table as shown in Figure 6. This condition will also be shown as "yellow" on the map. This indicates potential sensor issues that require recalibrating or potentially replacing the sensor.

The range of 0.9V-1.99V considered "Normal" condition indicating no leaks detected and will be shown as "green" on the map. If the sensor output rises to the 2V-5V range, this will be indicative of the "Leak" in the system. It will be shown as "red" pin on the map and unit will report immediately to the Elecsys Connect web portal along with email and text notifications to the appropriate users.

Figure 6: SentraLink-LD Data Table

Hide/Show	Time	Leak Sensor	Sensor Resistance	Temp.	Signal Strength	RMU Battery	Version
	22 Mar 2025 05:59	2.90 V Leak	0.20 V	4 °C	-71 dB	3.40 V	1.22.01
	22 Mar 2025 04:59	3.01 V Leak	0.20 V	5 °C	-69 dB	3.40 V	1.22.01
	21 Mar 2025 06:59	1.00 V Normal	0.20 V	3 °C	-69 dB	3.40 V	1.22.01
	20 Mar 2025 06:58	1.00 V Normal	0.20 V	6 °C	-71 dB	3.40 V	1.22.01

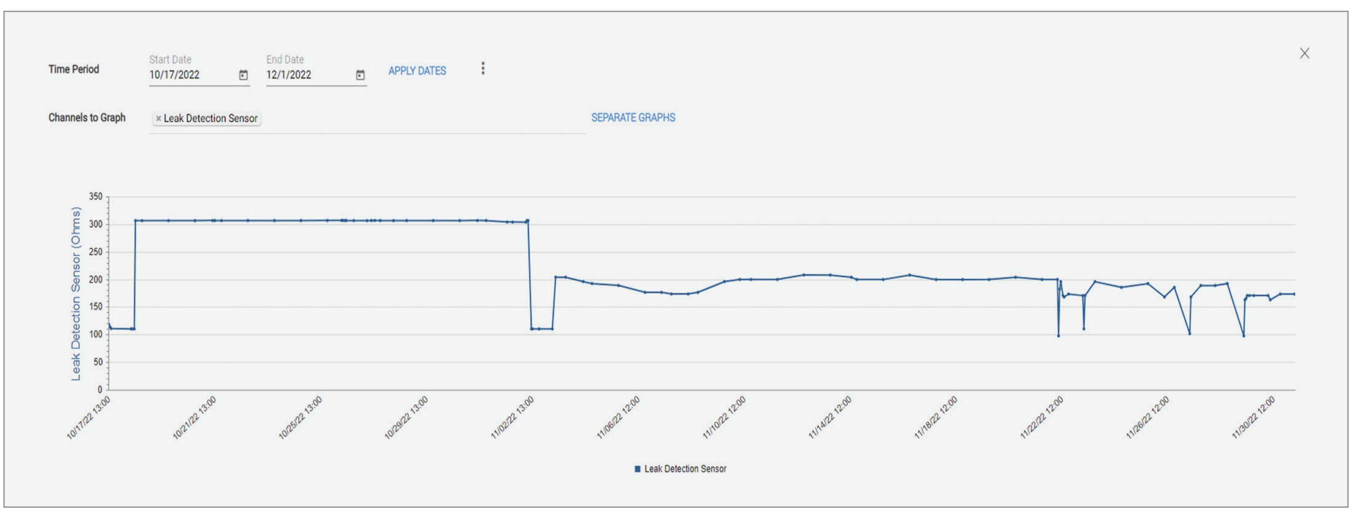
INITIAL TESTING AND FIELD DEPLOYMENT

The first task was to test the sensor output range and configure the monitoring system to accommodate the sensor output. A test system was set up and a series of tests were run using a mixture of naphtha and alcohol to trigger the sensor. When the correct configuration values were determined for the control module and the monitoring system, these values were tested across several monitoring platforms for validation.

The next step was producing a basic, controlled proof of concept demonstration for the end user company. A system was configured using a 4-channel, externally powered monitoring device. This system provided more configuration capability in the event the parameters required any additional tweaking. The sensor was inserted into a PVC tube and contaminated with fuel oil (Figure 7). The monitoring system detected and transmitted the alarm notification shortly following the saturation of the sensor. The sensor was "cleaned" and the test re-run several times over the next 45 days, using different amounts of contaminant and different lengths of exposure. The alarm and return to normal periods can be seen on the graphed data pulled from the web interface (Figure 8). Eventually, the sensor was contaminated to the extent it was unable to be cleaned for further use. Following the success of the proof-of-concept testing, sites were selected for installation of long-term field trials.

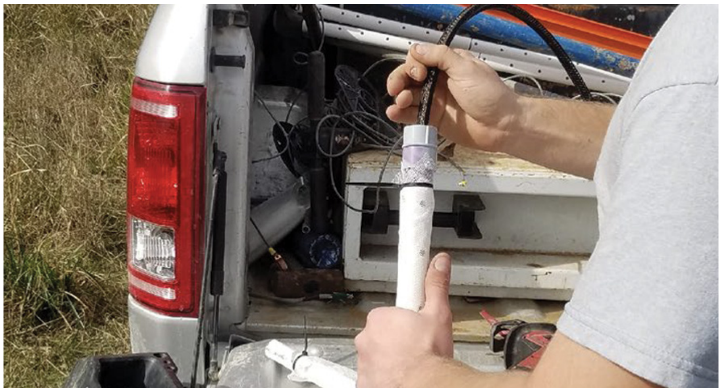
Figure 7: Proof-of-concept testing set-up

Figure 8: 45-day graph of data showing alarm periods (>150 ohms) and normal periods



Multi-site field testing

Figure 9: Inserting the sensor into the protective sleeve

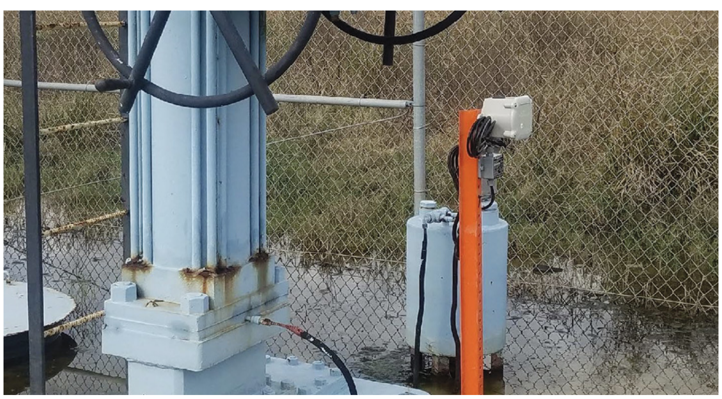


Battery powered; 2-channel monitoring devices (SL-LD) were selected for the field test applications. These systems were configured and prepared for installation in advance. Field testing started at three block valve site locations. The sensors used were 4 feet (1.22 meters) in length. The sensors were inserted inside mesh-covered, perforated PVC tubing to protect the sensor element from the soil while allowing hydrocarbons to contact the sensor (Figure 9).

Figure 10: Assembled system prepared for field installation

The sensor was secured to metal brace. The sensor data acquisition module and the remote monitoring unit were attached to the top of the metal brace and the final connections were secured (Figure 10).

Figure 11: Installation completed



Following the preparation of the system for installation, a vertical hole was excavated adjacent to the valve riser and the system was installed with the sensor buried in the ground and the monitoring components several feet above ground. The areas where the systems were installed were prone to flooding so care was taken to reduce the risk of the immersion of monitoring components (Figure 11).

When the installation was completed a “pushbutton” test was done to confirm connectivity to the web interface and to verify the sensors were reading in the expected ranges. The three field test sites are now undergoing a long-term (6-month) performance evaluation. In addition, number of units were commercially deployed to provide more real-world data for product improvement.

CONCLUSIONS/NEXT STEPS

The goal of this undertaking was to design a simple, repeatable, cost-effective leak detection monitoring system that can be used in nearly any pipeline or terminal application. The results thus far are very positive. The system is simple to deploy, and very cost-effective to operate. There are some aspects that can be improved upon, and some lessons learned in developing and testing the application. Though the cellular network provides adequate coverage throughout most of the US and North America, there are still areas requiring satellite communication. Work is underway enabling a satellite communication option in the battery-operated monitoring platform used in the field trials. Additionally, exploration of other communication topologies such as LoRa, wi-fi, wireless HART, and others may expand the feasibility of deployment in applications where conventional wide area communication methods are not suitable. Improvements also were made to the system hardware, specifically eliminating the need for use of 4-20mA signal converters. The refined control box provides signal output of 0-5V signal to work synchronically with the remote unit. Furthermore, addition of granularity to the alarm limits on web portal enables pipeline operators with more transparency on the asset condition and enables them to make data-informed decisions.

The sensors used in these tests produce very good results for detecting liquid hydrocarbons and heavy gases (propane, butane, etc.). Work is ongoing to develop similar sensor types for natural gas applications. In addition, this system model may be applicable for other hazardous materials sensors such as for hydrogen sulfide (H_2S) and carbon monoxide ($CO2$). With elevated attention regarding pipeline leaks by regulatory agencies at every level there is a great need for reliable and cost-effective leak detection for broad-based pipeline and terminal applications. The initial testing and successful field deployments of SentraLink-LD system to over 40 locations show a great deal of promise in meeting that need.

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About the Authors

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Jamey entered the corrosion/cathodic protection industry nearly two decades ago when he started his career as a sales and technical support specialist for “NTG.” A wholly-owned subsidiary of Elecsys International, “NTG” was a small, but growing supplier of rectifier and test station monitoring systems to the pipeline industry. By 2009 Jamey was focusing more on product development, designing the first comprehensive AC interference monitoring systems, along with new designs of rectifier and test station monitoring systems. In 2015, Elecsys International was acquired by Lindsay Corporation, further strengthening the global presence and application opportunities for remote monitoring systems, of which, Jamey has majorly influenced.

Jamey is continuing to develop new monitoring systems and new applications for existing systems, branching out into corrosion rate monitoring and leak detection monitoring, among other applications. Jamey is an AMPP-certified cathodic protection technician (CP2) and is currently the Product Manager for remote monitoring products.

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Danil entered the corrosion industry in 2025, bringing with him a multidisciplinary background in infrastructure and asset management. As an Associate Product Manager at Lindsay, he leads initiatives within the industrial remote monitoring portfolio, with a focus on end-to-end product development, system integration, and field deployment strategies. His work supports the advancement of intelligent monitoring solutions that enhance operational visibility and extend asset life cycles.

Prior to joining Lindsay, Danil contributed to large-scale infrastructure projects in the water utilities sector, where he gained practical experience mitigating corrosion in aging distribution systems. His hands-on involvement with condition assessment, materials performance, and rehabilitation planning informs his current approach to product innovation in corrosive environments.