

OHIO LUMEX®

Early Detection of a Tube Leak Using the Ei4200 Dewpoint Monitor

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1 EXECUTIVE SUMMARY

An Ei4200 was installed at a sulfuric acid plant (sulfur burner) in the central United States in October of 2025. The instrument operated continuously and as intended, with only one service visit from Ohio Lumex (OL) staff until a tube leak was reported by the plant to the Ohio Lumex Field Service representative on 9/16/2026.

During that initial report, it was stated that the Ei4200 "flatlined" as of 9/7/2026 but that the leak was discovered during the morning shift on 9/10/2026.

At the request of OL technical support, the plant recovered the daily operational data logs from the instrument covering the time period from 9/6 – 9/12/2026. This report covers the findings from that data when compiled with the plant actions during the same time period.

In summary, the instrument data logs showed that a "high current" event was logged on 9/7/2026 at roughly 1:00 AM. Following that event, these actions occurred:

- Whatever compound led to the initial "high current" event stayed resident on the probe sensor surface and resisted vaporization using native heat in the flue gas. This resulted in the probe never reaching "Start Temperature" for the next cycle.
- As a result of this failure to remove the condensate, the system never reported a successive "dewpoint" event. As a result of this, the output stayed constant and appeared to the operators as a loss of communication or a "flat line"
- This condition continued until roughly 5:30 PM on 9/8 when a significant current spike (to 328 uA) began. This spike was NOT due to decreasing cell temperature, so it must be attributed to a second, larger ingress of water into the ductwork.
- This current spike dissipated for several hours, then reappeared at 00:13 AM on 9/9/2026. This is nearly 48 hours after the initial current spike detected by the Ei4200
- The current spike at 0:13 AM on 9/9 persisted at 337 uA (this is the saturation current of the sensor cell) until the unit management discovered the leak and acted, more or less, at 3:00 AM on 9/10 (this is 72 hours after the initial current incident).
- Based on Instrument data, the current spike dissipated at 3:00 AM when, we assume, the plant discontinued water flow into the unit. This lack of water flow persisted until 6:30 AM on 9/10 when water flow was apparently resumed.
- The water flow/current saturation appears to persist for roughly 4 hours and then falls dramatically at 10:30 AM

We are anxious to correlate plant actions with the data reported by the instrument but, as of this writing, it appears that the instrument detected a small water leak just before 1:00 AM but no leak was reported to the plant. The plant reacted using its own methods 72 hours later.

Why the instrument failed to report the leak event, and the subsequent corrective measures taken, is the topic of this paper.

2 EI4200 BASIC OPERATIONAL APPROACH

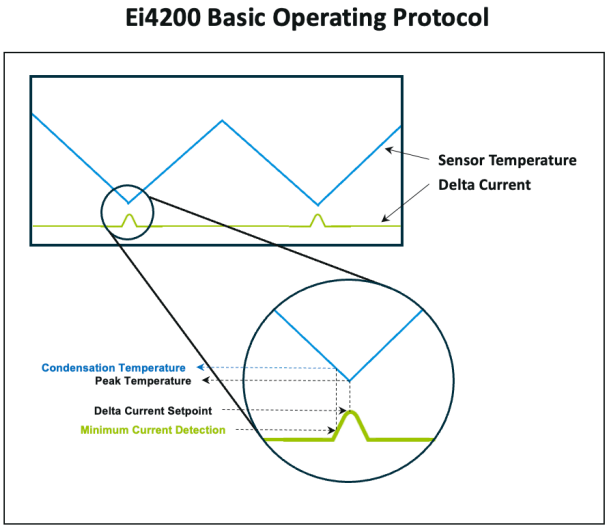
The fundamental detection process of the Ei4200 involves condensing vapor into liquid on a glass sensor. This sensor is equipped with two electrodes embedded in the surface as shown in Figure 1.



Figure 1 - Sensor on the Ei4200

The Ei4200 detects the presence of condensed acid vapor by executing a continuous series of operating "cycles". Each cycle operates as shown in the sequence below:

1. The temperature of the Sensor is reduced from high to low by means of cooling air on the inside of the cell (blue dashed arrow)
2. Two Electrodes, embedded in the sensor surface, look for current flow using condensed acid vapor as the conductive path (green dashed arrow)
3. As the temperature drops, there will come a point where vapor condenses and current is detected



4. When the current exceeds a preset threshold (Delta Current Limit), the Peak Temperature is recorded as "Dew Point"
5. Then the cooling air is limited, the condensate evaporates, the sensor temperature increases until it reaches "start" temperature and the process repeats

However, as detailed in the emphasized circle at the bottom of the graphic, the "Dew Point" is a function of the "Delta Current Setpoint". This setpoint defines the amount of current required to record the presence of condensate on the surface. In practice, the lower the "Delta Current Setpoint", the higher the "Dew Point" temperature reported. Also, in practice, the smaller the Delta Current Limit setting, the more susceptible the instrument becomes to transients and noise spikes that can, and do, create false "Dew Point" reports.

For optimum performance, the Ei4200 Delta Current Setpoint should be set at a level that is high enough to minimize transient detections yet small enough to minimize overall acid condensation on the platinum

electrodes. This is a site-specific setting that can only be determined through experimentation by the site Subject Matter Expert.

2.1 Data Routing

While “Dew Point Temperature” data can be routed from the Ei4200 to the plant DCS via a 4-20 mA analog output, it is highly recommended that data be transmitted using the instrument's serial output which employs a Modbus/TCP-IP protocol as defined in the Modbus Map.

Using the serial connection, both “Dew Point Temperature” and “Sensor Current” can be monitored by the plant. In normal practice, Delta Current will begin to report a non-zero value prior to a report of a new Dew Point. If greater sensitivity to condensation is desired, the plant can respond to minimal changes in Sensor Current rather than waiting for the more conservative Dew Point value. However, care and process understanding are required to allow this to be a viable process control element. In practice, a plant protocol that considers both is optimum.

This paragraph in the O&M Manual turned out to be prophetic in this case.

3 OPERATING MODES

Below are the main operating Modes as defined in the Ei4200 O&M Manual.

3.1 Service Mode

Service mode, as it implies, is intended for use when some form of manual intervention is warranted. This could be the result of sensor cell fouling through inappropriate temperature setting, or it could be used when the plant operator wants to explore what happens within the gas stream at specific, fixed temperatures. This mode allows for:

- Manual activation of a Cell Leak Check operation
- Manual activation of the internal heating system within the instrument to drive the cell temperature above the known condensation point of the gas
- Manual activation of the cooling system to force a “freeze” event on any collected condensate on the cell
- Manual activation of a cell cleaning cycle (this is not active in sulfuric acid plant applications)

3.2 Passive Mode

Passive detection mode is mainly used for applications such as sulfuric acid production, where the detection of unwanted condensation is the primary objective. This mode consists of maintaining the sensor at process temperature and detecting the moment condensation appears, thus warning the plant of a potential problem. So-called operability checks can be performed to test the system’s integrity and dew point of the process gas at specified intervals.

This mode has the following advantages & disadvantages:

- Adv – Uses the least amount of plant compressed air
- Adv – Least susceptible to changes in plant operating conditions
- Disadv – Least sensitive to small changes in Formation Temperature that could be precursors to major tube leaks
- Disadv – Only provides a Formation Temperature (Kinetic Dewpoint) when running an operability check:
- Disadv - No insight into Formation Temperature movement due to changes in plant operating conditions

3.3 Active Mode

Active mode is used for applications where the primary objective is continuously measuring the formation temperature. In this mode, a regulated supply of air cools the sensor surface. The rate of cooling is tightly controlled to allow for uniform cooling of the sensor. Following the detection of condensate, the cooling gas flow is gradually reduced, and the sensor is returned to the specified starting temperature. The reported dew point (Formation Temperature) is the temperature at which the difference between the base current and the sensor current exceeds a set threshold.

Several configurable variables impact the sensitivity of the device in Active Mode. These variables also impact the amount of compressed air consumed and the theoretical life of the sensor before it needs to be replaced. These variables and their impact on the operation are discussed below.

3.3.1 Start Temperature

This is the temperature that the sensor tip must reach before a new cycle is initiated. It is accessed by selecting “Active Mode” from the Mode Settings screen.

- A higher start temperature tends to extend the duration of each cycle since the sensor must transition from a higher starting point down to the current Formation Temperature of the acid gas.
- A lower start temperature runs the risk of starting a new cycle while residual condensate current is still present on the sensor. This can lead to premature reporting of Formation Temperatures and confusion by plant operators.

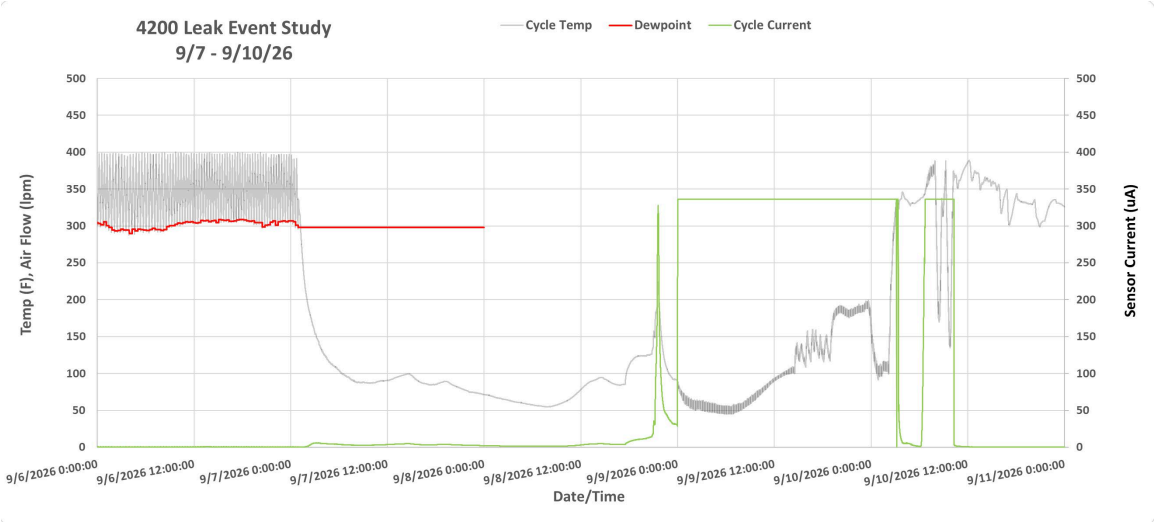
The Start Temperature can be configured manually by the plant, or a process termed “Intelligent Start Temperature” can be employed to automatically identify the starting temperature of the succeeding cycle based on the reported Formation Temperature of the current cycle plus a configured “Start Temperature Delta”. This process allows the starting point of each cycle to move up and down based on the detected Formation Temperature of each Active Mode cycle.

A completed system cycle is declared to have finished when the Start Temperature of the consecutive cycle is reached. This is a critical point to understand. In the Tube Leak Event detailed below, conditions reflected some form of tube leak that actually began in the early morning hours of September 7th. However, because the conditions detected directly at the sensor inhibited re-attainment of “Start Temperature”, a cycle end point was never achieved, and further dewpoints were neither identified nor reported.

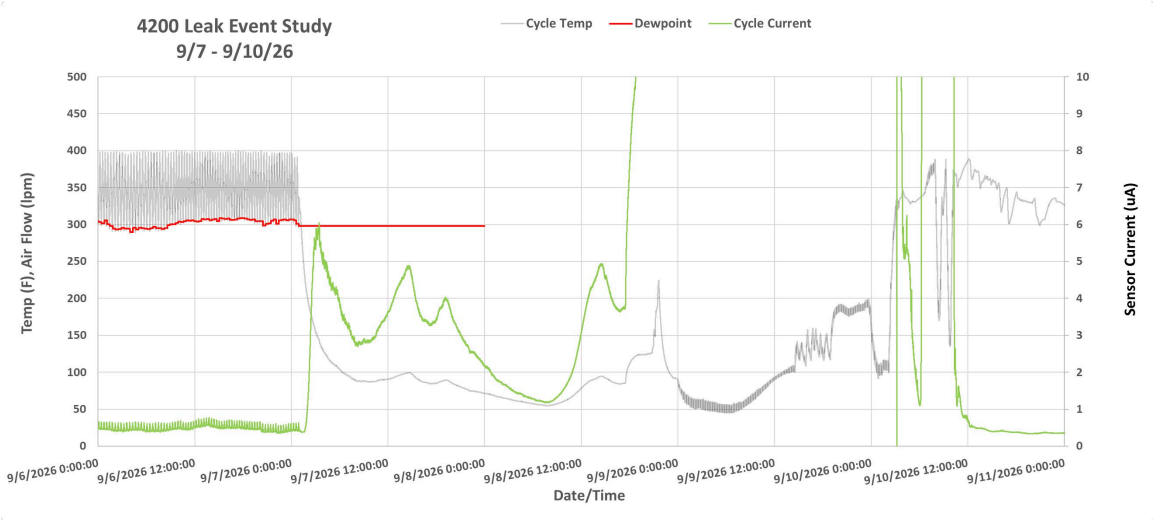
4 A TUBE LEAK LIFECYCLE

4.1 Performance Curve from Instrument Data

The following curve shows the data covering the period of this event:



This right-hand Y-axis is set to show the maximum current on the probe Cell. This is a 337 uA maximum showing up between 9/9 and 9/10. The curve below is the same data set but with the right y-axis set to show the impact of the initial current spike on 9/7/2026.

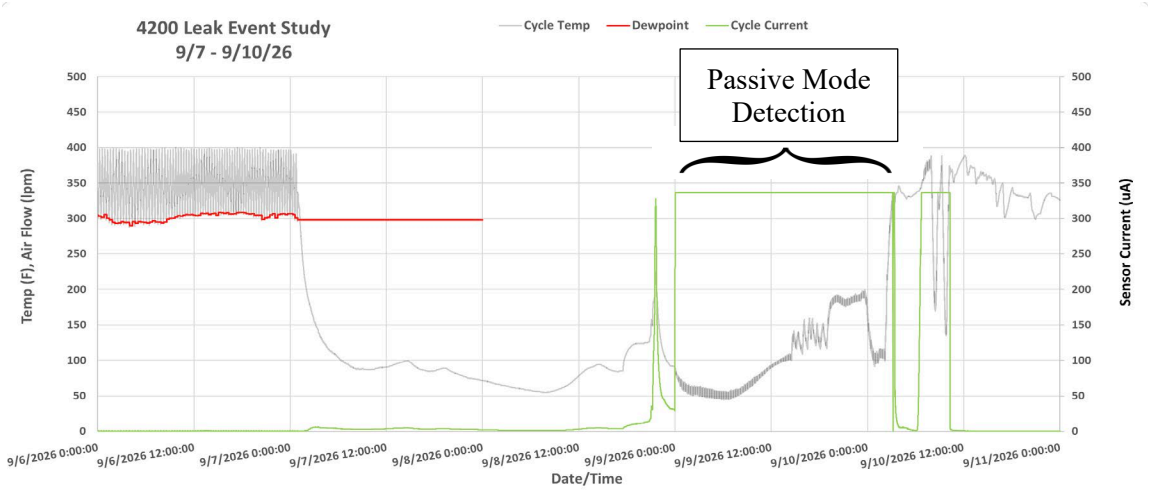


As you can see from this depiction, while the current spike in the early hours of 9/7 was small compared to the current saturation event on 9/9, it is significant compared to the typical process current of a normal cycle. Those values span between 0.2 uA and 0.6 uA in general, so a spike to nearly 6 uA is significant.

More importantly, the fact that the sensor temperature could not recover to flue gas temperature strongly suggests a deposit of some form of liquid on the sensor face that could not be evaporated using normal flue gas temperature conditions.

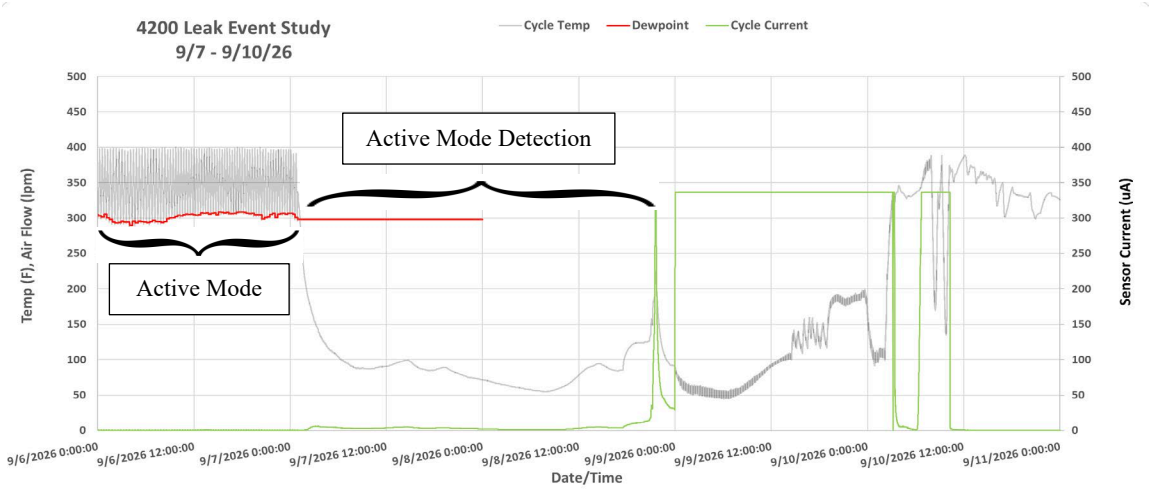
4.2 Passive Mode Leak Detection

As mentioned in paragraph 3.2, Passive Mode operates as a backstop against a high level of moisture ingress into the sulfuric acid manufacturing process. To conserve sensor life, it does not actively seek a dewpoint every cycle but instead waits until a saturation event occurs that drives the sensor current above 335 uA. These conditions exist from essentially midnight on September 9th through the plant activity on September 10th



It is possible that the spike late in the evening of September 8th might have triggered an event as well, but true Passive Mode detection is indicated by Sensor Current saturation.

4.3 Active Mode Leak Detection



Active Mode operation is explained in Section 3.3. In this Leak Event, true Active Mode operation is shown at times prior to midnight between September 7th and September 8th. At that point, as shown in the second graph of Section 4.1, Sensor Current rose, and Cycle Temperature was depressed. Because the Cycle Temperature never reaches Start Temperature, a new cycle is not defined, and any ongoing

dewpoints are not captured. This series of actions represents a weakness in the Instrument's Logic that was previously unseen.

The rise in Sensor Current above a defined setpoint is an internal flag for a heating action in Cyclic Mode, but this instrument was operating in Active Mode. Cyclic Mode was primarily intended for heavy industry and power generation applications where higher sulfur fuel and potential presence of ammonia exist. For this Sulfuric Acid Plant application, Cyclic Mode was not engaged.

In this example, the presence of elevated Sensor Current defines a condition where additional material is condensing and is inherently showing an increased dewpoint. However, without start temperature attainment, this condition was never reported.

4.4 Instrument Performance, Post-Event

Following identification of the leak by plant operating staff, the Ei4200 was still having difficulty clearing the deposit on the Sensor. To be conservative, Ohio Lumex pursued the possibility that the sensor may have been damaged in some way, leading to the odd data reporting. In the end, it turned out that a highly tenacious deposit had formed on the sensor, and external heating using the Service Mode tools provided enough temperature to evaporate and eliminate the deposit.

In other words, the instrument was not damaged prior to, or during, the 9/7 event and continues to run to the present time.

5 CONCLUSIONS & NEXT STEPS

5.1 Leak Propagation

On September 7, 2026, at just before 1:00 AM the Ei4200 detected a small presence of water in the flue gas at the secondary economizer outlet location. This small incursion of water into the flue gas persisted until roughly 5:30 PM on September 8th.

At roughly 5:30 PM on September 8th, a more dramatic water ingress was observed lasting for about 3 hours. At that point, a major water leak was detected, temporarily subsided, then manifested into a full-blown incursion just after midnight on September 9th.

Sometime around 3:00 AM on September 10th, this leak was detected by the plant and corrective action was taken.

As of this writing, we are not aware of the actual location of the tube leak(s), but it appears that it started as:

- A minor leak lasting for just over 40 hours,
- A subsequent increase in water flow for another 8 hours,
- Development of a full-blown leak event lasting 24 hours before discovery by plant staff

The persistent presence of water in the ductwork, starting on 9/7, caused the formation of a tenacious coating on the Ei4200 sensor that did not clear when the cell tried to heat up. Most likely, this is due to the evaporative cooling effect on the sensor cell and the deposition of additional condensate as the cell remained below the dewpoint created by the initial leak.

Because the cell never reached "Start Temperature" to initiate a dewpoint reading, the system appeared stalled, and no alarm occurred.

5.2 Revised Leak Alarm

All of the current alarm conditions are based on changes in measured dewpoint compared to a known, normal dewpoint. In this case, since a new dewpoint was inhibited by the conditions, no alarm occurred.

To remedy this situation in light of this new evidence, the "Dewpoint Alarm" will be modified to be a "Sensor Current" Alarm, and the 4-20 mA analog output assigned to SO_3 value will be repurposed to reflect Sensor Current. Since the Dewpoint is already reported to the DCS, that alarm function can reside in the DCS. The dry contact closure associated with an abnormally high sensor current will provide a fail-safe against this condition and would have saved the plant almost 72 hours in advance warning of the impending major leak