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Future of Sensory Technology

Continuous Monitoring as Plant Operating Intelligence

Framework for Real-Time Dust, Emissions, and Process Sensing in Gypsum Wallboard Manufacturing

Scentroid 2026.09.09

EXECUTIVE SUMMARY

Gypsum wallboard manufacturing runs as a continuous, high-volume process. Dust, moisture, and combustion by-products occur naturally throughout normal operation, and plants have long managed them mainly through periodic testing tied to regulatory schedules.

For years, plants have relied on quarterly stack tests, scheduled ambient samples, and manual dust checks made during routine walkthroughs. These practices confirm compliance at a single point in time, but they say little about what happens between one test and the next.

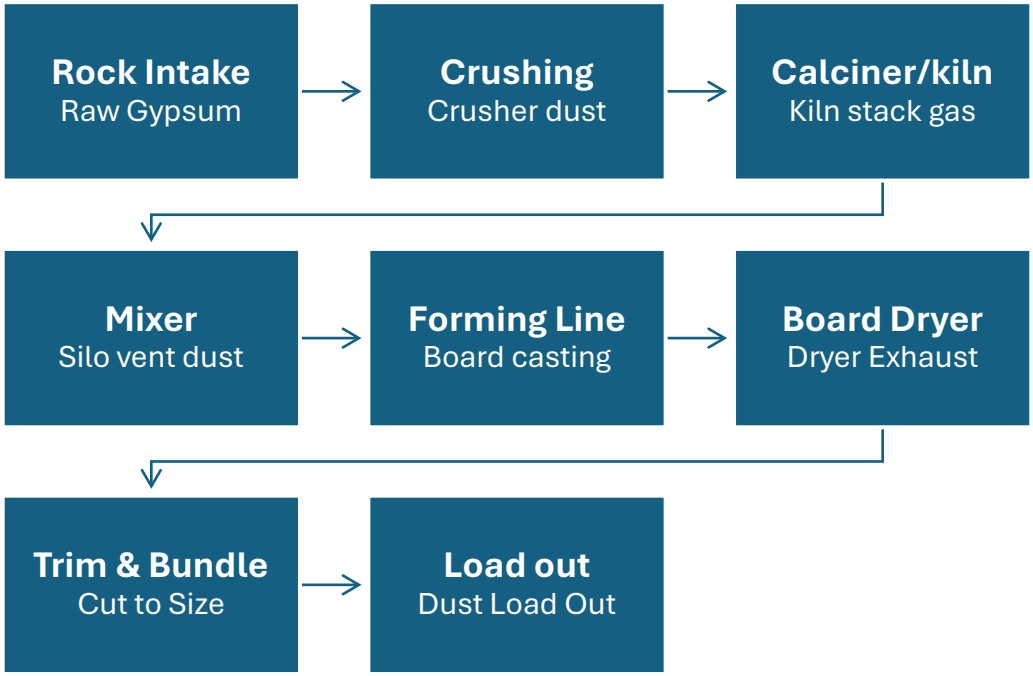
This white paper looks at a different approach that more manufacturers are adopting. A plant can treat environmental and process sensing as a continuous source of operating information for the whole facility, covering both the production floor and the occupied spaces around it. A network of low-cost sensors placed at key points across the plant, such as the calciner, the mixer, the board forming line, the dryer, and material handling areas, gives staff a live view of conditions that a scheduled test would only reveal every few months. The same approach extends into control rooms, offices, and break rooms, where staff spend their shift and where a related but distinct set of conditions matters.

This kind of visibility helps staff catch unusual conditions sooner. It helps them trace the cause of a dust collector problem or a process upset more quickly, and it lets them connect sensor readings with production and maintenance records to cut down on investigation time and unplanned downtime. This paper covers what a gypsum manufacturer should consider measuring beyond the standard particle size categories, both on the production floor and in occupied indoor spaces, how to set up a small pilot that tests the economics before a larger investment, and what a well-run pilot can realistically demonstrate within ninety days.

1. GYPSUM WALLBOARD MANUFACTURING

A typical gypsum wallboard plant moves raw or synthetic gypsum, either mined rock or FGD byproduct gypsum from power generation, through a series of high temperature and high friction process steps. The rock is crushed and screened, then calcined in a kiln or flash calciner to convert gypsum into stucco. Workers mix the stucco with water, starch, and other additives, form and cut it on a continuous board line, and dry it in a multi deck dryer before trimming, bundling, and moving it to load out. Except for raw material stockpiles and outdoor load out areas, this entire sequence typically runs inside one large, enclosed plant building. The dust and gas described throughout this paper are mostly an indoor, industrial environment, not an open air one.

Each of these steps produces its own mix of dust and gas. Crushing and screening create coarse and fine mineral dust. Calcining adds combustion byproducts from the burner, commonly nitrogen oxides, sulfur dioxide, and carbon monoxide, along with fine calcined gypsum dust. Mixing and forming create dust at transfer points, conveyors, and silo vents. Board drying releases moisture laden exhaust that can carry fine particulate and, depending on the additives and facer materials used, trace volatile organic compounds. Load out and bagging areas generate their own dust as well.



Eight process stages of gypsum Wallboard Manufacturing from rock intake to load out

Dust and gas are a normal part of this process. The real question for a plant is how much visibility it has into how those conditions change from hour to hour, as equipment ages, filters load up, dampers drift out of position, or a process parameter shifts outside its usual range. None of this stays confined to the production floor either. Dust and process air move into nearby control rooms and offices through doorways, foot traffic, and HVAC intake, which is why occupied indoor spaces are part of the same picture and are addressed later in this paper.

2. WHY COMPLIANCE-BASED MONITORING DOES NOT WORK

Most gypsum plants already monitor emissions to some degree, and this monitoring usually follows a regulatory calendar built around compliance deadlines. Stack testing typically happens once or twice a year and captures conditions at a single moment under specific test conditions. Where a plant has installed a continuous emissions monitoring system, it usually covers only one or two regulated stacks, since these systems cost a lot to install, calibrate, and maintain. Most plants have not extended this kind of continuous monitoring to the many smaller dust sources found throughout a facility, including conveyor transfer points, silo vents, baghouse discharge points, and load out areas.

A great deal can happen between compliance events. Filter bags in a dust collector can degrade gradually. A damper can drift out of position. A duct or seal can develop a leak, or a burner can drift off its ideal air fuel ratio. In most plants, nobody notices any of this until dust visibly builds up on structural steel, a worker raises a concern, a maintenance inspection happens to catch it, or the next scheduled test comes back with an unwelcome result. By then, the condition may have already cost the plant money through wasted energy, extra wear, or lower product quality, and it may have been building for weeks.

Industrial dust collection system used to capture particulate emissions from the production process.

COVERAGE GAPS

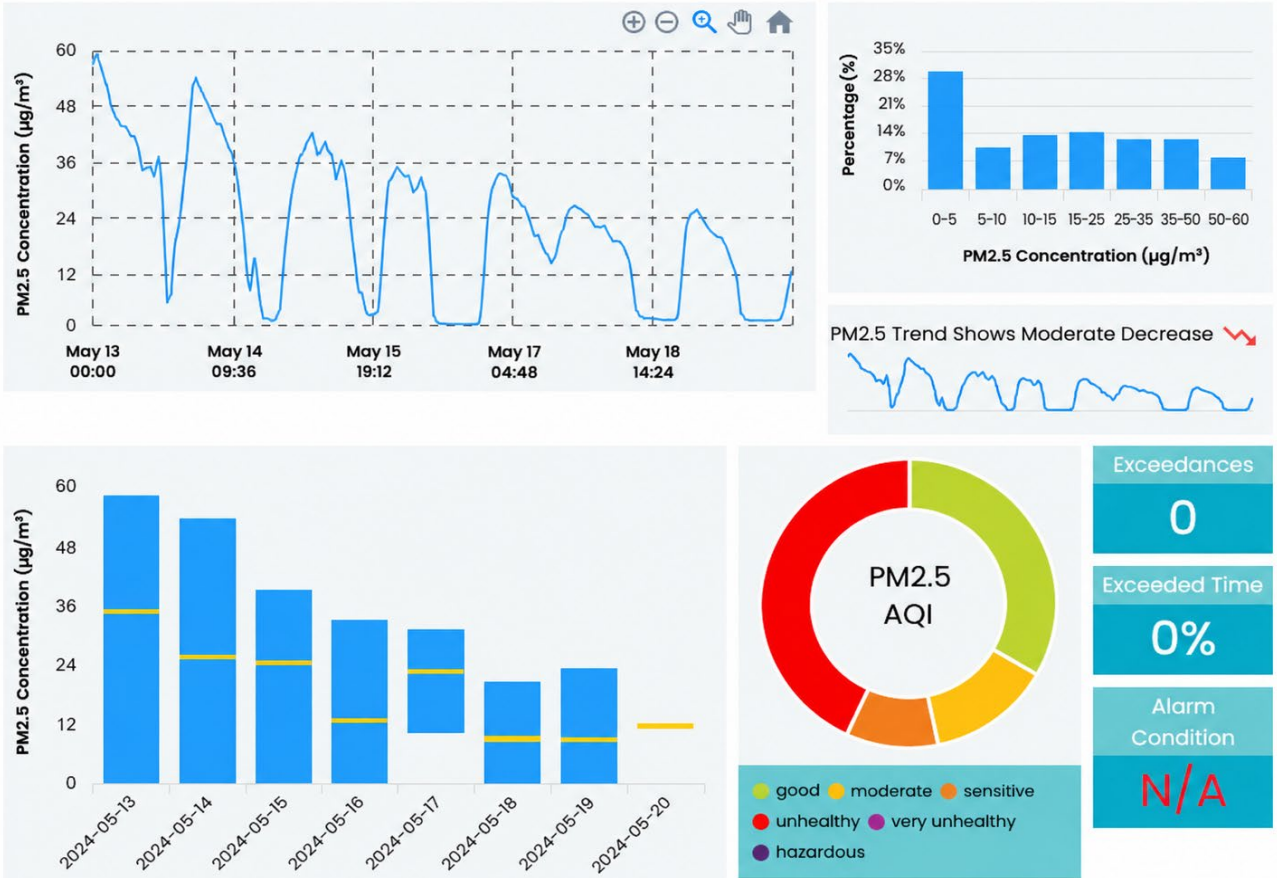
- Periodic testing shows conditions at a single moment. It says little about how those conditions change in between tests.
- A fixed continuous emissions monitor usually covers just one or two regulated stacks and rarely reaches the smaller, scattered dust sources around the plant.
- A manual walkthrough depends on someone noticing visible dust or an odor, and by that point the condition has often been building for a while.
- Investigating a problem after a complaint or a failed test takes time, uses a lot of staff labor, and rarely points straight to the root cause.
- Compliance monitoring almost never extends indoors. Control rooms, offices, and break rooms sit outside the scope of stack testing and ambient sampling entirely, even though staff spend a full shift in them.

3. PLANT OPERATING INTELLIGENCE

A plant gets more value from continuous sensing when it treats the data as operating information for the whole facility, the production floor and the occupied spaces around it alike, useful to maintenance and operations staff as much as to the environmental team.

The same particulate and gas readings that describe environmental performance also describe the health of the equipment producing them. A rising particulate trend at a baghouse discharge point is often the earliest available sign of a torn filter bag or a failing seal, showing up well before a compliance sample or a scheduled inspection would catch it.

This fits a broader pattern across process industries. As sensor networks and cloud-based analytics have become cheaper, plants can now afford to monitor far more points than traditional instruments ever allowed. A plant can spread a larger number of lower cost sensors across the areas that matter operationally and treat environmental compliance as one output of that network among several.



Sample SIMS3 report highlighting PM2.5 analysis

Environmental data that sits in a compliance file typically gets reviewed once a quarter, if at all. Operating data that appears on a live dashboard, with alerts tied to a plant specific baseline, gets used by shift supervisors and maintenance planners every day.

4. WHAT TO MONITOR ON THE PRODUCTION FLOOR

Particle size measurements are a natural starting point for any gypsum plant, since dust is the most visible and most regulated byproduct of the process. A well-designed monitoring program should grow beyond particulate alone, both in what it measures and where it measures it.

4.1 PARTICULATE AT MULTIPLE POINTS IN THE PROCESS

Placing particulate sensors at several distinct zones, such as the crushing and screening area, the calciner and kiln area, the dryer exhaust, conveyor transfer points, silo vents, and load out or bagging, lets a plant see which part of the process is contributing to a change. Comparing PM1, PM2.5, PM4, PM10, and total suspended particulate across these zones at the same time helps a plant tell a localized mechanical issue apart from a broader process shift.

4.2 COMBUSTION AND PROCESS GASES

- Nitrogen oxides, sulfur dioxide, and carbon monoxide from kiln or calciner burners give an early sign of combustion or air fuel ratio problems.
- Carbon dioxide works as both a combustion indicator and, in enclosed or below grade areas, a general marker of ventilation and worker safety.
- Volatile organic compounds matter where a plant uses additives, adhesives, or paper facer materials that can release them.

4.3 ENVIRONMENTAL AND PROCESS CONDITIONS

- Temperature and relative humidity at the dryer and forming areas affect both product quality and how dust behaves.
- Differential pressure across baghouses and dust collectors gives an early sign of filter loading, blinding, or a developing leak.
- Noise levels matter in enclosed process areas where worker exposure is a concern.

4.4 PROCESS DATA FOR CORRELATION

Sensor readings on their own only tell part of the story. Wherever possible, a plant should line up sensor data with information it already collects, such as line speed, kiln or calciner temperature, burner fuel flow, fan amperage, damper position, and maintenance and downtime logs. This is what turns a rising dust or gas trend into a specific, actionable finding.

Outdoor Sensor location candidate monitoring point map of Gypsum facility

5. WHAT TO MONITOR IN OCCUPIED SPACES

Even though the production floor sits inside the plant building, it is an industrial environment built around dust and heat, not a space designed for people to sit and work in for a full shift. A gypsum plant also has occupied comfort spaces, such as control rooms, offices, break rooms, and labs, set apart from the process itself even when they share the same building or sit close by. These spaces deserve their own look, since the pollutants that matter and the reasons to monitor them are somewhat different from the production floor.

Within a gypsum plant, these rooms sit close to a dusty, high temperature process rather than in a typical office building. Indoor air is often assumed to be fine simply because nothing is visibly wrong, and a short spot check misses the slow buildup that happens over a shift. Ventilation choices are rarely guided by real time data, even though nearby process conditions can change quickly.

5.1 PARTICULATE MATTER TRANSFER

Particulate is the clearest example of why these spaces cannot be treated as separate from the plant floor. Dust from crushing, calcining, and the board line does not stay where it is generated. It travels indoors through open doorways, foot traffic between zones, and HVAC systems that draw intake air from near the process. A control room or office close to the kiln or the board line can show particulate levels tied directly to what is happening in production, not to anything happening inside the room itself

5.2 OTHER POLLUTANTS TO MONITOR

A few other pollutants are worth tracking in these spaces. Some are tied directly to the plant's own process and materials. Others are part of managing any occupied building, regardless of what is made nearby.

- Carbon dioxide works as a simple, well-established indicator of ventilation, and it matters more in a control room or office that sits close to the heat of a kiln or dryer, where staff may keep doors closed or limit fresh air exchange to manage temperature. A level under 800 parts per million is generally considered good ventilation, while readings above 1,000 have been linked in some research to reduced cognitive performance and to symptoms such as headaches and drowsiness.
- Formaldehyde and other volatile organic compounds can come from ordinary office furnishings, but in a gypsum plant they may also trace back to adhesives and resins used in board additives and paper facers. The World Health Organization recommends keeping a 30-minute average under 0.1 milligrams per cubic meter for formaldehyde specifically.
- Ultrafine particles, smaller than 0.1 micron, are worth watching in spaces near the kiln or calciner, since combustion is a major source of this size fraction. They penetrate deep into the lungs and are not yet widely regulated but are increasingly recognized as a health concern.
- Nitrogen dioxide and carbon monoxide typically come from gas fired equipment such as space heaters or propane fork trucks, so they are worth tracking in break rooms, loading docks, or offices near any equipment that burns fuel indoors.
- Radon is unrelated to the manufacturing process itself. It is a naturally occurring radioactive gas that seeps in from soil and foundations, and the World Health Organization sets a reference level of 100 becquerels per cubic meter. It is worth a baseline check in any occupied building, gypsum plant or otherwise.
- Ozone is another building level factor rather than a process one. It forms outdoors and mostly enters through infiltration, and standard HEPA filters do not remove it, so control depends on activated carbon filtration and on limiting outdoor air intake during high ozone periods.

6. OUR TECHNOLOGY APPROACH

A practical monitoring network for a gypsum plant relies on modular, distributed sensors spread across many points. This keeps costs manageable, since a plant would otherwise need several high precision analyzers, each expensive to install and maintain. The network generally has three layers.

6.1 DISTRIBUTED SENSOR NODES

The CTair analyzer from Scentroid is a practical example of this kind of node. Each unit weighs about 2.5 kilograms and measures roughly 19 by 29 by 14 centimeters, small enough to mount on a wall or a pole at almost any point in a plant without competing for space with process equipment.

A single CTair can carry up to 11 sensors drawn from five categories, including a laser particle counter for PM1, PM2.5, and PM10, electrochemical cells for gases, a nondispersive infrared sensor for carbon dioxide, a photo ionization detector for volatile organic compounds, and a metal oxide sensor for methane. A plant can start with the particulate and gas sensors that matter most at a given point, then add sensors from the same list later as priorities shift, all within the same unit and without swapping hardware.

- Runs on standard power or on an optional solar module for points where running new power lines would be costly.
- Connects over WiFi, cellular data, or LoRa, and supports Modbus TCP/IP, the protocol many plant control systems already use.
- Reports to the SIMS3 software platform, where a plant can set alarm thresholds that trigger SMS or email alerts, a local audible alarm, or automatic control of connected equipment such as a misting system or a sampling pump.
- Comes with a 24-month warranty that covers the sensors.

Wall-mounted CTair device equipped with an Air Conditioning unit

6.2 SENSOR NODES FOR OCCUPIED SPACES

A monitor built for an office or break room has different practical requirements than a sensor node mounted on a baghouse. It needs to look discreet and unbranded rather than industrial, run silently with no fan noise, and sit in a slim, flat enclosure that does not draw attention on a wall. A local screen lets staff check current conditions briefly, and secure wireless access lets the same device feed its historical data into a central platform.

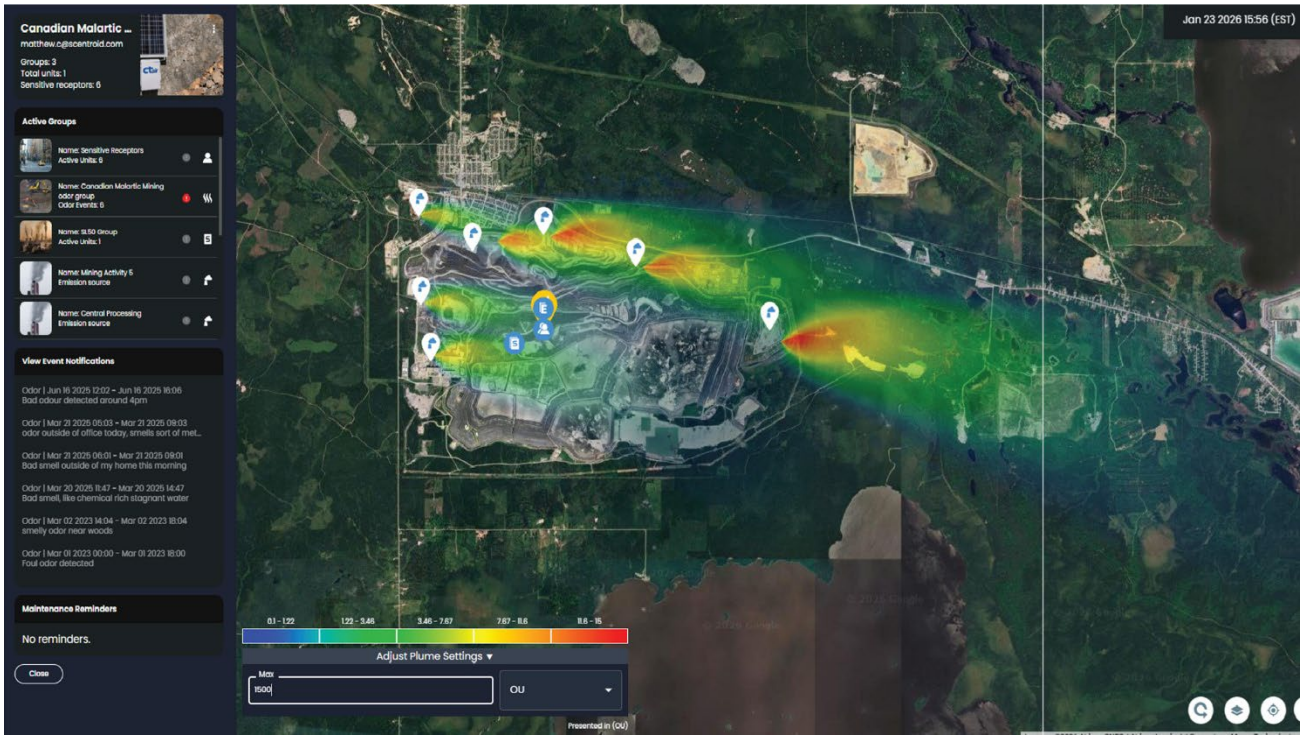
Compact, wall-mounted indoor air quality monitor with an integrated display

The AQmini from Scentroid fits this role well. It plugs into a standard USB power source, runs at under seven decibels so it is not noticeable in a quiet room, and arrives pre-calibrated and ready to mount. Its screen stays off during normal operation and only lights up when touched or when a reading crosses an alarm threshold, which keeps it unobtrusive in an office or break room. The base unit tracks carbon dioxide, PM2.5, PM10, and nitrogen dioxide, and a plant can add two more sensors from a longer list that includes carbon monoxide, formaldehyde, ozone, and volatile organic compounds, depending on which pollutants matter most in each room.

Like the CTair units on the production floor, the AQmini connects over WiFi, Bluetooth, or LoRa and reports into the same SIMS3 platform, so readings from occupied spaces sit alongside the process data already being collected. Extending the same platform into offices and control rooms costs relatively little once the production floor network and software are in place, and it gives a plant a fuller picture of conditions across the whole site rather than just the process itself. It can also flag a ventilation or HVAC problem in an office or control room before staff notice headaches or fatigue and give EHS staff a continuous record in place of an occasional spot check.

6.3 A CENTRALIZED SOFTWARE PLATFORM

Every node sends its data to a central software platform. Staff use this platform for live dashboards, historical trends, configurable alarms, and data export or API access. This turns a set of individual readings into one coherent picture of the whole plant, and it lets nonspecialist staff, such as shift supervisors, maintenance planners, and EHS coordinators, work with the data without needing to interpret raw sensor output themselves.



SIMS3 – Sensor Information Management System

6.3 INTEGRATION WITH PLANT SYSTEMS

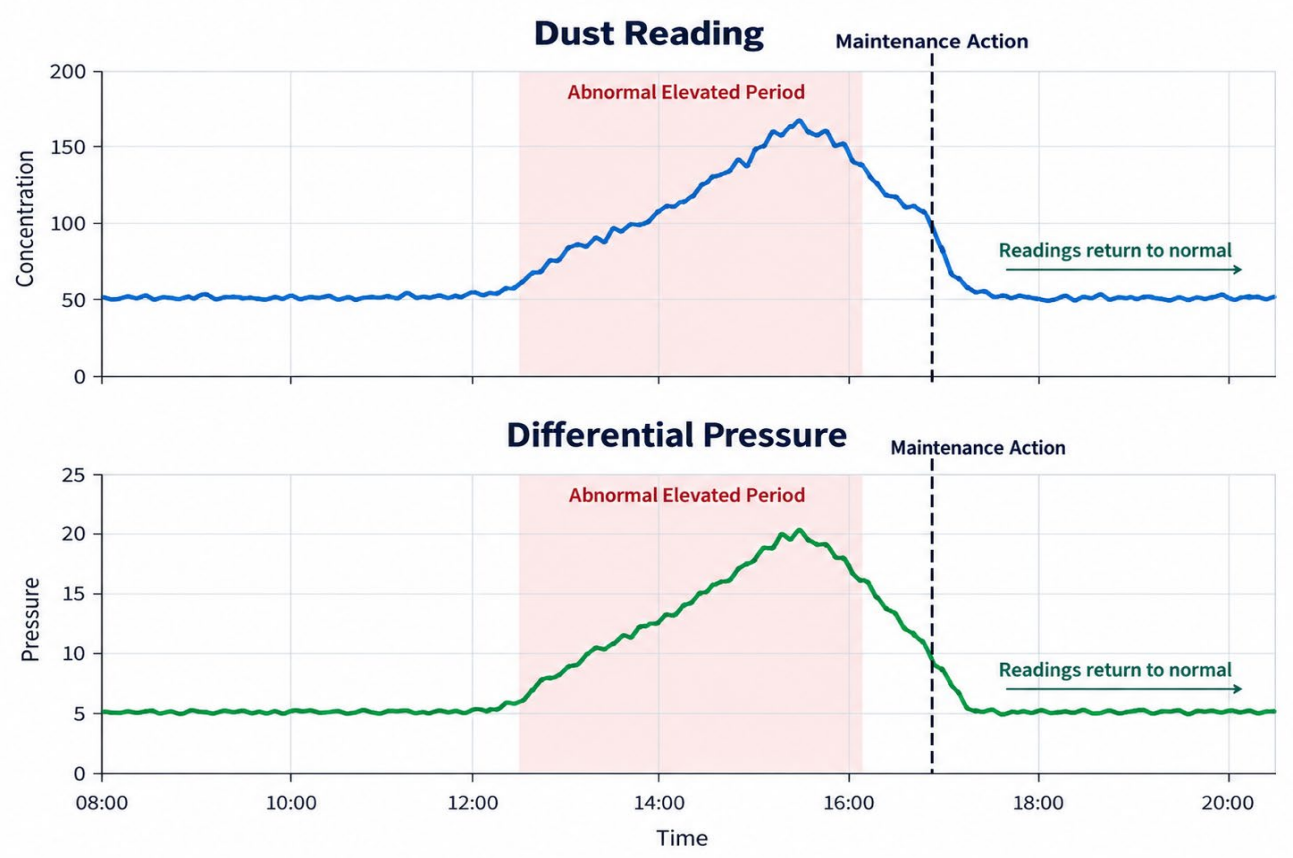
Many plants already run a control system, a SCADA system, or a CMMS that holds process and maintenance data. Where that system can share data through a standard interface, a plant can bring it into the same monitoring platform or export it alongside sensor data for joint analysis. This integration step supports the correlation work described next. A plant can begin monitoring without it, though the biggest gains in value tend to show up once it is in place.

7. CORRELATING SENSOR DATA WITH PLANT OPERATIONS AND MAINTENANCE

7.1 PRODUCTION FLOOR CORRELATION

The value of continuous sensing grows once a plant can view readings alongside production and maintenance data on the same timeline. A few patterns show up repeatedly across process industries that take this approach.

- A slow rise in differential pressure across a baghouse, checked against filter age and the last service date, gives maintenance a clear, data backed reason to schedule bag replacement, without relying only on a calendar interval or waiting for a visible failure.
- A particulate spike at a specific conveyor transfer point, checked against that conveyor's vibration alarm or motor amperage log, can narrow an investigation down to one piece of equipment within minutes. Without this data, the same investigation might take hours of walking the line.
- A shift in gas readings near the kiln, checked against burner fuel flow and kiln temperature, can flag a combustion tuning issue before it turns into a compliance exceedance or a loss in fuel efficiency.



Sample Correlation chart highlighting maintenance actions vs selected parameters

Over time, this builds a plant specific baseline for what normal looks like across different production rates, ambient conditions, and product runs. Once that baseline exists, a plant can flag a genuinely abnormal reading automatically, instead of waiting to find it in the next environmental report, the next scheduled test, or the next walkthrough.

7.2 COMBINING WITH OCCUPIED SPACE DATA

The sections above cover two separate layers of visibility. Sensors on the plant floor track dust and gases where they originate, at the crusher, the kiln, the dryer, and the baghouses. Sensors in occupied spaces track how those same conditions, along with a few building specific factors, show up where staff actually spend their shift. Run together on one platform, these two layers give a plant something neither one delivers alone, a complete picture of conditions across the whole site.

A rising CO2 reading in a control room next to the kiln means something different depending on what the process floor sensors show at the same time. If production is running normally, it likely points to a ventilation or HVAC issue inside the room. If a nearby process sensor also shows an unusual reading, the two together point toward a shared cause, such as a door left open near a dusty area or a duct pulling process air into an occupied space. Viewed side by side, process and occupied space data answer a question that neither can answer alone, whether a problem sits in the room itself or out in the process.

A plant already running a pilot on the production floor can add a handful of occupied space points, in a control room, an office near the board line, and a break room, without starting over on software or training. The result is one dashboard, one set of alarms, and one record that covers the site as a whole rather than the production floor in isolation.

A plant that can show a complete, correlated record across both the production floor and its occupied spaces has a stronger case for scaling up than one that can only speak to the process itself.

8. ECONOMIC BENEFITS

Much of the cost tied to dust and process upsets in a gypsum plant never shows up as its own line item. It appears as staff time spent walking the plant to trace a complaint or a failed sample. It appears as unplanned downtime when a process trip or a filter failure only becomes visible after it has already escalated. It appears as filter media or collector parts replaced too early out of caution, or too late because nobody caught the warning signs in time. It also carries a harder to measure cost tied to regulatory risk and worker exposure to dust.

A continuous, distributed sensing layer will not remove these costs on its own. It does convert several of them into measurable, trackable numbers, such as the hours needed to locate and diagnose an abnormal condition, the downtime avoided or shortened because a plant caught a condition early, and the extra life gained from replacing a filter or component based on its actual condition instead of a fixed calendar date. Because the price of a modular sensor network is modest next to the cost of one significant upset or unplanned outage, most plants can test this economic case directly, at a small scale, before deciding on a larger rollout.

9. STRUCTURING A 90-DAY PILOT

A single plant pilot is the most practical way to test this approach before committing to a larger system. A good pilot typically covers five to ten monitoring points, chosen mainly for their operational importance. Good candidate points include the calciner and kiln area, the main baghouse, a representative conveyor transfer point, the board dryer exhaust, the load out area, and a control room or office nearby, so the pilot speaks to occupied spaces as well as the process itself. A pilot built this way costs little enough to approve quickly, and it stays focused enough to produce a clear answer within a set window of time.

SCOPING AND INSTALLATION, WEEKS 1 AND 2

The pilot begins with a site walk to confirm which points to monitor, a review of the process and maintenance data already available for correlation, and installation of the sensor nodes and the software platform.

CONTINUOUS DATA COLLECTION, WEEKS 3 THROUGH 10

Live dashboards run around the clock. The team reviews the data on a regular schedule, usually weekly, against production and maintenance events. Staff investigate any abnormal readings together to confirm the root cause and start building early examples of correlation.

ANALYSIS AND THE SCALE UP DECISION, WEEKS 11 THROUGH 13

The team analyzes pilot data against the KPIs it agreed on at the start, presents the findings to plant and operations leadership, and makes a recommendation, backed by data, on whether and how to expand the approach beyond the pilot.

The key discipline in this model is agreeing on success criteria before installation begins. A pilot without KPIs set in advance tends to produce interesting data and an unclear decision. A pilot with KPIs set in advance produces a clear answer on whether to scale up.

10. DEFINING PILOT KPIS

The right KPIs vary from plant to plant, depending on which operating problems matter most locally. A well-rounded pilot usually tracks some combination of the following measures.

- The number of abnormal conditions the continuous data catches that a plant would have missed between scheduled tests or walkthroughs.
- The average time needed to find the source of a dust or process problem, compared with the plant's experience with similar events.
- The number of times a sensor trend led the team to a specific mechanical or process cause.
- The estimated hours of investigation and maintenance labor saved through faster, data backed root cause work.
- Any unplanned downtime avoided or shortened because the plant caught a problem early.
- Feedback from EHS, maintenance, and operations staff on how useful they find the live dashboard and its alerts.
- Any ventilation or indoor air issue identified and resolved in an occupied space, along with staff feedback on comfort.

10. CONCLUSION

Dust, moisture, and combustion byproducts are a normal part of gypsum wallboard manufacturing. What varies from plant to plant is how much visibility operations and EHS teams have into how these conditions change over time, and how quickly they can trace an abnormal condition back to its source.

A distributed, modular, low-cost sensing network gives plants that visibility across far more of the process, and the occupied spaces around it, than periodic testing or fixed compliance monitors ever could. Piloting this approach at a single plant, with a small number of well-chosen monitoring points and clear KPIs, lets a manufacturer test the economics directly and decide, based on real data, whether a wider rollout makes sense.

These principles apply broadly across gypsum wallboard operations, regardless of a plant's size, its raw material source, or the environmental controls it already has in place. Every facility can start the same way. Choose a small number of points that matter operationally. Monitor them continuously rather than periodically. Let the data, combined with what the plant already knows about its own process, make the case.

Interested in a pilot assessment your site?

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