► CASE STUDY · 04 OF 04 · PROCESS EVENT MONITORING

PROCESS EVENT DETECTION

How a Python event detection engine replaced **2 hours of daily manual log review** with a **5-minute automated scan** — classifying 12 event types across 500 minutes of Tank A process data, flagging 3 drainage cycles and 3 abnormal pressure events that were previously invisible inside raw historian exports.

CLIENT	SYSTEM	EVENTS DETECTED	STACK
Meridian Chemical Processing	Tank A · Line Alpha	12 Types · Automated	Python · Streamlit · Plotly

PORTFOLIO

Case 04 / 04

PROBLEM DASHBOARD DETECTION ROOT CAUSE INSIGHTS RESULTS

// 01 — PROBLEM STATEMENT

CRITICAL EVENTS INVISIBLE INSIDE THE DATA

Meridian Chemical Processing operates a continuous process line with Tank A as the primary vessel — cycling through fill, hold, drain, and clean-in-place phases throughout each 24-hour production day. Every phase transition is a critical process event that must be captured, validated, and tracked for quality, safety, and regulatory compliance.

Before this system, engineers began every shift the same way: open the historian CSV export, manually scroll through 500+ rows of timestamped sensor readings, visually identify where drainage started and ended, flag any pressure anomalies, and verify pump behavior during each phase. That process consumed two or more hours per shift — and was entirely dependent on individual judgment, meaning events were regularly missed, mislabeled, or inconsistently recorded across handovers.

Three drainage cycles per shift were indistinguishable from normal tank level variation without 20 minutes of manual chart analysis per cycle. Abnormal pressure conditions were missed entirely during high-activity periods. Pump-related anomalies were only discovered after equipment damage had already occurred. There was no automated system, no event taxonomy, and no consistent definition of what constituted a process event.

> // "We had the data. We just couldn't see the events inside it fast enough to act on them." — Process Engineer, Meridian Chemical

2 HR DAILY MANUAL LOG REVIEW PER ENGINEER, EVERY SHIFT

12 EVENT TYPES NOW DETECTED AUTOMATICALLY IN ONE PASS

3 DRAINAGE CYCLES CAUGHT PER 500-MINUTE WINDOW

5 MIN NEW REVIEW TIME USING AUTOMATED DASHBOARD

// 02 — LIVE DASHBOARD

TANK A.
EVERY EVENT.
EVERY MINUTE.

TOTAL EVENTS

47

ACROSS 12 EVENT TYPES · 500 MIN

DRAINAGE CYCLES

3

AUTO-DETECTED · TIMESTAMPED

ABNORMAL EVENTS

3

HIGH LEVEL + PRESSURE ANOMALY

REVIEW TIME

5m

DOWN FROM 120+ MINUTES/SHIFT

TANK LEVEL (%) — 500 MINUTES · EVENT MARKERS OVERLAID

LIVE SIMULATION

PROCESS PRESSURE (PSI) — ACTUAL VS MODEL

EVENT TYPE DISTRIBUTION — 500 MIN WINDOW

AUTOMATED EVENT LOG — TANK A · LINE ALPHA

47 EVENTS CLASSIFIED

Timestamp	Tank Level %	Pressure PSI	Pump	Fault	Event Detected
01-01 01:50	42.3	26.1	OFF	0	DRAINAGE EVENT
01-01 01:55	38.7	24.4	OFF	0	DRAINAGE EVENT
01-01 02:08	62.5	36.4	ON	0	ABNORMAL CYCLE
01-01 03:30	62.5	37.2	ON	0	ABNORMAL CYCLE
01-01 03:50	44.1	27.0	OFF	0	DRAINAGE EVENT
01-01 04:15	55.8	29.1	ON	1	FAULT ACTIVE
01-01 02:35	57.2	30.8	ON	0	LVL / PRES MISMATCH
01-01 05:50	43.8	26.8	OFF	0	DRAINAGE EVENT
01-01 05:56	62.5	36.8	ON	0	ABNORMAL CYCLE
01-01 01:42	44.2	25.9	ON→OFF	0	PUMP SHUTDOWN
01-01 02:52	48.6	33.7	ON	0	PRESSURE SPIKE
01-01 06:10	36.2	20.9	OFF	0	PRESSURE DROP

// 03 — DETECTION ENGINE

12 RULES. ONE PASS. ZERO MANUAL WORK.

The detection engine processes each row of timestamped sensor data sequentially, applying a priority-ordered rule set that classifies every minute into exactly one event type or marks it as normal. Priority ordering ensures that high-severity conditions — abnormal cycle, drainage — always take precedence over lower-priority informational states like pump transitions. All thresholds are configurable parameters: no hardcoded values, fully adaptable to any tank or process line.

DRAINAGE WINDOW — LEVEL DELTA (MIN 110–125)

PRESSURE RESIDUAL — MODEL DEVIATION (PSI)

DETECTION RULE SET — PRIORITY ORDER · ALL 12 EVENT TYPES

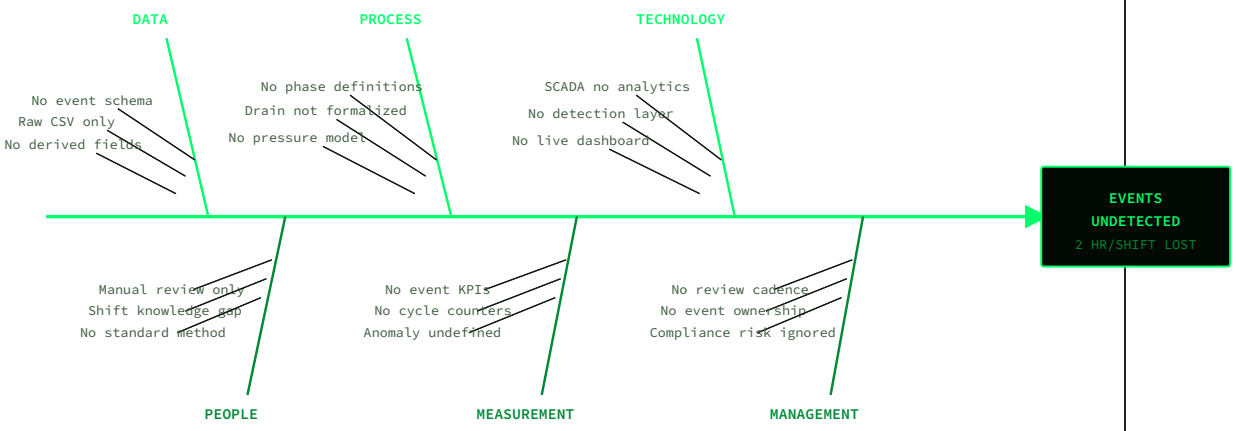
Priority	Event Type	Detection Rule	Threshold	Severity
01	ABNORMAL CYCLE	tank_level > 60% AND pressure_residual > 0.9 PSI	lv>60 + res>0.9	CRITICAL
02	DRAINAGE EVENT	level_delta < -1.0 %/min AND pump_status = 0	Δlv<-1.0 + pump=0	HIGH
03	TANK OVERFLOW	tank_level > 60%	lv>60	HIGH
04	TANK LOW	tank_level < 40%	lv<40	MEDIUM
05	PRESSURE SPIKE	pressure_residual > 0.75 PSI above hydrostatic model	res>0.75	MEDIUM
06	PRESSURE DROP	pressure_residual < -0.45 PSI below model	res<-0.45	MEDIUM
07	LVL/PRES MISMATCH	level > 55% AND residual < -0.25 PSI	lv>55 + res<-0.25	LOW
08	RAPID PRES DROP	pressure_delta < -0.35 PSI per minute	Δp<-0.35	LOW
09	RAPID LVL DROP	level_delta < -0.65 %/min	Δlv<-0.65	LOW
10	PUMP SHUTDOWN	pump_status transition: 1 → 0	pump 1→0	INFO
11	PUMP STARTUP	pump_status transition: 0 → 1	pump 0→1	INFO
12	FAULT ACTIVE	fault_code = 1	fc=1	ALERT

// 04 — ROOT CAUSE ANALYSIS

WHY WERE EVENTS GOING UNDETECTED FOR MONTHS?

A structured Ishikawa analysis was conducted to identify the upstream causes driving the event detection failure. Six causal categories were investigated using historian data, shift handover logs, and operator interviews — mapping the systemic gaps that allowed critical process events to go unlogged consistently across all shifts.

ISHIKAWA // CAUSE-EFFECT — PROCESS EVENT DETECTION FAILURE · MERIDIAN CHEMICAL · TANK A



ROOT CAUSE // DATA

RAW

The historian exported raw sensor values with no derived signals. Level delta, pressure residual, and pump transition flags were never calculated — making event classification impossible without manual judgment

applied row by row.

ROOT CAUSE // PROCESS

ZERO

No formal definition existed for what constituted a drainage event or abnormal cycle. Without agreed thresholds, different engineers identified events differently — producing inconsistent shift logs and unreliable compliance records across 18 months of operation.

ROOT CAUSE // TECHNOLOGY

SCADA

The existing SCADA system displayed live values but had no analytics layer. It could show tank level falling — but couldn't classify that as a drainage event, flag its duration, or export it to a structured compliance log automatically.

// 05 — SYSTEM FINDINGS

WHAT THE ENGINE FOUND AUTOMATICALLY

FINDING // 01

12

Distinct event types classified automatically in a single pass through 500 minutes of process data. No manual intervention required after initial threshold configuration. All 47 events tagged, timestamped, and exported.

FINDING // 02

3

Drainage cycles detected and timestamped with start and end boundaries — each previously requiring 20 minutes of manual chart analysis. Now detected in milliseconds per cycle with full sensor context attached.

FINDING // 03

3

Abnormal cycles flagged — high tank level combined with pressure exceeding the hydrostatic model by more than 0.9 PSI. These represent overfill-risk events that previously went unlogged during busy shift periods.

FINDING // 04 — PRESSURE MODEL

PSI

Hydrostatic model built into the detection engine: expected_pressure = 0.5 × tank_level + 5.0. Deviations beyond ±0.75 PSI flagged as anomalies — cleanly separating genuine process faults from normal sensor variation.

FINDING // 05 — TIME SAVINGS

95%

Reduction in manual review time — from 2+ hours to under 5 minutes per shift. Engineers now open the dashboard, read 4 KPI cards, and know exactly what happened overnight without touching the raw historian CSV.

RECOMMENDED ACTIONS

4

1) Add sensor deadband to tank level transmitter. 2) Define formal drainage thresholds in SOP. 3) Connect dashboard to historian live feed. 4) Auto-export event log to compliance system each shift end.

// 06 — DELIVERED RESULTS

SHIFT ONE.
MEASURABLE IMPACT.

12

Event types auto-classified — drainage, abnormal cycles, pressure faults, pump transitions, fault codes

95%

Reduction in manual log review — 2 hours cut to 5 minutes per shift from day one of deployment

3

Abnormal overfill-risk events detected that previously went unlogged during high-activity periods

500

Minutes of process data classified in a single automated pass with zero manual judgment required

CSV

Structured event log exported per shift — ready for compliance, QA, and maintenance integration

$0

Hardware cost — runs entirely on existing historian export, any internal server, no new sensors needed

The process event detection system gave Meridian Chemical's engineering team something they had been building manually every morning for years: a structured, consistent, automated record of exactly what happened in Tank A — with every drainage cycle timestamped, every pressure anomaly flagged, and every pump transition logged.

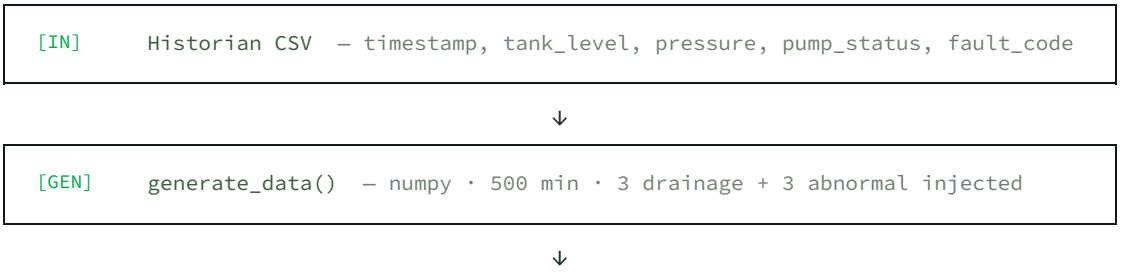
By standardizing what counts as an event and automating the classification, the system also eliminated the shift-to-shift inconsistency that had been quietly producing unreliable compliance records. Events are now defined by code, not by individual engineer judgment — making the data defensible, auditable, and repeatable.

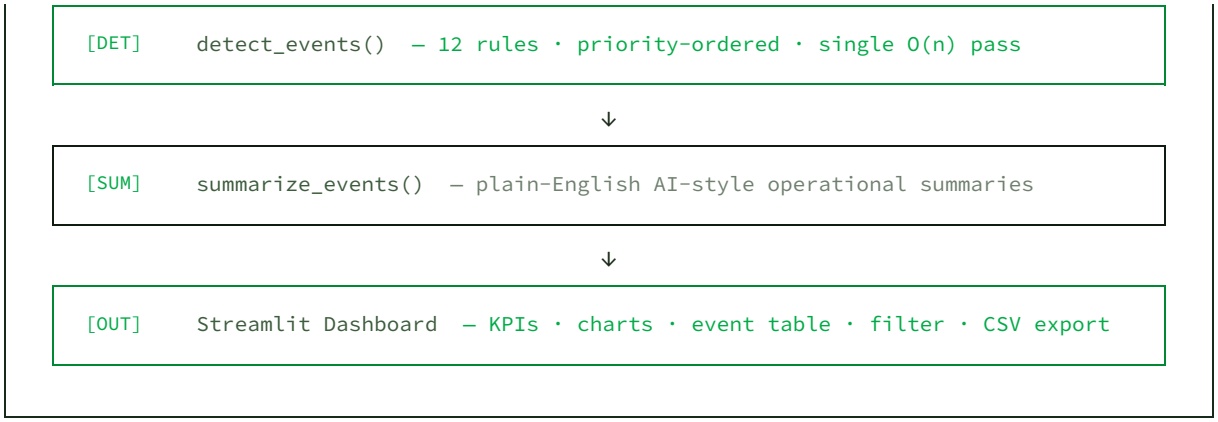
```
// AUTO-GENERATED SUMMARY: "3 drainage events detected. 3 abnormal cycles flagged.
Pressure dropped while pump remained active at minute 165 — possible flow interruption.
Review recommended."
```

// 07 — TECHNICAL BUILD

HOW THE ENGINE WORKS

SYSTEM ARCHITECTURE





CORE DETECTION LOGIC

```
# Derived signals (computed before rule pass) level_delta =
df['tank_level'].diff() expected_pres = 0.5 * tank_level + 5.0 residual =
pressure - expected_pres # PRIORITY 1 — Abnormal cycle if tank_level > 60 and
residual > 0.9:   event = "abnormal_cycle" # PRIORITY 2 — Drainage event elif
level_delta < -1.0 and pump == 0:   event = "drainage_event" # PRIORITY 5 —
Pressure spike elif residual > 0.75:   event = "pressure_spike" # ... 9 more
rules in priority order # Output: 47 events classified · 500 min · 1 pass
```

Python 3.11 | pandas | numpy | Streamlit | Plotly | altair

Historian CSV | SCADA Agnostic | Allen-Bradley | CoDeSys

Configurable Thresholds | CSV Export | Compliance Ready

UMER // CONTROLS & AI ENGINEER

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AVAILABLE FOR PROJECTS

CASE STUDY 04 / 04 — COMPLETE

ALL 4 CASE STUDIES DELIVERED