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Enterprise B (ProveItBeverage)
└── Site1 (Plant1)
    ├── FillerProduction (Area)
    │   └── FillingLine01 "Line A" [Asset ID: 7]
    │       ├── Filler [Asset ID: 23] – Rotary Filler, 300 bpm
    │       ├── Washer [Asset ID: 24] – Bottle Washer
    │       └── CapLoader "Capper" [Asset ID: 22]
    ├── LiquidProcessing (Area)
    │   └── MixRoom01 [Asset ID: 10]
    │       ├── Vat01 "Jeff" [Asset ID: 31] – 15,000L capacity
    │       ├── Vat02 [Asset ID: 32]
    │       ├── Vat03 "Billy" [Asset ID: 33]
    │       └── Vat04 [Asset ID: 34]
    ├── Packaging (Area)
    │   └── PackagingLine01 [Asset ID: 45]
    │       ├── Labeler [Asset ID: 46]
    │       ├── DateCoder [Asset ID: 47]
    │       ├── ShrinkWrapper [Asset ID: 48]
    │       └── CasePacker [Asset ID: 49]
    └── Warehouse (Area)
        └── Palletizing01 [Asset ID: 55]
            ├── LayerFormer [Asset ID: 56]
            ├── PalletizingRobot [Asset ID: 57] – FANUC M-410iC
            └── StretchWrapper [Asset ID: 58]

```

Demo Overview

Scenario	Duration	Equipment	Key Highlight
1. Filler Vibration Anomaly	4 min	Filler (23)	Real-time detection → Agent workflow
2. Mixing Vat Temperature Drift	4 min	Vat01 "Jeff" (31)	Process parameter anomaly → Quality impact
3. Capper Torque Degradation	4 min	CapLoader (22)	Predictive maintenance → RUL
4. Line Cascade Prevention	5 min	FillingLine01 (7)	Multi-agent collaboration
5. Quality Root Cause Analysis	3 min	Cross-line	AI investigation → Hidden correlation
6. Natural Language Interface	3 min	All assets	Conversational queries

Scenario 1: Rotary Filler Vibration Anomaly

Equipment Context

- **Asset:** Filler (Asset ID: 23)
- **Location:** Enterprise B/Site1/FillerProduction/FillingLine01/Filler
- **Type:** High-Speed Rotary Filler
- **Standard Rate:** 300 bottles/min
- **Current WO:** WO-L03-0428 (Orange Soda 0.5L)

MQTT Topics Monitored

Enterprise B/Site1/fillerproduction/fillingline01/filler/processdata/state/name
Enterprise B/Site1/fillerproduction/fillingline01/filler/metric/oee

Demo Flow

Step 1: Normal Operations (30 sec)

```
FILLER - Asset ID: 23          Status: ✓ RUNNING
Location: FillingLine01 "Line A"

OEE: 87.8%   Availability: 89.8%   Performance: 97.7%
Rate: 307 bpm (Standard: 300 bpm)
Vibration: 2.1 mm/s (Normal < 5.0 mm/s)
Temperature: 42°C

Work Order: W0-L03-0428 | Lot: L03-0428
Product: Orange Soda 0.5L | Progress: 19,586 / 52,000 (37.7%)
```

Step 2: Anomaly Detected (30 sec)

```
FILLER - Asset ID: 23          Status: ● ALERT
Location: FillingLine01 "Line A"

⚠ ANOMALY DETECTED - Vibration Spike

Vibration: 8.4 mm/s ⚠ 4x NORMAL (Threshold: 5.0 mm/s)
Temperature: 48°C ↑ Rising
Rate: 295 bpm ↓ Declining

Pattern Match: Bearing degradation signature (94% confidence)
```

Step 3: Agent Workflow (2 min)

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MULTI-AGENT WORKFLOW - LIVE

🤖 Anomaly Detection Agent:
"Vibration spike on Filler (Asset 23) at FillingLine01.
Pattern matches bearing wear signature from SOP document
SOP_HIGH_SPEED_ROTARY_FILLER.md - Error Code E008.
Failure probability: 89% within 4 days if uncorrected."

🤖 Impact Analysis Agent:
"Filler failure stops FillingLine01 (Line A).
Downstream impact: Washer (24) and Capper (22) idle.
Current W0-L03-0428 has 32,414 bottles remaining.
Production loss: $12,000/hour (52,000 bottles/shift)"

🤖 Inventory Check Agent:
"Replacement bearing SKF-6205-2RS available.
Warehouse location: Bin A-23. Quantity: 4 units.
Delivery to FillerProduction area: 45 minutes."

🤖 Scheduling Optimizer Agent:
"Current shift ends at 6:00 PM.
Recommended maintenance window: Tonight 10PM-2AM."
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Technician: Maria Garcia (Filler certified).
Estimated repair time: 2.5 hours per SOP procedure."

Step 4: Orchestrator Decision (1 min)

ORCHESTRATOR RECOMMENDATION

- Schedule emergency maintenance tonight 10PM–2AM
- Reserve bearing SKF-6205-2RS from warehouse (Bin A-23)
- Assign technician Maria Garcia
- Create work order W0-MAINT-2847 in CMMS
- Notify shift supervisor (auto-email sent)
- Pre-stage tools per SOP Section 4.2 (E008 resolution)

 Estimated Savings: \$42,000
(Avoided 3.5 hours unplanned downtime at \$12K/hour)

 SOP Reference: SOP_HIGH_SPEED_ROTARY_FILLER.md
Section 4.2 – Error E008: Drive Fault (Motor/Bearing)

[APPROVE] [RESCHEDULE] [VIEW SOP] [IGNORE]

Scenario 2: Mixing Vat Temperature Drift

Equipment Context

- **Asset:** Vat01 "Jeff" (Asset ID: 31)
- **Location:** Enterprise B/Site1/LiquidProcessing/MixRoom01/Vat01
- **Type:** Industrial Mixing Vat
- **Capacity:** 15,000 liters
- **Current WO:** WO-L02-0126 (Cola Mix)

MQTT Topics Monitored

Enterprise B/Site1/liquidprocessing/mixroom01/vat01/processdata/process/temperature
Enterprise B/Site1/liquidprocessing/mixroom01/vat01/processdata/process/weight
Enterprise B/Site1/liquidprocessing/mixroom01/vat01/processdata/state/name
Enterprise B/Site1/liquidprocessing/mixroom01/vat01/metric/oee
Enterprise B/Site1/liquidprocessing/mixroom01/vat01/workorder/quantityactual

Demo Flow

Step 1: Normal Mixing Operation

VAT01 "Jeff" – Asset ID: 31 Status: MIXING

Location: MixRoom01 / LiquidProcessing

State: Mixing Duration: 1,245 sec Agitator: 45 RPM

Temperature: 32.5°C (Target: 32°C ± 2°C)

Weight: 11,250 kg (Capacity: 13,000 kg)

Flow Rate: 0 L/min (Mixing – no transfer)

Recipe: Cola Mix | Batch: L02-0126

Step 2: Temperature Drift DetectedVAT01 "Jeff" - Asset ID: 31 Status: ⚠ WARNING

Location: MixRoom01 / LiquidProcessing

⚠ PROCESS ANOMALY - Temperature DriftTemperature: 38.2°C ⚠ +6.2°C above target

Trend: Rising 0.8°C per minute

Quality Risk: HIGH

- Cola Mix spec requires 30–34°C for proper dissolution

- Above 40°C: Caramelization risk, batch rejection

Root Cause Analysis in progress...

Step 3: Agent Investigation🤖 Root Cause Analysis Agent

Analyzing Vat01 "Jeff" temperature anomaly...

INVESTIGATION:

- Agitator motor current..... ✓ Normal (12.3A)
- Cooling jacket flow..... ⚠ LOW (15 L/min)
- Cooling water inlet temp..... ✓ Normal (18°C)
- Steam valve position..... ✓ Closed
- Ambient temperature..... ✓ Normal (22°C)

ROOT CAUSE IDENTIFIED:

Cooling jacket flow reduced 70% (normal: 50 L/min)

Probable cause: Cooling water valve V-201 partially closed

CORRELATION: Maintenance performed on V-201 yesterday

(WO-MAINT-2831 – valve stem lubrication)

RECOMMENDATION:

1. Immediately open V-201 to 100%
2. Monitor temperature decline
3. If temp exceeds 40°C, initiate emergency cooling

📋 SOP Reference: SOP_INDUSTRIAL_MIXING_VAT_SYSTEM.md

Section 4.3 – Error A001: High Temperature (CRITICAL)

Section 4.1 – Temperature Not Reaching Setpoint

Step 4: Automated Response⌚* ORCHESTRATOR ACTIONS✓ Alert sent to MixRoom01 operator panel

- Cooling valve V-201 command: OPEN 100% (pending confirm)
- Quality hold placed on batch L02-0126
- Lab sample request generated
- Incident logged: INC-2026-0128-001

BATCH STATUS:

Current: 12,930 kg produced (99.5% complete)
 Quality: HOLD pending temperature verification

If temperature returns to spec within 10 minutes:
 → Batch can be released after QC verification
 → Estimated impact: 15 minute delay

If temperature exceeds 40°C:
 → Batch rejection required per SOP
 → Loss: \$8,500 (materials + processing)

Scenario 3: Capper Torque Degradation (Predictive Maintenance)

Equipment Context

- **Asset:** CapLoader "Capper" (Asset ID: 22)
- **Location:** Enterprise B/Site1/FillerProduction/FillingLine01/CapLoader
- **Type:** Rotary Capping Machine
- **Function:** Applies and torques bottle caps
- **Parent:** FillingLine01 (Asset ID: 7)

MQTT Topics Monitored

```
Enterprise B/Site1/fillerproduction/fillingline01/caploader/processdata/state/name
Enterprise B/Site1/fillerproduction/fillingline01/caploader/metric/oee
Enterprise B/Site1/fillerproduction/fillingline01/caploader/processdata/torque/actual (simulated)
Enterprise B/Site1/fillerproduction/fillingline01/caploader/processdata/torque/variance (simulated)
```

Demo Flow

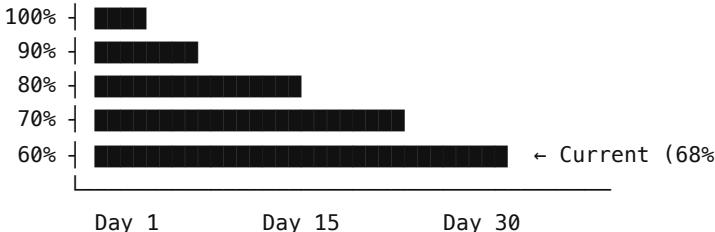
Step 1: Predictive Maintenance Dashboard

PREDICTIVE MAINTENANCE – FillingLine01 Equipment				
Equipment	Health	RUL (Days)	Trend	Action
Filler (23)	91%	28	Stable	Monitor
Washer (24)	94%	45	Stable	Schedule
Capper (22)	68%	9 ⚠	Declining	URGENT

⚠ Capper requires attention – click for details

Step 2: Capper Deep Dive

CAPPER (Asset ID: 22) – DETAILED ANALYSIS	
Health Score Trend (30 days):	



DEGRADATION INDICATORS:

- Torque variance: +15% (was $\pm 2\%$, now $\pm 17\%$)
- Capping head vibration: +8% above baseline
- Reject rate: 0.3% \rightarrow 0.8% (cap seal failures)

ML MODEL PREDICTION:

- Failure mode: Capping head clutch wear
- Confidence: 87%
- Remaining Useful Life: 9 ± 2 days

SIMILAR PAST FAILURES: 2 occurrences

- March 2025: Clutch replacement after 14 months
- September 2024: Clutch replacement after 13 months
- Current clutch age: 12.5 months

Step 3: Agent Recommendation

Predictive Maintenance Agent

DIAGNOSIS: Capping head clutch wear

CONFIDENCE: 87%

PREDICTED FAILURE: 9 ± 2 days

RECOMMENDED ACTION:

Optimal Maintenance Window: Saturday 6:00 AM – 11:00 AM

Reasoning:

- Production schedule: Planned line changeover
- Parts: Clutch kit #CAP-CLT-200 (in stock, Bin B-15)
- Technician: Carlos Rodriguez (Capper certified)
- Estimated repair time: 4 hours per SOP

Cost Comparison:

- Planned maintenance: \$1,800 (parts + labor)
- Unplanned failure: \$38,000
 - Emergency parts: \$2,400 (expedited shipping)
 - Downtime: 8 hours \times \$4,000/hr = \$32,000
 - Quality rejects: ~\$3,600 (loose caps)

SOP: SOP_HIGH_SPEED_ROTARY_FILLER.md

Section 4.1 – Poor Fill Accuracy (Torque Variance)

Section 6.1 – Quarterly: Replace filling valve seals

[APPROVE MAINTENANCE] [RESCHEDULE] [VIEW SOP] [GET MORE INFO]

Scenario 4: FillingLine01 Cascade Prevention

Equipment Context

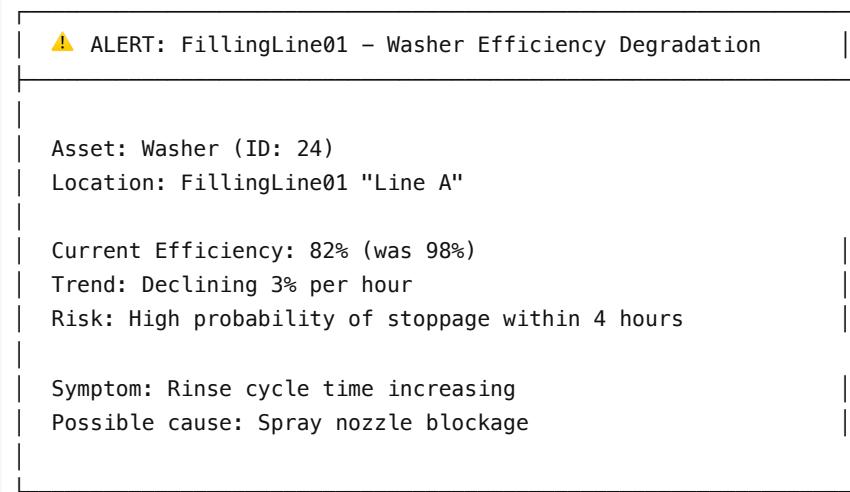
- **Asset:** FillingLine01 "Line A" (Asset ID: 7)
- **Location:** Enterprise B/Site1/FillerProduction/FillingLine01
- **Child Equipment:** Washer (24) → Filler (23) → Capper (22)
- **Downstream:** Packaging Line (45) → Palletizing (55)

Process Flow

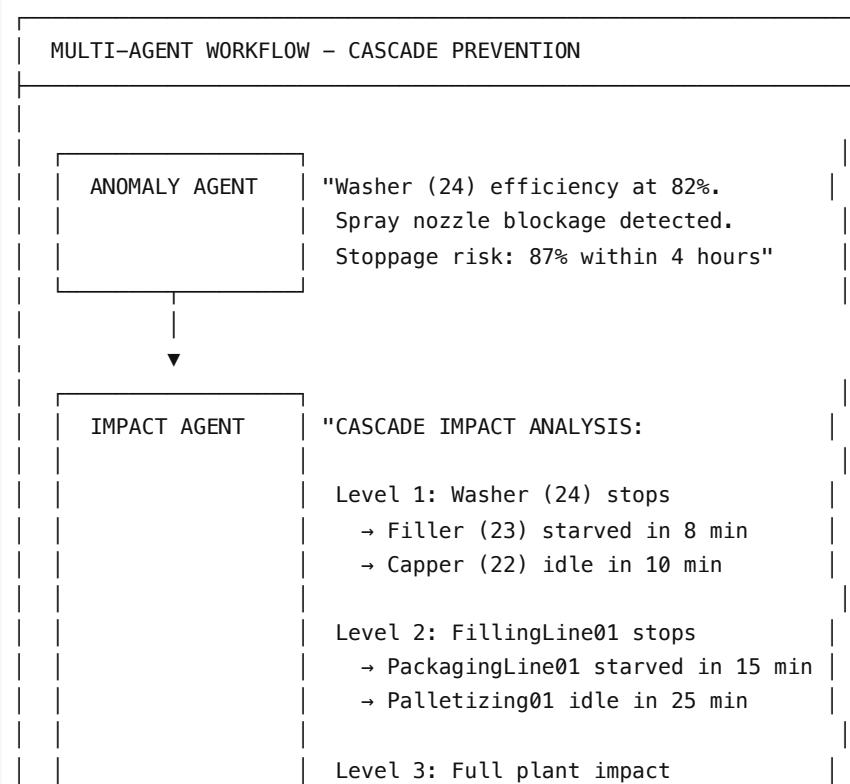
```
MixRoom01 (Vat01) → FillingLine01 → PackagingLine01 → Palletizing01
    ↓           ↓           ↓           ↓
  Cola Mix     Bottle Fill   Label/Pack   Palletize
  (Asset 31)   (Assets 22–24) (Assets 46–49) (Assets 56–58)
```

Demo Flow

Step 1: Trigger Event - Washer Efficiency Drop



Step 2: Multi-Agent Cascade Analysis



→ MixRoom01 Vat01 backup risk
→ Warehouse staging disruption

Total Impact: \$18,000/hour"

INVENTORY AGENT

"Spare nozzle kit #WSH-NZL-100:
In stock: 2 kits (Bin C-08)
Delivery to line: 20 minutes"

SCHEDULING AGENT

"Options analyzed:

Option A: Emergency stop now
Repair: 45 min | Loss: \$13,500

Option B: Run to shift end (2 hrs)
Risk: 87% failure | Loss: \$36,000

Option C: Micro-stop at break (30min)
Repair: 45 min | Loss: \$6,750
✓ RECOMMENDED"

ORCHESTRATOR

DECISION: Schedule micro-stop at next break (30 min)

COORDINATED ACTIONS:

- Alert Vat01 "Jeff" – reduce transfer rate 20%
- Notify PackagingLine01 – buffer mode in 25 min
- Reserve nozzle kit from warehouse
- Assign technician to FillerProduction area
- Create work order WO-MAINT-2848
- Update production schedule (-45 min)

SAVINGS: \$29,250 vs unplanned cascade failure

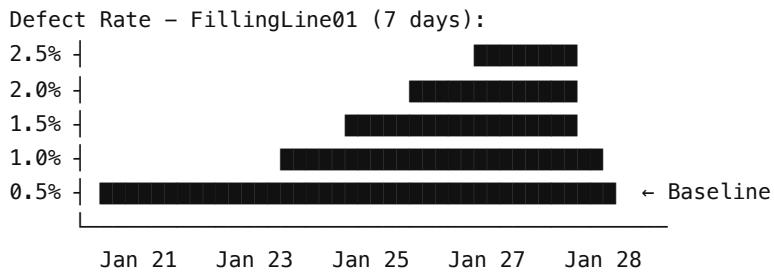
Scenario 5: Quality Root Cause Analysis

Context

- Quality defect rate increased across multiple products
- Affects bottles from FillingLine01
- Need to identify hidden correlation

Demo Flow

Step 1: Quality Alert Dashboard



⚠ Defect rate 4.2x above baseline
 Affected: Orange Soda 0.5L, Cola 0.5L, Lemon-Lime 0.5L
 Defect type: Fill level variance (underfill/overfill)

Step 2: User Query

👤 User: "Why did the fill level defect rate increase on Line A?"

Step 3: Agent Investigation

🤖 Root Cause Analysis Agent

Analyzing FillingLine01 quality data...

INVESTIGATION PROGRESS:

- Filler (23) calibration logs..... ✓ No change
- Product temperature from Vat01..... ✓ Within spec
- Bottle supplier batches..... ✓ No correlation
- Operator shift patterns..... ✓ No correlation
- Filler valve timing..... ✓ Within spec
- Product viscosity readings..... ⚠ CORRELATION
 - └ C02 carbonation level..... 94% correlation
- Upstream process review..... ⚠ RELATED EVENT

FINDINGS:

ROOT CAUSE IDENTIFIED

Primary Factor: C02 Carbonation Level Variance
 Correlation: 94%

Timeline Analysis:

- Jan 23: C02 supply tank changed (Tank B → Tank C)
- Jan 23: Carbonation level began varying ($\pm 8\%$ vs $\pm 2\%$)
- Jan 24: Fill level defects began increasing

Technical Explanation:

C02 Tank C has higher pressure variance than Tank B.
 Variable carbonation causes foam during filling,
 leading to inconsistent fill levels.

Affected Equipment:

- Carbonator (upstream of Vat01)
- Filler (23) – fill valve timing affected by foam

RECOMMENDATION:

1. Switch back to CO2 Tank B (immediate)
 2. Inspect Tank C pressure regulator
 3. Adjust Filler foam compensation parameter
- SOP Reference: SOP_HIGH_SPEED_ROTARY_FILLER.md
 Section 4.1 – Underfilled Bottles
 Section 4.1 – Excessive Foaming (Carbonated)
- Similar Past Incidents: 1 occurrence (Aug 2025)
 Resolution time (historical): 2 hours

[CREATE WORK ORDER] [VIEW DETAILS] [NOTIFY QUALITY] [DISMISS]

Scenario 6: Natural Language Interface

Context

- Conversational AI interface for plant operations
- Access to all ISA-95 asset data via MQTT
- Action execution capability

Demo Conversations

- EDGEMIND AI ASSISTANT – ProveIT Beverage Plant1
- 👤 "What's the current status of Line A?"
- 🤖 "FillingLine01 'Line A' (Asset ID: 7) status:
 Overall: RUNNING
 OEE: 87.8% | Availability: 89.8% | Performance: 97.7%
 Equipment Status:
 • Washer (24): Running
 • Filler (23): Running at 307 bpm
 • Capper (22): Running
 Current Work Order: WO-L03-0428
 Product: Orange Soda 0.5L
 Progress: 19,586 / 52,000 bottles (37.7%)"
- 👤 "How is Jeff doing?"
- 🤖 "Vat01 'Jeff' (Asset ID: 31) in MixRoom01:
 State: TRANSFER (transferring to FillingLine01)
 Duration: 270 seconds in current state
 Process Parameters:
 • Temperature: 30.1°C (Target: 30–34°C)
 • Weight: 9,762 kg (Capacity: 13,000 kg)
 • Flow Rate: 704 L/min (to filler)
 • Level: 75%"

Current Batch: W0-L02-0126 (Cola Mix)
Progress: 12,930 / 13,000 kg (99.5% complete)

Note: Batch nearly complete. Next batch: Lemon-Lime Mix"

👤 "Compare OEE across all filling lines"

⌚ [Displays comparison chart]

"OEE Comparison – All Filling Lines (Today):

FillingLine01 'Line A': 87.8% 
FillingLine02 'Line B': 82.3% 
FillingLine03 'Line C': 91.2% 

Plant Average: 87.1%

Analysis:

- Line C performing best (+4.1% vs average)
- Line B below average – investigating...
→ Cause: Extended changeover (product switch)
- Line A on target for shift goal"

👤 "What maintenance is due this week?"

⌚ "Scheduled maintenance for Site1 this week:

URGENT (within 48 hours):

1. Capper (22) – Clutch replacement
Due: Saturday 6AM | Tech: Carlos Rodriguez
Parts: CAP-CLT-200 (in stock)

SCHEDULED:

2. Vat03 'Billy' (33) – CIP cycle
Due: Wednesday 10PM | Duration: 4 hours

3. Palletizing Robot (57) – Lubrication
Due: Friday 6AM | Tech: Any available

4. Labeler (46) – Print head cleaning
Due: Sunday 6AM | Duration: 1 hour

Total scheduled downtime: 9.5 hours

All parts confirmed in stock 

👤 "Show me the error history for the filler"

⌚ "Filler (Asset ID: 23) – Error History (Last 30 days):

Date	Error	Description	Resolution
Jan 15	E001	Bottle Jam	12 min
Jan 08	E008	Drive Fault	Scheduled
Dec 28	E014	Valve Stuck	45 min
Dec 20	E011	High Product Temp	8 min

Summary:

- Total incidents: 4
- Total downtime: 65 minutes
- Most common: Mechanical (E008, E014)

 Full error codes in SOP_HIGH_SPEED_ROTARY_FILLER.md"

SOP Error Code Quick Reference

Filler Error Codes (SOP_HIGH_SPEED_ROTARY_FILLER.md)

Code	Priority	Description	Immediate Action
E001	HIGH	Bottle jam	Stop, clear jam
E002	MEDIUM	Missing bottle	Check infeed
E003	HIGH	Overfill	Stop, check valve
E004	CRITICAL	Low air pressure	Stop, check supply
E005	HIGH	Guard open	Close guard
E006	CRITICAL	E-stop	Investigate
E007	MEDIUM	Comm fault	Check network
E008	HIGH	Drive fault	Check motor/bearing
E009	LOW	Maintenance due	Schedule PM
E010	MEDIUM	CIP required	Run CIP
E011	HIGH	High product temp	Cool product
E012	CRITICAL	Overflow	Stop, clean
E013	MEDIUM	Low product level	Refill tank
E014	HIGH	Valve stuck	Replace valve
E015	LOW	Filter dirty	Replace filter

Mixing Vat Error Codes (SOP_INDUSTRIAL_MIXING_VAT_SYSTEM.md)

Code	Priority	Description	Immediate Action
A001	CRITICAL	High temperature	Stop heating, investigate
A002	CRITICAL	High pressure	Open vent, stop process
A003	HIGH	Agitator overload	Stop agitator, check load
A004	HIGH	Low level	Stop agitator, check level
A005	HIGH	Weight deviation	Verify additions
A006	MEDIUM	Temperature deviation	Check control loop
A007	MEDIUM	Agitator speed deviation	Check VFD
A008	LOW	CIP due	Schedule CIP

A009	LOW	Calibration due	Schedule calibration
A010	HIGH	Manway open	Close and seal
A011	CRITICAL	E-stop activated	Investigate cause

Labeler Error Codes (SOP_PACKAGING_LABELER_LINE.md)

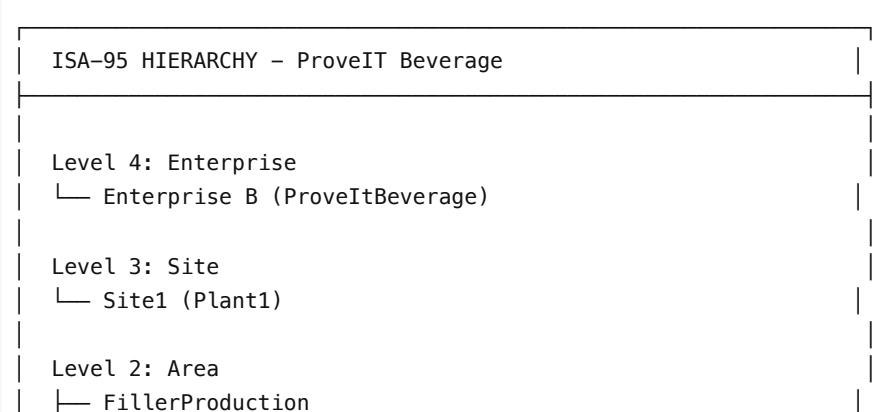
Code	Priority	Description	Immediate Action
L001	HIGH	Label roll empty	Replace roll
L002	MEDIUM	Label low warning	Prepare new roll
L003	HIGH	Misalignment detected	Check applicator
L004	CRITICAL	E-stop activated	Investigate
P001	HIGH	Case jam	Clear jam
P002	MEDIUM	Case blanks low	Refill
P003	HIGH	Bottle backup	Check downstream
S001	HIGH	Sealer fault	Check tape/glue

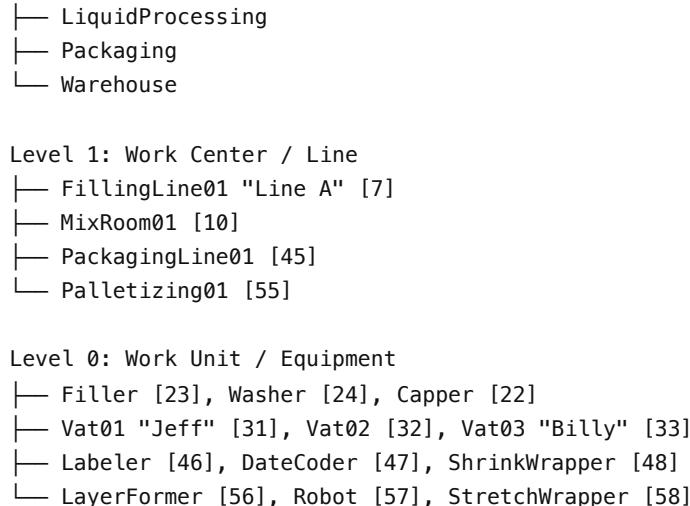
Palletizer Error Codes (SOP_PALLETIZING_SYSTEM.md)

Code	Priority	Description	Immediate Action
PAL-001	CRITICAL	Robot E-stop	Investigate cause
PAL-002	HIGH	Robot fault	Check teach pendant
PAL-003	HIGH	Gripper fault	Check vacuum/sensors
PAL-004	MEDIUM	Case jam	Clear infeed
PAL-005	MEDIUM	Pallet full	Exchange pallet
PAL-006	LOW	Pallet low	Replenish pallets
WRP-001	HIGH	Film break	Rethread film
WRP-002	MEDIUM	Film low	Prepare new roll
WRP-003	HIGH	Wrapper fault	Check wrapper

Technical Architecture

ISA-95 Data Model





MQTT Topic Structure

Enterprise B/Site1/{area}/{workcenter}/{equipment}/{category}/{metric}

Examples:

- └── Enterprise B/Site1/fillerproduction/fillingline01/filler/metric/oee
- └── Enterprise B/Site1/fillerproduction/fillingline01/filler/processdata/state/name
- └── Enterprise B/Site1/liquidprocessing/mixroom01/vat01/processdata/process/temperature
- └── Enterprise B/Site1/liquidprocessing/mixroom01/vat01/workorder/quantityactual
- └── Enterprise B/Site1/packaging/packagingline01/labeler/metric/availability