S4x27 Proof of Concept (POC) Pavilion Vendor Packet

Simulated Beverage Plant Environment

Prepared for S4x27

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Overall Environment Description

The POC Pavilion environment consists of three skids (Batch/Mixing, Bottling, and Packaging) and a half-height server rack, designed to simulate key stages of a beverage manufacturing plant. Each skid is equipped with representative industrial control systems, physical devices, and network infrastructure, while the server rack houses the shared network infrastructure and servers. The Packaging/Robotic skid is currently being retrofitted with safety equipment (Figure 2); the Batch/Mixing and Bottling skids are in development and will follow the same control-wall form factor as the previous year's skids shown in Figure 1.



Figure 1. Example pavilion control walls and server rack



Figure 2. Packaging/Robotic zone with cobot, conveyor, and operator interface

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Batch/Mixing Skid

The batching process showcases how beverage ingredients are combined in precise, controlled quantities to simulate real-world production consistency, quality, and repeatability. It highlights how automated measurement and mixing reduce human error, minimize waste, and ensure each simulated batch meets the intended flavor, texture, and aroma targets. The demo also illustrates recipe management features and flexible formulation control, allowing you to demonstrate how different ingredient ratios or product variations can be tested, adjusted, and replicated. It serves as a realistic representation of how a modern beverage batching system maintains accuracy and efficiency across production runs.

Bottling Skid

The bottling process illustrates how a beverage moves through a fully automated botting line, starting with clean, prepared bottles being conveyed into position for filling. The system then doses each bottle with precise volumes of product before sealing (capping depicted in the process), verifying quality through automated inspections, and applying labels for final identification.

Packaging Skid

The packaging process represents a realistic downstream packaging and handling cell, where finished product is transferred onto a conveyor belt driven by a VFD and moved through automated interactions with a Kinova collaborative robotic arm that picks the finished bottle from the conveyor and places it into cartons for shipping. The conveyor provides controlled motion and positioning, while an integrated safety PLC ensures safe operation through interlocks, e-stops, and hazard-mitigation logic.

Server Rack

In addition to the three skids, the POC Pavilion environment includes a 25U half-height standard depth server rack. This rack is included as part of the environment to contain various network switch infrastructure, servers, and reserved space for participating vendor equipment. Due to the electrical capabilities of the S4 conference hotel environment, only 120V electrical power will be available on the PDU with 15A and 20A standard plugs.

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Production Line Overview

The OT environment follows a tiered architecture with Enterprise, Industrial DMZ, Plant Operations, and production-cell networks. Three production cells are represented across Levels 0–2: Batch/Mixing (Rockwell), Bottling (Siemens), and Packaging (Kinova).

Batch/Mixing Skid – Rockwell Zone

The Batch/Mixing Cell represents the upstream beverage process where ingredients are combined and prepared for downstream packaging. The cell is centered on Rockwell automation and includes the following representative assets:

- Rockwell CompactLogix, MicroLogix, and Micro PLCs
- Rockwell PanelView HMI
- Rockwell PowerFlex VFD operating a small motor
- Physical control panel with buttons, switches, and indicator lights
- Windows 7 operator workstation running an Ignition HMI
- Windows 11 engineering workstation with Rockwell software

Bottling Skid – Siemens Zone

The Bottling Cell represents filling, capping, inspection, and labeling. It is centered on Siemens and includes:

- Siemens S7-1200, S7-1500, and LOGO! PLCs
- Siemens SIMATIC HMI panel
- Monigear IIoT temperature and humidity sensors using MQTT
- Physical control panel with buttons, switches, and indicator lights
- Windows 10 operator workstation running an Ignition HMI
- Windows 11 engineering workstation with Siemens software

Packaging Skid – Robotic Zone

The Robotic Zone hosts the packaging demonstration with a physical collaborative robot, conveyor, and safety controls. This zone includes:

- Kinova collaborative robotic arm
- NVIDIA Jetson Orin NX edge compute PC
- Apple iPad used as a robotic-arm control interface
- Conveyor belt driven by a Vention VFD
- Rockwell Remote I/O associated with the robotic packaging motion
- Guardmaster safety relay, dual-OSSD light curtain, and dual-channel E-stop circuit

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Figure 3. Beverage plant process graphic and HMI demonstration view



Figure 4. Robotic packaging zone physical layout and synchronized process behavior

OT Environment Description

The OT environment is structured in a layered Purdue Model (Levels 0-4) architecture, with each skid containing representative devices and systems that reflect real-world industrial operations. Below is a breakdown of the components and layout across all three skids as well as the shared services used across the environment.

Batch/Mixing Skid

LEVEL 0 – PHYSICAL PROCESSES

- Motor and Allen Bradley PowerFlex Variable Frequency Driver (VFD)
- Physical control panel with I/O indicators and manual controls

LEVEL 1 – INTELLIGENT DEVICES

- Allen Bradley CompactLogix 5370
- Allen Bradley MicroLogix 1400
- Allen Bradley Micro820
- Allen Bradley PanelView 800 touchscreen mounted on the control panel

LEVEL 2 – SUPERVISORY CONTROL

- Rockwell Engineering Workstation (Windows 11, physical)
- Ignition Operator Workstation (Windows 7, physical)
- All level 0-2 devices connect to a Stratix 5800 switch, with uplink to level 3 via Cisco IE9320

Bottling Skid

LEVEL 0 – PHYSICAL PROCESSES

- MQTT-based temperature & humidity sensors (PoE)
- Physical control panel with I/O indicators and manual controls

LEVEL 1 – INTELLIGENT DEVICES

- Siemens LOGO!
- SIMATIC S7-1200
- SIMATIC S7-1500
- SIMATIC HMI touchscreen mounted on the control panel

LEVEL 2 – SUPERVISORY CONTROL

- Siemens Engineering Workstation (Windows 11, physical)
- Ignition Operator Workstation (Windows 10, physical)
- All level 0-2 devices connect to a Cisco IE3400 switch, with uplink to level 3 via Cisco IE9320

Packaging/Robotic Skid

LEVEL 0 – PHYSICAL PROCESSES

- Kinova Gen3 Lite collaborative robotic arm with gripper
- Conveyor belt driven by a VFD
- Dual-OSSD light curtain and dual-channel E-stop (hardwired safety)

LEVEL 1 – INTELLIGENT DEVICES

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- Guardmaster 440C-CR30 safety relay
- Allen Bradley 1734-AENT Point IO-IP Remote I/O (packaging motion / conveyor + robot handshake)

LEVEL 2 – SUPERVISORY CONTROL

- Ignition Operator Workstation (Windows 11, physical)
- Apple iPad – Kinova control interface
- NVIDIA Jetson Orin NX (edge compute / digital twin)
- GigE Machine-vision camera
- Level 0-2 devices connect to a Hirschmann BRS30 switch, with uplink to Level 3 via Cisco IE9320

Shared Systems & Infrastructure

LEVEL 3 – PLANT OPERATIONS

- Ignition Plant Ops OWS (Windows 11, Physical) – Provides operator access to SCADA visualizations and controls for all three skids through the Ignition platform.
- Ignition MES Console (Windows 11, Physical) – Provides access to MES-related views and dashboards within Ignition. Used for monitoring production workflows, scheduling and KPI tracking.
- Kepware OPC Server (Windows Server 2022, VM) – Used to pull a small number of tags from select PLCs. Most PLCs communicate directly with Ignition via OPC UA.
- Historian (Windows Server 2022, VM) – Logs and stores process data.
- Main plant display (TV) – Large stand-mounted television showing the plant process graphics.
- All systems connected to Cisco IE 9320 switch.

LEVEL 3.5 – INDUSTRIAL DMZ

- Palo Alto PA-220 Firewall to control flow in and out of the iDMZ.
- Ignition Server (Windows Server 2022, VM) – Running Ignition version 8.3. Hosts SCADA projects for all three skids, with MES functionalities configured within the Ignition platform.
- AI Data Broker (VM) – Cloud-facing endpoint in the iDMZ. Collects process data and operational metrics from Level 3 (historian, OPC) and brokers them up to the Cloud AI/LLM.
- Jump Server (VM) – Internal remote access jump server.
- Remote Access Server (VM) – Dedicated endpoint for 3rd-party vendor VPN access, separate from the Jump Server.
- Tools/MQTT Server (Windows Server 2022, VM) – Handles IIoT sensor data. MQTT functionality will be handled through Ignition's licensed modules.
- Active Directory Server (Windows Server 2022, Physical) – Used to manage user authentication, access control, and centralized identity management across the environment (where applicable).

LEVEL 4 – ENTERPRISE

- Cisco 9200L switch connected to a second Palo Alto PA-220 Firewall
- User Workstations (Windows 11 VMs) for enterprise-level interaction

INTERNET / CLOUD

- Internet / ISP connectivity into the Enterprise firewall
- Cloud AI / LLM service (robotics performance analytics)
- AWS dashboards (AWS Greengrass) for performance management
- Approved third-party vendor remote access (into the iDMZ via VPN, terminating at the Remote Access Server)

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Network Architecture and Connectivity

The POC Pavilion environment uses a Purdue-aligned, tiered OT network architecture. The architecture includes Enterprise Level 4, Industrial DMZ Level 3.5, Plant Operations Level 3, and three production cells at Levels 0–2. The production cells are segmented into Rockwell, Siemens, and Robotic Zones.

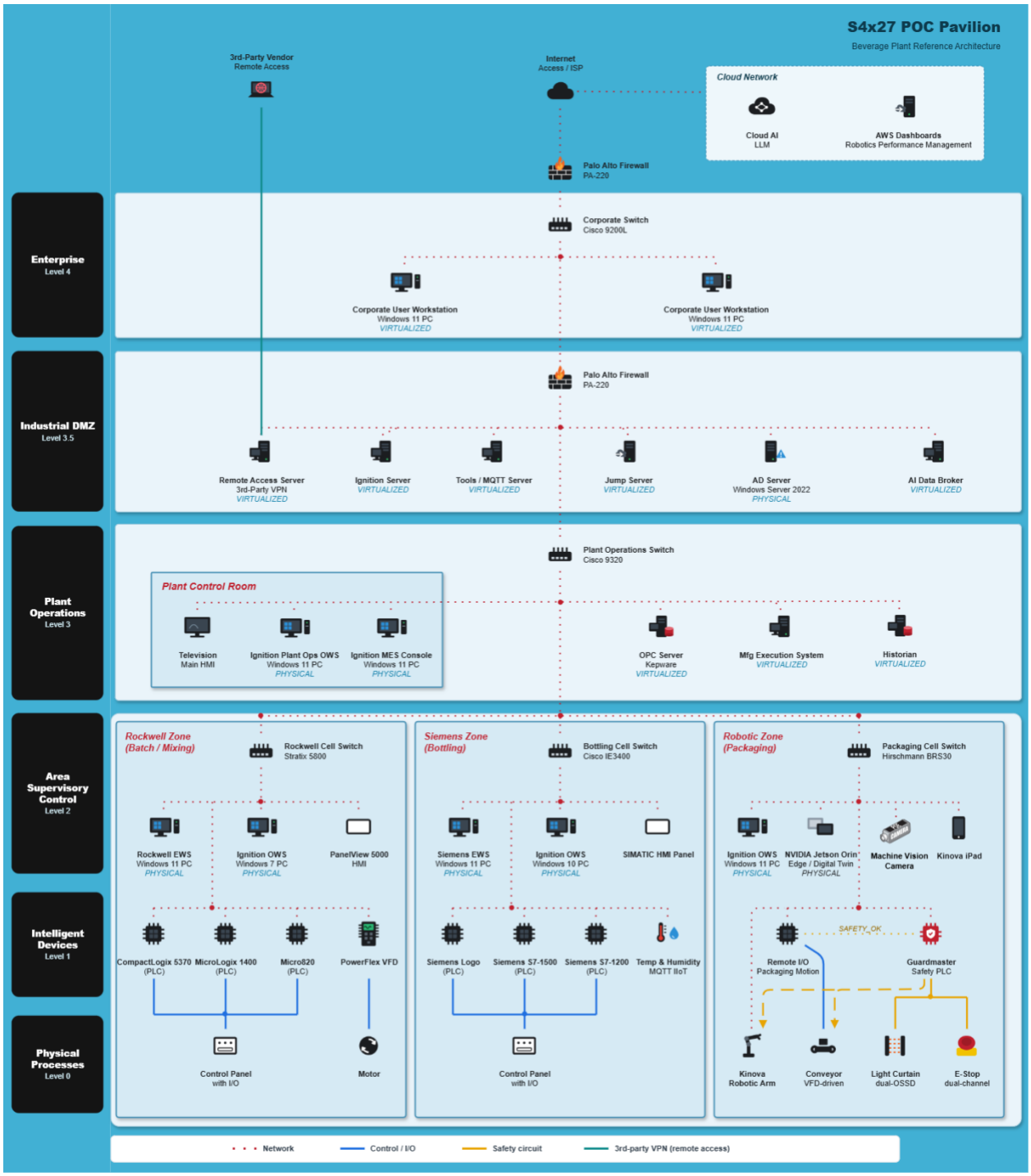


Figure 5. S4x27 OT Cybersecurity Pavilion reference architecture

IP Address Schema

Level & Zone	Subnet
Enterprise - Level 4	10.128.40.0/24
Industrial DMZ - Level 3.5	10.128.35.0/24
Plant Operations - Level 3	10.128.30.0/24
Production Cell - Levels 0-2 – Rockwell Zone	192.168.25.0/24
Production Cell - Levels 0-2 – Siemens Zone	192.168.20.0/24
Production Cell - Levels 0-2 – Robotic Zone	192.168.10.0/24

Routing/VLANs

Currently, only the Enterprise network (10.128.40.0/24) is configured on the Enterprise firewall and the 9200L switch utilizing VLAN 40. From the Enterprise firewall out to the Internet, there is a static default route allowing all unknown traffic out Ethernet 1/1 which will also go through NAT on the outside interface. There are also static routes on the Enterprise firewall that point to the iDMZ firewall for devices on Levels 3.5 to Level 0.

All other networks reside on the iDMZ firewall and the IE9320 switch, their VLANs are as follows:

- Industrial DMZ – VLAN 35
- Plant Operations – VLAN 30
- Rockwell Zone – VLAN 25
- Siemens Zone – VLAN 20
- Robotic Zone – VLAN 10

Currently the Enterprise firewall has an “any/any” rule in place; this will be tightened as the network matures. The iDMZ firewall enforces a least privilege policy: only required communication is permitted (for example, Ignition and OPC polling from Plant Operations down to the production cells), direct communication between the Plant Operations zone and the Enterprise zone is not allowed, and no direct traffic is permitted between the Rockwell, Siemens, and Robotic zones, except the EtherNet/IP connection from the Batch/Mixing controller to the Packaging remote I/O.

Firewall Rule Sets

The OT network is segmented into distinct zones (Enterprise, iDMZ, Plant Operations, and the three production cells), with firewall rules in place to manage traffic and ensure security. The table below summarizes key rules:

Source	Destination	Protocol/Port	Purpose	Allowed
Enterprise Zone	Plant Operations Zone	Any	Zone isolation	Blocked
Plant Operations Zone	Enterprise Zone	Any	Zone isolation	Blocked
Rockwell Zone	Siemens Zone	Any	Zone isolation	Blocked
Siemens Zone	Rockwell Zone	Any	Zone isolation	Blocked
Robotic Zone	Rockwell Zone	Any	Zone isolation	Blocked
Rockwell Zone	Robotic Zone	Any	Zone Isolation	Blocked

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Siemens Zone	Robotic Zone	Any	Zone isolation	Blocked
Robotic Zone	Siemens Zone	Any	Zone isolation	Blocked
Rockwell Zone (CompactLogix)	Robotic Zone (Point I/O)	EtherNet/IP	Remote I/O control	Allowed
Industrial DMZ (Ignition Server)	Production cells	OPC UA, EtherNet/IP, S7	PLC polling	Allowed
Plant Operations (OPC Server)	Production cells	OPC UA	Tag collection	Allowed

Software & Asset Inventory

Software Applications

Software Name	Purpose	Location
Ignition SCADA	SCADA visualization & control	Virtual SCADA Server
Siemens TIA Portal	Engineering and programming (Siemens PLCs)	Siemens Engineering Workstation (Physical)
Studio 5000	Engineering and programming (Allen-Bradley PLCs)	Rockwell Engineering Workstation (Physical)
Kepware	Communication bridge and data aggregation	Virtual Kepware Server
Kinova Kortex Web App	Robot programming and motion control	Physical Kinova Robot Controller
Proxmox	Hypervisor for virtualization	Physical Proxmox Server
CrowdStrike	Endpoint protection and threat detection	All supported Windows systems
Active Directory	Identity and access management	Virtual AD Server
AI Data Broker	Brokers OT process data to Cloud AI/LLM	Virtual AI Data Broker (iDMZ)
Unity Digital Twin	Robotic-arm digital twin / physics simulation	NVIDIA Jetson Orin NX

Hardware Asset Inventory

Skid	Vendor	Model	Device Type
Bottling Skid	Intel	NUC8i5BEH	NUC (PC)
Bottling Skid	Intel	NUC8i5BEH	NUC (PC)
Bottling Skid	Beetronics	19TS7M	19 in. Touch Screen Monitor
Bottling Skid	Beetronics	19TS7M	19 in. Touch Screen Monitor
Bottling Skid	Cisco	IE3400	Industrial Managed Switch
Bottling Skid	MokerLink	IND-F041FP	Unmanaged Industrial PoE switch

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			(powers temp/humidity sensors)
Bottling Skid	Monigear	MN-NTHM	Temperature and Humidity Sensor
Bottling Skid	Monigear	MN-NTHM	Temperature and Humidity Sensor
Bottling Skid	Siemens	Simatic S7-1500	PLC
Bottling Skid	Siemens	LOGO!	PLC
Bottling Skid	Siemens	Simatic S7-1200	PLC
Bottling Skid	Siemens	Simatic HMI	HMI
Bottling Skid	NVVV	DR-120-24	AC to DC DIN-Rail Power Supply
Bottling Skid	CHTAIXI	DZ47N-63	AC Circuit Breaker
Batch/Mixing Skid	Intel	NUC8i5BEH	NUC (PC)
Batch/Mixing Skid	Intel	NUC8i5BEH	NUC (PC)
Batch/Mixing Skid	Beetronics	19TS7M	19 in. Touch Screen Monitor
Batch/Mixing Skid	Beetronics	19TS7M	19 in. Touch Screen Monitor
Batch/Mixing Skid	Allen-Bradley	Stratix 5800	Industrial Managed Switch
Batch/Mixing Skid	Allen-Bradley	PowerFlex 523	Variable Frequency Drive (VFD)
Batch/Mixing Skid	IronHorse	MTR-P33-3BD36	General Purpose Industrial Motor
Batch/Mixing Skid	Allen-Bradley	PanelView 800	HMI
Batch/Mixing Skid	Allen-Bradley	MicroLogix 1400	PLC
Batch/Mixing Skid	Allen-Bradley	CompactLogix 5370 (1769-L30ER)	PLC
Batch/Mixing Skid	Allen-Bradley	Micro820	PLC
Batch/Mixing Skid	Mean Well	DR-120-24	AC to DC DIN-Rail Power Supply
Batch/Mixing Skid	CHTAIXI	DZ47N-63	AC Circuit Breaker
Packaging Skid	Kinova	Gen3 Lite	Robotic Arm
Packaging Skid	Apple	iPad	Control Interface for Kinova
Packaging Skid	NVIDIA	Jetson Orin NX	Edge Device / Digital Twin
Packaging Skid	Guardmaster	440C-CR30	Safety relay
Packaging Skid	Vention	Conveyor	Conveyor Belt
Packaging Skid	Allen-Bradley	PowerFlex 523	Variable Frequency Drive (VFD)
Packaging Skid	CGOLDENWALL	GW-35-8-40	Light Curtain dual-OSSD
Packaging Skid	Allen-Bradley	Remote I/O	1734-AENT Point IO-IP
Packaging Skid	Zyxel	IAP500BE	Wireless Access Point
Packaging Skid	HTENG VISHI	3664X2748	GigE Machine Vision Camera
Packaging Skid	Hirschmann	BRS30	Industrial Managed Switch
Packaging Skid	WEIDIAN	N100	Industrial Mini PC

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Server Rack	Palo Alto	PA 220	Firewall
Server Rack	Palo Alto	PA 220	Firewall
Server Rack	Cisco	IE9320	Switch
Server Rack	Cisco	9200L 48 PoE+ 4x1G	Switch
Server Rack	Dell	PowerEdge R430	Proxmox Hypervisor
Server Rack	Dell	PowerEdge R330	Proxmox Hypervisor
Corp Workstation 1	Win 11	Enterprise L4	Enterprise user VM
Corp Workstation 2	Win 11	Enterprise L4	Enterprise user VM
Tools/MQTT Server	Server 2022	iDMZ L3.5	OT tools and software VM
Jump Server	Server 2022	iDMZ L3.5	Remote access VM
Ignition Server	Server 2022	iDMZ L3.5	SCADA server VM
OPC Server	Server 2022	Plant Ops L3	Communication server VM
Remote Access Server	Server 2022	iDMZ L3.5	3rd-party VPN endpoint VM
AD Server	Server 2022	iDMZ L3.5	Identity server (physical)
AI Data Broker	Ubuntu 22.04	iDMZ L3.5	Data broker VM
Historian	Server 2022	Plant Ops L3	Historian VM
Ignition Plant Ops OWS	Win 11	Plant Ops L3	Operator workstation (physical)
Ignition MES Console	Win 11	Plant Ops L3	MES console (physical)

Security Access

User Roles & Access Control

Access to the simulated OT environment is segmented by user roles, each with defined permissions. The table below outlines the roles and their access levels:

Role	Access Level	Systems Accessed	Notes
Operator	Limited (HMI Only)	Ignition SCADA	Limited access to production data
Engineer	Full (PLC & SCADA)	TIA Portal, Studio 5000, Ignition SCADA	Can modify PLC logic and troubleshoot
Administrator	Full (All systems)	Proxmox, Virtual Servers, Switches, Firewalls	Manages user roles and system configs
Vendor (Demo)	Restricted	Virtual Servers	Temporary access for testing tools

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MES Functions (Integrated into Ignition)

MES functionalities are embedded directly into the Ignition SCADA, rather than by a separate MES system. These functions include:

Production scheduling

Bottle batches (e.g., 5 for Bottling, 10 for Packaging) are scheduled through Ignition interfaces.

Process Tracking

Ignition monitors each bottle batch's progress through the Batch/Mixing, Bottling, and Packaging stages using simulated PLC data.

KPI Monitoring

OEE, target production, and stage-specific metrics are visualized within Ignition dashboards.

Note: All MES-related data is simulated and managed within Ignition

PLC & Program Details

Component	Model / Type	Programming Software	System Role	Tag Communication	SCADA Integration
Siemens PLC	S7-1500	TIA Portal	Bottling cell control	OPC UA (direct to Ignition)	Ignition Vision
Siemens PLC	S7-1200	TIA Portal	Bottling cell control	OPC UA (direct to Ignition)	Ignition Vision
Siemens PLC	LOGO!	LOGO! Soft Comfort	Bottling cell control	OPC UA via Kepware OPC Server	Ignition Vision
Rockwell PLC	MicroLogix 1400	RSLogix 500	Batch/Mixing cell control	OPC UA (direct to Ignition)	Ignition Vision
Rockwell PLC	CompactLogix 5370 (1769-L30ER)	Studio 5000	Batch/Mixing cell control	OPC UA (direct to Ignition)	Ignition Vision
Rockwell PLC	Micro820	Connected Components Workbench	Batch/Mixing cell control	OPC UA via Kepware OPC Server	Ignition Vision
Rockwell Safety Relay	Guardmaster 440C-CR30	Connected Components Workbench	Packaging safety (light curtain / E-stop)	EtherNet/IP to CompactLogix 5370 via Point I/O (SAFETY_OK status)	Ignition Vision
Rockwell Remote I/O	1734-AENT Point IO-IP	Studio 5000	Packaging cell control (conveyor + robot handshake)	EtherNet/IP to CompactLogix 5370 (Batch/Mixing)	Ignition Vision
VFD + Motor	IronHorse MTR-P33-3BD36 + PowerFlex 523	N/A - (controlled via PLC)	Batch/Mixing motor demo	Ethernet/IP to CompactLogix, PLC tags to Ignition	Ignition Vision
Environmental Sensors	Temp & Humidity Sensors	N/A (MQTT-based)	Bottling cell environmental monitoring	MQTT & Ignition	Ignition Vision
Kinova Cobot	Gen3 Lite	Kortex Web App	Case packing (pick and place)	Kortex API (Ethernet) to Jetson / Ignition	Ignition Vision

Additional Notes

Tag Communication:

- Most PLCs communicate directly with Ignition via OPC UA.
- Two PLCs (LOGO!, Micro820) route tags through Kepware OPC Server.

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- Environmental sensors use MQTT to send data to Ignition.