# MANUFACTURING CANON

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**Abstract**

Example

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# Contents



Manufacturing operations MUST be structured according to ISA-95 hierarchy with governed interfaces between enterprise and control levels.

**Example**: ISA-95 (IEC 62264) defines five levels of enterprise-control integration: Level 0 (physical process sensors, actuators, field devices), Level 1 (basic control PLCs, PID loops, interlocks, cycle time 100ms-1s), Level 2 (supervisory control SCADA, HMI, batch control, cycle time seconds-minutes), Level 3 (manufacturing operations management MES/MOM, scheduling, quality, maintenance, cycle time minutes-hours-days), Level 4 (business planning ERP, supply chain, CRM, cycle time days-months). Process types: discrete (countable units automotive assembly, electronics), continuous (flowing materials refining, chemicals, pharmaceuticals), batch (finite quantities food, beverage, pharmaceuticals, per ISA-88/IEC 61512). B2MML (Business to Manufacturing Markup Language) provides XML schemas for ISA-95 data exchange: production schedule, production performance, material definition, equipment information. Activity models: production (order processing, dispatching, tracking), quality (SPC, inspection, CAPA), maintenance (preventive, predictive, reactive), inventory (material tracking, WIP). MAGIC gate: bitwise AND of required governance dimensions before production order executes.

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## 0.1 2. Industrial Cybersecurity

Industrial automation and control systems MUST be secured according to IEC 62443 with defense-in-depth across zones and conduits.

**Example**: IEC 62443 (Industrial Automation and Control Systems Security) series: Part 1-1 (concepts/models), Part 2-1 (security management system), Part 2-4 (service provider requirements), Part 3-2 (security risk assessment zones and conduits), Part 3-3 (system security requirements SL), Part 4-1 (secure development lifecycle SDL), Part 4-2 (component security requirements). Security Levels (SL): SL

1 (prevent casual/unintentional violation), SL 2 (prevent intentional violation using simple means low motivation), SL 3 (prevent intentional violation using sophisticated means moderate motivation, IACS-specific skills), SL 4 (prevent intentional violation using sophisticated means high motivation, state-sponsored). Zones: logical grouping of assets sharing common security requirements. Conduits: communication channels between zones each conduit has assigned SL. Reference architecture: Enterprise Zone (IT) DMZ Manufacturing Zone (Level 3) Cell/Area Zone (Level 2) Field Zone (Level 0-1). Foundational Requirements (FR): identification/authentication, use control, system integrity, data confidentiality, restricted data flow, timely response to events, resource availability.

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## 0.2 3. C5 Technology

Industrial control systems MUST be programmed and deployed using standardized automation frameworks with verified logic.

**Example**: IEC 61131-3 (Programmable Controllers Programming Languages) defines five standardized PLC programming languages: Ladder Diagram (LD relay logic), Function Block Diagram (FBD dataflow), Structured Text (ST high-level procedural), Instruction List (IL assembly-like, deprecated), Sequential Function Chart (SFC state machine). Program Organization Units (POUs): functions (no state), function blocks (stateful), programs (top-level). IEC 61499 (Function Blocks for Distributed Industrial-Process Measurement and Control Systems): event-driven execution model for distributed automation basic FB (algorithms triggered by events), composite FB (networks of FBs), service interface FB (hardware/communication interface). SCADA (Supervisory Control and Data Acquisition): centralized monitoring of distributed field devices via RTUs/PLCs. Communication protocols: Modbus TCP/RTU, PROFINET, EtherNet/IP, EtherCAT, POWERLINK, OPC UA (IEC 62541). Safety PLC programming per IEC 61508 / IEC 62061 / ISO 13849: safety function blocks, diagnostic coverage, proof test intervals. SIL-capable controllers: Siemens F-CPU, Allen-Bradley GuardLogix, ABB AC500-S.

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## 0.3 4. Industry 4.0

Smart manufacturing systems MUST implement digital integration with governed data flows across the RAMI 4.0 architecture.

**Example**: RAMI 4.0 (Reference Architecture Model Industrie 4.0) defines three axes: Hierarchy Levels (ISA-95 levels field device to connected world), Life Cycle & Value Stream (IEC 62890 type vs. instance), Layers (business, functional, information, communication, integration, asset). Digital Twin: virtual representation of physical asset geometry (CAD), physics (simulation), data (real-time sensor feeds), behavior (control logic). Types: digital model (manual sync), digital shadow (automatic data flow, physicaldigital), digital twin (bidirectional automatic data flow). IIoT (Industrial Internet of Things): sensor networks, edge computing (data processing at source), fog computing (intermediate layer), cloud analytics. Protocols: OPC UA (IEC 62541 platform-independent, secure, information modeling with companion specifications per industry), MQTT (ISO/IEC 20922 lightweight pub/sub messaging, QoS levels 0-2), AMQP, DDS. Edge computing: latency-sensitive processing (vibration analysis, vision inspection) at the machine level sub-millisecond response. Time-Sensitive Networking (TSN IEEE 802.1): deterministic Ethernet for converged IT/OT networks. Asset Administration Shell (AAS IEC 63278): standardized digital representation of Industry 4.0 components.

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## 0.4 5. Supply Chain Integration

Manufacturing supply chain data exchange MUST follow standardized interfaces with gov-

erned material and production traceability.

**Example**: ISA-95 B2MML (Business to Manufacturing Markup Language): XML schemas for production schedule exchange between ERP (Level 4) and MES (Level 3) production request, production response, production performance. OAGIS (Open Applications Group Integration Specification): canonical business object documents (BODs) SyncProductionOrder, ProcessProductionOrder, AcknowledgeShipment. EDI (Electronic Data Interchange): ANSI X12 (US) and EDIFACT (international) standards 850 (Purchase Order), 856 (Advance Ship Notice), 810 (Invoice), 862 (Shipping Schedule). MES/MOM (Manufacturing Execution/Operations Management) per ISA-95 Part 3: production management, quality management, inventory management, maintenance management. Traceability: lot/batch tracking (FDA 21 CFR Part 11 for pharma), serialization (DSCSA for pharmaceuticals, EU FMD), genealogy (component-to-finished-good). Material flow: raw material receiving incoming inspection WIP staging production in-process inspection finished goods shipping. Kanban/JIT: pull-based material replenishment with governed minimum/maximum levels.

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### 0.5 6. Worker Safety

Manufacturing workplaces MUST comply with occupational safety regulations with documented hazard controls and worker protections.

**Example**: OSHA (Occupational Safety and Health Administration) 29 CFR 1910 (General Industry Standards): Subpart D (walking/working surfaces), Subpart G (occupational health PELs for airborne contaminants), Subpart I (PPE head, eye, face, foot, hand, respiratory), Subpart J (general environmental controls LOTO per 1910.147), Subpart L (fire protection), Subpart O (machinery and machine guarding per 1910.212), Subpart S (electrical NFPA 70E arc flash). LOTO (Lockout/Tagout 29 CFR 1910.147): energy control procedures for servicing/maintenance of machines identify energy sources (electrical, mechanical, hydraulic, pneumatic, thermal, chemical, gravity), apply lockout devices, verify zero energy state, perform work, remove devices. Machine guarding per 1910.212: point of operation guards, fixed barriers, interlocked guards (per ISO 14119), light curtains (Type 2/Type 4 per IEC 61496), safety mats, two-hand controls. Confined space entry (29 CFR 1910.146): permit-required confined spaces atmospheric testing (O2, LEL, H2S, CO), ventilation, attendant, rescue plan. Hierarchy of controls: elimination substitution engineering controls administrative controls PPE.

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## 1. Constraints

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MUST:     Cite IEC 62443, ISA-95, OSHA, or domain-spec
MUST:     Map Security Level to MAGIC checkset governa
MUST:     Distinguish between discrete, process, and b
MUST NOT: Present ungoverned OT systems as acceptable
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