

Valves, Pumps & Actuation

The **Actuation Layer** defines all AOFS-compliant devices that perform actions on the farm. This includes irrigation pumps, valves, gates, and optionally generator start/stop controls.

All actuators must comply with AOFS **safety, logging, and operational rules**, even if the system operates offline.

1. Core Actuators

- **Pumps**

- Controls water delivery from sources to storage tanks or irrigation manifolds.
- Must support:
 - Start/stop commands from [Field Controller](#).
 - Safety interlocks (tank FULL/LOW, low voltage, pressure limits).
 - Optional energy-aware operation: integrate with [Power & Energy Sensors](#) to adjust schedule or warn operators.

- **Valves**

- Operate irrigation zones, distribution manifolds, or auxiliary water lines.
- Must support:
 - Open/close commands from Field Controller.
 - Flow or pressure monitoring feedback from [Water Monitoring Sensors](#).
 - Fail-safe closure in case of errors, power loss, or critical alarms.

- **Optional Generator Start / Stop**

- See [Optional Generator Integration](#).
- Can be automatic (remote start) or manual (operator alert).
- Must respect safety interlocks and event prioritization.

2. Actuation Control Principles

- **Local Authority:**

- All critical actuation commands are decided by the Field Controller.
- No remote system may bypass fail-safes or directly actuate pumps/valves.

- **Fail-Safe Operation:**

- Hardware and software protections prevent flooding, over-irrigation, pump damage, or valve misoperation.
- Actuators must respond to [Sensors](#) such as LOW/FULL tank switches, flow/pressure limits, and emergency stop signals.

- **Energy-Aware Operation (Optional):**

- Actuators may integrate with [Energy-Aware Operation Module](#).
- Event execution can be:
 - Delayed or skipped if insufficient energy is available.
 - Prioritized based on urgency or operator-defined importance.
- System may alert operators if an actuator is consuming **more power than expected**,

indicating possible maintenance needs (e.g., clogged pipe).

3. Scheduling & Automation

- **Event-Based Operation:**
 - Pumps and valves operate according to **scheduled irrigation events** defined in the Field Controller.
 - Can be triggered manually by operators or via automation rules.
- **Integration with Sensors:**
 - Actuators rely on [Sensors & Environmental Monitoring](#) for safe and efficient operation:
 - Soil moisture thresholds
 - Tank levels
 - Pressure and flow rates
 - Optional power measurements
- **Manual Override:**
 - Operators can manually actuate pumps or valves, respecting hardware safety interlocks.
 - Manual events are logged and visible to Farm/HQ controllers.

4. Logging & Documentation

- All actuator events **must be logged locally** on the Field Controller:
 - Event type (pump start/stop, valve open/close, generator start/stop)
 - Timestamp
 - Operator ID (if manual)
 - Relevant sensor readings at the time of actuation (flow, pressure, battery, energy)
- Logs are **synchronized with Farm and HQ Controllers** when connectivity is available.
- Supports analytics, energy assessment, and audit for compliance purposes.

5. Optional Modules & Extensions

- AOFS modules may define additional actuator types:
 - Greenhouse vents, fans, heaters, nutrient dosing pumps
 - Livestock feeders, water dispensers
 - Poultry egg collection or environmental actuators
- Any custom actuator must:
 - Integrate with Field Controller fail-safes.
 - Support logging and optional energy-aware prioritization.
 - Follow AOFS modular interface rules.

6. Optional Energy-Aware Operation

- AOFS controllers **may** measure power consumption of pumps, valves, and other actuators while running.

- Controllers **may** estimate battery drain or energy availability for upcoming scheduled irrigation events.
- AOFS supports **event prioritization**:
 - Each scheduled irrigation or actuator event can be assigned an **urgency or importance level** by operators.
 - If insufficient energy is available:
 - Low-priority events can be **delayed or skipped**.
 - High-priority events are executed **as soon as sufficient energy is available**.
 - Optional alerts notify operators of skipped or delayed events.
- AOFS can provide **proactive scheduling guidance** (optional):
 - When the operator attempts to schedule an irrigation or actuator event, the system **may simulate expected energy usage and availability**.
 - The controller can then **warn the operator**: "Based on current energy estimates, you will most likely not have enough power for this event."
 - Operators may then adjust **priority, timing, or load** before committing the schedule.
- All energy measurements, prioritization decisions, and resulting operational logs **may be recorded** for later analysis:
 - Enables visualization of energy usage and event execution history.
 - Helps operators determine if additional batteries, solar panels, or load rescheduling are needed.
- Optional anomaly detection:
 - Alerts operators if an actuator consumes more power than expected (e.g., clogged pipe, stuck valve).

7. Manual Fallback Mode

AOFS supports **manual fallback operation** for farms without fully automated actuators.

- **Purpose:**
 - Ensure irrigation and critical farm operations can continue when automatic valves or pumps are unavailable.
 - Maintain safety, compliance, and event logging even with manual operation.
- **Operation:**
 - Field Controller generates **step-by-step instructions** for operators:
 - Which pump to switch on/off.
 - Which valve to set to open/closed or partial position.
 - Timing recommendations based on **irrigation schedule, soil moisture, tank levels, and weather conditions**.
 - Operators must **confirm completion of each step** in the controller interface.
- **Logging & Documentation:**
 - All manual actions **must be logged**:
 - Operator ID
 - Action taken (pump/valve)
 - Timestamp
 - Relevant sensor readings at the time (tank level, flow, battery voltage, etc.)
 - Logs are synchronized with Farm/HQ controllers whenever connectivity is available.
- **Benefits:**
 - Allows farms to **comply with AOFS even with low-tech equipment**.

- Ensures operators follow optimized schedules and safety procedures.
- Enables full **auditing and analytics** later when automation is introduced.

8. References

- [Sensors & Environmental Monitoring](#)
- [Electrical & Power Control Interfaces](#)
- [Operational Logic & Decision Hierarchy](#)
- [Hydraulic & Water Systems](#)
- [Optional Generator Integration](#)
- [Optional Energy-Aware Operation](#)

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