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 **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)
  - 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. References

- Sensors & Environmental Monitoring
- Electrical & Power Control Interfaces

- Operational Logic & Decision Hierarchy
- Hydraulic & Water Systems
- Optional Generator Integration

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