# Measuring, Monitoring & Documentation Systems

The **Sensors Layer** defines all devices and measurement systems used by AOFS controllers to monitor irrigation, energy usage, water distribution, and environmental conditions. All AOFS-compliant deployments **must implement the sensors and documentation systems specified here**.

## 1. Sensor Categories

AOFS uses five main sensor categories:

1. **Soil Monitoring Sensors**
2. **Weather Monitoring Sensors**
3. **Water Monitoring Sensors**
4. **Power / Energy Sensors**
5. **Optical / Camera Monitoring Systems**

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## 2. Soil Monitoring Sensors

**Purpose:** Measure soil conditions to optimize irrigation schedules.

**Required Measurements:**

1. Soil moisture (volumetric water content) per zone
2. Soil temperature (optional but recommended)
3. Electrical conductivity (optional; for salinity monitoring)

**Placement Guidelines:**

1. At least one sensor per irrigation zone
    1. Multiple sensors for large or heterogeneous fields
2. Sensors should be placed at root depth appropriate to the crop type

**Data Collection:**

1. Sample at a frequency suitable for crop needs (typically 15–60 min)
2. Data logged locally in Field Controller and synced with Farm/HQ controllers

**Calibration & Maintenance:**

1. Sensors must be calibrated according to manufacturer recommendations
2. Regular inspection to prevent soil compaction or damage

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# 3. Weather Monitoring Sensors

**Purpose:** Monitor on-site weather conditions to inform irrigation decisions and safety lockouts.

**Required Measurements:**

1. Rainfall (e.g., tipping bucket rain gauge)
2. Ambient temperature
3. Relative humidity
4. Wind speed (optional but recommended)
5. Solar radiation / light intensity (optional)

**Placement Guidelines:**

1. Rain gauges placed in open areas, away from obstructions
2. Temperature and humidity sensors shielded from direct sunlight and precipitation
3. Wind sensors mounted at standard height for consistent readings

**Data Collection:**

1. Sample at frequency sufficient for crop and irrigation needs (typically 10–30 min)
2. Logs sent to Field Controller for local decision-making and later synced with Farm/HQ controllers

**Integration with AOFS:**

1. Rainfall triggers **irrigation suspension / rain lockout**
2. Temperature and humidity can refine irrigation thresholds and scheduling
3. Optional predictive analytics using solar radiation and wind

**Calibration & Maintenance:**

1. Regular inspection and cleaning of rain gauges
2. Sensors must be calibrated according to manufacturer specifications
3. Logs of calibration and maintenance events must be maintained

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# 4. Water Monitoring Sensors

**Purpose:** Ensure safe and efficient water delivery.

**Required Measurements:**

1. Tank levels: FULL and LOW float switches
2. Flow meters on main and zoned pipelines
3. Pressure sensors for distribution lines
4. Optional: rain gauges (redundant, for additional verification)

**Placement Guidelines:**

1. Tank sensors at critical fill/drain points
2. Flow meters before distribution manifolds
3. Pressure sensors after pumps and at main lines

**Safety Requirements:**

1. Water sensors must enforce Field Controller fail-safes (pump cutoff, overflow prevention)
2. Must function independently of network connection

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# 5. Power / Energy Sensors

**Purpose:** Monitor energy consumption and optimize PUE (productive use of electricity).

**Required Measurements:**

1. DC battery voltage and current
2. Pump energy consumption
3. Valve power usage
4. Optional: solar panel output monitoring

**Placement Guidelines:**

1. Measure energy at the main DC bus and key loads
2. Optional per-zone energy monitoring for detailed efficiency analysis

**Integration:**

1. Data feeds into Field Controller for fail-safe shutdowns on low voltage
2. Logged for auditing and analytics

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# 6. Optical / Camera Monitoring Systems

**Purpose:** Supplement sensor data with visual field observations.

**Use Cases:**

1. Crop growth monitoring
2. Pest or disease detection (optional, non-critical for irrigation)
3. Soil surface moisture and coverage assessment

**Requirements:**

1. Cameras must be oriented for optimal coverage of zones
2. Images or video must be timestamped and logged
3. Data should integrate with Field Controller for automated or semi-automated analysis

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# 7. Data Logging & Documentation

1. All sensor readings **must be logged locally** on the Field Controller
2. Logs include timestamp, sensor ID, measured value, and status/quality flags
3. Data must be synced with Farm Controller for aggregation and with HQ Controller for analytics
4. Field workers may document crop growth, harvest outcomes, and environmental observations via **Field Survey Interfaces**, complementing automated measurements

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# 8. Calibration & Maintenance

1. All sensors **must be regularly calibrated** according to manufacturer specifications
2. Field inspections are required to prevent sensor drift, damage, or misplacement
3. AOFS-compliant deployments **must maintain logs of calibration and maintenance events**

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# 9. Compliance Notes

1. All AOFS deployments **must implement at minimum**:
    1. Soil moisture per irrigation zone
    2. Tank LOW/FULL switches
    3. Flow meters and pressure sensors on all irrigation manifolds
    4. Power monitoring for pumps and valves
    5. Rainfall measurement for irrigation lockout

1. Optional sensors (temperature, conductivity, wind speed, solar radiation, cameras) are recommended for **advanced optimization**, but not mandatory

1. All data must be **timestamped, logged locally, and synchronized** according to federation rules

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# 10. References

1. Field Controller Layer
2. Farm Controller Layer (Local / Federated)
3. Hydraulic & Water Systems
4. Electrical & Control Interfaces
5. Optical Monitoring (Cameras)

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