FM Approvals

CLASS NUMBER 2505

Examination Standard for Early Warning Flood Sensor Systems

September 2021

Foreword

This standard is intended to verify that the products and services described will meet stated conditions of performance, safety and quality useful to the ends of property conservation. The purpose of this standard is to present the criteria for examination of various types of products and services.

Examination in accordance with this standard shall demonstrate compliance and verify that quality control in manufacturing shall ensure a consistent and reliable product.

TABLE OF CONTENTS

INTRODUCTION

1.1. PURPOSE

1.1.1. This standard states testing and certification requirements for early warning flood sensor systems that automatically sense and transmit data on programmed intervals.

1.1.2. Testing and certification criteria may include, but are not limited to, performance requirements, marking requirements, examination of manufacturing facility(ies), audit of quality assurance procedures, and a surveillance program.

1.2. SCOPE

1.2.1. This standard applies to systems that measure water elevations (i.e. static and rate of change types), rainfall, water flow, presence of water, soil moisture, etc. The equipment in this standard may include multiple sensors.

1.2.2. Communication between the equipment and the network infrastructure may be accomplished using industry protocols (i.e. ALERT, ALERT2, IoT, IIoT.) and/or proprietary software.

1.2.3. Early warning flood sensor systems used in this standard support the bidirectional transmission of sensor data via network topographies such as direct communication, node to node, mesh, star, etc. Systems may incorporate one or multiple technologies to ensure ability to transmit and receive data.

1.2.4. The equipment included in this standard may be powered by one or more means such as: electrical service, secondary (rechargeable) battery with solar panel, or by primary (non-rechargeable) battery.

1.2.5. The equipment included in this standard may be stand alone or housed within one or multiple enclosures to protect the components from the environment.

1.2.6. The equipment included within this standard may be mounted directly to a structure or a pole. Installations may result in all components being installed in close proximity or separated as needed to provide for easier access for maintenance and protection from the natural or human environment.

1.2.7. The requirements of this standard shall be used to measure and describe the performance, security and reliability of early warning flood sensor systems in a controlled test environment.

1.3. BASIS FOR REQUIREMENTS

1.3.1. The requirements of this standard are based on experience, research and testing, and/or the standards of other organizations. The advice of manufacturers, users, trade associations, jurisdictions and/or loss control specialists was also considered.

1.3.2. The requirements of this standard reflect tests and best practices used to examine performance characteristics for early warning flood sensor systems for the purpose of obtaining certification. Systems having characteristics not anticipated by this standard may be certified if performance is equal or superior, to that required by this standard is demonstrated

1.4. BASIS FOR CERTIFICATION

Certification is based upon satisfactory evaluation of the product and the manufacturer in the following major areas:

1.4.1. Examination and tests on production samples shall be performed to evaluate

- the suitability of the product;
- the performance of the product as specified by the manufacturer and required for certification; and as far as practical,
- the durability and reliability of the product.

1.4.2. An examination of the manufacturing facilities and audit of quality control procedures may be made to evaluate the manufacturer's ability to consistently produce the product which is examined and tested, and the marking procedures used to identify the product. Subsequent surveillance may be required by the certification agency in accordance with the certification scheme to ensure ongoing compliance.

1.5. BASIS FOR CONTINUED CERTIFICATION

The basis for continual certification may include, but is not limited to, the following based upon the certification scheme and requirements of the certification agency:

- production or availability of the product as currently certified;
- the continued use of acceptable quality assurance procedures;
- satisfactory field experience;
- compliance with the terms stipulated by the certification;
- satisfactory re-examination of production samples for continued conformity to requirements; and
- satisfactory surveillance audits conducted as part of the certification agencies product surveillance program.

1.6. EFFECTIVE DATE

The effective date of this certification standard mandates that all products tested for certification after the effective date shall satisfy the requirements of this standard.

The effective date of this Standard is eighteen (18) months after the publication date of the standard for compliance with all requirements.

1.7. SYSTEM OF UNITS

Units of measurement used in this standard are United States (U.S.) customary units. These are followed by their arithmetic equivalents in International System (SI) units, enclosed in parentheses. The first value stated shall be regarded as the requirement. The converted equivalent value may be approximate. Conversion of U.S. customary units is in accordance with ANSI/IEEE/ASTM SI 10.

1.8. NORMATIVE REFERENCES

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the cited edition applies.

ANSI/IEC 60529, *Degrees of Protection Provided by Enclosures (IP Code)*.

ANSI/IEEE/ASTM SI 10, *American National Standard for Metric Practice*

ANSI/UL 157, *Standard for Gaskets and Seals*

ANSI/UL 61010-1, *Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use – Part 1: General Requirements*

ISO/IEC 17025, *General Requirements for the Competence of Testing and Calibration Laboratories*.

ANSI/UL 50E, *Enclosures for Electrical Equipment, Environmental Considerations*

1.9. TERMS AND DEFINITIONS

For purposes of this standard, the following terms apply:

Brute Force Password Attack	A method of accessing an obstructed device by attempting multiple combinations of numeric/alphanumeric passwords.
Contact Sensor	This term refers to a sensor that is positioned in the fluid being measured. For example, pressure transducer, float, mechanical switch, etc.
Elevation	This term refers to the height of the water surface relative to a reference height. For the purposes of this standard other common terms such as “Stage” or “Gage Height” may be considered interchangeable with “Elevation” defined here.
Gateway	This term refers to a device that allows communication between two networks or translates data from one communication protocol to another. This allows a node to communicate using one protocol and have the data passed forward using another.
***IoT* Device**	This term refers to a device that supports bidirectional communication with other internet connected devices.
Node	This term refers to an individual location designating the combination of telemetry system and sensor(s).
Non-Contact Sensor	This term refers to a sensor that is positioned near, but not in the fluid being measured. For example, optical, acoustic, radar, etc.
Presence of Water	This term refers to a sensor that is looking to see if water is there or not. This information can be helpful in flood scenarios to determine if a body or channel of water is near overtopping it’s boundaries or in areas prone to flash floods.
Rate of Rise	This term refers to the change of surface water elevation over a period of time. These measurements are particularly useful in hydraulic modeling and creation of hydrographs that can be used to estimate the time when a body of water will overtop its boundaries, or discharge levels will reach peak for an event.
Telemetry Systems	This term refers to the assembly of components used to transmit measurements from the sensor to another node(s), central gateway or IoT device. The assembly may utilize one or multiple communication technologies for this purpose.

2. GENERAL INFORMATION

2.1. PRODUCT INFORMATION

2.1.1. Systems defined by this standard are categorized by the type of measurement, and by the method in which the measurement is taken.

2.1.2. Third party electronic modules and/or Printed Circuit Boards (PCBs) which are not designed or manufactured by the listing company can be used for approval with the following requirements.

1. All documentation for schematics and Bill of Materials (BOM) for the third party electronic modules and/or PCBs will be required for review and controlled by the certification agency. When the listing company purchases the electronic modules and/or PCBs from the Original Equipment Manufacturer (OEM) a declaration of conformance will be required to be supplied with the equipment designating the design documentation with revision number and date used for the manufacture. Requires a Non-Disclosure Agreement (NDA).

2. Alternatively, drawing numbers and revisions of design documents without the review of the documents by the certification agency is acceptable. When the listing company purchases the electronic modules and/or PCBs from the OEM a declaration of conformance will be required to be supplied with the equipment designating the design documentation with revision number and date used for the manufacture. (Would not require a NDA but would need validation from OEM).

3. No information for design documentation is provided for the electronic modules and/or PCBs. When the listing company purchases the electronic modules and/or PCBs from the OEM, 100% visual inspection will be required. (No NDA and no validation from the OEM).

Documentation to support the process for incoming inspection and compliance to the above requirements will be filed in the Controlled Drawing List (CDL).

- All proprietary drawings (schematics, BOMs, assembly…) will be filed in the Project Data Report (PDR).
- Incoming inspection documents will be required and will be filed in the CDL.

2.2. CERTIFICATION APPLICATION REQUIREMENTS

The manufacturer shall provide the following preliminary information with an application request for certification:

- A complete list of all models, types, sizes, and options for the products or services being submitted for certification;
- General assembly drawings, electrical schematics, description of product (i.e. sales literature or product brochure)
- Materials list including manufactured and purchased components including manufacturer's model numbers, size, ratings, etc.
- Installation, Operation and Maintenance manuals
- Anticipated marking format including product nameplate and electrical ratings
- The number and location of manufacturing facilities.
- All documents shall identify the manufacturer's name, document number or other form of reference, title, date of last revision, and revision level. All documents shall be provided with English translation.

2.3. REQUIREMENTS FOR SAMPLES FOR EXAMINATION

2.3.1. Following authorization of the project, the manufacturer shall submit / make ready samples for examination and testing as outlined in the proposal letter.

2.3.2. Requirements for samples may vary depending on design features, results of prior or similar testing, and results of any foregoing tests.

2.3.3. The manufacturer shall submit samples representative of production. Any decision to use data generated using prototypes is at the discretion of the certification agency.

2.3.4. It is the manufacturer's responsibility to provide any necessary test fixtures, such as those which may be required to evaluate product with unique constructions.

3. GENERAL REQUIREMENTS

3.1. REVIEW OF DOCUMENTATION

3.1.1. During the initial investigation and prior to physical testing, the manufacturer's specifications and details shall be reviewed to assess the ease and practicality of installation and use. The examination results may further define the limits of the final certification.

3.1.2. The manufacturer’s dimensional specifications and/or designs shall fully describe the product. All critical dimensions shall be shown with allowed upper and lower tolerance limits clearly defined.

3.1.3. All documents pertaining to product materials, dimensions, processing, and marking shall be controlled by the manufacturer’s Quality Assurance procedures, and shall identify the manufacturer’s name, document number or other form of reference, title, date of last revision, and revision level. All foreign language drawings shall be provided with English translation.

3.2. PHYSICAL OR STRUCTURAL FEATURES

3.2.1. Operating Range

3.2.1.1. All system components shall operate within the temperature range of 13°F to +104°F (-25°C to +40°C). Equipment submitted for examination with a wider operational temperature range will be examined at the limits stated by the manufacturer during testing.

3.2.2. Sensors

3.2.2.1. Electrical sensors may be either contact or non-contact type and wired or wireless.

3.2.2.2. Contact type sensors shall be protected from accumulation or damage from debris in order to maintain functionality. Sensors intended for continuous immersion shall be designed with a minimum ingress protection of IP68 as defined in ANSI / IEC 60529 or Type 6P as defined in ANSI/UL 50E.

3.2.2.3. Non-contact sensors shall not be influenced by wind, rain, dust in their measurements. Minimum ingress protection shall be IP54 as defined in ANSI / IEC 60529 or Type 3S as defined in ANSI/UL 50E.

3.2.2.4. Gaskets used in the sensor enclosure shall be tested in accordance with Clause 4.2.1.

3.2.2.5. Sensor enclosure housing shall provide outdoor corrosion protection defined in ANSI/UL 50E.

3.2.2.6. Measurement intervals shall be programmable either using the user interface on the unit or remotely.

3.2.3. Enclosure

3.2.3.1. Products evaluated in this standard shall have an environmental rating that’s suitable for the application. Minimum enclosure ratings per ANSI / IEC 60529 ingress protection rating of IP 54 or Type 3S as defined in ANSI/UL 50E. The sensing components, telemetry components and power related components shall be protected from the environment. It’s not a requirement that all these components be housed in the same enclosure.

3.2.3.2. The enclosure shall provide the means to prevent unauthorized access such as a lock, or tamper resistant screws, etc.

3.2.3.3. Gaskets used in the enclosure shall be tested in accordance with Clause 4.2.1.

3.2.3.4. The enclosures shall provide outdoor corrosion protection defined in ANSI/UL 50E.

3.2.4. Communication Technologies

3.2.4.1. Early warning flood sensor systems shall be designed to use one or more forms of communication in order to transmit / receive data. Examples of communication forms may be: cellular, radio, satellite, Wi-Fi, telephone, etc.

3.2.4.2. For systems that use more than one form of communication, the system shall indicate which type of communication is for primary / secondary.

3.2.5. Architecture/Network

3.2.5.1. Early warning flood sensor systems may communicate directly to the gateway or IoT device.

3.2.5.2. In order to extend coverage area, early warning flood sensor systems may also function as a repeater for nodes that do not have the signal strength to reach the gateway or IoT device directly.

3.2.6. Power Systems

3.2.6.1. Early warning flood sensor systems may be powered by electrical service with secondary battery (rechargeable), primary battery (non-rechargeable), or solar panel with secondary battery (rechargeable).

3.2.6.2. If AC power is available, the system shall be configured to operate on 120 VAC (NOM) and 240 VAC (NOM) Surge protection shall be used to defend against damage to the components.

3.2.6.3. Any accessible conductive surface which is likely to become energized in the event of a fault shall be bonded to the protective ground terminal with a circuit resistance of less than or equal to 0.1 ohm. This requirement applies to systems in which the maximum voltage is greater than 30 V rms or 60 V dc. The bonding conductor(s) shall be green or green with one or more yellow stripes. The size of the bonding conductor(s) shall be at least equivalent in size to the primary circuit conductors.

3.2.6.4. System shall have a power supply indication with a low battery notification if primary or secondary batteries are used.

3.2.6.5. Sensor types and accessories not included in the scope of this standard but are intended to be used with the equipment are to be included in the evaluation of power systems for the equipment.

3.2.7. Structure

3.2.7.1. The structure design shall ensure that the components are held appropriately in their intended orientations for proper operation.

3.2.7.2. For systems that utilize multiple enclosures for the different components, the structure design shall have provisions for mounting each enclosure.

3.2.7.3. Installation of these systems shall consider the conditions present in drought, normal level, and anticipated flood stages as defined within the installation manual.

3.2.8. Data Storage

3.2.8.1. The system shall store backup data measurements locally for a minimum period of 1 week.

Note: Factory default measurement internals shall be used for all stored system data.

3.2.9. Interface

3.2.9.1. The system shall provide the means to identify a sensor in alarm. Identification can be achieved with indication lights, on an integral display, through a wired or wireless connection or through software.

If only one indicating light is provided for signaling alarms, faults and other indications, it shall be colored red. If separate indicating lights are used or if a multi-colored indicating light is provided, the colors shall be used in the following order of priority ((1) being highest priority):

1) alarms indicating the presence of a trigger event shall be colored RED;
2) equipment fault indicators shall be colored YELLOW;
3) power supply indicators shall be colored GREEN.

In addition to the color requirements, the indicator lights shall be adequately labeled to show their functions.

3.2.10. Software

3.2.10.1. It shall be possible to adjust the measurement setting of the node either at the user interface on the device, or via remote access to the device. Adjustments shall be allowed for both normal conditions and for event conditions for sampling rate, thresholds for loss of communication, data collection, etc.

3.2.10.2. In order to prevent unauthorized access to the settings, there shall be password protection. Passwords that are susceptible to brute forced password attack or publicly available are to be excluded. Unchangeable default credentials shall not be used.

3.3. MATERIALS

All materials used in the construction of the system shall be suitable for their intended use. Raw materials shall be evaluated in accordance with the manufacturer's Quality Assurance manual plus any applicable national and/or international standards. For components expected to be in contact with water, material selection shall not contribute harmful effects to the water in addition to the requirements of the intended use.

3.4. MARKINGS

3.4.1. Marking on the product or, if not possible due to size, on its packaging or label accompanying the product, shall include the following information:

- name and address of the manufacturer or marking traceable to the manufacturer;
- date of manufacture or code traceable to date of manufacture or lot identification;
- model number, size, rating, capacity, etc., as appropriate; and
- electrical ratings and connection terminals.

When hazard warnings are needed for ANSI/UL 61010-1, the markings should be universally recognizable.

3.4.2. The model or type identification shall correspond with the manufacturer's catalog designation and shall uniquely identify the certification agency's mark of conformity.

3.4.3. The certification agency's mark of conformity shall be displayed visibly and permanently on the product and/or packaging as appropriate and in accordance with the requirements of the certification agency. The manufacturer shall exercise control of this mark as specified by the certification agency and the certification scheme.

3.4.4. All markings shall be legible and durable.

3.5. MANUFACTURER'S INSTALLATION AND OPERATION INSTRUCTIONS

3.5.1. The manufacturer shall

- prepare instructions for the installation, maintenance, and operation of the product.
- provide facilities for repair of the product and supply replacement parts, if applicable; and
- provide services to ensure proper installation, inspection, or maintenance for products of such nature that it would not be reasonable to expect the average user to be able to provide such installation, inspection, or maintenance.
- include equipment ratings, including supply voltage or voltage range, frequency or frequency range, and power or current rating.
- include environmental ratings; temperature range, relative humidity, and voltage supply fluctuations.

3.6. CALIBRATION

3.6.1. Each piece of equipment used to verify the test parameters shall be calibrated within an interval determined on the basis of stability, purpose, and usage. A copy of the calibration certificate for each piece of test equipment is required. The certificate shall indicate that the calibration was performed against working standards whose calibration is certified and traceable to an acceptable reference standard and certified by an ISO/IEC 17025 accredited calibration laboratory. The test equipment shall be clearly identified by label or sticker showing the last date of the calibration and the next due date. A copy of the service provider's accreditation certificate as an ISO/IEC 17025 accredited calibration laboratory should be available.

3.6.2. When the inspection equipment and/or environment is not suitable for labels or stickers, other methods such as etching of control numbers on the measuring device are allowed, provided documentation is maintained on the calibration status of thus equipment.

3.7. TOLERANCES

Tolerances on units of measure shall be as described in Appendix A, unless otherwise specified in the standard.

4. PERFORMANCE REQUIREMENTS

4.1. EXAMINATION

4.1.1. Requirement

Systems submitted for evaluation shall comply with the manufacturers drawings and specifications and to certification requirements.

4.1.2. Test/Verification

The samples shall be examined and compared to manufacturer's drawings and specifications. It shall be verified that the samples conform to the physical and structural requirements described in Section 3, General Requirements.

4.1.3. Vibration

The system shall be able to withstand potential vibrations produced within its operating environment.

4.1.4. Test/Verification

Prior to all tests, the system shall be subjected to 24 hours duration at a total displacement of 0.02 in. (0.5 mm) while swept every 30 seconds through a vibration frequency range of 10 to 30 Hz. No impairment of function is allowed; the system shall operate properly after this exposure.

4.1.5. Temperature Extremes

The system shall be able to withstand potential temperature changes produced within its operating environment.

4.1.6. Test/Verification

All sensors shall be able to withstand at least 30 day period in standby operation with the ambient temperature cycled between the rated temperature extremes six cycles per day for a total of 180 cycles. There shall be no false detection nor any evidence of instability. The test shall be conducted consistent with the manufacturer's intended installation environment (outdoor, submerged in water, buried…etc.)

Contact type sensors shall be submerged in water for this test.

4.2. ENCLOSURE

4.2.1. Aging Test (Non-Metallic)

Non-metallic enclosures or non-metallic parts of enclosures, including seals, gaskets and O-rings shall provide a suitable degree of protection according to 4.2.5.

Exception: Gasket material that complies with ANSI/UL 157 for suitable minimum and maximum service temperatures is considered to have met this requirement.

4.2.2. Test/Verification

The enclosure containing the seals, gaskets and O-rings is to be subjected to a temperature of 10 degrees above the maximum gasket service temperature, but not less than 158 °F (70 °C), in a circulating air oven for at least 168 hours. Following this preconditioning, the enclosure is to be subjected to the design tests required by the intended type rating(s).

Following the aging test the enclosure is to be subjected to the Impact Test of 4.2.3 and the ingress protection testing of 4.2.5, using the acceptance criteria for the test performed.

4.2.3. Resistance to Impact

System enclosures, sensors and attached parts shall be subjected to mechanical stresses likely to occur in normal use.

4.2.4. Test/Verification

System enclosures, sensors and attached parts shall be subject to the impact test of ANSI/UL 61010-1, refer to Table 1 for impact energy levels and IK code.

	Impact energy level and IK Code
System Enclosures	2J (IK07)
Sensor Enclosures	5J (IK08)

Table 1

Damage to the enclosure as a result of impact shall not invalidate the ingress protection testing of 4.2.5, using the acceptance criteria for the test performed.

4.2.5. Ingress Protection

System enclosure:

The system enclosures shall meet IP54 Ingress protection defined in ANSI/IEC 60529 or Type 3S as defined in ANSI/UL 50E as a minimum for outdoor applications.

Sensor Enclosure:

Contact type sensors shall meet IP68 Ingress protection defined in ANSI/IEC 60529 or Type 6P as defined in ANSI/UL 50E as a minimum for outdoor applications.

Non-Contact type sensors shall meet IP54 Ingress protection defined in ANSI/IEC 60529 or Type 3S as defined in ANSI/UL 50E as a minimum for outdoor applications.

4.2.6. Test/Verification

Testing is to be in accordance with ANSI/IEC 60529 and/or ANSI/UL 50E. Acceptance criteria is defined in ANSI/IEC 60529 or ANSI/UL 50E.

4.2.7. Saltwater Corrosion

System and sensor enclosures shall be compatible with the corrosion atmosphere specified by the manufacturer's claims. The manufacturer's installation instructions shall include suitable warnings if the system is not compatible with salt exposure.

4.2.8. Test/Verification

Enclosures shall be subjected to the Corrosion Protection Test defined in ANSI/UL 50E when specified for use in sea water or in environments that may have salt exposure. Acceptance criteria is defined in ANSI/UL 50E.

4.3. COMMUNICATION TECHNOLOGIES

4.3.1. Systems for Communication

Systems shall be designed to use one or more forms of communication in order to transmit and receive data.

4.3.2. Test/Verification

All forms of communication shall be verified according to the manufacturer's installation instructions.

4.3.3. Backup Systems for Communication

For systems with multiple forms for communication, the system shall indicate which type of communication is the primary connection and which type of communication is the secondary connection. If no connection is available, the system shall indicate a fault state.

4.3.4. Test/Verification

Indication of the communication type shall be validated to the manufacturer's documentation.

4.4. SENSING

Sensors being evaluated in this standard have a primary function of measuring of presences of water, elevation, rate of rise, or water flow. Depending on the supporting components, a sensor may be able to perform more than one of the primary functions.

4.4.1. Minimum Detection Level

Samples shall be subjected to a baseline sensitivity test in order to establish performance capabilities. Samples from other exposure testing outlined in this standard will be compared to the baseline sensitivity testing in order to determine changes in performance of the sensors.

4.4.2. Test/Verification

Based on the ranges specified by the manufacturer, sensors shall respond to the defined minimum detection levels in less than 30 seconds.

4.4.3. Sensor Failure Modes

Any failure of a sensor shall result in the system indicating a fault state.

4.4.4. Test/Verification

Tests will be conducted by introducing short circuit faults, open circuit faults and any other type of faults deemed to be appropriate for the construction of the system.

4.4.5. Sensor Repeatability

Sensors shall be capable of restoring operation without any changes to the operating characteristics.

4.4.6. Test/Verification

The baseline sensitivity detection time shall remain less than 30 seconds following 500 detection/reset cycles.

4.4.7. Humidity Cycling and Conditioning

Sensors shall be capable of withstanding changes in temperature and humidity without any changes to the operating characteristics.

4.4.8. Test/Verification

A. The system shall remain functional and produce no false indication of alarm when subjected to a change from 50% relative humidity at 70°F (21°C), to 90% relative humidity at 100°F (38°C) in 15 minutes.
B. The system shall remain functional; with no trouble signal or change in operating characteristics, detection time shall remain less than 30 seconds, and shall produce no false indication of alarm when subjected to a relative humidity of 95% ±3% and temperature of 140°F ±3°F (60°C ±2°C) for a period of 24 hours.
C. The system shall remain functional; with no trouble signal or change in operating characteristics, detection time shall remain less than 30 seconds, and shall produce no false indication of alarm when subjected to 4 hours at the rated high and low ambient temperature rating.

4.4.9. Presence of Water

Sensors capable of detecting the presence of water are to be tested based on the manufactuer's operating characteristics.

4.4.10. Test/Verification

Measurements will be taken to validate the manufacturer's claims for performance. Clause 4.4.1 will establish the minimum water level for the intended operation of the sensor.

4.4.11. Water Elevation

Sensors capable of recording changes to water elevation are to be tested based on the manufacturer's operating characteristics.

4.4.12. Test/Verification

Measurements will be taken at three different water elevations in order to validate the manufacturer's claims for performance. Clause 4.4.1 will establish the minimum water level for the intended operation of the sensor.

4.4.13. Flow

Sensors capable of recording the flow of water are to be tested based on the manufacturer's operating characteristics.

4.4.14. Test/Verification

Measurements will be taken at the maximum and minimum water flow levels in order to validate the manufacturer's claims for performance. Clause 4.4.1 will establish the minimum water level for the intended operation of the sensor.

4.4.15. Rate of Rise

Sensors capable of recording the rate of rise based on water elevation are to be tested based on the manufacturer's operating characteristics.

4.4.16. Test/Verification

Measurements will be taken from a known level to multiple elevations (up and down) over time to validate the manufacturer's claims for performance. Clause 4.4.1 will establish the minimum water level for the intended operation of the sensor.

4.5. POWER SUPPLY

4.5.1. Power Supply Indication

Systems shall be provided to display the following status indication:

A. Power (Green)
B. Fault (Yellow)
C. Alarm (Red)

These indicators shall be adequately labeled to show their functions. If only a single indicator is provided the priority of reporting/indication shall be Alarm, Fault, Power.

4.5.2. Test/Verification

The system shall provide status indication with the time limits defined in Table 2.

Indication	Response Time (Seconds)
Alarm	30
Low Battery (Low voltage for hard wired systems)	300
Fault	300
Loss of Communication	300

Table 2

4.5.3. Voltage Variation

The system shall produce no trouble signal or false detection and detection time shall remain below 30 seconds when operated between 85% and 110% of rated input voltage.

4.5.4. Test/Verification

The system shall be tested at the extremes of the range.

4.5.5. Reverse polarity

If the means of connection allows the reversal of polarity of the input connections, then a supply shall be connected for both normal and reversed polarity.

4.5.6. Test/Verification

The system shall be tested, and connection shall be maintained for a period of 30 minutes or until the resultant condition has stabilized.

4.5.7. Dielectric Strength

For systems with field wiring connections, the system assembly shall be capable of withstanding a high potential between input/output terminals and ground, for one minute without arcing or breakdown.

A. For an operating voltage of 30Vac (60Vdc) or less, a potential of 500Vac (710Vdc) shall be applied between input/output terminals and enclosure ground for one minute.

B. For an operating voltage greater than 30Vac (60Vdc), a potential of 1000Vac + twice the rated voltage shall be applied between input/output terminals and enclosure ground for one minute.

4.5.8. Test/Verification

The system shall be subject to the dielectric strength test of ANSI/UL 61010-1.

4.5.9. Bonding Resistance

For systems with field wiring connections, any accessible conductive surface which is likely to become energized in the event of a fault shall be bonded to the protective ground terminal with a circuit resistance of less than or equal to 0.1 ohm. This requirement applies to systems in which the maximum voltage is greater than 30 V rms or 60 V dc. The bonding conductor(s) shall be green or green with one or more yellow stripes. The size of the bonding conductor(s) shall be at least equivalent in size to the primary circuit conductors.

4.5.10. Test/Verification

The system shall be subject to the bonding resistance tests of ANSI/UL 61010-1.

4.5.11. Surge Transients

For systems with field wiring connections, protection against line surge transients will be a requirement for each submitted sensor.

4.5.12. Test/Verification

One powered sample of the system will be subjected to transient waveforms having peak levels of 100, 500, 1000, 1500, and 2400 V dc, as delivered into a 200 ohm load. This requirement applies to all field wiring terminals that have a possibility of being subjected to line-induced voltage (i.e., sensor circuits, power circuits, and remote/auxiliary connections).

4.5.13. Extraneous Transients

No false signal will be generated when the system is subjected to extraneous transients.

4.5.14. Test/Verification

One powered sample of the system will be subjected to extraneous transients described below.

A. radio frequency transmissions with radiation power levels equivalent to 5 Watts at 24 inches (0.6 m) in the 27 MHz, 150-174 MHZ, 450-467 MHZ, 850-870 MHz, and 900-920 MHz bands.
B. a sequential arc (Jacob's ladder) generated between two 15 in. (0.4 m) long, No. 14 AWG (2.1 mm) solid copper conductors attached rigidly in a vertical position to the output terminals of an oil burner ignition transformer or gas tube transformer rated 120 volts, 60 hertz primary; 10,000 volts, 60 hertz, 23 mA secondary. The two wires are to be formed in a taper, starting with a ⅛ in. (3.2 mm) separation at the bottom (adjacent to terminals) and extending to 1.25 in (32 mm) at the top.
C. operation of an electric drill rated 120 V, 60 Hz, 2.5 A.
D. operation of a soldering gun rated 120 V, 60 Hz, 2.5 A.
E. operation of a 6 in (150 mm) diameter solenoid-type vibrating bell with no arc suppression and rated 24 V dc.

The sensor will produce no false detection or trouble signal in the presence of these extraneous transients, and it will respond satisfactorily to a baseline test in the presence of the extraneous transients.

4.6. BATTERY

4.6.1. General Requirements

Systems that use solar panels or battery chargers, shall also be equipped with the ability to perform a load test to determine the health of the secondary battery.

4.6.2. Test/Verification

Indication of a fault shall be displayed if the health of the secondary battery is unacceptable. The system shall continue to operate for 7 days under the low battery indication. At the end of 7 days the system shall be capable of generating an alarm indication.

4.6.3. Power Supply/ Electrical Supervision

Systems shall be powered by electrical service with secondary battery (rechargeable), primary battery (non-rechargeable), or solar panel with secondary battery (rechargeable). Both primary and secondary sources shall be monitored at the point of connection to the equipment.

4.6.4. Test/Verification

With the system operating within a normal range, the primary supply voltage shall be reduced until the transfer to the secondary power source occurs. The system shall continue to operate on the secondary power source until the battery cutoff voltage and the system powers down. If the system is powered from a primary battery, the system shall continue to operate until the battery cutoff voltage and the system powers down. The results shall be seamless and not result in any loss of data or signal transmission. Fault condition indications for the power supply shall be verified with the manufacture's documentation.

4.6.5. Primary Batteries

Primary batteries shall be sized to allow for a minimum of 1 year of operation over its operating temperature range.

4.6.6. Test/Verification

Suitability shall be calculated based on manufacturer's performance characteristics of the battery.

4.6.7. Secondary Batteries

Secondary batteries shall be sized to allow for a minimum of 10 days of operation without solar panel or battery chargers providing recharge.

4.6.8. Test/Verification

Suitability shall be calculated based on manufacture's performance characteristics of the battery.

4.6.9. Battery Chargers

Battery chargers that are powered by electrical service shall be sized to recharge the secondary battery from minimum cutoff voltage to fully charged within 8 hours.

4.6.10. Test/Verification

A sample of the battery charger and secondary battery is to be tested to validate the manufacturer's claims for performance.

4.6.11. Solar Recharging

Solar panels shall be sized to recharge the secondary battery from minimum cutoff voltage to fully charged over 3 days (24 hours, 8 hours of sunlight per day).

4.6.12. Test/Verification

Suitability shall be calculated based on manufacture's performance characteristics of the battery.

4.7. ADDITIONAL TESTS

Additional tests may be required, at the discretion of the certification agency depending on design features and results of any foregoing tests.

Any test following a failure shall be acceptable only at the discretion of the certification agency and with a technical justification of the conditions or reasons for failure.

5. OPERATIONS REQUIREMENTS

5.1. DEMONSTRATED QUALITY CONTROL PROGRAM

5.1.1. A quality assurance program is required to assure that subsequent products produced by the manufacturer shall present the same quality and reliability as the specific products examined. Design quality, conformance to design, and performance are the areas of primary concern.

- Design quality is determined during the examination and tests and may be documented in the certification report.
- Continued conformance to this standard is verified by the certifier's surveillance program.
- Quality of performance is determined by field performance and by periodic re-examination and testing.

5.1.2. The manufacturer shall demonstrate a quality assurance program which specifies controls for at least the following areas:

- existence of corporate quality assurance guidelines;
- incoming quality assurance, including testing;
- in-process quality assurance, including testing;
- final inspection and tests;
- equipment calibration;
- drawing and change control;
- packaging and shipping; and
- handling and disposition of non-conforming materials.

5.1.3. Documentation/Manual

There should be an authoritative collection of procedures/policies. It should provide an accurate description of the quality management system while serving as a permanent reference for implementation and maintenance of that system. The system should require that sufficient records are maintained to demonstrate achievement of the required quality and verify operation of the quality system.

5.1.4. Records

To assure adequate traceability of materials and products, the manufacturer shall maintain a record of all quality assurance tests performed, for a minimum period of two years from the date of manufacture.

5.1.5. Drawing and Change Control

- The manufacturer shall establish a system of product configuration control that shall allow no unauthorized changes to the product. Changes to critical documents, identified in the certification report, may be required to be reported to, and authorized by the certification agency prior to implementation for production.
- Records of all revisions to all certified products shall be maintained.

5.2. SURVEILLANCE AUDIT

5.2.1. An audit of the manufacturing facility may be part of the certification agencies surveillance requirements to verify implementation of the quality assurance program. Its purpose is to determine that the manufacturer's equipment, procedures, and quality program are maintained to ensure a uniform product consistent with that which was tested and certified.

5.2.2. Certified products or services shall be produced or provided at, or provided from, location(s) disclosed as part of the certification examination. Manufacture of products bearing a certification mark is not permitted at any other location prior to disclosure to the certification agency.

5.3. MANUFACTURER'S RESPONSIBILITIES

5.3.1. The manufacturer shall notify the certification agency of changes in product construction, components, raw materials, physical characteristics, coatings, component formulation or quality assurance procedures prior to implementation.

5.4. MANUFACTURING AND PRODUCTION TESTS

5.4.1. The manufacturer shall test 100% of production of the main control board and user interface (where applicable) for normal operation. This test may be completed during production or after final assembly of the whole unit. The manufacturer shall have a written controlled procedure outlining the details and acceptance criteria for this production test.

APPENDIX A: Tolerances

Unless otherwise stated, the following tolerances shall apply:

Angle:	±2°
Frequency (Hz):	±5 percent of value
Length:	±2 percent of value
Volume:	±5 percent of value
Rotation:	±1 RPM
Pressure:	±3 percent of value
Temperature:	±2°C
Time:	+5/–0 seconds +0.1/–0 minutes +0.1/–0 hours +0.25/–0 days

Unless stated otherwise, all tests shall be carried out at a room (ambient) temperature of 68 ± 9°F (20 ± 5°C).

APPENDIX B: Sample Listing

ACME Company 123 Main St. Norwood, MA 02062 USA[1]
FMYYNUS999[2]

Model	Approved Sensors	Ambient Temperature Range	Enclosure Type	Product Manual
123-ABC	Elevation	-25F to 90F	Type 4X, IP66	999000, Rev 1

Notes:

1) Company Name and Address.
2) FM certificate number:

FM	=	Issued by FM Approvals
YY	=	Year of issue
NUS	=	Issued against US standards
9999	=	Serial number of certificate (in the year of issue)