# CONTENTS

CONTENTS ............................................................................................................. ii
FOREWORD ........................................................................................................ iii

Section 1 GENERAL ............................................................................................... 1
1.1 Scope .............................................................................................................. 1
1.2 Definitions ..................................................................................................... 1

Section 2 ILLUSTRATIONS .................................................................................. 3
2.1 General .......................................................................................................... 3
2.2 Minimum Illustration .................................................................................... 3
2.3 Format of Illustration .................................................................................. 3

Section 3 TESTING ............................................................................................... 5
3.1 Operating Conditions for Coverage Area Testing ........................................ 5
   3.1.1 Indoor Products .................................................................................... 5
   3.1.2 Outdoor Products ............................................................................... 5
   3.1.3 Test Setup ........................................................................................... 5

3.2 Major Motion Testing ................................................................................... 6
   3.2.1 Test Subject ........................................................................................ 6
   3.2.2 Test Environment .............................................................................. 6

3.3 Minor Motion Testing .................................................................................. 6
   3.3.1 Test Apparatus .................................................................................. 6
   3.3.2 Test Environment ............................................................................ 6
   3.3.3 Direction of Motion ......................................................................... 6
   3.3.4 Setup and Test Procedure ............................................................... 7

ANNEX A .............................................................................................................. A-1
FOREWORD

The purpose of this standard is to promote uniformity for the definition and measurement of characteristics relevant to the use and application of occupancy motion sensors. The standard is not intended to set performance levels.

In the preparation of this standard publication, input of users and other interested parties has been sought and evaluated. Inquiries, comments, and proposed or recommended revisions should be submitted to the NEMA Wiring Device Section by contacting the:

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This is the first edition of this standard. It was developed from a former technical guide under the same designation.

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This standard was developed by the NEMA Wiring Device Section. Section approval of the guide does not necessarily imply that all section members voted for its approval or participated in its development. At the time it was approved, the NEMA Wiring Device Section was composed of the following members:

2D2C, Inc. — Kitchener, ON, Canada
BSafe Electrix — Manhasset, NY
Cooper Wiring Devices — Peachtree City, GA
Ericson Manufacturing Company — Willoughby, OH
Euroloft Inc. — Toronto, ON, Canada
Hubbell Incorporated — Bridgeport, CT
Interpower Corporation — Oscaloosa, IA
KCSM — Irvine, CA
Leviton Manufacturing Co., Inc. — Little Neck, NY
Lutron Electronics Company, Inc. — Coopersburg, PA
Pass & Seymour/Legrand — Syracuse, NY
Schneider Electric — Palatine, IL
Technology Research Corporation — Clearwater, FL
Thomas & Bets Corp. — Memphis, TN
Tyco Electronics Corp — Harrisburg, PA
TyMac — Gilbert, AZ
Watt Stopper, Inc./Legrand — Santa Clara, CA
Section 1
GENERAL

1.1 SCOPE

This standard publication covers the definition and measurement of field of view and coverage characteristics relevant to the use and application of vacancy and occupancy sensors using individual or any combination of passive infrared, ultrasonic, or microwave technology. These sensors are used in systems for control of lighting, heating, ventilating, and air conditioning (HVAC), and other devices.

1.2 DEFINITIONS

The definitions below apply to terms used in this guide publication or in manufacturers’ specification sheets and product literature, or both. Where the terms are used in this guide publication or in a manufacturer's specification sheet or other product literature, the following definitions apply.

bypass: the means of forcing loads into "ON" or "OFF" condition by circumventing the device.

cell: a 3 foot by 3 foot section of the grid.

coverage area: the area in which the sensor can detect motion, comprised of the horizontal and vertical fields of view.

energy consumption: total consumption in milliwatts for 1 hour with the controlled load "ON" for 30 minutes and "OFF" for 30 minutes.

grid: the area in which the sensor is tested divided into 3 foot by 3 foot sections.

horizontal field of view: the area of coverage in a horizontal plane to the sensor while the sensor is mounted in the orientation recommended by the manufacturer. The height of the horizontal field is at a level of 36 ± 1 in. above the ground.

immunity to false activation: the ability to ignore external events which are not intended to activate the product.

initial trigger motion detection: the condition when the sensor is operating in an unoccupied coverage area.

line of sight coverage: the ability to detect motion when there is not any object(s) between the motion and sensor to obscure or to block the detection of motion.

maintained motion detection: the condition when the sensor is operating in an occupied coverage area.

major motion: movement of a person walking into or through an area.

measurement units: degrees for viewing angles
feet (m) for distance
feet and inches (m) for mounting height
feet per second (m/s) for velocity
square feet (m²) for coverage area

microwave: type of occupancy motion sensor that emits a low power microwave into the area being monitored. The frequency of this wave is between 1 GHz and 100 GHz. Changes in the
reflection pattern caused by motion are received by the sensor and converted into an electrical signal.

**minor motion**: movement of a person sitting at an office desk reaching for a telephone, turning the pages in a book, opening a file folder, picking up a coffee cup, etc.

**motion detection**: a means to determine that the sensor has detected motion.

**mounting height**: the height above the floor to the center of the sensor.

**motion sensor**: an outdoor sensor that automatically turns lighting on when motion is detected, and off when an outdoor area is vacant.

**occupancy sensor**: an indoor sensor that automatically turns lighting on when occupancy is detected, and off when the space is vacant.

**override**: the means of modifying the normal detection operation of the device to alter control functions.

**passive infrared**: type of occupancy sensor that uses thermal detectors to absorb the received energy focused on them. A change in energy received by a thermal detector results in a change in detector temperature which results in an electrical signal. The more common thermal detector (the pyroelectric detector) has an output that is proportional to the rate of change of its temperature. Pyroelectric detectors respond to changes in received energy in the 7 to 14 micron portion of the electromagnetic spectrum. The detector aperture is converted optically, e.g., by a multi-segment, Fresnel lens array into multiple discrete fields of view that are strategically located throughout the occupancy sensor pattern. When a person moves into or out of a field of view, the detector experiences a change in received energy, which is converted into an electrical signal.

**sensitivity**: the ability of the sensor to detect the designated magnitude of motion for a given application.

**time delay**: the duration of time from the time the motion was last detected until the controlled loads are deactivated, e.g., lights turned off, signal given to other equipment, etc.

**ultrasonic**: type of occupancy motion sensor that emits a low power sound into the area being monitored. The sound wave is at a frequency above the range that a person can hear. Changes in the reflection pattern caused by motion are received by the sensor and converted into an electrical signal.

**vacancy sensor**: an indoor sensor that automatically turns lighting off when a space is vacant, and requires manual activation of lighting to turn lighting on.

**vertical field of view**: the area of coverage in a vertical plane to the sensor while the sensor is mounted in the orientation recommended by the manufacturer.

**volumetric coverage**: the ability to detect motion that is generated behind an object that obstructs the line of sight between the motion and the sensor.
Section 2
ILLUSTRATIONS

2.1 GENERAL

The horizontal or vertical fields of view may be illustrated in product literature, specifications, etc. The use of illustration is optional. If any illustration is used, it shall meet the requirements below for minimum illustration and illustration format.

2.1.1 Any manufacturer claiming to have tested or used the WD-7 standard as the criteria for establishing occupancy sensor field of view and coverage characteristics shall publish and make available the measurements of the field of view and coverage characteristics in the format provided under Section 2 of the standard.

2.2 MINIMUM ILLUSTRATION

The illustration shall include at least the following information:

- Mounting height
- Maximum horizontal coverage angle
- Dimensions of coverage area
- Dimensions of room (length, width, height)
- Floor surface material

The manufacturer shall state whether the illustration is for initial trigger motion detection or for maintained motion detection.

2.3 FORMAT OF ILLUSTRATION

The illustration of the horizontal or vertical fields of view for passive infrared and ultrasonic devices shall have the following format:

- Grid pattern, with a maximum 3x3 ft cell size
- Crosshatched cells where major motion is detected
- Shaded or solid cells, where minor motion is detected

An example illustration is in Figure 2-1.
Figure 2-1
WALL SWITCH PIR PATTERN
(3 ft blocks)
Section 3
TESTING

3.1 OPERATING CONDITIONS FOR COVERAGE AREA TESTING

3.1.1 Test Conditions

The test shall be conducted in an indoor environment as described section 3.1.2, regardless of the actual intended operating environment of the sensor. Mounting height and commissioning adjustments shall be per manufacturer’s instructions, except for high bay sensors. High bay sensors shall be tested at one or more of the following mounting heights of 20ft, 30ft, 40ft, 50ft & 60ft.

There shall be no other people or moving objects in the coverage area.

3.1.2 Test Environment

a) The room shall be divided into a square grid with cell dimensions of 3x3 ft.

b) The room shall be larger than the test area such that the tester can walk into the FOV of the sensor.

c) Temperature:
   1. For any sensors mounted over 10ft, the temperature shall be measured at the sensor and at the ground.
   2. For all other sensors, the temperature of the room must be maintained at 70 ± 5°F throughout the test, and shall be measured at the sensor.

d) The humidity of the room during the test shall be recorded.

e) The standard method shall test the sensor in a room that is slightly greater in size than the specified coverage area of the sensor. If the coverage area exceeds the size of the test room, an alternate test method may be followed. The alternate method shall test one half of the field of view, then, by re-positioning the sensor, test the other half of the field of view. The illustration shall note which test method is used. See appendix A for examples of acceptable methods for the alternate test.

Note: The alternate test method is acceptable for:
   • line of sight sensors
   • ultrasonic sensors that have opposing transmit & receive ports, such that the FOV can be divided in half.

Other types of sensors shall be tested with the standard method.

The sensor will be mounted on a surface that is stable and vibration free.

3.1.3 Test Setup

a) Prepare a template drawing for the test room.

b) Install and wire the sensor in accordance with the manufacturer's instructions.

c) Record the mounting height.

d) For sensors that have adjustable positioning, record the orientation of the sensor and mounting angle.

e) Sensor shall be horizontally leveled for ceiling mount and vertically leveled for the wall mount.

f) Allow the sensor to stabilize in accordance with the manufacturer's instructions.

g) Adjust the sensitivity of the sensor being tested in accordance with the manufacturer's instructions.

h) Record the temperature of the room at the sensor.

i) Record the humidity of the room.
3.2 MAJOR MOTION TESTING

3.2.1 Test Subject

The test subject shall meet the following criteria:

Height: 5ft 7in. (67in.) (+/- 4in.)
Weight: 170 ± 20 lb

The person shall be dressed in shirt, long pants, and shoes, with their head and hands exposed. Test subject shall not be wearing a coat or other insulated garments. Clothing shall fit the test subject with no hanging or swaying material.

The person shall be moving at a velocity of 4 ± 0.5 ft/s

3.2.2 Test Procedure

a) To normalize sensors that have different thresholds for on and off state, all sensors shall be tested in the “ON” state, as long as there is a visible indication of motion detection. If load activation is the only indication, the test shall be performed by activating the sensor for each cell.

b) The test person shall methodically walk in the direction parallel to the x-axis or parallel to the y-axis, or both, at the test velocity.

c) The test person shall start from a point outside the coverage area at the center of the outer edge of the first cell.

The test person shall walk move from cell to cell with a 2 s stop at the edge of each cell. If either of the movements parallel to the x-axis or parallel to the y-axis is detected by the sensor being tested, the test is positive for this cell. If the result is positive, crosshatch the cell on the template drawing. If the result is not positive, leave the cell open on the template drawing.

3.3 MINOR MOTION TESTING

3.3.1 Test Apparatus

Minor motion shall be tested using a robotic arm with dimensions 3 in. x 3 in. x 15 in., mounted at a height of 36 ± 1 in. above the ground. The arm shall move at a velocity of 90°/s.

3.3.2 Test Environment

The test shall be conducted in an indoor environment as described in section 3.3.4 regardless of the actual intended operating environment of the sensor. Mounting height and commissioning adjustments shall be per manufacturer’s instructions. The minor motion simulator shall be started remotely, and there shall be no other moving objects or people in the coverage area.

3.3.3 Direction of Motion

Minor motion shall be up to four 90° sweeps as described below and shown in Figure 3-2.

For the horizontal 90° sweep motion, the arm shall move in the x-y plane from 270° to 0° or from 90° to 0°, or both.

For the vertical 90° sweep motion, the arm shall move in the x-z plane from 270° to 0° or from 90° to 0°, or both.
3.3.4 Setup and Test Procedure

a) Install the sensor to be tested in a room equal to or greater in size than the specified coverage area of the sensor. Wire in accordance with the manufacturer's instructions.

b) Prepare a template drawing for the test room showing the sensor location and divided into a square grid. The maximum size of each cell within the grid shall be 3x3 ft.

c) Allow the sensor to stabilize in accordance with the manufacturer's instructions.

d) If necessary, adjust the sensitivity of the sensor being tested in accordance with the manufacturer's instructions.

e) The temperature of the test room shall be maintained at 70 ± 5˚F throughout the test.

f) The humidity of the test room is maintained between 35 and 70 % throughout the test.

g) Setup the NEMA minor motion simulator on a movable platform and place it in the first cell. The simulator shall be located in the center of the cell ± 2 in. off the x- and y-axis.

h) The temperature of the simulator shall be 95 ± 2˚F. The arm temperature shall be stable for a minimum of 10 min prior to testing.

i) Start with the minor motion simulator to test motion in either the x-y plane or the x-z plane, or both.

j) If any of the four 90˚ sweep motions are detected by the sensor being tested, the test shall be positive for this cell. If the test is positive, shade in the cell on the template drawing. If the result is not positive, leave the cell open on the template drawing.

k) Relocate the minor motion simulator to the center of the next grid area. Repeat steps i and j.
Direction of Major Motion

Wallbox or Corner Mount Sensor

Direction of motion is perpendicular to sensor face

Ceiling Mount Sensor

Figure 3-1
ANNEX A

A. STANDARD METHOD – PIR Wallbox or Wall-mount

B. ALTERNATE METHOD – PIR Wallbox or Wall-mount