

## Setting High Reliability Standards with NEMA 6 Microinverter Enclosures

To promote the safe and effective use of electrical equipment, the National Electrical Manufacturers Association (NEMA) sets technical standards for a broad collection of products ranging from industrial automation systems to small electronic devices. NEMA uses different enclosure rating systems based on a product's location and its exposure to high-voltage energy. Type 6 is the second-highest rating for devices in outdoor, nonhazardous locations that withstand up to 1,000 volts.

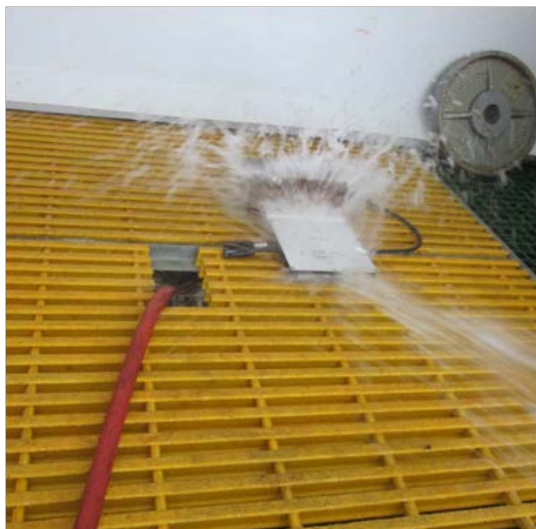
An enclosure designated NEMA 6 demonstrates five distinct levels of protection. It guards against:

- Outside access to hazardous parts
- Entry of rain, sleet or snow
- Ingress of solid foreign objects like windblown dust and lint
- Exposure to hose-directed water
- Damage caused by temporary submersion under water.

NEMA 6 is an important standard across various high-tech industries because it shows that electrical products are designed with the capability to weather adverse conditions. The telecommunications industry and other established technology providers also use the NEMA 6 standard. Enphase designs and produces microinverters that meet or exceed the NEMA6 standard.

### Vigorous Testing

Each level of protection has a corresponding set of test methods that independent laboratory technicians must follow before a product can receive NEMA 6 certification. To find out if a product guards against outside access to hazardous parts, test labs try inserting a set of rods sized to NEMA specifications through ventilated and non-ventilated enclosure openings. Contact with live electrical parts results in a failure. To show protection against rain, sleet or snow, a product must pass three separate tests: the test for entry of water through dripping or light splashing, entry of water from falling rain, and entry of water due to external icing. Each test follows standardized protocol. For example, the external ice test exposes products to subzero temperature and a continuous water spray until a sheet of ice with average thickness of roughly 0.75 inches has formed inside the test chamber.



*View of the Enphase M250 Microinverter undergoing the test for ingress of water (left) and the external icing test (right). Both tests were performed by an accredited, independent laboratory.*

To show protection against ingress of solid foreign objects, test labs blast compressed air with Portland cement inside a controlled test environment. The check for exposure to hose-directed water shoots water at the test unit at a rate of 65 gallons per minute. And for temporary submersion, products are dunked into six feet of water and left there for half an hour. If any of these tests expose the inside of the enclosure to dust or water, the test unit cannot obtain NEMA 6 certification.

## International Protection Rating

For international markets, Enphase Microinverters follow International Electrotechnical Commission (IEC) 60529, which has its own numerical system indicating the level of protection an enclosure has to isolate electrical components from people, foreign objects and water. These international ratings begin with the letters IP, standing for International Protection, and end with two numerals. The first numeral addresses the degree of protection against a person's access to hazardous parts and ingress by solid objects. The second numeral addresses protection against ingress by water. Enphase Microinverters have an IP67 rating, indicating the greatest protection with respect to people and solid objects and protection against temporary immersion in water. (For a full description of the IP codes and how they relate to NEMA ratings, see the NEMA white paper, "A Brief Comparison of NEMA 250 and IEC 60529".<sup>1</sup>)

## Enhanced Testing

Reliability testing on Enphase Microinverters goes well beyond the parameters set by NEMA and IEC. In our Petaluma, California, test lab, Enphase engineers repeat the temporary submersion test—only this time we extend the testing depth to 15 feet and leave the microinverter under water for 20+ days, all while the system is connected to power. We refer to this as "Enhanced NEMA" testing. In addition to water immersion, we simulate exposure to salt, fog and atmospheric acid. The salt test subjects microinverters to a five percent salt solution in 24 hour increments lasting a total of ten days. For the acid test, microinverters face down a solution of sulfuric acid and nitric acid for a total of 72 hours. Three times during the experiment, microinverters are sprayed with the solution in two-hour increments. These tests help to make sure microinverters can survive local environments where high levels of salt, fog and acid are present. The purpose of Enhanced NEMA is to take our microinverters far above their design limits to see how they perform when pressure and temperature go to the extreme.

## Reliability

Using an inverter that passes NEMA 6 testing provides the best degree of certainty for solar installers and system owners that the inverter will operate reliably throughout its expected lifetime. Historically, the solar industry has experienced high rates of inverter failures with products that fell short of the NEMA 6 standard. Inverters with NEMA 6 can also simplify supply chain management for installers by delivering a single product line that is suitable for conditions worldwide. With inverters that are certified to the NEMA 6 standard, there's no need for installers to stock one set of inverters for Arctic winters and another for the salty Pacific Coast shoreline. NEMA 6 enclosures can handle these extreme climates and more. The same cannot be said for inverters with enclosures using lower NEMA standards, such as Type 3R and 4X, which are subjected to only a portion of the tests that a NEMA 6 enclosure must pass.

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<sup>1</sup> <http://www.nema.org/Standards/Pages/A-Brief-Comparison-of-NEMA-250-and-IEC-60529.aspx>, accessed May 9, 2014

## NEMA Enclosure Types for Non-Hazardous Locations\*

Type	Description
<b>1</b>	Enclosure for indoor use. Provides protection against access to hazardous parts and ingress of solid foreign objects (falling dirt).
<b>2</b>	Enclosure for indoor use. Provides protection against access to hazardous parts, ingress of solid foreign objects (falling dirt) and ingress of water (dripping and light splashing).
<b>3</b>	Enclosure for indoor or outdoor use. Provides protection against access to hazardous parts, ingress of solid foreign objects (falling dirt and windblown dust), ingress of water (rain, sleet or snow), and damage caused by external formation of ice.
<b>3R</b>	Same as Type 3 enclosure except that protection against ingress of solid foreign objects does not include windblown dust.
<b>3S</b>	Same as Type 3 except that, instead of keeping enclosure undamaged by external formation of ice, external mechanisms remain operable when ice laden.
<b>3X</b>	Same as Type 3 plus an additional level of protection against corrosion.
<b>3RX</b>	Same as Type 3R plus additional protection against corrosion.
<b>3SX</b>	Same as Type 3S plus additional protection against corrosion.
<b>4</b>	Enclosure for indoor or outdoor use. Provides protection against access to hazardous parts, ingress of solid foreign objects (falling dirt and windblown dust), ingress of water (rain, sleet or snow, splashing water, hose-directed water), and damage caused by external formation of ice.
<b>4X</b>	Same as Type 4 enclosure plus additional protection against corrosion.
<b>5</b>	Enclosure for indoor use. Provides protection against access to hazardous parts, ingress of solid foreign objects (falling dirt and settling airborne dust), and ingress of water (dripping and light splashing).
<b>6</b>	Enclosure for indoor or outdoor use. Provides protection against access to hazardous parts, ingress of solid foreign objects (falling dirt, windblown dust and airborne dust), ingress of water (hose-direct water and temporary submersion), damage caused by external formation of ice.
<b>6P</b>	Same as Type 6 enclosure except this one provides protection against ingress of water during prolonged submersion and protection against corrosion.
<b>12</b>	Enclosure without knockouts for indoor use. Provides protection against access to hazardous parts, ingress of solid foreign objects (falling dirt and airborne dust), and ingress of water (dripping and light splashing).
<b>12K</b>	Same as Type 12 enclosure except this one has knockouts.
<b>13</b>	Enclosure for indoor use. Provides protection against access to hazardous parts, ingress of solid foreign objects (falling dirt and airborne dust), ingress of water (dripping and light splashing), and spraying, splashing and seepage of oil or non-corrosive coolants.

\*Table does not include NEMA Types 7, 8, 9 and 10, which are designed for hazardous locations.

Source: National Electrical Manufacturers Association white paper on NEMA enclosure types.  
<https://www.nema.org/Products/Documents/nema-enclosure-types.pdf>, accessed May 9, 2014.