

Enclosures & Weatherproofing

Guidance on selecting enclosures, IP ratings, cable management, and keeping your outdoor nodes reliable long-term.

- [Weatherproofing Your Build](#)

Weatherproofing Your Build

IP Ratings Explained

IP (Ingress Protection) ratings are defined by IEC 60529 and describe the degree of protection an enclosure provides against solid particles and liquids. The rating takes the form **IP[X][Y]** where X = dust protection (0 - 6) and Y = water protection (0 - 9K).

Ratings commonly used for outdoor LoRa mesh builds:

- **IP65** - Fully dust-tight. Protected against water jets from any direction. Suitable for outdoor use in most weather conditions. Minimum recommended for any outdoor fixed install.
- **IP67** - Fully dust-tight. Protected against temporary immersion in water up to 1 metre depth for 30 minutes. Preferred rating for outdoor installations exposed to rain, condensation, or occasional flooding.
- **IP68** - Fully dust-tight. Protected against continuous immersion at a depth specified by the manufacturer (commonly 1.5 - 3 m). Required for underground or submerged installations.

Recommendation: For outdoor fixed installations (repeaters, solar nodes, rooftop deployments), target IP67 minimum. IP65 is acceptable for sheltered or semi-covered locations.

Enclosure Types

- **Hammond 1554 Series** - Polycarbonate boxes available in many sizes, widely stocked by electronics distributors (Mouser, Digi-Key, RS). Clear or opaque lids available. Rated IP67. Excellent gasket quality. A popular and reliable choice.
- **Bud Industries PN Series** - NEMA 4X rated polycarbonate enclosures. Good availability in North America. Comparable quality to Hammond.
- **Fibox TEMPO Series** - European-origin polycarbonate enclosures with strong IP ratings. Often available with integrated mounting flanges.
- **PVC Electrical Junction Boxes** - Very cheap and widely available at hardware stores. Can be adequate for IP54 - IP65 applications, but gasket quality and seal consistency vary significantly between manufacturers. Avoid for IP67 requirements. Suitable as a low-cost option in sheltered outdoor locations.
- **RAK/Rokland Branded Enclosures** - Purpose-designed for WisBlock and common LoRa boards. Convenient mounting hardware but limited size options and higher cost-per-volume than generic enclosures.

- **Aluminium Die-Cast Boxes** - Excellent rigidity and EMI shielding. Good for installations near sources of interference. Heavier and more expensive than polycarbonate. Ensure the casting seams are properly gasketed.

Cable Glands

Every cable or connector penetrating the enclosure wall is a potential ingress point. Use proper cable glands:

- Select **IP68-rated cable glands** sized to match the outer diameter (OD) of each cable or pigtail. Most glands have a stated clamping range - e.g., "5 - 10 mm OD". Measure your cables before ordering.
- Common types include single-cable compression glands (most common), multi-cable glands, and armoured cable glands. For SMA pigtails, a standard single compression gland is appropriate.
- Apply **thread sealant** (PTFE tape or anaerobic thread sealant) to the threaded portion before installing the gland in the enclosure wall. This prevents water from wicking along the thread over time.
- After routing cables through the gland, tighten the compression nut firmly to form a seal around the cable jacket. Do not over-tighten - this can cut the jacket.
- After final installation, inspect glands annually and re-tighten if they have backed off.

Connector Weatherproofing

RF connectors are a significant vulnerability in outdoor antenna systems:

- **SMA connectors** are not inherently weatherproof and will corrode and degrade if left exposed to moisture. Protect all exposed SMA connections with **self-amalgamating (self-fusing) silicone tape**. Stretch and wrap tightly to form a watertight seal. Unlike electrical tape, self-amalgamating tape fuses to itself and does not unravel over time.
- **Rubber weather boots** are an alternative to self-amalgamating tape for frequently disconnected connections.
- For permanent or semi-permanent installations, consider upgrading the antenna interface to **N-type connectors**, which are inherently more weatherproof than SMA. RP-SMA connectors (used on some Meshtastic devices) are also more weather-resistant than standard SMA due to their larger contact area and thread pitch.
- Apply a thin layer of **dielectric grease** to connector threads before assembly to prevent corrosion and galvanic action between dissimilar metals (e.g. brass connector on aluminium mount).

Anti-Condensation Measures

Sealed enclosures are subject to condensation from thermal cycling - when the temperature drops rapidly, moisture from humid air inside the enclosure condenses on the coldest surfaces (often the PCB and electronics).

- **Silica gel desiccant packets** - Place one or more packets inside the enclosure to absorb residual moisture. Inspect and replace annually, or when the indicator colour changes. Reusable desiccant can be regenerated by heating in an oven at 120°C for 1 - 2 hours.
- **Gore-Tex breather vents** - Small membrane vents (available from Gore and from TE Connectivity) allow slow air and pressure equalisation without admitting liquid water. These dramatically reduce condensation in installations subject to frequent temperature swings. Drill a small hole in the bottom or side of the enclosure and install the vent according to the manufacturer's instructions.
- When sealing an enclosure, try to do so in dry conditions (low humidity). Sealing an enclosure containing humid air guarantees condensation when temperatures drop.

Thermal Management

Sealed enclosures in direct sunlight can reach internal temperatures well above ambient:

- A sealed black polycarbonate box in full summer sun can reach **70 - 80°C internally**, even with only 25 - 30°C ambient temperature.
- Most electronics (ESP32, nRF52840, SX1262) are rated to operate up to **85°C**, so they will likely survive. However, **Li-ion and LiPo batteries degrade significantly above 45°C** - expect accelerated capacity loss and reduced cycle life.
- Mitigation options:
 - Use a **light-coloured or white enclosure** to reduce solar heat absorption.
 - Mount the enclosure in a **shaded location** (north-facing in the Northern Hemisphere, under a roof overhang, etc.).
 - Drill a **screened vent hole at the bottom** of the enclosure to allow convective airflow. Use insect-proof mesh over the opening and silicone RTV around the mesh perimeter to maintain water resistance.
 - For battery longevity in hot climates, consider LiFePO4 chemistry, which tolerates higher temperatures better than Li-ion.

Sealing Cable Entries

1. After routing all cables through their glands and tightening the compression nuts, inspect each entry point from inside and outside the enclosure.
2. Apply a bead of **silicone RTV sealant** around the gland body on the inside of the enclosure wall, filling any gap between the gland and the enclosure surface.
3. Similarly, apply a small bead around the cable jacket immediately inside the gland nut.

4. Allow the RTV to cure for at least **24 hours** before exposing the installation to weather. Acetic-cure RTV (the type that smells like vinegar) releases acetic acid during curing - avoid contact with copper traces or sensitive electronics. Use neutral-cure RTV for electronics-adjacent applications.
5. Inspect all seals annually as part of routine maintenance.

Common Failure Modes

- **Gland nuts backing off** - Vibration (wind, vehicle traffic) can gradually loosen gland compression nuts, breaking the seal. Apply a drop of **medium-strength thread locker** (e.g. Loctite 243) to the nut threads after final tightening to prevent backing off.
- **Gaskets drying out and cracking** - Most enclosure lid gaskets are EPDM or silicone rubber. UV exposure and temperature cycling cause gradual hardening and cracking over 3 - 5 years. Inspect gaskets annually; replace when they show cracks, compression set, or fail to spring back when released.
- **Condensation from thermal cycling** - As described above, even well-sealed enclosures accumulate moisture over time. Include desiccant and inspect annually. A persistent wet interior despite intact seals is a sign the breather vent is absent or blocked.
- **Corrosion at SMA connections** - Particularly common in coastal or industrial environments with salt or pollutant exposure. Self-amalgamating tape plus dielectric grease prevents this. Inspect and re-tape annually.
- **UV degradation of polycarbonate** - Clear polycarbonate yellows and becomes brittle after several years of direct UV exposure without UV stabilisation. Use UV-stabilised (UV-resistant) enclosure materials, or apply a UV-protective coating to the outside of standard polycarbonate boxes.