Cable Glands and Penetrations

The gasket between the lid and body of your enclosure gets all the attention, but **cable penetrations are the number-one field failure mode in outdoor electronics**. Water does not enter through a well-maintained lid seal - it enters through poorly installed or incorrect cable glands, or through cables that enter the enclosure without any gland at all. This page covers everything you need to seal cable entries correctly.

Why Cable Glands Matter

A cable gland (also called a cable strain-relief fitting or PG fitting) serves three functions simultaneously:

1. **Sealing:** It forms a watertight seal around the cable jacket, preventing liquid ingress at the point where the cable crosses the enclosure wall.
2. **Strain relief:** It clamps the cable so that tension on the external cable cannot be transmitted to the internal solder joints or connectors.
3. **Anti-rotation:** It prevents the cable from twisting inside the enclosure as it moves in wind or is pulled during servicing.

A common mistake is to drill a hole, pass the cable through, and seal around it with silicone RTV. This is not reliable long-term: silicone can shrink and crack, adhesion to polycarbonate is poor, and the seal is permanently destroyed the first time you need to reroute the cable. Use proper cable glands.

IP68-Rated vs IP65-Rated Cable Glands

Cable glands carry their own IP rating, independent of the enclosure:

- **IP65-rated glands:** Suitable for covered outdoor use and most exposed outdoor installations with rain. Less expensive and widely available. Typically a simple rubber cone insert that compresses around the cable.
- **IP68-rated glands:** Required for marine, submersion, or mission-critical outdoor nodes. These use a clamping insert with a labyrinth seal or a multi-piece compression fitting. Cost approximately $1 - $3 more per gland. Brands: Roxtec, Icotek, Jacob GmbH, and generic metric cable glands from Digi-Key.

Rule: If your enclosure is rated IP67 or IP68, every cable gland installed in it must also be rated IP67 or IP68. Installing an IP65 gland in an IP68 enclosure brings the system rating down to IP65.

Gland Sizing by Cable Type

Cable glands are sized to match both the thread entry in the enclosure wall and the diameter range of the cable passing through. Metric thread sizes (M-series) are standard for most IP-rated enclosures. Knockout-style enclosures (Hammond, Polycase) ship with blanked holes sized for common gland threads.

Thread size	Cable diameter range	Common use in LoRa builds
M12	3 - 6.5 mm OD	Thin antenna coax (RG-174, LMR-100), USB cables, small 2-conductor power leads
M16	5 - 10 mm OD	Standard antenna coax (RG-58, LMR-195), FTDI/serial cables, 3-conductor leads
M20	7 - 13 mm OD	LMR-400 coax, multi-conductor power cables, heavier solar charge cable
M25	10 - 17 mm OD	Multi-conductor shielded cable bundles, large solar panel leads

Always measure your cable's actual outer diameter with calipers before ordering glands. Cable labeling often specifies conductor gauge, not OD. An RG-58 coax, for example, is approximately 5.0 mm OD - it fits an M16 gland but is too large for most M12 glands.

Material Selection

Material	Environment	Notes
Nylon (PA66)	General outdoor, UV exposure, fresh water	Best choice for most LoRa builds; lightweight, inexpensive, good chemical resistance; can become brittle after 5 - 10 years in direct UV without UV stabilization - buy UV-stabilized nylon glands if possible
Polypropylene (PP)	Chemical environments, fuel/oil exposure	Better chemical resistance than nylon; slightly more flexible at low temperatures

Material	Environment	Notes
Stainless steel (316L)	Marine, saltwater, coastal	Required for saltwater environments - nylon and PP glands corrode and seize in marine conditions; more expensive (~$3 - $8 per gland) but the only correct choice within 5 km of saltwater
Brass (nickel-plated)	Industrial, high-vibration	Strong and resistant to vibration-induced loosening; avoid in saltwater (galvanic corrosion with aluminum enclosures)

Sealing Technique: Getting It Right

A cable gland is only as good as its installation. Follow this procedure:

1. **Drill the correct hole size** for the gland thread. M12 requires a 16 mm hole; M16 requires a 20 mm hole; M20 requires a 25 mm hole. Use a step drill bit for clean holes in polycarbonate - standard twist bits can crack PC.
2. **Apply PTFE (Teflon) thread tape** to the gland's male threads before insertion. Two or three wraps is sufficient. This improves the seal between the gland body and the enclosure wall, especially if the knockout hole is slightly oversized.
3. **Insert the gland body from outside the enclosure** and thread the locknut on the inside. Hand-tighten, then add 1/4 turn with a wrench - no more. Over-tightening cracks the nylon nut and defeats the seal.
4. **Pass the cable through the open gland** (with the compression nut backed off) and route it to its termination point inside the enclosure.
5. **Tighten the compression nut** hand-tight plus 1/4 turn until the cable is firmly gripped and cannot be pulled through. Test by tugging the cable - it should not move.

Over-tightening warning: Nylon glands crack at the compression nut if overtorqued. If you feel significant resistance before the cable is gripped, stop and check that you have the correct gland size for your cable diameter. A gland that is too large for the cable cannot seal properly regardless of torque.

Potting Compound: Permanently Sealed Entries

For entries that will never need to be reopened - a permanently-installed power cable or antenna coax - potting compound (also called cable entry seal or cable fill) provides a superior seal to a mechanical gland. Two-part polyurethane or silicone potting kits are available from RS Components and Digi-Key. The procedure:

1. Pass the cable through the entry hole.
2. Build a small dam around the hole with tape or a temporary form.
3. Mix and pour the potting compound, ensuring it wets the cable jacket and enclosure wall.
4. Allow to cure fully before installation (typically 24 hours at room temperature).

Do not use potting compound on entries that might ever need cable replacement or service access.

Self-Amalgamating Tape on External Antenna Connectors

Every antenna connector that is exposed to weather outside the enclosure must be weatherproofed with **self-amalgamating (self-fusing) tape**. This applies to N-connectors, SMA connectors, and any PL-259 connector on your antenna feedline junction:

1. Wipe the connector with isopropyl alcohol and allow to dry.
2. Stretch the self-amalgamating tape to approximately twice its resting length as you wrap - this activates the self-fusing adhesive.
3. Begin wrapping 2 cm below the connector junction and end 2 cm above it, overlapping each wrap by 50%.
4. Apply at least two layers for exposed outdoor connectors; four layers for marine environments.
5. Optionally apply a layer of standard black vinyl electrical tape over the self-amalgamating tape as UV protection (self-amalgamating tape degrades in UV faster than vinyl).

Drip Loops

A **drip loop** is the practice of routing every cable entering the enclosure so that it hangs below the entry point before rising to its termination - forming a low point where water drips off rather than running into the enclosure along the cable jacket.

Install drip loops on every cable entering the enclosure, including the antenna feedline, power cables, and any USB or serial connections. A drip loop requires only 10 - 15 cm of extra cable length and is the single most effective passive measure against water ingress through cable entries.

Conduit Entry vs. Direct Cable Gland

For fixed permanent installations where cables run long distances from the enclosure to a power source or antenna base, conduit is preferable to direct cable glands:

- Conduit protects the cable from UV, abrasion, and rodent damage over its entire run.

- Conduit entries use a weatherproof conduit connector at the enclosure wall rather than a cable gland - these are available in liquidtight flexible conduit (LFMC) versions for IP65+ use.
- Use **Schedule 40 PVC conduit** for buried runs and UV-rated gray PVC or LFMC for exposed above-ground runs.
- The conduit entry at the enclosure must still be sealed - use a conduit-to-enclosure seal or conduit hub with an integrated gasket.
- Direct cable glands are preferable when the cable run is short (under 1 m) or when flexibility is needed at the enclosure end (e.g., an antenna cable that may be repositioned).

Revision #2
Created 2026-05-03 05:49:40 UTC by Mesh America Admin
Updated 2026-05-03 13:00:46 UTC by Mesh America Admin