Cable Glands and Penetrations

The gasket between the lid and body of your enclosure gets all the attention, but **cable penetrations are among the most common ingress failure points in outdoor electronics**. Cable penetrations are a more common water-ingress path than a properly maintained lid seal - water tends to enter 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. Acceptable for IP65/IP67 sheltered builds. 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 (use only where the enclosure itself is IP68 or for marine). These use a clamping insert with a labyrinth seal or a multi-piece compression fitting. Cost approximately $1 - $3 more per gland (cost delta is approximate). Brands: Icotek, Jacob GmbH, and generic metric cable glands from Digi-Key. (Roxtec makes cable-transit systems for sealing multiple cables through a frame rather than standard single-cable glands.)

Rule (gland IP must meet or exceed enclosure IP): Every cable gland must be rated at least equal to the enclosure's IP rating. IP65 glands are acceptable for IP65/IP67 sheltered builds; reserve IP68 glands for IP68 or marine enclosures. Installing a gland rated lower than the enclosure brings the system rating down to the gland's rating. This is the same rule used on the weatherproofing pages - see Weatherproofing Enclosures for the canonical convention.

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. This page is the canonical gland-sizing reference for the build pages; other pages should link here rather than restate sizes.

Thread size	Cable diameter range	Common use in LoRa builds
M12	3 - 6.5 mm OD	Thin antenna coax (RG-174, LMR-100), RG-58, 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	8 - 13 mm OD (ranges vary by maker, roughly 6 - 13.5 mm)	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

PG-to-Metric Cross-Reference

Some builds and suppliers specify glands in PG (Panzergewinde) thread sizes rather than metric M. Use this crosswalk so every gland-mentioning page can reference one canonical sizing reference. PG sizes refer to the cable OD range each accepts:

PG size	Cable OD range	Closest metric equivalent

PG7	3 - 6.5 mm	~M12
PG9	4 - 8 mm	~M16
PG11	5 - 10 mm	~M16 / M18
PG13.5	6 - 12 mm	~M20
PG16	10 - 14 mm	~M20 / M22
PG21	13 - 18 mm	~M25

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 both an M12 gland (3 - 6.5 mm) and an M16 gland; M16 is often preferred for easier strain relief. Note that RG-58 is lossy at 915 MHz (~0.5 dB/m), so use it only for very short jumpers; prefer LMR-195/LMR-240 or better for any run longer than about 0.3 m.

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 in direct UV without UV stabilization (an often-cited estimate is 5 - 10 years, but this depends heavily on UV exposure and stabilization) - buy UV-stabilized (black) nylon glands for direct sun
Polypropylene (PP)	Chemical environments, fuel/oil exposure	Better chemical resistance than nylon; slightly more flexible at low temperatures. Note: unstabilized PP degrades faster than nylon under UV - reserve PP for shaded or chemical-exposure use
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. Metric M-glands thread into a hole of approximately their nominal thread diameter plus a little clearance: M12 needs about a 12.5 mm hole, M16 about 16.5 mm, M20 about 20.5 mm, and M25 about 25.5 mm. Use a step drill bit to reach the gland's nominal thread diameter for clean holes in polycarbonate - standard twist bits can crack PC. **Wear eye protection when drilling enclosures; deburred plastic chips can injure eyes.**
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 - follow the product datasheet; full cure is often around 24 hours at room temperature but varies by product.

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 one of the most effective low-cost passive measures 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).

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