HUIJUE GROUP

# Why Outdoor Telecom Cabinets Condense—and How to Prevent It

Learn why outdoor telecom cabinets condense, how to distinguish dew from water ingress, and which monitoring, sealing and control measures prevent recurrence.

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Use water patterns, event timing, dew-point margin and equipment-state records to distinguish condensation from leaks and select the right corrective action.

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**Contents**
 Water on a cabinet floor is evidence, not yet a diagnosis. Wiping it away, replacing a door gasket or adding a heater before recording the pattern can erase the distinction between dew, rain ingress, an air-conditioner drain fault and moisture arriving through a conduit.

A useful **outdoor cabinet condensation** investigation preserves the first evidence: where the water started, which surfaces were wet, whether rain occurred, how cabinet and outdoor temperatures changed, and which fans, heaters, cooling units and loads were operating. The corrective action should follow that history.

**Electrical safety comes first.** If water is near exposed energized conductors, protection devices, battery terminals or damaged insulation, restrict access and follow the operator’s approved isolation and electrical-safety procedure. Do not reach into an energized wet cabinet to collect measurements.

## Why do outdoor telecom cabinets condense?

Condensation forms when a cabinet surface falls to or below the dew-point temperature of the air touching it. The event needs both a moisture source and a sufficiently cold surface; high relative humidity by itself does not identify where water will appear.

NOAA’s humidity explanation defines dew point as the temperature at which water vapour turns into liquid droplets. It also explains why relative humidity changes with temperature: cooler air reaches saturation with less water vapour than warmer air.

Inside a telecom cabinet, the trigger may be a rapid outdoor temperature fall, cold rain or wind cooling a panel, reduced equipment load after a shutdown, cooling-unit operation, or humid air admitted during service. Metal frames, door returns, mounting rails, roof joints and cooling-unit interfaces can run colder than the air sensor indicates.

The amount and location of **telecom cabinet moisture** also depend on air movement. Natural convection carries warm moist air toward upper surfaces; supply air can create a cold local zone; cable ducts and floor entries can deliver moisture near the base. A single sensor in the warmest part of the cabinet may miss the surface that reaches dew point first.

## Is water inside an outdoor cabinet always condensation?

No. Water inside an outdoor cabinet may be condensation, direct weather ingress, cooling-system condensate, conduit drainage, cable wicking or residual installation moisture. Location and timing narrow the cause, but they should be checked against measurements and inspection rather than treated as proof on their own.

| Observed pattern | Cause to investigate | Evidence to collect next |
|---|---|---|
| Fine droplets or a film across an inner roof, door or other cold metal after a temperature fall | Surface temperature crossing the internal-air dew point | Time-aligned internal humidity, air temperature and surface temperature at the wet location |
| A localized track below a roof seam, gasket, handle, gland or fastener after rain or washdown | External water path | Run marks, dust trails, gasket compression, fastener sealing and an approved water-ingress inspection |
| Water begins near an air conditioner, drain pan or hose during cooling operation | Condensate collection or drainage fault | Drain slope, blockage, trap arrangement, hose routing, pan condition and cooling-state log |
| Water appears at a cable entry or conduit even without recent rain at the cabinet | Conduit drainage, capillary path or moisture from another enclosure | Upstream route, conduit seals, cable loop, entry orientation and water found inside the pathway |
| Wet insulation, packaging, filters or floor material shortly after installation or cleaning | Moisture trapped before the cabinet was closed | Commissioning record, drying method, material condition and door-opening history |

Do not drill an improvised drain hole as a diagnostic shortcut. It can change ingress protection, insect and rodent control, airflow, fire behaviour, corrosion protection and the path of water toward live equipment. Any drain or breather belongs in the approved enclosure design.

## Can a sealed or IP-rated telecom cabinet still condense?

Yes. An IP-rated cabinet can still condense because ingress classification does not mean the enclosure contains dry air forever or that every internal surface remains above dew point. Moisture can be trapped during assembly or service, and the completed cabinet may exchange air through intended vents, pressure-equalization devices, cable systems or imperfect interfaces.

Temperature cycles change internal air density and pressure. This “breathing” can move small amounts of air through the available path, while a door opening can exchange much more air in minutes. Once humid air is inside, an evening temperature drop or a cold structural bridge can produce dew without a rain leak.

The IP55 versus IP65 telecom cabinet guide explains the separate dust-and-water boundary. Neither rating is a humidity-control specification. ETSI EN 300 019-1-4 V3.1.1 classifies environmental conditions for stationary telecom equipment at non-weatherprotected locations, including temperature and humidity conditions that must be selected for the deployment.

Huijue references reviewed for this article describe outdoor cabinet families with project-dependent natural ventilation, fan, heat-exchanger and air-conditioner variants. They also list temperature/humidity sensing and some thermal-control equipment with heating among available options. Those documents do not establish one universal anti-condensation mode, setpoint or humidity performance; the active model, control logic and bill of materials must be confirmed.

## How can a site team prove what caused cabinet condensation?

Build a time-aligned event record that compares internal dew point with the temperature of the surface that became wet. Add weather, load, door and thermal-control states so the team can see what changed before the first droplets appeared.

At minimum, record internal air temperature and relative humidity, temperature at the suspected cold surface, outside temperature and humidity, rain or washdown, cabinet load or power state, door openings, fan/heater/cooling commands and alarms. For a cooling unit, include compressor state and condensate-drain observations. Use synchronized timestamps.

ETSI ES 202 336-12 V1.3.1 provides a current telecom monitoring information model that includes environmental parameters such as temperature and humidity. The measurement chain, sensor accuracy, location, time synchronization and retained history still need to be specified for the cabinet and the fault being investigated.

**Dew-point margin:** $M = T_{surface} - T_{dew}$

A positive M means the measured surface is above the calculated dew point at that time. At or below 0 °C margin, condensation is physically possible. Apply sensor uncertainty and allow for colder unmeasured spots before choosing an alarm or control threshold.

The **cabinet dew point** is calculated from air temperature and relative humidity at the same location and time. For an illustrative screening case, air at 28 °C and 85% RH has a dew point of approximately 25.2 °C. If a nearby metal return is measured at 23 °C, its margin is about −2.2 °C. These are hypothetical values, not Huijue operating limits or a universal control setting.

Place sensors to answer the fault, not merely where installation is easy. One probe near a warm exhaust cannot represent a cold door edge. A practical investigation may use one air sensor near the equipment inlet, another near the suspected moisture zone and temporary surface probes on the roof, door return, base or cooling interface. Keep probes away from direct spray and document their accuracy and mounting.

**Preserve the sequence.** A photograph taken after the cabinet warms up may show only a puddle. Trend data can reveal whether the surface cooled first, humid air entered first, a compressor started, the load disappeared or rain reached a particular interface.

## Trace the moisture path before choosing a fix

Start at the first wet point and work outward. The inspection should connect a physical path to the event timeline; finding a damaged gasket is not enough if water consistently begins at an air-conditioner drain.

1. **Roof and door:** inspect drip edges, seams, welds, fasteners, gasket continuity, compression marks, corner joints and door alignment. Look for deposits that reveal repeated flow.
2. **Cable and conduit entries:** check gland size, blanking plugs, entry orientation, drip loops, conduit sealing, cable jacket damage and whether water can arrive from an upstream chamber.
3. **Cooling assembly:** inspect the evaporator zone, drain pan, hose, slope, trap if specified, outlet blockage and sealing around the mounted unit. Compare findings with compressor runtime.
4. **Ventilation route:** verify filter condition, fan direction, louvre drainage, emergency vent operation and whether humid outside air is being drawn into a colder cabinet.
5. **Cold structures:** map door frames, roof stiffeners, mounting rails, base members and attached cooling frames. A thermal bridge can condense while the cabinet air remains above the sensor’s alarm threshold.
6. **Installation and service history:** check wet packaging, cleaning water, uncured sealant, open-door work during humid weather, stored spare filters and

recent field drilling.

Material corrosion is a consequence pathway rather than the condensation diagnosis itself. Use the telecom cabinet material guide to specify substrates, coatings, cut-edge repair and dissimilar-metal interfaces after the moisture source is understood.

## Which method prevents outdoor cabinet condensation?

The effective method removes the identified moisture source, keeps vulnerable surfaces above dew point, removes water vapour, or combines those actions. A heater, fan, desiccant, air conditioner, membrane vent or thicker wall can each help under specific conditions, but none corrects every failure mechanism.

| Confirmed mechanism | Engineering response | Shortcut to avoid |
|---|---|---|
| Rain, washdown or conduit water | Repair and verify the exact external path; correct drainage, seals, entry geometry or upstream conduit condition | Adding heat to evaporate water that should not enter |
| Humid air trapped during installation or service | Dry the cabinet and materials, limit open-door exposure and define a controlled recovery period | Closing the cabinet quickly with wet filters, insulation or floor material inside |
| A localized surface falls below dew point | Reduce the thermal bridge, adjust insulation where justified, or apply controlled heat with verified clearances | Raising the whole cabinet temperature without checking batteries, electronics or energy demand |
| Open-loop ventilation imports moisture | Control airflow from outside-air dew point or moisture content, cabinet temperature and equipment limits | Using outside relative humidity alone to decide whether air is “dry” |
| Cooling condensate does not drain | Correct pan, hose, slope, outlet, freeze or blockage issues and add maintainable inspection access | Sealing the puddle inside the cooling compartment |
| Pressure cycling moves moist air through leaks | Repair unintended leakage and evaluate a qualified pressure-equalization strategy within the enclosure design | Assuming a membrane vent is a dehumidifier |

Good **condensation prevention** also respects the thermal architecture. Open-loop fans exchange internal and external air; they may dry the cabinet only when the incoming air and surface temperatures make that possible. A closed-loop heat exchanger transfers sensible heat but does not inherently remove internal water vapour. An air conditioner can dehumidify while its refrigeration cycle produces condensate, provided that condensate is collected and drained correctly.

Desiccant can absorb a limited amount of moisture during shipping, storage or a controlled transient. It saturates and needs a defined inspection or replacement interval, so it should not mask a continuous leak or repeated breathing problem. Likewise, a pressure-equalization vent can reduce pressure-driven exchange through uncontrolled gaps but cannot guarantee a dry interior.

Wall construction affects the location and duration of cold surfaces. The single-wall versus double-wall cabinet comparison explains why insulation can reduce inward heat flow in one condition yet slow the escape of internal heat in another. Address remaining thermal bridges and moisture access instead of specifying “double-wall” as a universal cure.

## Can an anti-condensation heater solve the problem?

An anti-condensation heater can help when it keeps the vulnerable surface safely above dew point, but it does not remove liquid water or repair an ingress path. Heater capacity, placement, control logic, energy source, surface temperature, cable clearance and nearby battery limits must be engineered together.

Temperature-only control may miss a humid event, while humidity-only control can energize heat when surfaces already have adequate margin. A dew-point-margin or combined temperature/humidity strategy is more directly related to condensation, provided the sensors represent the critical location and include suitable deadband, minimum runtime, alarm handling and failure behaviour.

A complete **cabinet humidity control** sequence should state what happens during loss of grid or generator supply, low battery reserve, cooling shutdown, fan failure, door opening and sensor failure. The project may choose to preserve critical load rather than run a heater during an energy emergency; that priority must be explicit rather than discovered during the first outage.

Do not place a heater beneath a battery, cable bundle, plastic component or drain without a thermal and safety review. Confirm surface-temperature limits, protective guards, over-temperature protection, wiring protection and maintenance access for the active cabinet configuration.

## Verify the correction under the event that caused the fault

A repair is complete only when the original moisture path no longer recurs under a representative condition. Repeat the relevant rain, cooling, temperature-drop, door-opening or low-load sequence with synchronized measurements and agreed acceptance criteria.

Commissioning should verify dry internal materials, drain function, gasket and gland workmanship, fan direction, filter condition, heater and cooling commands, sensor calibration or comparison, timestamp alignment, alarm delivery and the response to a failed sensor. Preserve photographs, trends, settings and inspection results against the cabinet or project identifier.

IEC 60068-2-30:2025 defines a cyclic damp-heat test that generally produces condensation on the specimen. IEC 60068-2-38:2021 provides a composite temperature/humidity/cold procedure intended mainly for component-type specimens. These methods can inform an environmental verification plan, but the project must state the applicable specimen, operating state, severity, measurements and pass criteria; a component result is not automatic proof for a populated cabinet.

IEC 61969-3:2023 establishes basic environmental requirements, tests and safety aspects for outdoor enclosures at non-weatherprotected locations. Operator requirements, the selected environmental class and the final integrated configuration still govern acceptance.

## Standards and technical references

- NOAA: What Is Humidity? — relative humidity and dew-point fundamentals.
- ETSI EN 300 019-1-4 V3.1.1 — environmental conditions for stationary telecom equipment at non-weatherprotected locations.
- ETSI TR 101 576 V1.1.1 — application of environmental classes in outdoor cabinet environments.
- ETSI ES 202 336-12 V1.3.1 — telecom power, energy and environmental monitoring information model.
- IEC 60068-2-30:2025 and IEC 60068-2-38:2021 — cyclic damp-heat and composite temperature/humidity/cold tests.
- IEC 61969-3:2023 — outdoor enclosure environmental requirements and tests.

The troubleshooting paths in this guide are engineering guidance, not a declaration that a specific Huijue cabinet has passed a particular humidity, condensation or environmental test. Use the approved model documentation and project acceptance plan.

## Turn a cabinet water event into an engineering record

Send Huijue the first-wet-location photographs, cabinet configuration, site weather, internal temperature/humidity trend, suspected surface temperatures, load and thermal-control states, door history and drain observations. Our engineering team can help separate the likely mechanism from the evidence still needed.

Request a condensation review

## Related engineering resources

Outdoor Telecom Cabinet Guide
Single-Wall vs Double-Wall Cabinets
Outdoor Telecom Cabinet Materials
Telecom Energy Monitoring KPIs

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