techno
TECHNOLOGY & INNOVATION



COMPLETE E-BOOK

Industrial electrical connections

Engineering, reliability and efficiency in industry

66 pages | 7 parts · 29 chapters | Professional checklist

TECHNICAL CONTENT
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This is the complete version, for reference and specification. There is also the **basic e-book**, a 20-page introduction.

How to use this guide

This material is organised in seven independent parts. Designers can start with Part II. Maintenance teams, with Part III. Buyers and those accountable for results, with Part IV. Those leading continuous improvement, with Part VII.

Throughout the text, each piece of information shows its origin:

MARKING	MEANING
TECHNO	Data from the company's general catalogue or technical presentation
STANDARD	Content from an IEC, ISO, ABNT, EN or UL technical standard
LITERATURE	Established concept in maintenance, reliability or Lean literature
ILLUSTRATIVE EXAMPLE	Hypothetical figure or situation, created to explain a concept

No illustrative example represents a result measured at a customer. When there is a real record, the text states the source.

Technical content: Mario Adinolfi, Director of Techno do Brasil. **Analysis and editing:** Prof. Eng. Vagner Soares, Manufatura Enxuta portal (manufaturaenxuta.com.br).

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PART

1

Fundamentals of industrial connections

01 The connection as a strategic element of production

02 Anatomy and operation

03 Technologies and functions

04 Industrial environments and their demands

CHAPTER 01

The connection as a strategic element of production

An electrical design details loads, protections and conductor sizes. It rarely states how many times the cable is interrupted between the panel and the load. Yet it is at these interruptions that the reliability of the circuit is decided.

The cable is continuous and protected. The motor is enclosed. The sensor is factory-sealed. The splice, the branch, the panel entry and the connection to the equipment are the points where someone, in the field, has to rebuild the insulation and sealing the cable had from the factory.

Three reasons make this point strategic:

1. **It works in series.** A single failed connection brings down the whole circuit.
2. **It fails silently.** Degradation from moisture and oxidation is slow and stays hidden in boxes and trays.
3. **It costs little and decides a lot.** The component price is small next to the cost of a stoppage.

KEY IDEA

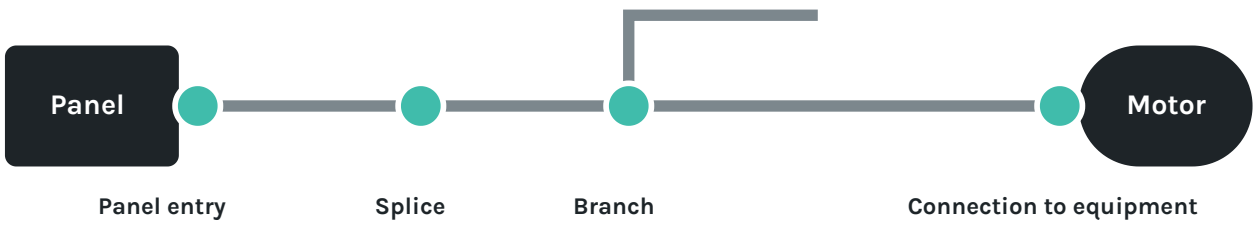
Treating the connection as a line on a shopping list transfers the cost of the decision to maintenance and production.



THE ENGINEER'S VIEW

The electrical design details loads, protections and conductor sizes, but almost never states how many times the cable is interrupted on a critical line. Without that number there is no way to calculate the reliability of the circuit or prioritise investment.

Prof. Vagner Soares, Manufatura Enxuta



Each green dot is a cable interruption, where the original protection has to be rebuilt in the field.

CHAPTER 02

Anatomy and operation

Every high-protection connection is made of the same elements.

ELEMENT	FUNCTION	MATERIALS CITED IN THE CATALOGUE TECHNO
Contacts	Carry current or signal	Brass, with steel screws
Insulating body	Separates the poles and holds the contacts	PA66 with glass fibre, UL94 V0
Enclosure	Protects against the environment and impact	PA66, with or without glass fibre
Seals	Close the interfaces between parts	TPE or silicone, depending on the series
Cable gland	Holds the cable and seals the entry	PA66 UL94 V2, with TPE grommet
Lock	Keeps the coupling together under vibration	Push-pull, twist or bayonet

How the contact is made

The way the conductor is clamped changes installation time and the tool needed. The Techno product code indicates the system TECHNO:

PREFIX	CONTACT SYSTEM	FEATURE
THB	Screw	Traditional solution, wide cross-section range
THS	Spring	Tool-free, accepts solid and stranded cable
THP	Insulation-piercing	Contact without stripping the conductor
THF	Push-in	Fast assembly
THC	Overmoulded	Cable factory-moulded onto the connector

How the seal is made

There are three paths for water to enter a connector, and each one calls for a barrier:

- **Between the enclosure parts:** sealed by gaskets.
- **Around the cable:** sealed by the cable gland, which compresses a rubber onto the sheath.
- **Inside the cable:** the gaps between conductor strands act as capillaries. This path is only closed by an internal barrier, the subject of chapter 10.

CHAPTER 03

Technologies and functions

Techno's catalogue is organised by the function the point performs in the circuit, not by sector TECHNO. This logic helps with specification: first define what the point does, then the environment it works in.

FUNCTION	SOLUTION	WHEN TO USE IT
Splice	In-line connector	Cable repair or extension, permanent connection
Branch	T, Y or H connector	One input and two or three outputs, as in lighting runs
Disconnect	Plug and socket	Equipment removed for maintenance, calibration or replacement
Enter a panel	Panel connector	Connection made from outside, without opening the equipment
Distribute	Box or distributor	Several cables, terminals or electronics at the same point
Seal the entry	Cable gland	Cable entry into a box or machine

Permanent or disconnectable?

The question that separates a splice from a plug and socket is simple: **how often will this point be opened?**

- If the answer is "never, except for repair", a splice does the job and takes less space.
- If the equipment is removed for maintenance or calibration, a plug and socket cuts replacement time and removes the risk of swapping phases on reconnection.

The catalogue states the number of mating cycles per series, 100 or 1,000 cycles TECHNO. This figure guides the choice at frequently used points.

Field-assembled or pre-wired?

In pre-wired versions the cable leaves the factory already moulded onto the connector. The catalogue describes options from 2 to 5 poles, up to 17.5 A and 500 V, IP68 and cables from 0.5 to 5 m, with electrical and mechanical tests on every production run TECHNO. Assembly and testing move from the field to the factory.

1

What does the point do?

- Splice or branch
- Disconnect
- Enter a panel
- Distribute or seal

2

Will it be opened often?

- No: splice
- Yes: plug and socket
- Check the series cycles

3

Field or factory assembly?

- Field: screw or spring
- Factory: pre-wired, tested version

CHAPTER 04

Industrial environments and their demands

The environment defines the connection. The table gathers applications shown in Techno's catalogue and technical presentation, with the dominant aggressor in each.

ENVIRONMENT	DOMINANT AGGRESSOR	MAIN REQUIREMENT
Food and meat processing	Hot-water and chemical washdown, thermal shock	Resistance to high-pressure, high-temperature jets
Water and wastewater	Immersion, sewage, constant humidity	IP68, hydrolysis-resistant materials
Pulp and paper	Humidity, heat, chemicals	Stable sealing under continuous heat
Underground networks	Flooded pull boxes	Prolonged immersion, reinspectable connection
Outdoor areas	Sun, rain, daily thermal cycle	UV resistance and condensation control
Grain and milling	Fine dust, vibration	Dust-tightness and secure lock
Ports and coastal areas	Salt mist	Corrosion resistance
Agricultural machinery and vehicles	Washdown, vibration, impact	Lock, high IK and jet protection
Field instrumentation	Floodable chambers, periodic calibration	Quick disconnection with high protection

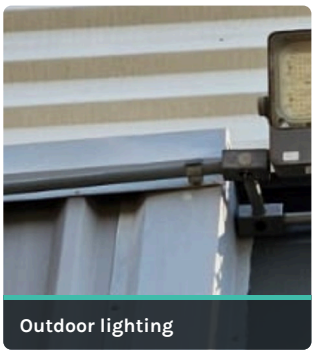
PRACTICAL TIP

Describe the environment by what happens on the worst day of the year, not by what happens most of the time. The connector has to survive the worst day.


Meat processing


Underground network


Ground lighting


Outdoor lighting

Photos of real applications. Source: Techno technical presentation.

TO GO DEEPER

- Conexões elétricas industriais: o ponto fraco da produção
- Techno do Brasil: tecnologia em conexões elétricas

PART

II

Engineering and technical specification

05 The three-stage selection method

06 Sizing and compatibility

07 Protection rating: IP66, IP67, IP68 and IP69

08 Mechanical strength: the IK code

09 Materials, sealing and ageing

10 Condensation, ingress and capillarity

11 Common specification and installation errors

CHAPTER 05

The three-stage selection method

Techno's technical presentation sums up specification in three stages, for a correct and durable power or signal installation TECHNO.

Stage 1: analysis of the external environment

Seven agents must be assessed at the exact point of installation:

1. Humidity
2. Water
3. Chemicals
4. Pressure
5. Heat
6. Temperature variation
7. Condensation

Stage 2: choosing and matching the cables

Four pieces of cable data go into the specification:

1. Outer diameter
2. Number of poles
3. Cross-section of each pole
4. Technical specification of the cable

Stage 3: eliminating the weak points

1. Draw the circuit layout.
2. Measure the distances between components.
3. Identify and count every cable interruption.
4. Classify each interruption: straight splice, T, Y, H or multiple branch.
5. Highlight changes in cable size at the interruptions.
6. Measure the distances between interruptions.

> **WHY STAGE 3 IS THE MOST FORGOTTEN**
>
> Stages 1 and 2 deal with each point in isolation. Stage 3 looks at the whole circuit. That is where you discover that a critical line has twenty interruptions when it could have twelve.

CHAPTER 06

Sizing and compatibility

Electrical parameters

PARAMETER	WHAT TO CHECK
Current	Series rated current equal to or higher than the circuit's
Voltage	Series rated voltage equal to or higher than the circuit's
Number of poles	Power and signal may need different poles and connectors
Conductor cross-section	Must be within the terminal range
Alternating or direct current	Confirm DC application, as in lighting and IoT

In Techno's catalogue the series cover up to 41 A and 690 V in TEETUBE splices and up to 25 A and 630 V in TEEPLUG connectors TECHNO.

Temperature: two different figures

The catalogue gives two temperature figures that should not be confused TECHNO:

- **Minimum and maximum material temperature:** in most series, from −40 °C to +125 °C.
- **T-marking:** the operating temperature for which the series was qualified, which varies between +60 °C, +85 °C, +100 °C and +125 °C depending on the product.

The figure that limits the application is the series T-marking.

The cable is part of the seal

The cable gland seals by compressing a rubber onto the cable sheath. This only works within the stated diameter range.

- **Cable too thin:** the rubber does not reach the necessary compression.
- **Cable too thick:** the rubber is crushed and suffers permanent deformation.
- **Oval cable or uneven sheath:** the seal is uneven.

Permanent deformation under compression, known as compression set, is the phenomenon by which rubber loses its reaction force over time LITERATURE. Keeping the cable in the correct range preserves the sealing margin.

Cable sheath material

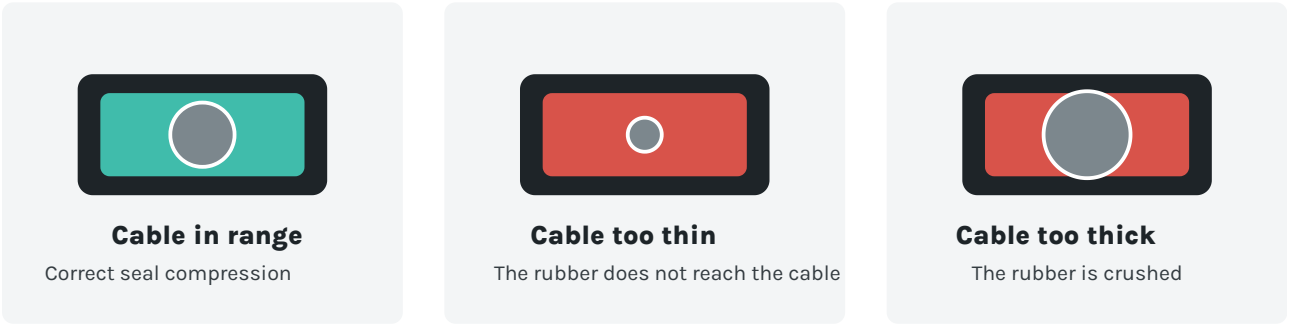
Techno's presentation highlights two materials TECHNO:

MATERIAL	FEATURE	INDICATION
EPR	Flexibility and good performance in water and damp locations	Underground networks, wet areas
Polyether-based PU (TPU)	Immune to hydrolysis: does not degrade with fresh or salt water, humidity or sewage. Compatible with mineral oils, greases, solvents and weak acids and bases	Water and wastewater, oily environments

For conduits, the same presentation recommends yellow corrugated PVC in walls, orange corrugated PVC in slabs and floors and black high-density polyethylene, with UV protection, outdoors TECHNO.

PRACTICAL TIP

Measure the outer diameter with a caliper, on the actual cable to be installed. The catalogue value for a cable can vary between manufacturers.



Schematic cross-section of the cable gland. The seal (in colour) only works within the stated diameter range.

CHAPTER 07

Protection rating: IP66, IP67, IP68 and IP69

The logic of the code

The IP code is defined by IEC 60529, adopted in Brazil as ABNT NBR IEC 60529 STANDARD. The standard applies to enclosures of electrical equipment with rated voltage up to 72.5 kV.

- **First digit (0 to 6):** protection against solids and dust. Level 6 means totally protected against dust.
- **Second digit (0 to 9):** protection against water.
- **Letter X:** indicates that this aspect was not rated.

SECOND DIGIT	TEST CONDITION STANDARD
5	Water jets
6	Powerful water jets
7	Temporary immersion
8	Continuous immersion, under conditions agreed between manufacturer and user, more severe than level 7
9	High-pressure, high-temperature water jets

The water digits do not form a ladder

Up to level 6, each rating includes the previous ones. From 7 onwards, it does not. Jet and immersion are tests of a different nature, and passing one does not guarantee passing the other STANDARD. That is why manufacturers declare combined markings, such as IP66/IP68 or IP66/IP68/IP69.

Practical reading of each rating

IP66. Dust does not get in, and powerful jets cause no damage. It is the rating for heavy rain, outdoor areas and hose washing.

IP67. Withstands temporary immersion. Suitable for points that may flood for a short time.

IP68. Withstands continuous immersion. Test depth and duration are declared by the manufacturer. Two IP68 products may have been tested under very different conditions.

IP69. Withstands close-range, high-pressure, high-temperature jets. Techno's presentation cites 80 °C and 80 to 100 bar TECHNO, values consistent with the test described in the standard.

IP69 OR IP69K?

The IP69K marking was born in the automotive sector and today is in ISO 20653, the road vehicle standard. In 2013, IEC 60529 added an equivalent test as second digit 9. Techno's catalogue uses the form IP69. The technical presentation uses IP69K. Both indicate resistance to high-pressure, high-temperature washdown.

The North American reading: NEMA 6 and 6P

Techno's presentation also cites the NEMA ratings TECHNO:

- **Type 6:** protection against water entry during temporary submersion at limited depth.
- **Type 6P:** protection during prolonged submersion, with resistance to corrosive environments.

The NEMA rating is not a direct translation of IP, because it includes requirements IP does not assess, such as corrosion.

What IP does not tell you

WARNING

The IP rating comes from a type test: new product, correctly assembled, stable temperature, for a limited time and with water coming from outside. It does not assess ageing from UV, ozone, salt mist or heat, nor the condensation that forms inside.

Three questions to ask the manufacturer:

1. What are the depth and duration of the IP68 test?
2. Does the rating apply to the mated pair or also to the socket without a plug?
3. In which cable diameter range was the rating obtained?



THE ENGINEER'S VIEW

You do not compare one protection rating label with another. You compare test condition with service condition. When the data sheet does not state depth, time and cable range, the comparison between suppliers has not started yet.

Prof. Vagner Soares, Manufatura Enxuta



IP66

POWERFUL JET

Outdoor areas and hose washing



IP67

TEMPORARY IMMERSION

Points subject to brief flooding



IP68

CONTINUOUS IMMERSION

Underground boxes, pumps and probes



IP69

HIGH PRESSURE AND TEMPERATURE

Sanitising in food and meat plants

CHAPTER 08

Mechanical strength: the IK code

IEC 62262, equivalent to the European EN 62262 and adopted in Brazil as ABNT NBR IEC 62262, classifies the protection of enclosures against external mechanical impacts STANDARD. The code has two digits, linked to impact energy.

IK RATING	IMPACT ENERGY	PRACTICAL READING
IK06	1 J	Light handling
IK07	2 J	Light knocks during installation
IK08	5 J	General industrial use
IK09	10 J	Areas with material handling
IK10	20 J	Areas subject to severe impact

The 2021 amendment to the standard added the IK11 rating, 50 J STANDARD.

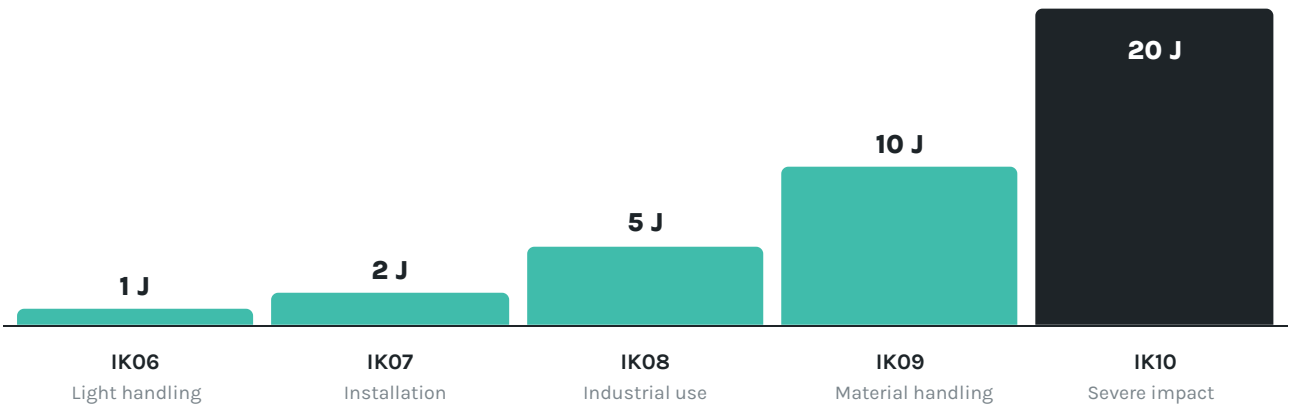
How IK appears in the Techno catalogue

The rating varies by series TECHNO:

- IK07 in branches such as TH390, TH402 and TH399 and in connectors such as TH387;
- IK08 in boxes such as TH209, TH211, TH219 and TH212;
- IK10 in reinforced versions, such as TH400 UP and the IoTH210 box.

COMMON MISTAKE

Specifying IP68 for a box installed in a yard floor and forgetting impact. The box cracks under the first wheel, and the IP rating no longer exists. At points exposed to knocks, IP and IK are specified together.



CHAPTER 09

Materials, sealing and ageing

The IP rating shows how the connector behaves when new. The materials define how it behaves after years.

The body: polyamide 66 with glass fibre

Techno uses nylon 66 filled with glass fibre. According to the company's presentation, the 30% reinforcement gives dimensional stability and wear resistance TECHNO.

Declared tests and ratings

AGENT	TEST OR RATING	WHAT IT REPRESENTS
Flame	UL 94 V0 and V2, depending on the part	Behaviour of the plastic under flame
Glow wire	Glow-wire 850 °C and 960 °C	Resistance to contact with glowing parts
Outdoor use	UL 746C, f1 rating	Suitability for exposure to UV and water
Enclosure flammability	UL 94 5VA	Most demanding class in UL 94
UV radiation	Test to EN 60079-0, 1,000 hours	Resistance to sunlight
Ozone	ISO 1431-1	Rubber resistance to cracking
Salt mist	EN 60068-2-11	Corrosion resistance
Impact	EN 62262	IK rating

Source of the table data: technical presentation and general catalogue TECHNO.

Composition

The catalogue and the presentation declare materials that are TECHNO:

- **halogen-free**, in compliance with REACH and RoHS;
- **silicone-free** in several series, which matters for paint lines, where silicone is a contaminant;
- **sulphur-free**, for LED compatibility.

The "Silicone Free" statement does not apply to every series. Some use silicone gaskets to withstand higher temperatures. Check the data sheet for each series.

Chemical resistance

Techno's presentation includes a chemical resistance table for the materials. Agents listed as compatible include ammonia, calcium chloride, petrol, fertilisers, lubricating oils, petroleum, phosphates and sea water. Methyl alcohol and chlorine appear with partial resistance TECHNO.

> **WARNING**
>
> Chemical resistance tables are general guides. Concentration, temperature and contact time change the result. For specific cleaning and sanitising products, consult the manufacturer with the chemical's data sheet in hand.

The co-moulded seal

In a co-moulded seal, plastic and rubber are injected together and bond chemically and mechanically. Techno points to three effects TECHNO:

- fast installation, with few components;
- fewer installation errors, with leak-proof gaskets;
- greater strength, thanks to the bond between plastic and rubber.

From an engineering standpoint, every loose part eliminated is one less interface to fail and one less step to get wrong.



TEEGLAND® cable gland with co-moulded seal. The teal ring is injected together with the body: there is no loose part to position and no sealing ring to forget during assembly. Photos: Techno do Brasil.

CHAPTER 10

Condensation, ingress and capillarity

Water inside a connector does not necessarily mean a faulty seal. There are three distinct mechanisms, and each calls for a different action.

Mechanism 1: ingress

This is water coming in from outside, through a failed seal or incorrect assembly: cable outside the diameter range, connector not locked, wrong tightening, damaged gasket. The fix is in the installation.

Mechanism 2: thermal breathing and condensation

A sealed enclosure that heats up and cools down behaves like a small pump. By the gas law, internal pressure follows absolute temperature.

> **ORDER OF MAGNITUDE (ILLUSTRATIVE EXAMPLE)**
>
> Internal air at 60 °C (333 K) cooling to 20 °C (293 K) loses about 12% of its pressure. In approximate values, that is a vacuum of 0.12 bar, equivalent to a 1.2 m column of water.

This vacuum draws in moist air through any micro-path. Inside the enclosure, the vapour condenses on cold surfaces when the temperature falls below the dew point. Each cycle deposits little, but the water has no way out and builds up.

Air at 30 °C and 80% relative humidity carries about 24 g of vapour per cubic metre. At 15 °C, saturated air holds about 13 g per cubic metre. The difference becomes liquid water LITERATURE, PSYCHROMETRIC DATA.

Mechanism 3: capillarity through the cable

The gaps between the strands of a stranded conductor act as capillaries. Water that reaches the cable end, in a submerged splice or a poorly sealed termination, migrates inside it, even with the sheath intact and the cable gland properly tightened.

When the equipment breathes, the suction adds to this path. Sealing only the outer sheath does not solve it.

The barrier solution: xDRY®

xDRY® technology, described in Techno's catalogue as a patented anti-condensation system, places a barrier between the connector and the equipment, interrupting the path inside the cable. The catalogue states TECHNO:

- 90% reduction in water ingress;
- guaranteed electrical continuity;
- insulation with no voltage drop;
- product ready for use and installation.

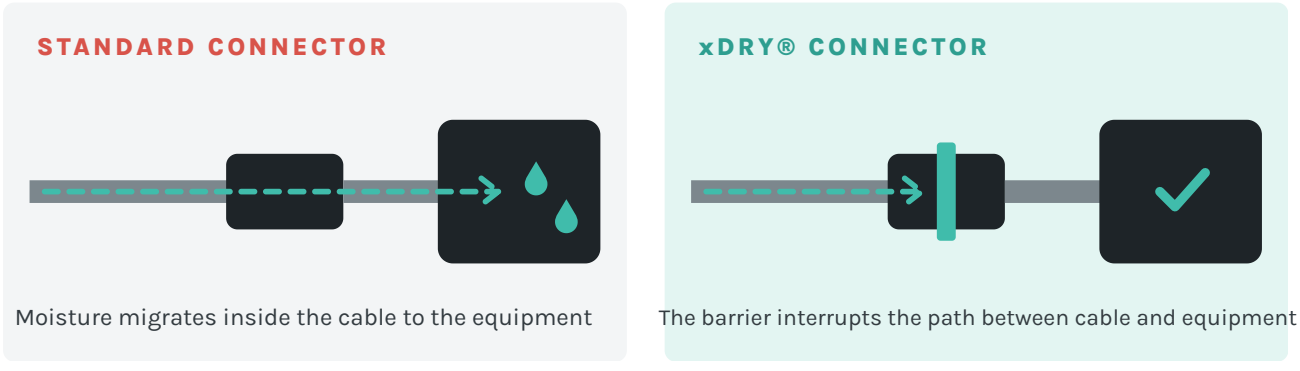
xDRY® versions are identified in the code by THB.xxx.Rxx, THB.Dxxx.xxx or THB.xxx.xxx.XD.

When to specify anti-condensation protection

SIGN	INDICATION
Daily thermal cycle combined with high humidity	Strong
Sensitive electronics connected to the connector, such as probes and transmitters	Strong
Outdoor luminaires that heat up when on and cool down at night	Strong
History of internal water with no apparent sealing defect	Decisive

PRACTICAL TIP

When you find water inside a connector, take a photo before cleaning. Clean water in drops on the walls suggests condensation. Dirty water with a trail from a gasket suggests ingress. Moisture concentrated at the conductor ends suggests capillarity.



Principle of the anti-condensation barrier. Schematic illustration, based on Techno's technical presentation.

CHAPTER 11

Common specification and installation errors

In specification

MISTAKE	CONSEQUENCE	HOW TO AVOID IT
Specifying for the average condition of the environment	Failure on washdown day or in heavy rain	Describe the worst real condition
Reading IP68 as "proof against everything"	Failure under high-pressure jet	Require a suitable combined marking
Ignoring IK	Cracked enclosure, IP lost	Specify IP and IK together
Choosing the connector before the cable	Diameter outside the sealing range	Match cable and connector
Splice where replacement is frequent	Long repair time, risk of swapped wiring	Use plug and socket
Confusing material temperature with T-marking	Operation above qualification	Check the series T-marking
Not counting the circuit interruptions	Low series reliability	Apply stage 3 of the method

In installation

MISTAKE	CONSEQUENCE	HOW TO AVOID IT
Stripping too much sheath	Cable gland clamps on the conductors, not the sheath	Follow the stripping length in the instructions
Insufficient or excessive tightening	Seal without compression or damaged rubber	Follow the stated torque or end stop
Half-mated connector	Micro-movement, heating, water entry	Confirm the tactile and visual feedback of the lock
Socket left without plug or without cap	Loss of protection rating	Use a protective cap
Cable under tension or with a forced bend at the exit	Stress on the seal	Provide strain relief and bend radius
Finishing the seal with tape or mastic	Layers that hide the defect and prevent inspection	Use the connection designed for the environment

COMMON MISTAKE

"Reinforcing" a splice with self-amalgamating tape, mastic and more tape. Each layer adds installation time and no guarantee. At the next failure, nobody can open it to inspect.

TO GO DEEPER

- Como escolher conectores elétricos industriais: checklist
- IP66, IP68, IP69K e IK: como interpretar
- Condensação e infiltração de água em conexões



PART

III

Reliability and maintenance

12 Connections and TPM

13 Inspection and planned maintenance

14 Signs of degradation and diagnosis

15 Reliability, availability and unplanned downtime

CHAPTER 12

Connections and TPM

Total Productive Maintenance, systematised by Seiichi Nakajima at the Japan Institute of Plant Maintenance, aims to eliminate equipment losses with the participation of operations and maintenance LITERATURE. It requires every component capable of generating a loss to have a standard of normality, with an owner, a frequency and an action in case of deviation.

Electrical connections usually stay outside this standard. After the initial cleaning in autonomous maintenance, hardly anyone defines what a connection in good condition looks like.

The connection in the six big losses

LOSS LITERATURE	HOW THE CONNECTION CONTRIBUTES
Breakdowns	Ingress, oxidised contact, cable broken at the splice
Setup and adjustments	Replacing a motor or sensor means loosening terminals inside boxes
Minor stops	Poor contact or moisture in a sensor connector
Reduced speed	Running below rate for fear of a known electrical failure
Defects and rework	Unstable sensor or scale reading
Start-up losses	Condensation built up during the stoppage

The operator's inspection standard

Autonomous maintenance inspects from the outside, without opening and without measuring. The standard fits on a card.

ITEM	NORMAL CONDITION	IF IT IS OUT OF STANDARD
Mating and lock	Fully mated, lock closed	Tag it and call maintenance
Cable and cable gland	No play, crack, crushing or forced bend	Tag it and call maintenance
Connector body	No crack, deformation or heat mark	Tag it and call maintenance
Moisture and dirt	No water, product build-up or visible oxidation	Clean the outside and tag it if there is oxidation
Identification	Legible label with the point code	Redo the identification

WARNING

Opening connectors, measuring insulation and replacing components are maintenance tasks, with the circuit de-energised and the plant's lockout/tagout procedures applied.

Maintenance prevention starts at the design stage

The best time to reduce the maintenance of a connection is before it exists. Three design decisions help:

- bring the connection outside the box, with a panel connector, so it can be seen and inspected;
- choose reinspectable connections, without resin or gel;
- use plug and socket where there is periodic replacement.

CHAPTER 13

Inspection and planned maintenance

1. Classify by criticality

Not every connection deserves the same effort. Start with:

- safety circuits, such as interlock switches and emergency stop buttons;
- main line drives;
- instruments that control quality or process;
- hard-to-reach points, buried or at height.

2. Inspect by condition

TECHNIQUE	WHERE TO APPLY IT	WHAT IT REVEALS
Visual inspection on a route	All accessible points	Crack, play, oxidation, open lock
Insulation resistance	Splices and branches exposed to moisture	Water entry before failure
Thermography	Power connections	Heating from a degraded contact
Internal reinspection	Critical splices, during scheduled shutdowns	Actual condition of contacts and seals

Internal reinspection is only possible in connections that can be opened and closed again. The TEETUBE® line is described in the catalogue as free of resin or gel, reinspectable and re-accessible even after long periods of operation TECHNO.

3. Standardise spares

Defining a few connector families per function reduces spare parts stock, simplifies training and shortens repairs.

4. Record the cause precisely

"Electrical failure" teaches nothing. "Ingress at the splice of motor M-12" lets you build a history. A record with a coded cause is the basis of the Pareto that guides the next improvement.

5. Use scheduled shutdowns

The general shutdown is the opportunity to replace critical connections at end of life and reinspect hard-to-reach splices.

> **PRACTICAL TIP**
>
> Include connections in the existing lubrication and inspection plan, with the same point code. A separate route just for connections rarely lasts.

CHAPTER 14

Signs of degradation and diagnosis

What to look for

SIGN	LIKELY CAUSE
Discolouration or heat mark on the body	High contact resistance
Greenish or white powder on the contacts	Corrosion from moisture
Dark powder on the contacts	Fretting corrosion, caused by micro-movement
Dried-out or cracked rubber	Ageing from UV, ozone or heat
Rubber that does not recover its shape	Compression set
Drops or fogging inside	Condensation
Dirt trail starting from a gasket	Ingress
Swollen or sticky cable sheath	Chemical attack or hydrolysis

Friction corrosion, known as fretting, occurs when vibration and thermal cycling cause micro-movement between the contact surfaces. The oxide layer that forms raises resistance, the contact heats up, and the process accelerates LITERATURE.

Seven-step investigation roadmap

1. **Record the failure pattern.** Time, weather, process stage, recent washdown.
2. **Open and photograph before cleaning.** The position of water and oxidation is the main evidence.
3. **Check the installation.** Cable diameter, tightening, lock, gaskets.
4. **Follow the cable.** Look for the other end and the intermediate splices.
5. **Apply the 5 whys.** Go beyond "water got in".
6. **Choose the action.** Correct the installation, add a barrier, or both.
7. **Measure before and after.** Without measurement there is no way to standardise the solution.

COMMON MISTAKE

Replacing the connector with an identical one without investigating the cause. If the problem is condensation or capillarity, the new connector will fail the same way, in the same time.



THE ENGINEER'S VIEW

In TPM, every component that can generate a loss needs a standard of normality. The connection almost never has one. If the same connection has failed twice, the third replacement is waste: what is called for is root cause analysis.

Prof. Vagner Soares, Manufatura Enxuta

CHAPTER 15

Reliability, availability and unplanned downtime

Series reliability

When several elements must work for the system to work, the reliability of the system is the product of the individual reliabilities LITERATURE:

> **R system = R1 × R2 × … × Rn**

CONNECTIONS IN SERIES	RELIABILITY OF EACH ONE	CIRCUIT RELIABILITY	CHANCE OF AT LEAST ONE FAILURE
10	99%	90%	10%
20	99%	82%	18%
20	96%	44%	56%
12	99%	89%	11%

Illustrative values, calculated with the formula above ILLUSTRATIVE EXAMPLE.

The table shows the two levers available. Going from 96% to 99% at each point cuts the chance of failure from 56% to 18%. Reducing from 20 to 12 interruptions, from 18% to 11%.

Indicators

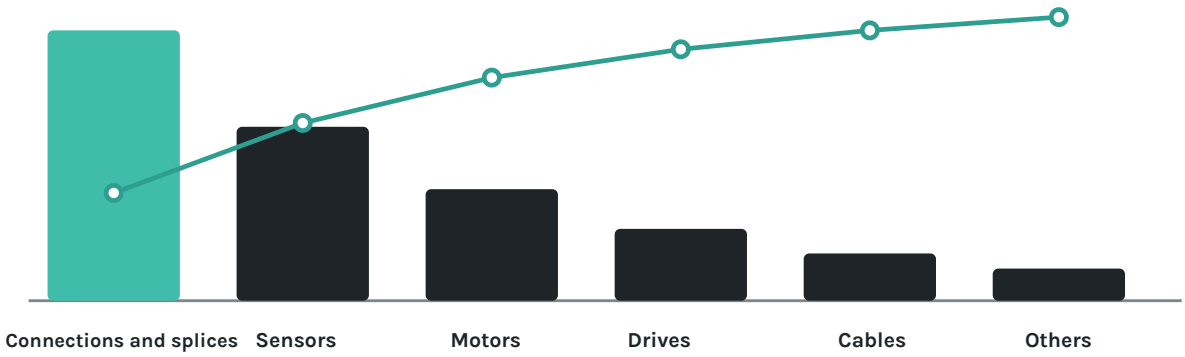
INDICATOR	DEFINITION	RELATION TO THE CONNECTION
MTBF	Mean time between failures	Rises with a product suited to the environment
MTTR	Mean time to repair	Falls with plug and socket and easy access
Availability	MTBF divided by the sum of MTBF and MTTR	Combined result of the two

Five actions to reduce unplanned downtime

1. **Gather the data.** How many corrective work orders last year originated in a connection, splice or cable entry?
2. **Apply Pareto.** A few points usually account for most of the events.
3. **Address the cause.** Use the roadmap in chapter 14.
4. **Run a pilot.** One machine, one change, measurement before and after.
5. **Standardise what worked.** In the purchasing specification and the maintenance standard.

PRACTICAL TIP

You do not need to replace every connection in the plant. Start with the machine with the most recorded electrical failures.



Pareto of electrical stoppages by cause, with cumulative curve. Illustrative values, no customer data.

TO GO DEEPER

- Conexões industriais e TPM
- RCFA
- 5 whys
- MTBF e MTTR



PART

IV

Lean Manufacturing and competitiveness

16 Waste starts with the choice of component

17 Connections and OEE

18 Total cost of ownership

19 The hidden cost of electrical failures

CHAPTER 16

Waste starts with the choice of component

In lean thinking, waste is any activity that consumes resources without creating value for the customer LITERATURE. Specifying a component is a process decision: it determines how much installation, inspection and repair work will exist throughout the life of the equipment.

A badly chosen connector does not appear on the value stream map as a cause. It appears later, as downtime, scrap or rework.

WASTE LITERATURE	HOW IT SHOWS UP IN THE CONNECTION	DECISION THAT PREVENTS IT
Defects	Unstable sensor or scale reading due to moisture	Suitable protection rating and anti-condensation
Waiting	Line stopped waiting for diagnosis or a part	Reinspectable connection and standardised spares
Material handling	Technician opening boxes and redoing terminals in the field	Plug and socket or pre-wired version
Over-processing	Splice with layers of tape, mastic or resin	Splice designed for the environment
Inventory	Dozens of models for the same function	Standardisation by function and environment
Unused talent	Skilled technician fixing a badly made connection	Simple installation, less dependent on skill

The link between each waste and the connection is an engineering reading, not a measurement. It serves to guide where to look.

Poka-yoke: the error prevented by the component

Poka-yoke is the device that prevents the error instead of detecting it later LITERATURE. Some connection design features play this role:

- **Co-moulded seal:** there is no loose ring to forget.
- **Mechanical keying and different colours:** Techno's catalogue describes distinct versions for power and signal circuits, which prevent mismating TECHNO.
- **Lock with tactile and visual feedback:** makes it clear when mating is complete.
- **Spring system:** removes the variation in tightening torque between installers.

Quality at the source

In pre-wired versions, assembly and testing move from the field to the factory, under controlled conditions. What reaches the site is a single part, already tested.

Standardise without freezing

1. List the plant's connection functions.
2. Choose a reference family per function and per environment.
3. Record exceptions with the reason.
4. Review the standard when the environment or the failure history changes.

A one-machine kaizen

1. Choose the machine with the most electrical failures.
2. Map all its connections.
3. Classify the wastes using the table in this chapter.
4. Test one change.
5. Standardise if there is a measured gain.

CHAPTER 17

Connections and OEE

OEE, overall equipment effectiveness, is the product of three factors LITERATURE:

> **OEE = Availability × Performance × Quality**

FACTOR	ASSOCIATED LOSS	EFFECT OF AN UNSUITABLE CONNECTION
Availability	Breakdowns, setup and adjustments	Stoppage due to electrical failure, slow component replacement
Performance	Minor stops, reduced speed	Micro-stops from poor contact, running at a cautious rate
Quality	Defects, start-up losses	Scrap from unstable readings, instability after stoppages

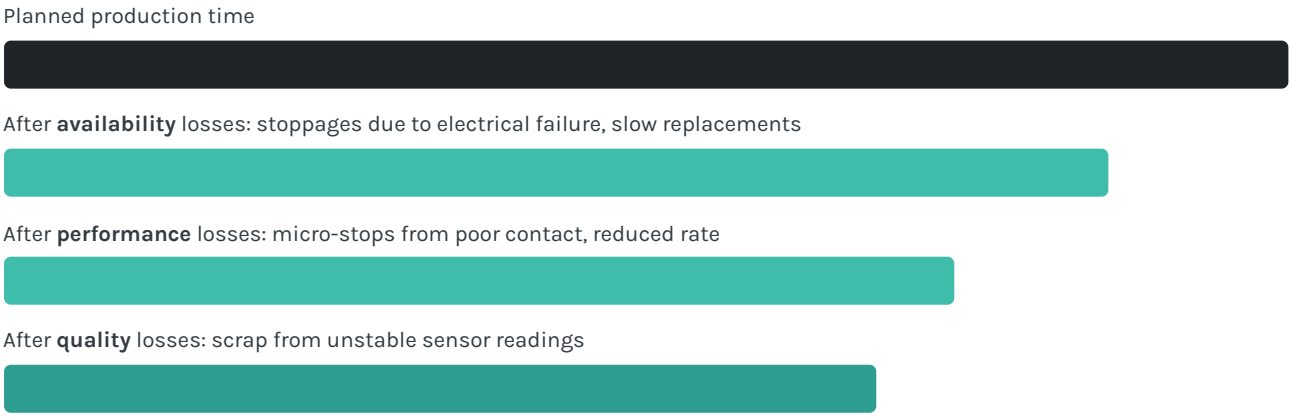
Why the micro-stop weighs so much

A three-hour stoppage goes into the report. Six twenty-minute stoppages, spread over the month, often do not. The intermittent connection failure produces exactly this pattern: the machine stops, the operator moves the cable, it starts again.

> **ILLUSTRATIVE EXAMPLE**
>
> A line with a cost of R$ 8,000 per hour of downtime suffers 6 stoppages of 25 minutes in a month from an intermittent failure. That is 2.5 hours, or R$ 20,000 in the month, without any single stoppage drawing attention. Hypothetical values, in Brazilian reais.

From the indicator to the cause

OEE shows that there is a loss. It does not show the cause. To get to the connection, the downtime record needs a specific cause code, such as "connection, splice or cable entry", separate from the generic "electrical".



OEE waterfall. Proportions are illustrative.

CHAPTER 18

Total cost of ownership

Total cost of ownership, or TCO, brings together everything an item costs over its life. IEC 60300-3-3 covers the subject under the name life cycle costing STANDARD.

The components

COMPONENT	WHAT TO CONSIDER	TECHNICAL FEATURE THAT MATTERS
Purchase	Connector, cable gland, accessories	Material, protection rating, number of poles
Installation	Technician hours, tools, rework	Number of parts, co-moulded seal, pre-wiring
Inspection and maintenance	Time to inspect, disconnect and reconnect	Reinspectable connection, plug and socket
Failures	Probability of failure multiplied by the cost of each failure	Suitability for the environment
Replacement	End-of-life replacement and spare parts	Resistance to ageing

> **TCO = purchase + installation + maintenance over the period + (expected failures × cost per failure)**

> **Cost per failure = hours stopped × line hourly cost + labour + materials + scrap**

Worked example

The example below uses hypothetical values, in Brazilian reais, adapted from the article series on the Manufatura Enxuta portal ILLUSTRATIVE EXAMPLE.

Assumptions: 5-year horizon. Each failure causes 1 hour of downtime at R$ 8,000, plus R$ 1,000 in repairs. Technician at R$ 80 per hour.

ITEM, PER CONNECTION POINT	OPTION A, CONVENTIONAL	OPTION B, ROBUST
Purchase	R$ 40	R$ 180
Installation	1,5 h = R$ 120	0,5 h = R$ 40
Initial subtotal	R$ 160	R$ 220
Probability of failure per year	4%	1%
Expected failures in 5 years	0,20	0,05
Expected cost of failures	R$ 1.800	R$ 450
5-year TCO	**R$ 1.960**	**R$ 670**

Option B costs R$ 60 more at the start and R$ 1,290 less over the period.

Break-even point: R$ 60 divided by R$ 9,000 gives 0.0067 failures per point. Avoiding one failure in every 150 installed points is enough for option B to pay for itself.

At scale: on a line with 120 points, the difference adds up to R$ 154,800 in five years, with 18 fewer expected stoppages.

> **WARNING**
>
> The failure probabilities in this example are hypothetical. In a real analysis they must come from the plant's history. The comparison is only valid between options that meet the same technical requirements.

Roadmap for purchasing and management

1. Gather last year's failures by cause and component.
2. Calculate the cost per failure using the line hourly cost.
3. Build the TCO of the options and the break-even point.
4. Propose a pilot, with MTBF and MTTR measured before and after.
5. Measure installation time as well.
6. Standardise what the pilot confirms.

Option A · conventional



5-year TCO: **R$ 1,960** (initial R$ 160)

Option B · robust



5-year TCO: **R$ 670** (initial R$ 220)

In dark, purchase and installation. In colour, the expected cost of failures. Hypothetical values.

CHAPTER 19

The hidden cost of electrical failures

The TCO spreadsheet captures what can be measured. Part of the cost stays outside it.

Troubleshooting intermittent failures. Before getting to the connection, the technician tests the sensor, replaces the PLC card and measures the cable. Good parts are replaced.

Spare parts stock. Many connector families for the same function take up storeroom space and capital.

Difficult access. Buried boxes, points at height and confined spaces require equipment, work permits and more people.

Safety. An interlock switch or an emergency stop button that fails stops protecting. This cost is not measured in money per hour.

Trust. A line that stops without explanation starts being run cautiously, below rated speed.

Where the decision costs least

A rule of thumb known as 1-10-100 sums up the idea: fixing a problem at the design stage costs one unit, at installation it costs ten, in operation it costs a hundred. The numbers are orders of magnitude, not measurements. The logic, however, is confirmed every day: the later the fix, the more expensive.

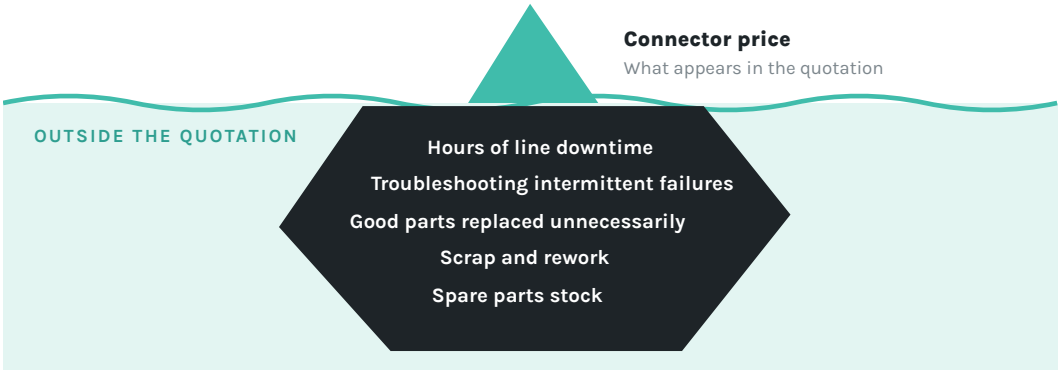
> **FOR THE BUDGET MEETING**
>
> The cost of a connection is a decision. The cost of a failure is an event. Comparing the two in the same table usually ends the discussion about unit price.



THE ENGINEER'S VIEW

You do not need to replace every connection in the plant to prove the point. Start with data, focus and standard: gather the failures, choose one machine, measure before and after. A well-measured pilot is more convincing than any catalogue.

Prof. Vagner Soares, Manufatura Enxuta



TO GO DEEPER

- Lean: os desperdícios começam na escolha do componente
- Custo total das conexões industriais (TCO)
- OEE, with calculator
- Machine-hour cost



PART

V

Applications and cases

20 Applications in hostile environments

21 Case studies

22 Lessons learned

CHAPTER 20

Applications in hostile environments

The technical presentation "Complicated and Hostile Applications", given by Mario Adinolfi, Director of Techno do Brasil, gathers field applications of the brand's products TECHNO. The table summarises the main ones.

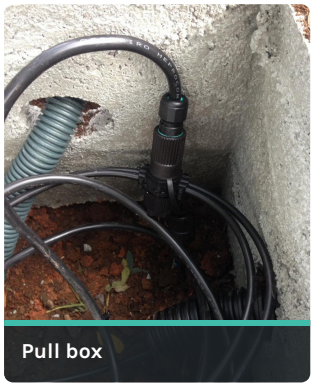
APPLICATION	ENVIRONMENT	PRODUCT SHOWN IN THE PRESENTATION
Football pitch lighting	Underground boxes that flood	THB.402
Underground street lighting	Buried network	THB.370
Outdoor and in-ground lighting	Water and mechanical load	THB.391.A4A
Outdoor industrial lighting	Thermal cycle and humidity	THB.391.R4A.L, xDRY® version
Telemetry in water and wastewater	Water and sewage pipes	Box 210, connectors 381 and 387
Water purity probe	Immersion and thermal gradient	THB.387.N4A, xDRY® version
Flat table in pulp and paper	Humidity and heat	THB.391.A4A
Pasta machine	85 °C continuous and 90% humidity	THB.387.A4A
Equipment in a meat plant	Washdown	THB.405.S5A
Scales with 2 and 4 load cells	Humidity	THB.389 mini connectors and THH.629 branch
Motors in the rice industry	Dust	THB.387 family
Tool motors	Factory assembly	THB.387 family, 4 poles
Field instrumentation	Exposed transmitters	THB.381
pH sensor	Replaceable probe	THB.400 with THB.381.A2A and THB.381.B2A
Guard interlock switch	Safety circuit	THB.405.A8A with THB.405.B8A
Machine panels	Several cables per panel	Circular connectors with 3, 8 and 12 ways

TRANSPARENCY NOTE

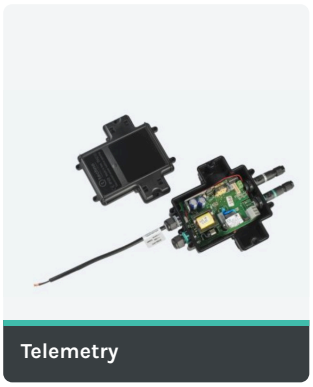
The presentation records the product and environment of each application. Only two include follow-up over time: the football pitch, inspected after 4 years, and the pasta machine, inspected after 8 months. For the others, this guide does not attribute results.



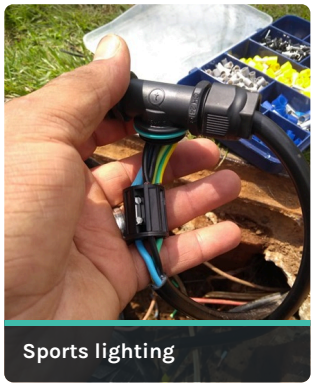
Street lighting



Pull box



Telemetry



Sports lighting

Photos of real applications. Source: Techno technical presentation.

CHAPTER 21

Case studies

The first four cases are based on Techno records. The last two are hypothetical and are identified as such.

Case 1. Sports lighting with submerged splices

Origin: real record TECHNO.

1. **Operating context.** Lighting of a football pitch in Mogi das Cruzes, SP, Brazil. The splices sit in buried pull boxes.
2. **Problem identified.** The boxes fill with water in rainy periods, and the splices stay submerged.
3. **Technical causes.** Prolonged, repeated immersion, a more severe condition than splashing or jets.
4. **Consequences for the operation.** In installations of this kind, water entry leads to leakage current, tripped protections and loss of lighting.
5. **Solution criteria.** IP68 branch, with no resin or gel, to allow future inspection.
6. **Solution applied.** T branch model THB.402. The catalogue states IP68, IK07, up to 6 poles and 32 A / 450 V for the TH402 series.
7. **Documented result.** Four years after installation, the installer himself opened the connector and reported, in a social media post reproduced in the presentation, that he found no trace of water.
8. **Lessons.** It is a single account with no laboratory measurement. It illustrates two things: the value of specifying for real immersion, and the value of a connection that can be opened for checking.



Installation day



Four years later



Connector opened: dry inside

Source: Techno technical presentation.

Case 2. Motor in a pasta machine

Origin: real record TECHNO.

1. **Operating context.** Pasta production machine in a food plant.
2. **Problem identified.** According to the presentation, the motor connection point works at 85 °C continuous and 90% humidity.
3. **Technical causes.** Continuous heat accelerates seal ageing. High humidity favours oxidation and condensation during stoppages.
4. **Consequences for the operation.** Under such conditions, degradation of the motor connection results in equipment downtime.
5. **Solution criteria.** Disconnectable connector, with twist lock and materials qualified for the temperature.
6. **Solution applied.** Connector THB.387.A4A.
7. **Documented result.** The presentation shows photos from installation day and from an inspection carried out 8 months later. There is no published measurement.
8. **Lessons.** With heat and humidity combined, it is worth scheduling an inspection in the first months to confirm the specification before standardising it.

> **POINT TO VALIDATE BEFORE PUBLICATION**
>
> The T-marking stated in the catalogue for the TH387 series is +60 °C, and the material range is –40 °C to +125 °C. As the application is described at 85 °C continuous, it is recommended to confirm the technical wording of this case with Techno's engineering team.

Case 3. Telemetry in water and wastewater

Origin: real record TECHNO.

1. **Operating context.** Telemetry system for water and sewage pipes.
2. **Problem identified.** The electronic board and the sensor connections sit in a damp environment subject to flooding.
3. **Technical causes.** Electronics are sensitive to moisture and contaminants. Each sensor adds a cable entry.
4. **Consequences for the operation.** Loss of monitoring data and crews sent out to the field.
5. **Solution criteria.** IP68 protection for the board and disconnectable connection for sensors.
6. **Solution applied.** Box 210, which according to the presentation ensures IP68 protection of the board and a secure connection with connectors of the 381 and 387 series. In a related application, a water purity control probe uses the THB.387.N4A connector in the xDRY® version.
7. **Documented result.** There is no published result.
8. **Lessons.** When there are electronics at the point, the specification must treat enclosure, cable entries and anti-condensation barrier as a whole.

Case 4. Machine panels with circular connectors

Origin: real record TECHNO.

1. **Operating context.** Machine panels with several power and signal cables.
2. **Problem identified.** Replacement of multi-pole rectangular connectors.
3. **Technical causes.** A single connector for several cables concentrates different functions at the same sealing point.
4. **Consequences for the operation.** A failure in the shared connector affects every circuit passing through it.
5. **Solution criteria.** One circular connector per cable, sized by the number of ways.
6. **Solution applied.**

CABLE	CONNECTORS
12 ways	THB.406.A1E with THB.405.B2E
8 ways	THB.405.A8A and THB.405.B8A with accessory 6000087LF
3 ways	THB.381.A3E and THB.381.B3E
3 ways	THB.384.A1A and THB.384.B1A with accessory 6000347LA

7. **Documented result.** There is no published result.
8. **Lessons.** Separating circuits by connector makes diagnosis easier and lets you replace one cable without touching the others.

Case 5. Outdoor luminaires with internal water

Origin: hypothetical example, prepared for teaching purposes.

1. **Operating context.** Factory yard with 40 LED luminaires on poles. The drivers sit in boxes at the top of the poles.
2. **Problem identified.** After the first winter, some luminaires start flickering or tripping. The opened boxes show drops of water, although the seals are intact.
3. **Technical causes.** The luminaires heat up when on at night and cool down before dawn. On each cycle the assembly draws in moist air through the supply cable. It is condensation plus capillarity, not ingress.
4. **Consequences for the operation.** Poorly lit area, repeated driver replacement and work at height on every intervention.
5. **Solution criteria.** Barrier between cable and equipment, disconnectable connection for replacement without rewiring, UV resistance.
6. **Recommended solution.** Connector with anti-condensation barrier at the entry of each luminaire, and a review of cable diameters against the cable gland range.
7. **Result.** Not applicable, as this is a hypothetical example.
8. **Lessons.** An intact seal with water inside points to condensation. Replacing the connector with an identical one repeats the failure.

Case 6. Sensors on a line washed daily

Origin: hypothetical example, prepared for teaching purposes.

1. **Operating context.** Food filling line with 60 sensors, sanitised every day with a hot water jet and alkaline detergent.
2. **Problem identified.** Frequent micro-stops from false sensor readings, concentrated in the first hours after washdown.
3. **Technical causes.** The original connectors are IP67, suited to temporary immersion and not to high-pressure, high-temperature jets. The thermal shock of washdown makes water entry worse.
4. **Consequences for the operation.** Performance loss in OEE and start-up scrap.
5. **Solution criteria.** Marking that includes IP69, materials compatible with the detergent in use, plug and socket for quick sensor replacement.
6. **Recommended solution.** Pilot replacement at ten points, recording micro-stops before and after, and standardisation only after the gain is confirmed.
7. **Result.** Not applicable, as this is a hypothetical example.
8. **Lessons.** The protection rating must match the type of attack. Immersion and jet are different requirements.

CHAPTER 22

Lessons learned

The cases and applications point to the same recommendations.

1. **Specify for the worst day.** The flooded pitch and the washed line show that the extreme condition, even if occasional, defines the specification.
2. **Tell ingress, condensation and capillarity apart.** Each mechanism has its own solution.
3. **Prefer connections that can be opened.** Without inspection there is no learning.
4. **Use plug and socket where things get replaced.** Motors, sensors and probes come out for maintenance.
5. **Treat a point with electronics as a whole.** Box, entries and barrier work together.
6. **Measure before standardising.** A pilot with data is worth more than a blanket replacement based on conviction.
7. **Record with photos and dates.** The two cases with follow-up only exist because someone photographed the installation and came back later.

PRACTICAL TIP

Adopt the "installation day" habit: one photo of each critical connection, with date and point code. At the next inspection, the comparison is immediate.



THE ENGINEER'S VIEW

Of the cases gathered here, only two have follow-up over time, and both exist because someone took a photo and came back later. That is the kind of evidence industry lacks. Whoever installs today should schedule the photo for a year from now.

Prof. Vagner Soares, Manufatura Enxuta

TO GO DEEPER

- Cases de conexões elétricas em ambientes hostis
- Account by the football pitch installer: instagram.com/p/C-Gn03dRojN

PART

VI

Technology and solutions

23 Techno's technology

24 Product families and technical data

25 How to evaluate solutions

26 Professional specification checklist

CHAPTER 23

Techno's technology

Techno started as a manufacturer of technical plastic parts and specialised in electrical connections with high protection against water and dust. In 2026 the company completed 40 years in plastic injection moulding. Design and production take place in Italy, with "Made in Italy" certification under the Italian legislation cited in the catalogue TECHNO.

Four technical pillars

1. Co-moulded seal. Plastic and rubber injected as a single part, with fewer components and fewer installation errors.

2. Resin- and gel-free connection. The seal is mechanical, and the connection can be reopened and inspected. The "Resin-gel free" badge identifies this feature in the catalogue.

3. xDRY®. Patented anti-condensation barrier, which blocks moisture migrating inside the cable.

4. Materials qualified for the long term. PA66 with glass fibre, rubbers resistant to UV and ageing, with the tests described in chapter 9.

IoTH® platform

The IoTH® platform organises the integration of electronics and sensors into connections on four levels TECHNO:

LEVEL	TYPE	DESCRIPTION
1	Passive	Catalogue connector and junction box
2	Passive	Techno or third-party components pre-installed
3	Active	Electronic and IoT components integrated into the connectors
4	Custom active	Product adaptation for special projects

The technical presentation also mentions the development of items aimed at the Zhaga standard, for lighting and IoT, with IP66 to IP68 protection and use at up to 400 VAC and 60 VDC TECHNO.

Custom solutions

The Techno Innovation Lab brings together research, development, production and quality for custom projects. The catalogue describes the full path: choice of raw material, product design, CAD/CAM modelling, 3D printing for single parts or small batches, laboratory verification and series production. The in-house tests cited include resistance to dust and water (IP), accelerated ageing, heating, electrical testing and mechanical testing (IK) TECHNO.

CHAPTER 24

Product families and technical data

The data below was taken from the general catalogue and must be confirmed in the data sheet for each code before specification TECHNO.

TEETUBE®: splices and branches

SERIES	CONFIGURATION	CATALOGUE HIGHLIGHTS
TH391	In-line, screw	Extra compact, 2 to 5 poles, IP68 and IP69, xDRY® version
TH393	In-line, spring	Tool-free installation, IP66 and IP68, xDRY® version
TH400	In-line and branch	Up to 41 A and 690 V, up to 6 poles, cable up to 21 mm, IP68. UP version with IK10
TH390	T branch	3 ways, IP68, IK07
TH402	T branch	3 ways, up to 6 poles, 32 A and 450 V, IP68, IK07
TH399	Y branch	3 ways, cables up to 4 mm², IP68, IK07
TH392	H branch	4 ways, fast assembly, xDRY® version
TH394	Panel	Snap closure, IP66, IP67 and IP68, IK08

Reference standard stated in the catalogue for branches: EN 60998-1.

TEEPLUG®: plug and socket

SERIES	LOCK	CYCLES	CATALOGUE HIGHLIGHTS
TH381	Push-pull	100	14 mm mini connector, IP66, IP68 and IP69
TH387	Twist	1.000	2 to 5 poles, IP66 and IP68, IK07, xDRY® version
TH389	Push-pull	100	IP66, IP68 and IP69, UP version up to 630 V
TH384	Twist	1.000	2, 3 and 5 poles, IP66 and IP68, IK07
TH405	Bayonet	1.000	2 to 8 poles, cable up to 16.5 mm, IK08. Standard version with IP66, IP68 and IP69. UP version up to 25 A and 630 V, with IP66 and IP68

Reference standard stated in the catalogue: EN 61984. Some codes also carry UL 2238 and CSA C22.2 No. 182.3.

TEEBOX®: boxes and distributors

SERIES	TYPE	CATALOGUE HIGHLIGHTS
TH200	3-way box	Up to 5 poles, IP67
TH211	3-way box	IP65, IK08
TH209	Hybrid box	Modular accessories, IP66 and IP68, IK08
TH219	Empty 3- and 4-way box	IP68, IK08
TH210	Box for electronics	IP66, IP67 and IP68
TH212	Mini box with up to 6 inputs and outputs	IP66 and IP67, IK08
TH625, TH624, TH623, TH629	Disconnectable distributors	IP68, with IP66 declared for some series
TH631	Pre-wired distributor	Quarter-turn lock, up to 8 poles, IP65

TEEGLAND®, TEEBLOCK® and TEEDRUM®

LINE	FUNCTION	CATALOGUE DATA
TEEGLAND®	Co-moulded cable glands	M16, M20, M25, PG9, PG13.5 and PG16 threads, IP68
TEEBLOCK®	Linear terminal blocks	Up to 5 poles, 32 A and 450 V
TEEDRUM®	Circular terminal blocks	Up to 5 poles, 32 A and 450 V

How to read the product code

CODE	MEANING
THB.xxx.xxx	Screw contact
THS.xxx.xxx	Spring contact
THP.xxx.xxx	Insulation-piercing contact
THF.xxx.xxx	Push-in contact
THC.xxx.xxx.xxx	Overmoulded product
THR.xxx.xxx or THB.xxx.xxx.R	Kit
IoTH.xxx.xxx	IoTH® platform
THB.xxx.Rxx, THB.Dxxx.xxx or THB.xxx.xxx.XD	xDRY® technology

The three middle digits identify the series. The final block identifies polarity and configuration.

CHAPTER 25

How to evaluate solutions

These criteria serve to compare any connection supplier, not just to evaluate Techno.

CRITERION	QUESTION FOR THE SUPPLIER	WHY IT MATTERS
Protection rating	Under what conditions was IP68 tested?	IP68 is not a single value
Combined marking	Does the product withstand jet and immersion?	The tests are independent
Impact	What is the IK rating of the series?	IP depends on the integrity of the enclosure
Temperature	What is the T-marking?	It is the qualified operating limit
Ageing	Are there UV, ozone and salt mist tests?	IP does not assess time
Chemicals	Is there a chemical resistance table?	Cleaning and process attack the materials
Assembly	How many loose parts does the set have?	Every part is a chance of error
Inspection	Can the connection be reopened?	Without access there is no condition-based maintenance
Cycles	How many mating cycles does it withstand?	Defines the life at frequently replaced points
Standards	Which product standards are met?	Basis for objective comparison
Support	Is there help with specification and customisation?	Hostile environments fall outside the standard

Recommendation by need

NEED	SUGGESTED PATH
Cable repair or extension in a wet area	IP68 in-line splice, reinspectable
Lighting runs	T or H branches, or a distributor
Motor or sensor with periodic replacement	Plug and socket with lock
High-pressure washdown	Series with a marking that includes IP69
Equipment with thermal cycling and electronics	Version with anti-condensation barrier
Signal entry into a panel	Panel connector, one per cable
Electronics in the field	IP68 box with disconnectable entries
Repetitive series installation	Pre-wired, factory-tested version



THE ENGINEER'S VIEW

The criteria in this chapter apply to any supplier, Techno included. A well-written specification describes the environment, the cable and the circuit, and lets the products compete to meet it.

Prof. Vagner Soares, Manufatura Enxuta

CHAPTER 26

Professional specification checklist

A. IDENTIFICATION OF THE POINT

- [ ] Point and equipment code
- [ ] Criticality: safety, main drive, process control, auxiliary
- [ ] Function: splice, branch, plug and socket, panel, box, cable gland

B. ENVIRONMENT, WORST REAL CONDITION

- [ ] Water: splashes, rain, jet, high-pressure jet, temporary immersion, continuous immersion
- [ ] Depth and duration of immersion, if any
- [ ] Dust: type and intensity
- [ ] Chemicals: name, concentration and temperature
- [ ] Minimum, maximum and daily temperature swing
- [ ] Relative humidity and risk of condensation
- [ ] Exposure to sun, ozone and salt mist
- [ ] Impact and vibration

C. ELECTRICAL DATA

- [ ] Current and voltage, AC or DC
- [ ] Number of power and signal poles
- [ ] Conductor cross-section in mm^2

D. CABLE

- [ ] Measured outer diameter
- [ ] Sheath material
- [ ] Solid or stranded conductor
- [ ] Change of conductor size at the point

E. CONNECTOR REQUIREMENTS

- [ ] Required IP rating, with combined marking if there is jet and immersion
- [ ] Required IK rating
- [ ] T-marking equal to or above operating temperature
- [ ] Contact type: screw, spring, insulation-piercing
- [ ] Lock type and number of cycles
- [ ] Anti-condensation barrier
- [ ] Reinspectable connection
- [ ] Restriction on silicone or halogens
- [ ] Required product standards

F. CIRCUIT

- [ ] Circuit layout drawn
- [ ] Interruptions counted and classified
- [ ] Interruptions that can be eliminated
- [ ] Possibility of a pre-wired version

G. MAINTENANCE

- [ ] Point accessible for visual inspection
- [ ] Point included in the inspection plan
- [ ] Standardised spare in stock
- [ ] Installation-day photo on file



PART

VII

Toolbox of production engineering

27 The tools and where each one fits

28 From problem to standard: an applied roadmap

29 Going deeper: reading path

CHAPTER 27

The tools and where each one fits

The previous parts dealt with the component. This part deals with the method. The tools below are familiar from any Lean, TPM or quality programme LITERATURE. What changes here is the object: instead of the machine or the process, the analysis falls on the connection point.

Used in sequence, they answer the question management usually asks: why invest in a better connection?

To see and understand the problem

TOOL	QUESTION IT ANSWERS	APPLICATION TO CONNECTIONS
Gemba	What actually happens at the point?	Observe the connection in the worst real condition: washdown, rain, cold start
5S	Is the point clean, identified and accessible?	Identify each connection with a code and keep boxes and trays inspectable
Pareto	Where are most of the failures?	Stratify electrical stoppages by cause and by point
5 whys	What is the cause behind the cause?	Move from "water got in" to the design, the cable or the assembly
Ishikawa	Which families of causes are involved?	Organise the hypotheses into method, material, manpower, machine, measurement and environment
RCFA	What does the failed part reveal?	Open, photograph and analyse the connector before cleaning or replacing it
FMEA	What can fail, and how severely?	Treat each assembly interface as a possible failure mode

To prevent, measure and consolidate

TOOL	QUESTION IT ANSWERS	APPLICATION TO CONNECTIONS
Poka-yoke	How do we prevent the error at the source?	Co-moulded seal, lock with feedback, mechanical keying and colours
Standard work	Does everyone install the same way?	Standard for stripping, tightening and checking the lock
Autonomous maintenance	Does the operator know what is normal?	Visual inspection card for connections
MTBF e MTTR	Did the change work?	Measure the interval between failures and the repair time before and after
OEE	How much does the failure cost in efficiency?	Specific downtime code for connection, splice and cable entry
Machine-hour cost	How much is one hour of downtime worth?	Basis for the cost per failure and the total cost calculation
Kaizen, PDCA and A3	How do we consolidate the improvement?	Pilot on one machine, verification and standardisation



THE ENGINEER'S VIEW

A tool without data becomes an opinion with a form. When the work order records only "electrical failure", the cause is lost. The first gain rarely comes from the new connector: it comes from starting to record the connection as a cause.

Prof. Vagner Soares, Manufatura Enxuta

CHAPTER 28

From problem to standard: an applied roadmap

The roadmap below links the tools in a hypothetical situation, created for teaching purposes ILLUSTRATIVE EXAMPLE. The figures do not represent measured results.

Situation. A filling line records 14 stoppages for "electrical failure" in six months. Maintenance replaces sensors and cables, and the stoppages continue.

Step 1. See: gemba and 5S

The team follows the line's washdown. They see a hot water jet aimed straight at the sensor connectors and find unidentified points inside closed trays. Result: each connection gets a code, and the trays get inspection covers.

Step 2. Prioritise: Pareto

The 14 events are reclassified by cause and by point.

RECLASSIFIED CAUSE	EVENTS
Sensor connector with water	8
Splice in tray with oxidation	3
Faulty sensor	2
Broken cable	1

Eleven of the 14 stoppages start at connection points. The problem stops being "electrical" and gets an address.

Step 3. Understand: 5 whys, Ishikawa and RCFA

1. Why did the sensor fail? Because there was water in the connector.
2. Why was there water? Because the seal did not withstand the washdown.
3. Why didn't it? Because the connector is IP67, and the washdown uses a hot high-pressure jet.
4. Why was IP67 specified? Because the specification described the average condition of the area, not the washdown.
5. Why was washdown left out of the specification? Because there is no specification standard that asks for the worst condition.

The root cause is in the specification process, not in the part. Opening the removed connectors, photographed before cleaning, confirms water entry through the seal.

Step 4. Prevent: FMEA and poka-yoke

The team lists the failure modes of the point: forgotten seal, cable outside the diameter range, half-mated connector, material incompatible with the detergent. For each one, they look for a solution that prevents the error: co-moulded seal, measuring the cable before purchase, lock with tactile feedback, checking the chemical resistance table.

Step 5. Standardise: standard work and autonomous maintenance

Installation gets a one-page instruction, with stripping length, lock check and installation-day photo. The operator receives the visual inspection card from chapter 12.

Step 6. Measure: MTBF, MTTR, OEE and cost

A pilot replaces ten points. The team records the interval between failures and the repair time before and after, uses the specific downtime code in OEE and converts the hours into money with the machine-hour cost. With this data, they build the total cost comparison from chapter 18.

Step 7. Consolidate: kaizen, PDCA and A3

If the pilot confirms the gain, the purchasing specification is changed and the standard goes to the other lines. The case is recorded in an A3 report, so the group's next plant does not start from scratch.

> **WARNING**
>
> The roadmap does not end with replacing the connector. It ends with changing the specification standard, which is what prevents the problem from repeating on another line.

CHAPTER 29

Going deeper: reading path

This guide grew out of a series of articles on the Manufatura Enxuta portal and Techno's technical material. The links below lead to the sources (in Portuguese), organised by topic.

The series on industrial electrical connections

- Techno do Brasil: tecnologia em conexões elétricas
- Conexões elétricas industriais: o ponto fraco da produção
- Como escolher conectores elétricos industriais: checklist
- IP66, IP68, IP69K e IK: como interpretar
- Condensação e infiltração de água em conexões
- Conexões industriais e TPM
- Lean: os desperdícios começam na escolha do componente
- Cases de conexões elétricas em ambientes hostis
- Custo total das conexões industriais (TCO)

Analysis and improvement tools

- Gemba walk
- 5S
- Pareto chart
- 5 whys
- Ishikawa diagram
- RCFA
- FMEA
- Poka-yoke
- Standard work
- Kaizen
- PDCA
- A3 report
- Visual management

Maintenance and reliability

- TPM
- Autonomous maintenance
- Preventive, predictive and corrective maintenance
- RCM
- Bathtub curve
- MTBF e MTTR

Indicators and cost, with calculators

- OEE: how to calculate it, with calculator
- Machine-hour cost, with worked example
- Break-even point, with calculator

Techno

- Techno do Brasil website: technodobrasil.com.br
- Product lines: technodobrasil.com.br/produtos
- General catalogue and data sheets: techno.it
- Anti-condensation technology: xdry.it
- Connectivity platform: ioth.it
- Video on choosing and matching cables, cited in the technical presentation: youtube.com/watch?v=D-NIUmdnJfk
- Account by the football pitch installer, four years later: instagram.com/p/C-Gn03dRojN

Frequently asked questions

Can an IP68 connector be washed with a high-pressure jet? Not necessarily. Immersion and jet are different tests. For high-pressure, high-temperature washdown, the marking must include IP69 STANDARD.

What is the difference between IP69 and IP69K? IP69K comes from the road vehicle standard ISO 20653. IP69 is the equivalent test added to IEC 60529. In practice they indicate the same kind of requirement STANDARD.

I found water in a connector with a perfect seal. How?
Probably from condensation or capillarity through the cable. See chapter 10.

Can I use tape or resin to reinforce the seal? That prevents inspection and hides assembly defects. The recommendation is to use a connection designed for the environment.

When is plug and socket worth using instead of a splice? Whenever the equipment is removed periodically, or when repair time is critical.

What does reinspectable connection mean? It is a connection that can be opened, checked and closed again without losing its function, because it uses no resin or gel.

How do I know if I need anti-condensation protection? Thermal cycling with humidity, sensitive electronics at the point or a history of internal water with no sealing defect are the main indicators.

Does the IP rating guarantee durability? No. IP is a type test on a new product. Durability depends on the materials and the ageing tests.

Why is cable diameter so important? Because the cable gland only seals within a diameter range. Outside it, the rubber compression is insufficient or excessive.

Is it worth replacing every connection in the plant?
No. Start with the critical points and those where failures concentrate, with a pilot and measurement.

Conclusion: better connections, more reliable operations

The electrical connection concentrates, in a few centimetres, almost every risk of an installation: the environment, the assembly, the cable and time. Being small and cheap, it usually gets little attention. Working in series, one is enough to stop the line.

This guide has covered the whole path:

- **Specify** from the environment, the cable and the circuit.
- **Interpret** IP and IK ratings correctly and recognise their limits.
- **Tell apart** ingress, condensation and capillarity.
- **Maintain** with a visual standard, condition-based inspection and cause recording.
- **Decide** on total cost, not unit price.

The final recommendation is practical. Choose one machine, count the connections, gather last year's failures and test one improvement with measurement. The result of that pilot will be the best argument for the next step.

Techno do Brasil's technical team supports environment analysis, cable selection and the definition of connections for complicated and hostile applications.

Credits



TECHNICAL CONTENT

Mario Adinolfi

Director of Techno do Brasil

Author of the technical presentation "Complicated and Hostile Applications", the basis for the product data and applications gathered in this guide.



TECHNICAL ANALYSIS AND EDITING

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About Techno do Brasil

Techno is an Italian manufacturer of high-protection electrical connections, with design and production in Italy. The general catalogue records 20 patents, 12 trademarks, around 3,000 product codes, 30 custom projects in the last three years and a presence in 80 countries TECHNO.

The company's stated mission is to design and develop high-quality thermoplastic polymer components for heavy-duty electrical connection solutions, making installation and maintenance easier and making electrical installations and equipment safe TECHNO.

In Brazil the operation is based in Curitiba, PR, under the direction of Mario Adinolfi.

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Glossary

Capillarity. Migration of liquid through narrow spaces, such as the gaps between the strands of a conductor.

Co-moulding. Joint injection of two materials, such as plastic and rubber, forming a single part.

Compression set. Permanent deformation of a rubber kept under compression.

Fretting. Friction corrosion caused by micro-movement between contact surfaces.

IK. Code for protection against mechanical impacts, defined by IEC 62262.

IP. Code for protection against solids and water, defined by IEC 60529.

MTBF. Mean time between failures.

MTTR. Mean time to repair.

OEE. Overall equipment effectiveness.

PA66 GF. Polyamide 66 reinforced with glass fibre.

Poka-yoke. Device that prevents the error from occurring.

Dew point. Temperature below which the water vapour in the air condenses.

T-marking. Operating temperature for which the product was qualified.

TCO. Total cost of ownership.

TPE. Thermoplastic elastomer.

TPM. Total Productive Maintenance.

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The roadmap in chapter 28, cases 5 and 6 in chapter 21, the series reliability calculations in chapter 15, the downtime values in chapter 17 and the total cost example in chapter 18 were prepared for teaching purposes and do not represent measured results.