techno
TECHNOLOGY & INNOVATION



BASIC E-BOOK

Industrial electrical connections

The link that protects the reliability of your operation

20 pages | 13 chapters | Basic checklist

TECHNICAL CONTENT
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This is the basic version, for a first read. There is also the **complete e-book**, a 66-page technical reference guide.

Introduction

A modern production line depends on thousands of points where one cable ends and another begins. Hardly anyone thinks about them while they work. When one of them fails, the line stops, and the search for the cause usually starts in the wrong place: the motor, the sensor, the PLC card.

This guide was written to change that order. In a few pages, it explains what an industrial electrical connection is, where it works, why it fails and how to choose it well. The language is direct, and the concepts apply to any connection manufacturer.

At the end, you will have a simple checklist to take to your next specification.

> **ABOUT THE SOURCES OF THIS GUIDE**
>
> Product data comes from Techno's general catalogue and technical presentation. Protection rating concepts come from the IEC standards listed in the references. Figures used in calculation examples are illustrative and are always identified as such.

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



Branch connector ready for installation in a pull box. Photo: Techno technical presentation.

CHAPTER 01

The link nobody sees

The cable is continuous, protected by insulation and sheath. The motor is enclosed. The panel has a door and a seal. The weakness of a circuit lies in the points where the cable is interrupted: the splice, the branch, the panel entry, the connection to the equipment.

Every interruption is an opening in the protection. That is where water looks for a path, where vibration loosens the contact and where an assembly error stays hidden for months.

That is why the connection deserves the same care as the equipment it feeds. It costs little, but it decides whether the expensive equipment will run.

KEY IDEA

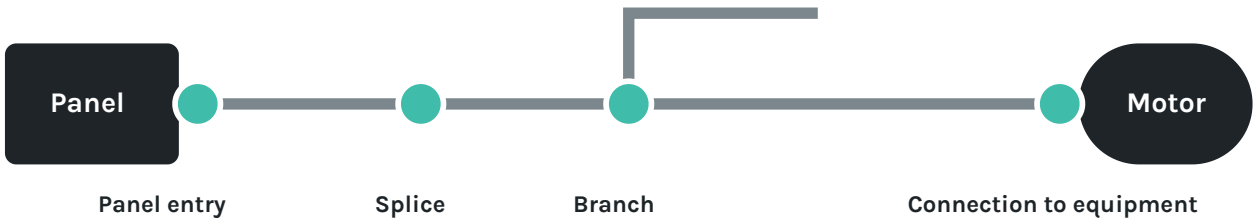
A circuit is only as reliable as its weakest connection.



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, nobody can calculate the reliability of the circuit or decide where to invest first.

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

The role of connections in the operation

An industrial electrical connection performs three functions at the same time.

Conduct. Metal contacts ensure the flow of current or signal with low resistance. An oxidised or loose contact heats up and drops the voltage.

Insulate. The connector body separates the poles from each other and from the outside, even with dust and moisture around.

Seal. Seals keep out water, dust and chemicals. The cable gland holds the cable and closes the passage around it.

When the connection has to be undone often, a fourth function comes in: **disconnect**. A plug and socket lets you replace a motor or a sensor without opening boxes or redoing terminals.

FUNCTION OF THE POINT	TYPE OF SOLUTION
Join two cables permanently	In-line splice
Take one or more outputs from a cable	T, Y or H branch
Connect and disconnect often	Plug and socket
Pass through a panel wall	Panel connector
House terminals or electronics	Junction box
Fix and seal a cable entry	Cable gland

CHAPTER 03

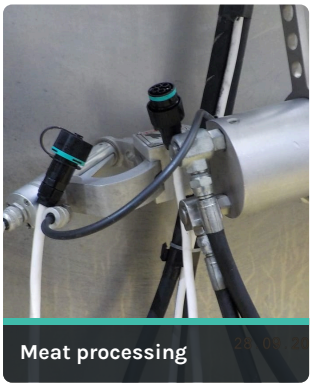
Where they work

High-protection connections appear where the environment is unforgiving. Techno's catalogue and technical presentation show applications such as these TECHNO:

- **Food and meat processing:** equipment washed every day with hot water and cleaning products.
- **Water and wastewater:** telemetry of water and sewage pipes, probes and pumps.
- **Pulp and paper:** constant humidity, heat and chemicals.
- **Street and sports lighting:** underground networks and pull boxes that flood.

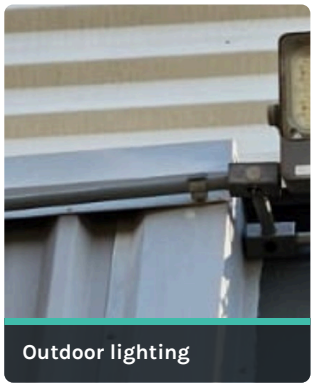
- **Machines and motors:** dust, vibration and frequent replacement.
- **Field instrumentation:** transmitters and sensors exposed to the weather.
- **Infrastructure:** tunnels, ports and construction sites.
- **IoT applications:** sensors and embedded electronics outdoors.

In all these cases the common point is the same: the environment attacks the connection every day, while the laboratory test lasts a short time.


Meat processing


Underground network


Ground lighting


Outdoor lighting

Photos of real applications. Source: Techno technical presentation.

CHAPTER 04

What usually goes wrong

Most connection failures come from four causes.

1. Product unsuited to the environment. An indoor connector installed in a washdown area. A rating against water jets used at a point that stays submerged.

2. Cable and connector that do not match. The cable gland only seals within a diameter range. Outside it, the rubber does not compress enough and water gets in.

3. Assembly error. Forgotten sealing ring, wrong tightening, half-mated connector. The more loose parts, the more chances of error.

4. Ageing. Sun, ozone, heat and chemicals dry out rubbers and weaken ordinary plastics over the years.

The symptoms are familiar to any maintenance team:

- oxidised contacts and overheating;
- voltage drop and unstable sensor readings;
- protections tripping for no apparent reason;
- the intermittent failure that disappears when the technician arrives.

> **WARNING**
>
> The intermittent failure is the most expensive. It consumes hours of troubleshooting, leads to replacing good parts and wears down trust in maintenance.

CHAPTER 05

The aggressors in the environment

Techno organises the analysis of the environment into seven agents TECHNO:

AGENT	WHAT IT DOES TO THE CONNECTION
Humidity	Slow oxidation of contacts
Water	Short circuit, leakage current, corrosion
Chemicals	Attack on plastics and rubbers
Pressure	Forces water inside, by jet or submersion
Heat	Ages seals and insulation
Temperature variation	Expands and contracts, creates gaps
Condensation	Forms water inside, with no visible entry

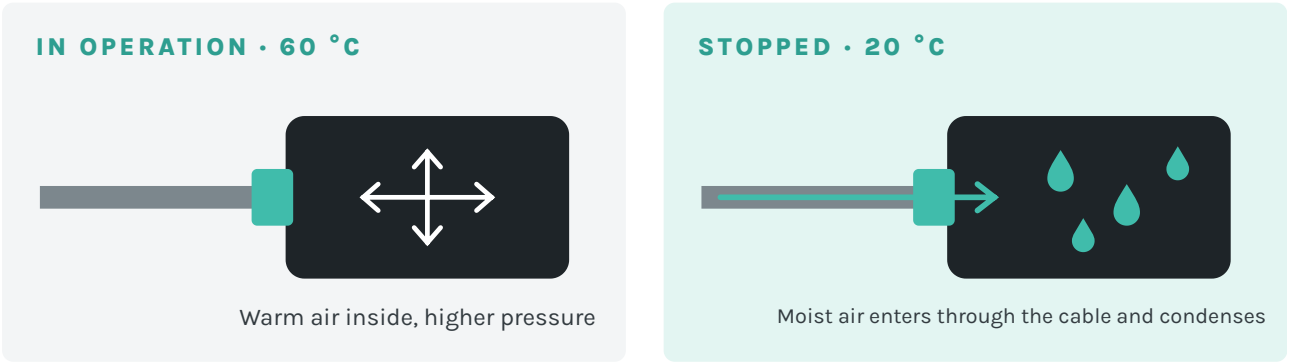
Two mechanical agents add to these: **dust**, which gets into gaps and contaminates contacts, and **vibration and impact**, which loosen connections and can crack the connector body.

The water that forms inside

Condensation deserves attention because it is deceptive. A well-sealed enclosure heats up during operation and cools down when stopped. As it cools, the air inside loses pressure and the assembly starts drawing in moist air through any micro-path, including through the cable itself, between the conductor strands.

An order-of-magnitude example: air cooling from 60 °C to 20 °C loses about 12% of its pressure ILLUSTRATIVE EXAMPLE, CALCULATED WITH THE GAS LAW. That is enough to draw in moisture on every cycle.

The result is water inside a connector that was never wet on the outside.



Thermal breathing of the enclosure. Schematic illustration.

CHAPTER 06

IP and IK made simple

The IP code

The IP protection rating is defined by IEC 60529, adopted in Brazil as ABNT NBR IEC 60529 STANDARD. It has two digits:

- the **first** indicates protection against solids and dust. Level 6 means totally protected against dust;
- the **second** indicates protection against water.

MARKING	PROTECTS AGAINST	WHERE IT MAKES SENSE
IP66	Dust and powerful water jets	Outdoor areas, hose washing
IP67	Dust and temporary immersion	Points subject to brief flooding
IP68	Dust and continuous immersion, under conditions agreed with the manufacturer	Underground boxes, pumps, probes
IP69	Dust and high-pressure, high-temperature jets	Sanitising in food and meat plants



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

Three precautions avoid most mistakes:

1. **Jet and immersion are different tests.** An IP68 product is not automatically suitable for jets. That is why dual markings exist, such as IP66/IP68.
2. **IP68 is not a single value.** Immersion depth and time are defined by the manufacturer. Ask for this data.
3. **The rating applies to the assembled set.** Cable within the diameter range, connector fully mated, cover in place.

> **IP69 OR IP69K?**
>
> The "K" comes from the road vehicle standard ISO 20653. IEC 60529 added an equivalent test as second digit 9. In everyday use, both forms indicate resistance to high-pressure, high-temperature washdown.

The IK code

IP says nothing about knocks. For that there is the IK code, from IEC 62262 STANDARD, which classifies the impact energy the enclosure withstands.

RATING	IMPACT ENERGY
IK07	2 J
IK08	5 J
IK09	10 J
IK10	20 J

CHAPTER 07

How to choose in three steps

Techno proposes a simple three-stage method for a correct and durable installation TECHNO.

Step 1: analyse the environment

Go through the seven agents in chapter 5 and describe the **worst real condition** at the point, not the average. Equipment that stays dry all year and is washed with a hot jet once a week has to be specified for the washdown.

Step 2: choose and match the cable

Cable and connector are chosen together. Collect four pieces of data:

- outer diameter of the cable;
- number of poles;
- cross-section of each pole;
- technical specification of the cable, including the sheath material.

Step 3: eliminate the weak points

Draw the circuit layout and count every cable interruption. Note the type of each one (straight splice, T, Y, H or multiple branch), the changes in conductor size and the distances.

Fewer interruptions, and better interruptions, mean a more reliable circuit.

CHAPTER 08

The price of getting it wrong

The price of a connector is small. The cost of a failure can be large. Comparing the two changes the purchasing conversation.

Here is a simple calculation ILLUSTRATIVE EXAMPLE, HYPOTHETICAL VALUES:

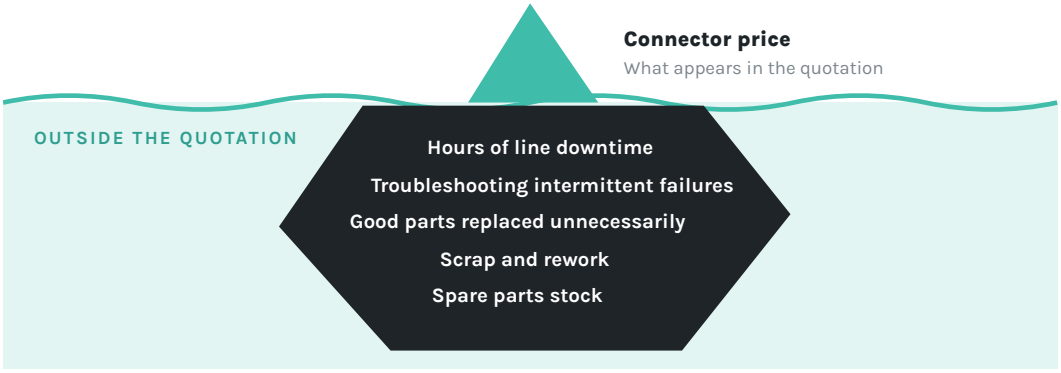
ITEM	VALUE
Cost of one hour of line downtime	R$ 8.000
Duration of the stoppage	3 hours
Cost of the stoppage	**R$ 24.000**

The connection that caused the stoppage costs a tiny fraction of that amount. And the figure still leaves out repair labour, scrap, rework and late delivery.

An unsuitable connection weighs on the three OEE factors, the overall equipment effectiveness indicator:

- **Availability:** stoppages due to electrical failure.
- **Performance:** minor stops and running at reduced speed.
- **Quality:** unstable readings from sensors and scales, which generate scrap.

> **A USEFUL QUESTION FOR THE NEXT PURCHASE**
>
> Instead of "how much does this connector cost?", ask "how much will this connection point cost over the next few years?".



CHAPTER 09

Reliability and continuity

The connections in a circuit work in series. If one fails, the circuit stops. That is why the reliability of the whole is the product of the individual reliabilities LITERATURE.

An example shows the effect ILLUSTRATIVE EXAMPLE:

> A circuit with 20 connections, each with a 99% chance of getting through the year without failing, has about an 82% chance of getting through the whole year without a stoppage. That is almost an 18% chance of at least one failure.

There are two levers to improve this number:

1. **Reduce the number of interruptions** in the circuit design.
2. **Raise the reliability of each one**, with a product suited to the environment and assembly with less chance of error.

For maintenance, three features help day to day:

- **Reinspectable connection.** Splices without resin or gel can be opened, checked and closed again.
- **Plug and socket with lock.** Replacing a motor or sensor is faster, with no risk of swapping connections.
- **Standardisation.** A few connector families per function reduce stock and simplify training.



$0{,}99^{20} \approx 0{,}82$

20 connections in series, each with 99% reliability per year. One link failing is enough to stop the circuit.

CHAPTER 10

Techno's technology

Techno do Brasil, based in Curitiba, is the Brazilian operation of the Italian manufacturer Techno Srl. In 2026 the company completed 40 years in plastic injection moulding. The products are designed and manufactured in Italy TECHNO.

Three technologies sum up what the brand offers.

Co-moulded seal

Plastic and rubber are injected together, forming a single part. According to Techno, the result is faster installation, with few components, and fewer assembly errors, because there is no loose sealing ring to forget or misplace.



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.

Connection without resin or gel

The brand's splices and boxes seal by mechanical design, with no encapsulation. That is why they can be reopened for inspection and reused.

xDRY®, the anti-condensation barrier

It is a barrier placed between the connector and the equipment, described in the catalogue as a patented system. It blocks moisture travelling inside the cable, the path the outer seal does not close. The catalogue states a 90% reduction in water ingress, with no voltage drop TECHNO.

The product families

FAMILY	FUNCTION
TEETUBE®	In-line splices and T, Y and H branches
TEEPLUG®	Disconnectable plug and socket
TEEBOX®	Junction boxes and distributors
TEEGLAND®	Co-moulded cable glands
IoTH®	Platform for integrating electronics and sensors

General data stated in the catalogue: electrical performance up to 41 A and 690 V, protection up to IP69 and impact resistance up to IK10, depending on the series TECHNO.



TEEBOX® box with embedded electronics and disconnectable entries. Photo: Techno technical presentation.

CHAPTER 11

A real case

On a football pitch, the lighting splices sit in buried pull boxes that fill with water in every heavy rain. The installation used the T branch model THB.402, rated IP68 TECHNO.

Four years later, the installer opened the connector on his own initiative and published the result:

> "Four years after I installed the waterproof connector from Techno do Brasil I decided to open it to check how well it worked, and the result surprised me: no trace of water. One detail: this pull box stays full of water in the rainy season."
>
> Installer's account, reproduced in Techno's technical presentation (translated)

It is a single account, with no laboratory measurement. Even so, it shows what matters in practice: the connection stayed dry after years in a condition that the type test only simulates for a short time.



Installation day



Four years later



Connector opened: dry inside

Source: Techno technical presentation.

CHAPTER 12

Toolbox: where to start

The choice of connection is easier to defend when it comes with a method. Six classic production engineering tools are enough to move from opinion to data.

TOOL	QUESTION IT ANSWERS	HOW TO USE IT FOR CONNECTIONS
Gemba	What actually happens at the point?	Go to the machine on a washdown or rainy day and observe
Pareto	Where are most of the failures?	Split electrical stoppages by cause and by point
5 whys	Why did the failure happen?	Go beyond "water got in" to the design or installation cause
Poka-yoke	How do we stop the error from recurring?	Prefer co-moulded seals, locks and keying that prevent wrong assembly
OEE	How much does the failure cost in efficiency?	Record the connection as a specific cause of stoppage
Machine-hour cost	How much is one hour of downtime worth?	Turn hours of downtime into money to compare with the connector price



THE ENGINEER'S VIEW

The connection usually becomes a topic only after several stoppages from the same cause. The cheapest tool is the first in the table: go to the point, look and take photos. The rest of the method depends on what you see there.

Prof. Vagner Soares, Manufatura Enxuta

TO GO DEEPER

- Full series on connections on the Manufatura Enxuta portal (in Portuguese): Techno do Brasil: tecnologia em conexões elétricas
- Pareto chart
- 5 whys
- Poka-yoke
- OEE, with calculator
- Machine-hour cost
- Techno do Brasil website: technodobrasil.com.br
- Product lines: technodobrasil.com.br/produtos

CHAPTER 13

Basic specification checklist

Use this list before asking for a quotation.

ENVIRONMENT

- [ ] Does the point get rain, splashes, jets or stay submerged?
- [ ] Is there high-pressure or hot-water washdown?
- [ ] Which chemicals come into contact?
- [ ] What are the minimum, maximum and daily temperature swing?
- [ ] Is there thermal cycling with humidity that favours condensation?
- [ ] Is there a risk of impact or vibration?

ELECTRICAL

- [ ] Circuit current and voltage.
- [ ] Number of poles, separating power and signal.
- [ ] Conductor cross-section in mm^2.

CABLE

- [ ] Outer diameter measured, within the connector range.
- [ ] Sheath material compatible with the environment.

FUNCTION

- [ ] Splice, branch, plug and socket, panel or box?
- [ ] How often will the point be disconnected?
- [ ] Does the point need to be reinspectable?

CIRCUIT

- [ ] Have all cable interruptions been counted?
- [ ] Can any be eliminated in the design?

Conclusion

The electrical connection is small, cheap and easy to forget. It is also the point where water gets in, where vibration does its work and where the intermittent failure hides.

Treating the choice of connection as a technical decision, and not as a line on a shopping list, protects what is really expensive: production time.

Three ideas to take from this guide:

1. Specify for the worst real condition of the environment.
2. Choose cable and connector together.
3. Count the interruptions in the circuit and eliminate those you can.

WANT TO GO FURTHER?

The complete e-book, "Industrial electrical connections: engineering, reliability and efficiency in industry", goes deeper into each of these topics, with sizing criteria, maintenance routines, total cost calculation and applications in hostile environments.

Credits



TECHNICAL CONTENT

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Director of Techno do Brasil

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TECHNICAL ANALYSIS AND EDITING

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Manufatura Enxuta
manufaturaenxuta.com.br

About Techno do Brasil

Techno began as a manufacturer of technical plastic parts and specialised in electrical connections with high protection against water and dust. The general catalogue records 20 patents, 12 trademarks, around 3,000 product codes and a presence in 80 countries, with production certified as "Made in Italy" TECHNO.

In Brazil the company operates from Curitiba, with technical support for specification, pre-wired products and custom solutions.

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