

# The Top 25 Connectivity Failure Points Checklist

## For Packaging Machine Builders and OEMs

Use this checklist before every machine build, commissioning visit, or design review. Each item represents a real failure point drawn from 35+ years of field experience in industrial control systems. A single unchecked item can cost you days of downtime, thousands in rework, or a customer relationship.

01	Terminal & Screw Connections	5 items + bonus
02	Cable Management & Routing	5 items
03	Connector & Plug Selection	5 items + bonus
04	Grounding & Shielding	5 items
05	Documentation & Labelling	5 items

## A Note on Honesty

### A note on honesty:

This checklist is most valuable when you are brutally honest with yourself. It is tempting to check an item because you believe it is probably fine, rather than because you have physically verified it. The failure points that cause the most damage are always the ones that were assumed to be fine. If you are not certain, do not check it.

## How to Use This Checklist

- 1 Work through each category in order.**  
The categories are sequenced to mirror the build and commissioning process.
- 2 Check each item only when you have physically verified it.**  
Not when you believe it is probably fine.
- 3 Note any items you cannot verify.**  
These are your highest-priority follow-up actions.
- 4 Use the severity ratings to prioritize.**  
Critical items must be resolved before commissioning. High items should be resolved before shipment.
- 5 Keep a completed copy with the machine documentation.**  
It is evidence of due diligence and a useful reference for future service visits.

### SEVERITY RATINGS:

**CRITICAL**

Must resolve before commissioning

**HIGH**

Resolve before shipment

**MEDIUM**

Address in next design review

# Terminal & Screw Connections

Loose terminal connections are the single most common cause of intermittent faults in industrial control systems. Every connection in this category must be physically verified, not assumed.



01

**All terminal screws are torqued to the manufacturer's specified torque value using a calibrated torque screwdriver**

**CRITICAL**

Under-torqued terminals are the leading cause of intermittent faults and thermal failures. A connection that passes initial testing can fail weeks later as vibration works the wire loose. Torque specification is not a suggestion.

**ACTION:** Obtain the torque specification from the terminal manufacturer's datasheet for each terminal type used. Use a calibrated torque screwdriver. Do not rely on feel.



02

**Ferrules are used on all stranded wire terminations into screw terminals**

**CRITICAL**

Stranded wire without a ferrule fans out under a screw terminal, creating a connection that degrades over time as individual strands break or loosen. A ferrule consolidates the strands into a solid termination that maintains consistent contact force.

**ACTION:** Specify ferrules as a build standard for all stranded wire terminations. Ensure the correct ferrule size is used for each wire gauge. Use a ratchet crimping tool, not pliers.



03

**No more than two wires are terminated in any single terminal point**

**HIGH**

Terminals are rated for a specific number of conductors. Exceeding this creates uneven clamping force, increases resistance, and creates a fault point that is difficult to identify visually.

**ACTION:** Review all terminal assignments during design. Where more than two wires must connect at a point, use a jumpered terminal block or a distribution terminal rather than overloading a single terminal.



04

**All terminal blocks are labelled with wire numbers that match the wiring diagram**

**HIGH**

Unlabelled or incorrectly labelled terminals transform a 10-minute fault-finding task into a multi-hour wire-tracing exercise. Labels must match the wiring diagram exactly, not approximately.

**ACTION:** Apply terminal labels before wiring begins. Verify label accuracy against the wiring diagram as part of the pre-shipment inspection. Use printed labels, not handwritten ones.



05

**Terminal blocks are grouped and separated by function with clear physical dividers between power, control, and signal circuits**

**MEDIUM**

Mixing power, control, and signal terminals in a single unmarked row creates confusion during fault-finding and increases the risk of cross-wiring errors during modifications.

**ACTION:** Define a terminal block layout standard that physically separates power, control, and signal circuits. Use end stops and labelled section markers between groups.

# Terminal & Screw Connections

BONUS

**Motor Terminal Connections: Install Flange Connectors and Use Loctite Blue**

CRITICAL

Motor terminal connections are notorious for vibrating loose in service. The solution is to install a male flange connector (such as the Murrelektronik MQ15) on all motors so the cable connects to the flange rather than directly to the motor terminal box. This provides two additional benefits: it enables quick disconnect of the motor cable when shipping the machine or troubleshooting, and it enables faster motor swap-out for the end user, which directly reduces MTTR. Whether or not you use a flange connector, always apply Loctite Blue (or equivalent medium-strength thread-locker) to all motor terminal screws to prevent vibration loosening.

**ACTION:** Specify flange connectors as standard on all motors. Apply Loctite Blue to all motor terminal screws during assembly.

**WARNING:** Never use Loctite Red on terminal screws. Red is a permanent-strength compound and the screws will be impossible to remove without heat.

## Field Tips: Terminal and Screw Connections

Loose terminal connections rarely announce themselves politely. Most of the time, they pass the first test, survive the factory acceptance test, and then wait until vibration, heat, and production pressure expose the weakness. That is why terminal work should never be treated as “basic wiring.” It is one of the highest-risk areas of the whole machine.

Tip	What to Check	Why It Matters
<b>Torque every screw, then mark it</b>	Use the manufacturer’s torque value and a calibrated torque screwdriver. Add a small paint mark after verification.	A terminal that feels tight can still be under-torqued. The paint mark gives the next inspector visual proof that it was checked.
<b>Use ferrules on every stranded conductor</b>	Match the ferrule to the wire gauge and use a ratchet crimping tool, not pliers.	Loose strands, poor crimps, and wrong ferrule sizes create weak connections that may not fail until the machine is running.
<b>Do not double up unless the terminal is rated for it</b>	Check whether the terminal is approved for two conductors and whether both conductors are the same type and size.	Two wires under one screw often create uneven clamping force. One wire may be tight while the other is barely held.
<b>Separate power, control, and signal wiring</b>	Keep terminal groups physically separated and labelled by function.	Mixed terminal rows make troubleshooting slower and increase the risk of noise, wiring errors, and accidental cross-connection.
<b>Treat motor terminal boxes as vibration zones</b>	Use a flange connector where possible and apply medium-strength threadlocker, such as Loctite Blue, to the motor terminal screws.	Motor vibration works on every screw connection. Moving the cable strain to a connector and protecting the screws reduces future nuisance faults.
<b>Never use permanent thread-locker on terminal screws</b>	Avoid red permanent-strength thread-locker on any terminal connection that may need service later.	If the terminal needs to be opened, permanent thread-locker can turn a simple service task into a damaged terminal box.

**Design rule:** If a wire needs to be disconnected during shipping, installation, service, or motor replacement, consider using a connector rather than a hand termination. Every avoidable termination is one less future fault point that will cause downtime.

# Cable Management & Routing

Poor cable management is a slow-burning problem. It does not cause immediate failures, but it makes every future fault harder to find, every modification more expensive, and every service visit longer than it needs to be.

**06** **Power and signal cables are routed in separate cable trays or conduits with a minimum separation of 200mm** **CRITICAL**

Routing power cables alongside signal cables induces electromagnetic interference that causes intermittent faults, communication errors, and sensor noise. These faults are notoriously difficult to diagnose because they are not consistent and do not leave physical evidence.

**ACTION:** Define cable routing zones in the machine design before wiring begins. Power cables (including VFD output cables) must be in a dedicated tray. Signal cables must be in a separate tray with a minimum 200mm separation. Where they must cross, cross at 90 degrees.

**07** **All cables are supported at regular intervals and are not under tension at any termination point** **HIGH**

Cables under tension at termination points experience continuous mechanical stress that fatigues the conductor and degrades the connection over time. This is particularly damaging in applications with vibration.

**ACTION:** Specify cable support intervals in the build standard (typically every 300-500mm for cabinet wiring). Ensure cables have a service loop at every termination point. Verify that no cable is pulling against its connector or terminal under any operating condition.

**08** **Flexible conduit or cable carriers are used for all cable runs that cross moving machine sections** **CRITICAL**

A cable routed across a moving section without a proper cable carrier will fail. It is not a question of if, it is a question of when. The failure mode is typically a broken conductor that creates an intermittent fault.

**ACTION:** Specify cable carriers (energy chains) for all moving axis cable runs. Size the carrier for the cables it contains plus 20% spare capacity. Verify that the minimum bend radius of all cables is not exceeded at any point in the carrier travel.

**09** **All cables entering the cabinet through cable glands are properly sealed and the gland is sized for the cable outside diameter** **HIGH**

An incorrectly sized or unsealed cable gland allows moisture, dust, and contaminants to enter the cabinet. In a food or beverage packaging environment, this is a hygiene risk as well as a reliability risk.

**ACTION:** Specify cable gland sizes for each cable entry point during design. Verify that the gland is correctly sized for the cable OD, not the conduit OD. Verify IP rating of the gland matches the cabinet IP rating requirement.

**10** **Cable tray fill does not exceed 60% of the tray cross-sectional area** **MEDIUM**

Overfilled cable trays make it impossible to add cables during modifications, create heat retention problems, and make fault-finding significantly more difficult. The 60% rule is an industry standard for good reason.

**ACTION:** Calculate cable tray fill during design, not after wiring. If fill exceeds 60% at design stage, increase tray size. Leave documented spare capacity for future modifications.

# Connector & Plug Selection

Connector selection is one of the highest-leverage decisions in machine design. The right connector choice reduces wiring time, improves reliability, and makes the machine significantly easier to service.

**11 All field-mounted devices have connectors with the correct IP rating for the installation environment** **CRITICAL**

An IP-rated device with a non-IP-rated connector is not IP-rated. This is one of the most common mistakes in machine wiring. In a wet, washdown, or dusty environment, a connector that is not rated for the environment will fail. There should be no RJ45 connectors outside of the control cabinet under any circumstances. RJ45 is an office-grade connector not designed for industrial environments. Replace all field-located RJ45 connections with M12 D-coded (100Mbps Ethernet) or M12 X-coded (Gigabit Ethernet) equivalents.

**ACTION:** Define the minimum IP rating for connectors in each machine zone as part of the design specification. Verify connector IP ratings against the zone specification during design review. Replace any RJ45 connectors in field locations with M12 industrial equivalents immediately.

**12 Connectors are keyed or colour-coded to prevent incorrect mating** **HIGH**

A connector that can be mated incorrectly will eventually be mated incorrectly. In a packaging machine with dozens of similar connectors, the risk of incorrect connection during service or after a cable replacement is significant.

**ACTION:** Specify keyed or colour-coded connectors for all applications where incorrect mating could cause damage or safety issues. Document the colour coding scheme in the machine documentation.

**13 All connectors are rated for the voltage and current they carry with a minimum 20% derating** **CRITICAL**

Operating a connector at its rated maximum is operating it at the edge of its design envelope. Temperature, contact resistance, and current capacity all degrade over time. A 20% derating provides the margin needed for reliable long-term operation.

**ACTION:** Verify connector current ratings against actual load current during design. Apply a 20% derating factor. Document the derating calculation for each connector type in the design review.

**14 Connectors in high-vibration locations are secured with a locking mechanism (bayonet lock, screw lock, or push-pull lock)** **HIGH**

A connector that relies on friction alone for retention in a high-vibration environment will work loose. The result is an intermittent fault that is extremely difficult to diagnose because the connection may appear secure during inspection.

**ACTION:** Identify all high-vibration locations in the machine design. Specify locking connectors for these locations. Verify that the locking mechanism is engaged during assembly inspection.

**15 A connector standard is defined and applied consistently across all machines in the product range** **MEDIUM**

A machine that uses a different connector for every application is a spare parts and training problem. Standardizing on a small number of connector families reduces inventory cost, simplifies training, and dramatically speeds up field repairs.

**ACTION:** Create a connector standard document that defines the approved connector family for each application type. Apply the standard to all new designs. Review existing designs against the standard and plan a migration path.

# Connector & Plug Selection



**BONUS**

## Eliminate All Field-Attachable Connectors: Use Factory-Made Over-molded Cables Only

**CRITICAL**

Field-assembled connectors are one of the biggest causes of machine downtime in the packaging industry. They introduce wiring variability, create intermittent faults that are extremely difficult to troubleshoot, and are typically buried inside cable trays where they cannot be inspected. An intermittent fault in a field-assembled connector buried in a cable tray can take days to diagnose. The rule is simple: all device connections should be made using factory-made over-molded cables with no field-attachable connectors. Have cables made to the exact lengths you need. The cost difference is negligible compared to the cost of a single unplanned downtime event.

**ACTION:** Audit your current build standard and identify all locations where field-assembled connectors are used. Replace them with factory-made over-molded cables of the correct length. Work with your connector supplier to establish a custom cable program for your standard machine configurations.

### Field Tips: Field-Attachable Connectors

Field-attachable connectors look convenient on the build floor, but they transfer risk to the customer's production floor. The problem is not that technicians cannot properly wire connectors. The problem is that every hand-wired connector depends on strip length, conductor preparation, seal compression, strain relief matching cable diameter, tool condition, lighting, time pressure, and human consistency.

Risk Area	What Goes Wrong	Better Standard
Installation variability	A field-wired M8 or M12 connector may pass commissioning even if the strip length, crimp, seal, or torque is marginal.	Use factory-made, over-molded cordsets that are electrically tested before shipment.
Moisture ingress	IP ratings on field-assembled connectors depend on the correct grommet, cable diameter, jacket cut, seal position, and strain relief torque. One mistake compromises the seal.	Use over-molded cables where the seals are part of the connector body, not dependent on field assembly technique.
Vibration and fretting corrosion	Micromotion can wear contact surfaces, build oxide, increase resistance, and create intermittent faults that disappear when the machine is stopped.	Use detented, over-molded connectors designed for machine vibration and repeatable contact force.
Troubleshooting time	Intermittent connector faults often look like sensor, I/O, network, or software problems. Maintenance may replace good parts before finding the real cause.	Standardize cordsets so the first diagnostic step is inspect, swap, and restart.
Cable tray blind spots	Field-assembled connectors buried in cable trays are hard to inspect and often forgotten after commissioning.	Keep connections visible, accessible, and built from standard cable lengths wherever possible.
Specification gaps	If the machine specification does not prohibit field-attachable connectors, then they will often be used for convenience.	State clearly that M8 and M12 device connections must use factory-made over-molded cordsets, with written approval required for exceptions.

**Design rule:** Field-attachable connectors should be treated as exceptions rather than standard practice. If using one is unavoidable, document the location, reason, cable type, assembly procedure, inspection method, and maintenance interval.

# Grounding & Shielding

Grounding and shielding problems are the most difficult category of fault to diagnose in a control system. They produce symptoms that look like component failures, software bugs, or communication errors. Getting this right at the design stage is far less expensive than diagnosing it in the field.



16

## A single-point grounding architecture is used, with all equipment grounds returning to a single ground bus in the main cabinet

CRITICAL

Multiple ground paths create ground loops that act as antennas for electromagnetic interference. The symptoms include unexplained communication errors, sensor noise, and drive faults that cannot be reproduced consistently.

**ACTION:** Define the grounding architecture in the machine design specification. All equipment grounds must return to a single ground bus. Verify the single-point architecture during design review and during commissioning.



17

## Cable shields are terminated at one end only (typically the cabinet end) and are not used as a current-carrying conductor

CRITICAL

Terminating a cable shield at both ends creates a ground loop. Using a shield as a current return path destroys its shielding effectiveness. Both mistakes are common and both produce the same difficult-to-diagnose interference symptoms.

**ACTION:** Define shield termination practice in the build standard. Shields terminate at the cabinet end only, connected to the shield bus, not the signal ground. Verify shield termination during pre-shipment inspection.



18

## VFD output cables are shielded and the shield is terminated at the VFD and at the motor using 360-degree shield clamps

CRITICAL

VFD output cables are the most significant source of conducted and radiated EMI in a packaging machine. An unshielded VFD output cable will cause interference in every sensitive circuit in the machine.

**ACTION:** Specify shielded cable for all VFD output runs as a build standard. Use 360-degree shield clamps at both ends. Do not rely on pigtail shield connections. Verify shield continuity and termination during commissioning.



19

## All cabinet panels and doors are bonded to the cabinet frame with short, low-impedance bonding straps

HIGH

A cabinet panel that is not bonded to the frame is not grounded. Paint, anodizing, and corrosion all create high-impedance connections that defeat the grounding of any equipment mounted on the panel.

**ACTION:** Specify bonding straps as a build standard for all cabinet panels and doors. Use star washers to ensure metal-to-metal contact at mounting points. Verify panel bonding resistance during pre-shipment inspection.



20

## Sensor and signal cable screens are not connected to the signal common (0V) at any point

HIGH

Connecting a cable screen to the signal common creates a ground loop through the signal circuit. This is a common mistake that produces noise on analog signals and communication errors on digital circuits.

**ACTION:** Define screen termination practice in the build standard. Screens connect to the dedicated shield bus only, never to the signal common. Verify screen termination during design review and pre-shipment inspection.

# Documentation & Labelling

Documentation and labelling are the tools that make every future interaction with the machine faster and less expensive. They are also the area most commonly sacrificed under schedule pressure, and the area whose absence is most acutely felt during a fault at 2am.

**21** **Every wire in the cabinet is labelled at both ends with a wire number that matches the wiring diagram** **CRITICAL**

An unlabelled wire in a cabinet is a mystery that must be solved every time someone works on the machine. In a fault situation, tracing an unlabelled wire adds hours to the diagnosis time. In a modification situation, it creates the risk of incorrect disconnection.

**ACTION:** Specify wire labelling as a build standard. Labels must be applied at both ends of every wire. Labels must match the wiring diagram exactly. Use heat-shrink printed labels, not handwritten tape.

**22** **All field devices are labelled with their tag number as shown on the wiring diagram and P&ID** **HIGH**

A field device without a tag number label cannot be identified without tracing its cable back to the cabinet. In a machine with hundreds of sensors and actuators, this is a significant time cost during commissioning and fault-finding.

**ACTION:** Specify field device labelling as a build standard. Labels must be applied to the device or its mounting bracket. Labels must match the tag number on the wiring diagram and P&ID exactly.

**23** **As-built wiring diagrams accurately reflect the machine as shipped, including all changes made during build and commissioning** **CRITICAL**

A wiring diagram that does not reflect the actual machine is worse than no diagram at all. It sends the fault-finder in the wrong direction and destroys confidence in the documentation. Every change made during build or commissioning must be captured before the machine ships.

**ACTION:** Implement a formal change control process for wiring modifications. All changes must be marked up on the working drawing set and transferred to the as-built drawings before shipment. The as-built drawings must be reviewed and signed off as part of the pre-shipment inspection.

**24** **A complete documentation package is delivered with every machine, including wiring diagrams, I/O list, network topology, drive parameters, and PLC program backup** **HIGH**

The documentation package is the maintenance team's primary tool for every fault they will ever diagnose on the machine. Delivering an incomplete package is delivering an incomplete machine.

**ACTION:** Define the required documentation package in the machine specification and in the customer contract. Create a documentation checklist that is signed off before shipment. Include a digital copy of all documentation on a USB drive or in a cloud folder accessible to the customer.

**25** **Cabinet layout drawings are current and accurately show the location of all components, terminal blocks, and cable entries** **MEDIUM**

A cabinet layout drawing that does not match the actual cabinet layout is useless for fault-finding and dangerous for modification work. It is particularly important that terminal block locations and numbering are accurate.

**ACTION:** Update cabinet layout drawings whenever components are added, moved, or removed. Include the cabinet layout drawing in the as-built documentation package. Verify accuracy of the layout drawing during the pre-shipment inspection.





# How Did You Score?

Count the number of unchecked items in each category and enter your totals below.

Items 01-05 – Terminal & Screw Connections	Unchecked items: ____
Items 06-10 – Cable Management & Routing	Unchecked items: ____
Items 11-15 – Connector & Plug Selection	Unchecked items: ____
Items 16-20 – Grounding & Shielding	Unchecked items: ____
Items 21-25 – Documentation & Labelling	Unchecked items: ____

**TOTAL UNCHECKED ITEMS:** \_\_\_\_ / 25

## What Your Score Means:

-  **0 unchecked — Outstanding:** Your machine meets best practice across all 25 failure points. This is a rare result.
-  **1-3 unchecked — Good:** Minor gaps. Address the unchecked items before commissioning or shipment.
-  **4-7 unchecked — Needs Attention:** Meaningful gaps that represent real risk. Prioritize Critical and High severity items immediately.
-  **8+ unchecked — High Risk:** Significant structural issues. Book a Connectivity Workshop before this machine ships.

YOUR NEXT STEP

# Found Gaps?

## Let's Fix Them.

Every unchecked item on this list is a fault waiting to happen. Some will show up during commissioning. Some will show up six months after the machine ships. Either way, they will cost you more to fix than they would have cost to prevent.

The Connectivity Workshop is a onsite session where we go through your architecture, your build processes, and your field performance data and build a prioritized plan to eliminate the gaps. No obligation, no sales pitch.

- A complete review of your control system architecture against all 25 failure points
- Identification of your highest-priority improvement opportunities
- A prioritized action plan you can take back to your team immediately
- Access to 35+ years of field experience in packaging machine connectivity

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