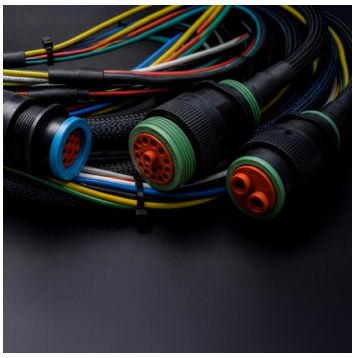
WHITE PAPER

PREVENTING CONNECTIVITY FAILURES IN HARSH ENVIRONMENTS

Explaining the Root Causes, System Level Impact, and Proven Design Countermeasures for Industrial and Commercial Transportation Applications



THE ENGINEERING REALITY:
CONNECTIVITY IS A SYSTEM, NOT A COMPONENT

Electrical connectivity failures in harsh environment transportation platforms are rarely caused by a single defect. In post mortem analysis, failures typically trace back to system level design oversights, not isolated part failures.

From an engineering standpoint, connectors in wiring harnesses operate at the intersection of mechanical stress, environmental exposure, electrical loading, manufacturing variability, and service lifecycle events. Failure occurs when one or more of these domains is weakly controlled.
This paper addresses the engineering mechanisms behind connectivity failure, then maps each to design level solutions implemented in DEUTSCH based architectures.

TOP ENGINEERING FAILURE MODES IN HARSH ENVIRONMENTS

Vibration Induced Intermittency

Engineering question:

Why do we see intermittent faults that disappear during diagnostics?

Micromotion between contact interfaces due to continuous vibration results in loss of normal force, fretting corrosion, and temporary opens below ECU fault thresholds. These failures are commonly associated with friction only retention systems, low mass stamped contacts, and the absence of secondary contact locking.

Design response:

Positive contact retention, contact systems designed to maintain spring force over life, and connector interfaces validated under multi axis vibration loads provide stable contact resistance without micro discontinuities under vibration spectra typical of trucks, buses, and off highway equipment.

Moisture and Contaminant Ingress

Engineering question:

Why does this connector pass validation but fail after 18–24 months in the field?

Capillary ingress at wire seals or interface seals, combined with exposure to oils, fuels, fertilizers, and washdown fluids, leads to progressive corrosion and increasing contact resistance. Common design oversights include sealing performance evaluated only at initial assembly, elastomer selection not aligned to fluid exposure, and inconsistent wire OD versus seal compression.

Design response:

Redundant environmental sealing, elastomers stable across temperature and fluid exposure, and connector designs tolerant to wire insulation variation ensure predictable electrical behaviour over full-service life.

Thermal Cycling and Crimp Degradation

Engineering question:

Why do failures cluster near engines, inverters, or power electronics?

Differential thermal expansion between conductor, terminal, and housing degrades crimp gas tightness over repeated hot cold cycles. This increases contact resistance and generates localized heating, accelerating failure.

Design response:

Thermally stable contact geometries, crimp systems validated for conductor tolerance and plating consistency, and housing materials that maintain dimensional integrity prevent thermal mechanical drift over lifecycle.

Assembly Variability

Engineering question:

Why does performance vary between plants using the same BOM?

Mis seated contacts, partial insertion, and mis mating often go undetected without mechanical confirmation.

Design response:

Secondary locks, keyed housings, and assembly processes that fail fast reduce variability between harness builds, accelerate ramp up, and lower dependency on operator skill.

THE COST ENGINEERS CARE ABOUT:

DOWNTIME AMPLIFICATION

From a systems perspective, connectors act as force multipliers, not single point risks. One failed connection can disable multiple sensors or actuators, collapse a communication bus, or trigger limp home or full shutdown logic. In commercial and agricultural transportation, a single harness issue can immobilize a vehicle, with diagnostics often consuming more time than repair.

Engineering takeaway:

Connectivity reliability directly influences system availability, not just component MTBF.

Connectivity as a Diagnostic Variable

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THE DEUTSCH DESIGN PHILOSOPHY:

FOUR ENGINEERING PILLARS

Harsh Environment Performance

Validated sealing for immersion, washdown, dust, and chemicals; vibration resistance aligned to heavy duty vehicle spectra; and maintained contact normal force over mechanical and thermal aging.

Consistent Assembly

Shared contact systems, mandatory secondary locks, and tolerance to real world wire variation design reliability into manufacturing rather than inspection.

Lifecycle and Uptime

Stable electrical performance across repeated mating cycles, resistance to fretting and corrosion, and serviceable designs support predictable uptime.

Engineering Authority and Supply Continuity

Established performance history, documented validation methodologies, and architecture level support reduce redesign and qualification risk for long life platforms.

WIRING HARNESS RELIABILITY AND ASSEMBLY CONSISTENCY IN HARSH-ENVIRONMENT TRANSPORTATION

In harsh environment transportation platforms, wiring harnesses are exposed to mechanical, environmental, and operational stresses that far exceed traditional automotive assumptions. The role of the connector is not simply to enable electrical continuity, but to preserve system integrity over time, across environments, and through service events.

Wiring Harness in Industrial and Commercial Transportation

Industrial platforms expose harnesses to sustained vibration, long routing paths, fluid contamination, and extended service life expectations. DEUTSCH connectors provide positive contact retention, long term sealing integrity, and consistent assembly outcomes, enabling predictable electrical behavior under continuous mechanical and environmental stress

Trucks and Buses

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Agricultural Machinery and Transportation

Agricultural applications involve chemical exposure, pressure washdown, long idle periods, and seasonal uptime constraints. DEUTSCH wiring harness solutions are engineered for chemical compatibility, environmental survivability, and lifecycle reliability, protecting uptime during critical operating windows.

Harness Level Design Considerations Across Applications

While environmental exposure varies, several wiring harness requirements remain consistent across industrial, on road, and agricultural platforms. Connector interfaces must remain electrically stable under continuous harness movement, retain sealing performance after repeated service and washdown, and maintain contact retention without reliance on friction alone.

Assembly confirmation should be mechanical rather than visual. DEUTSCH connector architectures support these requirements by enabling repeatable harness designs that perform consistently regardless of application specific duty cycles.

Designing for reliability requires connector systems engineered for these exact failure modes. Explore DEUTSCH solutions

DT Series

DTM Series

HD 30 Series

KEY ENGINEERING TAKEAWAYS

Across industrial, on road, and agricultural transportation

- Wiring harnesses function as system reliability enablers
- Connector performance directly influences uptime, serviceability, and safety
- Failure mechanisms are application specific, but predictable
- Assembly and lifecycle behavior matter as much as IP ratings
- Upfront design rigor prevents downstream diagnostics cost

DEUTSCH connectivity addresses these realities through architecture level reliability design, not incremental correction

Design for reliability from the start

- Explore DEUTSCH connectivity → DEUTSCH Connectors for Industrial and Commercial Vehicles | TE Connectivity
- Talk to an engineer → (campaign landing page to be inserted)
- Download connector selection guide → (ICT Connector Selector)

About TE Connectivity

TE Connectivity plc (NYSE: TEL) is a global industrial technology leader creating a safer, sustainable, productive, and connected future. As a trusted innovation partner, our broad range of connectivity and sensor solutions enable the distribution of power, signal and data to advance next-generation transportation, energy networks, automated factories, data centers enabling artificial intelligence, and more.

Our more than 90,000 employees, including 10,000 engineers, work alongside customers in approximately 130 countries. In a world that is racing ahead, TE ensures that EVERY CONNECTION COUNTS.
Learn more at www.te.com and on LinkedIn, Facebook, WeChat and Instagram.

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