



Shielded vs Unshielded Wire in Military Harness Design

Summary

Military wiring harnesses are critical components in aircraft, vehicles, missiles, and naval systems, ensuring reliable signal and power transmission in extreme environments. The choice between shielded and unshielded wire impacts electromagnetic compatibility (EMC), signal integrity, system reliability, and maintenance requirements. Shielding is essential for high-speed or sensitive circuits exposed to interference, while unshielded wire suffices for low-speed or non-critical signals. Designers must carefully balance electromagnetic protection against increased weight, reduced flexibility, and higher cost, often employing a hybrid approach for optimal performance.

Introduction

Modern military systems operate in complex electromagnetic environments where interference, crosstalk, and signal degradation can compromise mission-critical performance. Wiring harnesses connect sensors, actuators, communication lines, and power distribution networks, and must maintain electrical integrity despite mechanical vibration, temperature extremes, and exposure to moisture or chemicals.

A fundamental design decision in harness construction is whether to use shielded or unshielded wire. Shielding adds material and labor costs but dramatically improves signal fidelity in high-interference environments. Understanding the trade-offs is crucial for achieving optimal system performance, reliability, and maintainability.



Overview of Shielded and Unshielded Wire

Feature	Shielded Wire	Unshielded Wire
Structure	Conductor(s) surrounded by metallic shield (braid, foil, or combination)	Conductor(s) without any metallic shielding
Primary Purpose	Reduce electromagnetic interference (EMI), crosstalk, and noise	Cost-effective transmission in low-noise environments
Typical Applications	High-frequency signal lines, communication networks, sensitive sensor feeds	Power lines, low-speed signals, ground wiring, non-critical circuits
Flexibility	Lower flexibility due to shield and additional insulation	Higher flexibility; easier routing in complex harnesses
Weight	Heavier due to shielding material	Lighter, contributing to reduced harness weight
Cost	Higher due to materials and labor for shielding and termination	Lower cost, simpler assembly
Failure Modes	Shield damage can reduce EMI protection; improper grounding causes noise issues	Susceptible to EMI, crosstalk, and voltage spikes in electrically noisy environments

Electromagnetic Considerations

When Shielding is Required

Shielding is required when wires carry high-speed digital signals, sensitive analog sensor data, or operate near high-power electromagnetic sources such as radar, RF transmitters, or directed-energy systems. In these environments, shielding prevents crosstalk, signal degradation, and EMI-induced failures that could compromise mission-critical functions.



When Shielding is Not Required

Shielding is often unnecessary for low-speed power distribution, non-critical control circuits, or wiring in electrically quiet areas, where the risk of interference is minimal. Using unshielded wire in these cases reduces weight, increases flexibility, and lowers material and labor costs.

Grounding Practices

Effective shield performance requires proper termination to chassis or local ground. Improperly grounded shields can act as antennas, amplifying interference rather than mitigating it. Designers must apply shielding strategically to achieve maximum benefit without introducing secondary issues.

Mechanical and Environmental Considerations

Aspect	Shielded Wire	Unshielded Wire
Vibration Resistance	Slightly less flexible; requires careful routing to prevent shield fatigue	More flexible; less prone to mechanical stress
Temperature Range	Typically similar; must consider shield materials (aluminum vs. copper braid)	Standard conductor insulation materials dictate performance
Moisture/Corrosion Resistance	Shielding may introduce galvanic corrosion risk if dissimilar metals are used	Simpler insulation reduces corrosion concerns
Weight & Volume	Slightly higher	Lower, beneficial for airborne systems

Design Recommendations

- Critical Signal Lines:** Use shielded wire for communication, control, and sensor signals near high-power sources.
- Power and Low-Speed Circuits:** Unshielded wire is sufficient for low-frequency, low-voltage, or mechanically simple circuits.



3. **Shield Termination:** Ground shields at one or both ends depending on EMI environment to prevent ground loops.
4. **Bundle Segregation:** Separate shielded and unshielded bundles in high-noise environments.
5. **Strain Relief:** Assure harness connectors provide proper strain relief to prevent shield damage during vibration or maintenance.

Failure Modes and Risk Analysis

Failure Mode	Shielded Wire	Unshielded Wire
Shield Fracture	EMI protection lost, signal degradation	N/A
Insulation Cracking	Potential exposure of shield and conductor	Conductor exposed to EMI and short circuits
Improper Termination	Ground loops, amplified EMI	Increased crosstalk and noise
Abrasion in Harness	Shield may wear, causing intermittent shielding	Wire conductor damage; higher susceptibility to EMI

Conclusion

The decision between shielded and unshielded wiring in military harnesses must balance electromagnetic protection, mechanical flexibility, weight, and cost. Shielded wires provide superior EMI mitigation for high-speed or sensitive signals but introduce additional complexity, weight, and expense. Unshielded wires remain appropriate for low-noise, low-speed, or non-critical circuits. Optimal military harness design often involves a hybrid approach: shielding only the circuits most vulnerable to interference while leaving less critical lines unshielded.

Important Takeaway: Strategic use of shielding—applied where necessary and avoided where unnecessary—maximizes system reliability, reduces unnecessary weight and cost, and promotes mission readiness in the harshest operating environments.