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## High-Flex Cable Designs for Moving Military Systems

### Summary

Military platforms increasingly demand high-reliability cabling capable of enduring repeated motion, vibration, and harsh operational environments. High-flex cables are critical for unmanned systems, turrets, rotorcraft, and other dynamically moving components, where standard wiring can fail prematurely due to fatigue and mechanical stress. This whitepaper examines design considerations for high-flex military cables, focusing on stranding geometry, jacket materials, and fatigue life testing to assure long-term operational reliability.

### Introduction

Modern military systems, ranging from autonomous ground vehicles to shipboard gun mounts and rotorcraft control surfaces, depend on cabling that can withstand constant movement without degradation. Traditional wire and cable constructions are insufficient for these dynamic applications, often succumbing to fatigue failure, jacket cracking, or conductor breakage. High-flex cable designs are engineered to withstand continuous flexing, torsion, and vibration, preserving electrical performance while extending service life.

The design of high-flex cables requires a holistic understanding of three critical factors:

1. **Stranding geometry**, which affects flexibility, current-carrying capacity, and fatigue resistance.
2. **Jacket materials**, which protect conductors against environmental hazards, abrasion, and repeated bending.
3. **Fatigue life testing**, which validates cable performance under real-world dynamic conditions, securing mission-critical reliability.

By optimizing these factors, military systems can maintain operational readiness while minimizing downtime, maintenance costs, and the risk of mission failure.



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## **Stranding Geometry**

Stranding geometry, the arrangement and size of individual conductor strands within a cable, directly impacts flexibility, bend radius tolerance, and fatigue resistance. High-flex cables typically employ:

- **Fine-stranded conductors:** Smaller gauge strands increase flexibility and distribute mechanical stress more evenly across the conductor.
- **Compacted vs. bunch-stranded configurations:** Compacted strands improve current density and mechanical robustness, whereas bunch-stranded geometries enhance flexibility for repeated bending.
- **Tension-balanced lay patterns:** Optimized lay lengths reduce stress concentration during flexing and torsion, extending the conductor's fatigue life.

By carefully engineering stranding geometries, designers can achieve a balance between electrical performance and mechanical durability, critical for moving components in military systems.

## **Jacket Materials**

The outer jacket of a high-flex cable provides mechanical protection, environmental resistance, and insulation stability. Material selection must account for continuous bending, abrasion, chemical exposure, and temperature extremes. Common high-performance jacket materials include:

- **Thermoplastic Elastomers (TPEs):** Offer excellent flexibility, resistance to cracking, and chemical resilience.
- **Fluoropolymers (FEP, ETFE):** Provide high-temperature tolerance and superior chemical resistance while maintaining flexibility.
- **Polyurethane (PUR):** Combines abrasion resistance with good flex properties, ideal for exposed or high-wear applications.
- **Composite or layered jackets:** Combine materials to optimize mechanical protection, flexibility, and environmental resistance simultaneously.

The jacket's physical properties directly influence the cable's operational life, particularly in systems subject to repeated movement and harsh conditions.



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## **Fatigue Life Testing**

High-flex cable performance cannot be inferred solely from material properties; rigorous testing is essential. Fatigue life testing simulates real-world operational stress to validate cable durability and identify potential failure modes. Typical testing approaches include:

- **Dynamic flex testing:** Measures conductor and jacket integrity under repeated bending cycles.
- **Torsion testing:** Evaluates cable performance under rotational stress, critical for systems like turret drives and rotorcraft linkages.
- **Environmental aging under motion:** Combines thermal, chemical, and mechanical stress to simulate long-term field conditions.

By incorporating these tests during design and qualification, manufacturers and procurement teams can establish that cables meet stringent military reliability standards, reducing unexpected maintenance and operational risk.

## **Conclusion**

High-flex cable design is vital for modern moving military systems, where repeated flexing, torsion, and harsh environmental exposure are unavoidable. Stranding geometry determines mechanical resilience and electrical stability, jacket materials protect against environmental and mechanical stress, and fatigue life testing validates the cable's ability to perform reliably over its intended service life. Together, these factors create a robust, mission-ready cable solution that enhances system longevity, reduces maintenance costs, and promotes operational success under dynamic conditions.

**Investing in optimized high-flex cable designs guarantees that military platforms can maintain peak performance in the most demanding environments.**