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## Fire, Smoke, and Toxicity Requirements in Naval and Submarine Cabling

### Executive Summary

The safe and reliable operation of naval and submarine platforms depends heavily on cabling that performs under extreme conditions, including fire, high heat, and toxic gas exposure. Electrical cable systems must not only maintain electrical integrity but also mitigate risks to personnel and mission-critical systems during fire events.

This whitepaper examines the technical requirements, standards, and material considerations for fire-resistant, low-smoke, and low-toxicity (FST) cabling in naval applications. It incorporates **Low-Smoke Zero-Halogen (LSZH) materials**, **MIL-DTL-24643 requirements**, and **survivability standards**, providing guidance for procurement and engineering professionals seeking compliant and mission-ready solutions.

### Introduction

Naval vessels and submarines operate in environments where fire presents unique hazards. Confined spaces, limited evacuation options, and the presence of high-value mission systems demand cabling that minimizes smoke generation, toxic gas emission, and fire propagation. Inadequate cabling can result in catastrophic outcomes, including system failures, crew injury, or loss of vessel.

Modern naval cable design emphasizes **fire retardancy**, **low smoke emission**, **low halogen content**, and **toxicity reduction**, aligning with regulatory mandates and operational safety priorities. Additionally, compliance with **MIL-DTL-24643**, which governs performance and quality of LSZH shipboard cables, assures these solutions meet military-grade survivability standards and operational readiness.

Survivability standards in naval and submarine platforms require that cabling **maintains circuit integrity** during fire, shock, and battle-damage scenarios, preserving mission-critical systems such as propulsion, navigation, communications, and life-support.



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## **Fire Performance Requirements**

### **Flame Resistance**

- **Flame-retardant cables** are engineered to resist ignition and limit flame propagation along the conductor.
- Materials commonly used include **crosslinked polyethylene (XLPE)**, **fluoropolymers (FEP, ETFE, PFA)**, and **LSZH thermoplastics**.

**Testing:** IEC 60332-1 and IEC 60332-3 series measure vertical flame spread and circuit integrity under fire conditions. Naval cables must maintain continuity to critical systems during onboard fire events.

### **Circuit Integrity**

- Fire-resistant cables must maintain electrical continuity even under **direct fire exposure**. MIL-DTL-24643 defines cable requirements for shipboard and submarine applications where circuit integrity is paramount.
- Submarine cables often require **survivability under multi-hour fire exposure**, maintaining vital systems remain operational.

### **Smoke Emission Requirements**

- Smoke reduction is critical in confined naval environments where visibility loss can impede evacuation and firefighting.
- **LSZH cables** are particularly advantageous, minimizing particulate density during combustion and reducing smoke obscuration in compartmented spaces.
- Testing standards include **IEC 61034** (measurement of optical density of smoke) and **NFPA 130** (smoke control for life safety), supporting that personnel can evacuate and operate safely during fire incidents.

### **Toxicity Requirements**

- Traditional cable jackets often release halogenated gases (HCl, HF), which are highly corrosive and toxic.
- LSZH materials drastically reduce **toxic gas release**, preventing harm to personnel and corrosion of sensitive electronics.



- Toxicity testing follows **ISO 4589-10** and similar protocols, establishing emissions remain below allowable limits during combustion, in line with MIL-DTL-24643 specifications.

### **LSZH Materials and MIL-DTL-24643 Considerations**

- **Low-Smoke Zero-Halogen (LSZH) materials** are preferred for naval and submarine cabling because they:
  - Reduce smoke density and toxicity
  - Minimize corrosive effects on electrical systems
  - Maintain flame resistance in confined or high-risk zones
- **MIL-DTL-24643** specifies:
  - Electrical performance requirements under thermal, mechanical, and fire stress
  - Compliance with flame, smoke, and toxicity standards
  - Mechanical robustness for **shock, vibration, and mission-critical survivability**

This standard aligns LSZH materials with **shipboard and submarine survivability requirements**, ensuring cabling supports mission continuity even in fire or combat scenarios.

### **Material Selection for Naval Cables**

<b>Material</b>	<b>Fire Resistance</b>	<b>Smoke Emission</b>	<b>Toxicity</b>	<b>Typical Application</b>
Crosslinked Polyethylene (XLPE)	High	Moderate	Low	Power distribution, signal wiring
Fluoropolymer (FEP, ETFE)	Very High	Low	Very Low	Critical circuits, fire zones
LSZH (Low-Smoke Zero-Halogen)	High	Very Low	Very Low	Submarine cable, confined areas, mission-critical circuits
PVC / Halogenated Compounds	Moderate	High	High	Legacy applications, low-risk areas



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## **Survivability Standards**

Naval and submarine cables must meet **survivability criteria** including:

- **Fire endurance:** Maintain continuity for critical systems under fire for extended periods
- **Shock and vibration tolerance:** Sustain electrical performance during platform maneuvers, combat, or underwater pressure variations
- **Redundancy and compartmentalization:** Designed to prevent single-point failures, supporting mission-critical circuits remain operational

Incorporating LSZH and MIL-DTL-24643-compliant cables enhances platform survivability by combining **electrical resilience, reduced toxic exposure, and operational continuity** during emergency scenarios.

Certified suppliers provide mission-ready naval cable solutions with comprehensive testing and strict adherence to MIL-DTL-24643 and survivability standards, implementing compliance and operational reliability.

## **Testing and Quality Assurance**

- **Fire Testing:** Verifies flame spread, smoke generation, and circuit integrity under operational fire conditions
- **Smoke Density Measurement:** Confirms visibility remains within safe operational levels
- **Gas Toxicity Testing:** Evaluates halogen and toxic gas output in accordance with MIL-DTL-24643 and ISO 4589-10
- **Routine QA:** Confirms continuity, insulation integrity, and AS9100-compliant traceability

## **Conclusion**

Fire, smoke, and toxicity considerations are central to naval and submarine cabling. **LSZH materials** and compliance with **MIL-DTL-24643** facilitate cables maintain performance while minimizing crew risk and equipment damage. Integrating survivability standards guarantees continuity of mission-critical systems under fire, shock, and combat conditions. By selecting high-performance materials and certified suppliers, naval platforms gain **safe, compliant, and resilient cabling capable of sustaining operations under the most demanding fire and survivability scenarios.**