

Mil-Spec Backshells for Circular Connectors Used in Aerospace and Defense: Design, Standards, Selection, and Qualification

Summary

This paper reviews Mil-Spec backshells used with circular military and aerospace connectors, summarizing their functions, common designs and materials, applicable specifications, environmental and EMI/RFI considerations, testing and qualification practices, and practical guidance for selection and procurement. The goal is to provide a concise technical reference for engineers, procurement specialists, and test teams involved in mission-critical interconnect assemblies.

Introduction

A backshell is an accessory attached to the rear of a circular connector that improves the reliability, durability, and electromagnetic performance of the cable-to-connector junction. Primary functions include **strain relief**, **environmental sealing**, **EMI/RFI shielding**, and cable management in constrained assemblies.

The Aerospace and Defense environments present unique challenges: high vibration levels, rapid pressure and temperature changes, and exposure to fluids and contaminants. Without proper backshells, connectors and wiring harnesses are vulnerable to premature failure. To ensure uniformity and reliability, backshells are governed by AS85049/M85049 specifications, which define design, interchangeability, and qualification requirements across Defense and Aerospace platforms.

Background and Motivation

- **Why backshells matter:** In high-vibration, harsh-environment, and high-sensitivity electronic systems, the failure point is often the cable termination. Backshells reduce mechanical stress at the wire–contact junction, protect against ingress of contaminants, and maintain cable shield continuity for electromagnetic compatibility.
- **Industry role:** Major interconnect suppliers and integrators produce extensive mil-spec backshell product lines and cross-reference matrices to support design-to-purchase workflows and QPL (Qualified Products List) compliance.

Types of Backshells and Standard Features

- **Strain Relief Backshells**
 - Provide mechanical retention and cable redirection; available in straight, 45°, and 90° geometries.

- Usually, they do not provide environmental sealing or EMI/RFI shielding and are suitable for clean, dry environments.
- **Environmental Backshells**
 - Include grommets, cable glands, or sealing boots that close the termination against moisture, dust, and fluids.
 - Often designed to achieve IP67 (IP= ingress protection, 6= first digit – dust tight, 7= second digit – water resistant)-equivalent protection when mated and properly assembled.
- **EMI/RFI Environmental Backshells**
 - Combine environmental sealing with conductive bodies and shield termination provisions to maintain cable shield continuity and attenuate interference.
 - Common in mission-critical avionics and defense electronics where both sealing and EMC are required.
- **Shrink Boots and Low-Profile Seals**
 - Polymer shrink boots provide low-mass, low-profile sealing and strain relief alternatives where metal backshell mass or volume is unacceptable.

Materials, Finishes, and Mechanical Options

- **Materials:** Customary materials include aluminum alloys, stainless steel, and plated copper alloys for conductive needs; elastomers and heat-shrink polymers are used for boots and grommets.
- **Finishes and compatibility:** Matching connector and backshell materials/finishes is critical to avoid galvanic corrosion and to meet appearance and corrosion resistance requirements. Aluminum, stainless steel, and composite backshells are available with finishes such as cadmium, nickel, or zinc-nickel plating.
- **Mechanical features:** Self-locking clamps for vibration resistance, cable clamps sized for wire harness diameters, and various mounting threads and coupling interfaces matching MIL connector series are standard options.

Relevant Standards and Specification Guidance

- **MIL specifications and industry references:** Backshell design and procurement commonly reference connector family specifications (e.g.,

MIL-DTL-38999 series) and accessory specifications or manufacturer cross-reference guides to identify qualified parts and QPL listings.

- **Procurement notes:** Use vendor part-number cross-reference tables and product datasheets when specifying backshells to ensure compatibility with connector shell size, thread form, and performance requirements. The most common Aerospace and Defense connector families include:
 - **MIL-DTL-38999 (Series I-IV):** The dominant connector series in Aerospace, offering high contact density and environmental sealing.
 - **MIL-DTL-5015:** Rugged circular connectors used in power and signal applications.
 - **MIL-DTL-26482:** Widely used in avionics and ground support equipment.
 - **MIL-DTL-28840:** Specialized connectors for Shipboard and Aerospace systems.

AS85049 backshells are designed for interchangeability across multiple connector series, providing procurement flexibility and reducing supply chain complexity.

Environmental and EMI/RFI Considerations

- **Sealing performance:** Proper assembly with cable grommets, adhesive or molded seals, and correct torque on threaded interfaces is required to achieve specified environmental protection levels such as IP67.
- **Shield termination:** Effective EMI/RFI performance depends on continuous conductive paths from cable braid or foil to the connector shell via the backshell; braid clamps, conductive boots, and properly chosen materials are critical design elements.

Testing and Qualification

- **Conventional tests:** Mechanical vibration and shock, salt spray/corrosion, ingress protection, thermal cycling, and EMI/RFI screening where required by system-level EMC testing.
- **Assembly verification:** Inspectors should verify correct grommet/cable gland sizing, shield termination continuity, torque on clamps, and absence of mechanical interference with the harness routing.

Application in Defense Systems

- Fighter and Transport Aircraft

- Rotorcraft
- Ground Combat and Tactical Vehicles
- Naval and Shipboard Systems
- Space and Strategic Systems
- Defense Communications and Radar

Selection and Procurement Checklist

- **Functional requirements:** Strain relief only, environmental sealing, EMI/RFI + environmental, or low-profile boot.
- **Mechanical fit:** Match connector shell size and thread form; confirm straight/45°/90° orientation and harness routing constraints.
- **Material and finish:** Verify alloy, plating, and compatibility with connector and environment.
- **Shield termination method:** Braid clamp, conductive boot, or integral termination; measure expected insertion loss/continuity.
- **Qualification needs:** QPL listing, test data, and vendor traceability for safety- or mission-critical systems.
- **Documentation:** Request vendor Certificate of Conformance (CoC), assembly instructions, torque values, and recommended part-number cross-reference.

Recommendations and Best Practices

- Specify the minimal backshell feature set that satisfies functional needs to reduce mass, cost, and assembly complexity.
- Always request vendor assembly instructions and verify that installed harnesses have correct gland/grommet sizing and shield termination continuity.
- For high-vibration or safety-critical applications, prefer backshells with self-locking clamps or positive retention features.
- Use environmental EMI/RFI backshells when both sealing and EMC are required and validate at the system level with representative cable assemblies and installation geometry.

Conclusion

Mil-spec backshells are essential accessories for ensuring reliability, environmental protection, and electromagnetic compatibility at cable terminations for military and aerospace connectors. Proper selection, material compatibility, assembly practice, and

qualification test evidence are all necessary to meet system performance and procurement requirements.