

DEFENSE LOGISTICS AGENCY

AMERICA'S COMBAT LOGISTICS SUPPORT AGENCY

DLA Land and Maritime Document Standardization Division Interconnection Branch

Standardization of Alternatives to Cadmium Plating for Electrical and Fiber Optic Connectors

Lisa Hoffer
Electronics Engineer
DLA Land and Maritime – VAI
lisa.hoffer@dla.mil

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- Background – DLA Standardization Program (DSP)
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Background – DLA Land and Maritime

DLA Land and Maritime

- One of DLA's three Inventory Control Points (ICPs) for weapon system spare parts. The other main ICPs include DLA Aviation (Richmond, VA) and DLA Troop Support (Philadelphia, PA)
- Over 24,000 military and civilian customers
- Material Management Offices (Customer and Supplier Support) and Technical Offices (Operations Support)
- Located in Columbus, Ohio

DLA Land and Maritime, Operations Support

- Includes Document Standardization (specs, drawings, and technical documents), Sourcing and Qualification, Product Verification, Packaging, Standardization Office (for example, reviews interchangeability and substitutability of products, including commercial parts) and Value Management.

DLA Land and Maritime, Operations Support, Document Standardization

- Serves as Preparing Activity or Technical Agent for thousands of standardization documents for a wide variety of electronic components and other items. Engineers and technicians coordinate and prepare technical documents (over 6,500 mil spec and mil standard documents) for 70 Federal Supply Classes (FSCs), and provide engineering support to DoD customers that use these documents.
- Electronic components covered include passive devices (such as electrical connectors), electromechanical components, semiconductors, microcircuits, wire and cable, and fiber optics. Hardware products include hoses, fittings, vehicle and engine components, pumps, pipe, tubing, and powered and non-powered valves.

Preparing Activity:

- Interprets requirements, evaluates change proposals, prepares drafts, resolves comments, approves/ dates final draft of a document.
- PAs work closely with military and industry to reach consensus.



Background – Defense Standardization Program

Defense Standardization Program (DSP)

- **Required by Law:** Defense Cataloging & Standardization Act, Title 10, U.S. Code Chapter 145, Sections 2451-2457 (approved 1 July 1952).
 - Requires achievement of highest practicable degree of standardization of items & practices used throughout DoD.
 - Establishes a single, integrated DoD Standardization Program
 - Controlled and directed by the Defense Standardization Program Office

References

DoDI 4120.24 – “Defense Standardization Program” and DoD 4120.24-M – “Defense Standardization Program (DSP) Policies & Procedures” (documents available at <http://www.dsp.dla.mil>).

- **DSP Guidance Documents – Standardization Documents (SDs)**
Including SD-1, “Standardization Directory”, which provides the following information:
Lead Standardization Activities (LSA) for each Federal Stock Class (FSC) or standardization area and Preparing Activities (PAs). PAs prepare DoD specs, standards and handbooks, acts as the Point of Contact for questions and problems related to a specific document. The PA is identified on the document itself and in the ASSIST database (see <https://assist.daps.dla.mil/online/start/> or http://www.assistdocs.com/search/search_basic.cfm).



Mil Specs and Mil Standards

- **Military Specification** – Defines requirements & tests for Military Unique Items (Note: Prior to 1996, a mil spec was identified by the first word of a title followed by a number (e.g. MIL-C-38999); After 1996, a format change required that mil specs be identified by MIL-PRF-xxxxx (“Performance” spec) or MIL-DTL-xxxxx (“Detail” spec). A revision letter appears after the document number (e.g. MIL-DTL-38999L). The format and content are governed by MIL-STD-961.
- **Military Standard** – Defines requirements for military unique processes, test methods and practices, including the following five types: 1) Interface, 2) Test method, 3) Standard practice, 4) Manufacturing process and 5) Design criteria. It is identified by MIL-STD-xxxxx (e.g. MIL-STD-1560) followed by the revision letter. Format and content are governed by MIL-STD-962.
- **Note** – Over 40% of active documents (over 29,000 total) used by DoD are Mil Specs and Standards. The next most popular types of documents used by DoD are NGSs, or Non-Government Standards, such as SAE-AS39029 (Elec pin and socket contacts), SAE-AS85049 (Connector backshells / accessories) and SAE-AS50151 (Connectors).



Qualification and Sourcing

DSP Guidance Documents

- SD-6: Provisions Governing Qualification (requirements for QPL or QML, such as plant audits, reports, requal, and Qualifying Activity responsibilities, including issuing, maintaining and removing qual approval).

A specification describes the minimum essential requirements. “Product Qualification” is a legal process for testing products or materials to specification requirements. Qualification is done in advance of and is independent of a specific acquisition.

A Qualified Products List (QPL) is a list of products and their manufacturing sites. The QPL provides a continuous source of standardized, reliable products that meet minimum spec requirements prior to acquisition, and ensures fair competition for contract bids.

QPL Process –

- 1) Spec Published
- 2) Manufacturer Requests Qualification
- 3) Qualifying Activity grants permission to conduct qual testing
- 4) Manufacturer conducts qual testing
- 5) Qual Activity reviews test report
- 6) Qual Activity lists (or denies) manufacturer as a source on the QPL



Points of Contact - Electrical and FO Mil Specs/ Standards maintained and qualified by DLA Land and Maritime)

Electrical Connectors mil specs impacted by search for Cadmium alternatives

– **Circulars**: some of the most active include MIL-DTL-38999, MIL-DTL-83723, MIL-DTL-26482, MIL-DTL-28840, MIL-DTL-22992 and MIL-DTL-55181.

Document Standardization / **Preparing Activity POC is**

CircularConnector@dla.mil.

- **Rectangulars**: MIL-DTL-24308, MIL-DTL-83513 and MIL-DTL-32139.

Document Standardization / **Preparing Activity POC is**

RectangularConnector@dla.mil.

Fiber Optic (FO) mil specs impacted by search for Cadmium alternatives

- **Fiber Optic**: MIL-PRF-28876 and MIL-PRF-64266.

(Note: For 28876, the PA is Navy–SH, and the Agent is DLA–CC)

Document Standardization **POC is** **FiberOpticsGroup@dla.mil**.

Qualifying Activity Points of Contact: Website link to qualifying activity contact information is **<http://www.landandmaritime.dla.mil/programs/qmlqpl/>** .

Note: NAVAIR is the Qualifying Activity for SAE-AS50151, SAE-AS85049 and SAE-AS39029 – see **<http://www.navair.navy.mil/qpl/>** .



Cadmium Alternatives for Electrical Connectors

Standardization timeline

DLA Land and Maritime actions –

2005 - In response to industry proposals, DLA Land and Maritime-VAI conducted an Engineering Practices Study titled “Alternatives to Cadmium Plating”. The objective of the study was to solicit input from users and manufacturers on the use of alternative finishes to provide finish options to Cadmium with a hexavalent chromate conversion coating (i.e. Olive Drab Cd, or OD-Cd), while maintaining Cadmium as an option if needed.

2007 -The study resulted in four options being proposed for the initial draft of MIL-DTL-38999L.

2008 - Coordination on that document subsequently resulted in the addition of three Cd alternatives to MIL-DTL-38999, including Nickel-fluorocarbon polymer (Ni-PTFE), Zinc-Nickel (Zi-Ni) and Pure Electrodeposited Aluminum.

2008 – 2012 - These alternatives were later added to the nine detail specifications (MIL-DTL type specs) and their associated MS sheets as applicable, which are listed on the previous page.

2012 - A fourth option, black electroless nickel with trivalent conversion coat, was recently added to MIL-DTL-55181 (Note: The corrosion requirement for 55181 is 48 hours (non-dynamic), as compared with 500 hours for OD-Cd).

Note: SAE has also taken action to update related documents that specify OD-Cd, including SAE-AS50151 and SAE-AS85049, with alternative plating options.



38999 – OD-Cd (Class W) and Cadmium Alternatives (Classes P, T and Z)

MIL-DTL-38999 class and finish descriptions (requirement paragraph 3.3.6.4):

- Class W (series III and IV) (also Finish B for series I and II)
Olive drab, Cd plate in accordance with (IAW) SAE-AMS-QQ-P-416 over a suitable underplate. Final finish shall be electrically conductive.
- Class T – Nickel fluorocarbon polymer (also called Ni-PTFE). Ni with fluorocarbon polymer additives co-deposited over a suitable underplate to withstand 500 hours dynamic salt spray. Conductive finish shall be “non-reflective”. (Note: upcoming change in 38999 revision M – add reference to SAE AMS2454).
- Class Z – Zinc nickel in accordance with ASTM B841, type D (black), to withstand 500 hours dynamic salt spray testing, with conductive, non-reflective finish.
- Class P – Pure, dense, electrodeposited aluminum in accordance with MIL-DTL-83433, Type II, to withstand 500 hours dynamic salt spray testing. Conductive finish color shall be non-reflective.

Requirements in common: All 38999 shells are machined or impact extruded aluminum (Al) (note: alternatives not specified for composite class), all meet -65°C to +175°C temp range, all are conductive, all non-reflective, all must meet 500 hr dynamic salt spray requirement.



CRITICAL MIL-DTL-38999 REQUIREMENTS – Drop-in replacement for Class W, OD-Cd with Hexavalent Chromium (Cr^{6+}) top coat

Olive-Drab Cadmium finish requirements (Note: Passivation process with a Cr^{6+} conversion coat bath naturally results in an olive drab color)

MIL-DTL-38999 requirements are referenced below. MIL-DTL-38999 requirements are the most stringent as compared to the eight other electrical connector MIL-DTL specs listed previously:

- Corrosion / Salt Spray – (IAW EIA-364-26) 500 hours dynamic (50 durability mating cycles, followed by 500 hrs salt spray (452 hours mated, 48 hours unmated), followed by 450 mating cycles). For class W, the outer anodic finish is sacrificial to the undercoat - the required “suitable undercoat” provides poreless seal to the base aluminum).
- Durability: mate/unmate cycles – mechanical performance – finish must resist wear / galling (other test requirements that may provide an indication of the plating material’s mechanical performance include vibration and high-impact shock).
- Conductivity/Electrical grounding before and after conditioning (“conditioning” includes temp exposure and salt spray) – must maintain extremely low shell-to-shell voltage drop.



CRITICAL MIL-DTL-38999 REQUIREMENTS – Drop-in replacement for Class W, OD-Cd with Cr+6 top coat – OTHER CONSIDERATIONS

- Galvanic compatibility – all electrical connector mil specs maintained by DLA Land and Maritime include a standardized paragraph for “dissimilar metals and compatible couples” (as specified in MIL-STD-889) which states that dissimilar metals in contact with each other are not acceptable. For connectors, consideration should be given to compatibility with connector subcomponents, including SS coupling nut retaining rings, EMI spring fingers, mounting panels and shielding materials used with cables.
- Fluids – resistance to solvents and to de-icing /anti-icing products
- Coupling torque – after conditioning (after Corrosion/Salt Spray)
- Marking legible - including part number/ date code, supplier identification, and red and blue bands
- Reflectivity - finish must be non-reflective



38999 Test Requirements

Corrosion with durability: 38999 IAW para. 4.5.13.2 Dynamic test. The wired, assembled plugs and receptacles shall be mated and unmated 50 cycles at a rate of 300 cycles per hour maximum. The mating and unmating shall be accomplished so that the plug and receptacle are completely separated during each cycle. The connectors shall then be subjected to the salt spray test in accordance with test procedure EIA/ECA-364-26. The connectors (series I and II, finishes B, C, and E; and series III and IV, classes C, H, K, P, S, T, W, Y and Z) shall be tested for 452 hours mated followed by 48 hours unmated. After salt spray exposure, the remaining number of durability cycles specified in 4.5.8 shall be completed.

Conductivity: 38999 IAW 4.5.25 Shell-to-shell conductivity. Applicable to all classes and finishes except class C and finish C, see 3.29. Mated connectors shall be tested in accordance with test procedure EIA-364-83.

Paragraph 3.29, states "Series III and IV with spring fingers:

(1) Classes P, T, W, X and Z - 2.5 millivolts" and "After conditioning (salt spray and coupling torque) the above values may increase 100 percent".



Feedback on Cd Alternatives

Class T – Ni-PTFE: Positive feedback: Good lubricity – lower coefficient of friction than Cd. Teflon particles help prevent galling and increase durability. Good corrosion protection. Good electrical bonding - meets 2.5 mV resistance requirement. No conversion coat needed. Concerns: Unsuitable for certain applications? Is the fluorocarbon content toxic when burned? Reported technical concerns over durability of marking the part number and other required markings on the connector shell. Not self-healing like OD-Cd. May be better for machined or impact extruded Al shells than for cast Al shells, due to porosity of cast Al.

Class Z – ZINi: Questions over conductivity and durability. Reports of flaking and chipping of plating. Concerns that ASTM B841, which specifies 12% max Ni, does not allow enough Ni (more Ni may allow for better corrosion resistance). Requires passivation/conversion coat.

Class P – Pure electrodeposited Al: Questions over durability (galling / flaking). Uses a lubricant. Higher costs of process related to technical issues. Process highly flammable. Higher costs due to sole source. Requires passivation/conversion coat. Appearance reportedly appears to be “reflective”.



QPL status - Elec Connector Cd Alternatives P, T and Z

Ni-PTFE, Zi-Ni and Pure electrodeposited Al plated connectors and accessories that have been qualified by DLA Land and Maritime-VQP (through Aug 2012 – more qualifications actions are currently in process):

38999, Classes T and Z (ser III or IV) or Finish T and Z (ser I or II):

Amphenol QPL'd in Feb 2010 for Class T, 38999/20, /24 and /26.

Glenair QPL'd in Sep 2010 for Classes T and Z, 38999/28, /32 and /33 and Finishes T and Z for MS27501 and MS27502.

Souriau QPL'd Class Z, Series III: 38999/20, /24, /26, /28, /32 and /33.

Finish Z, Series I & II: MS27466 thru MS27468, MS27472 thru MS27474, MS27484, MS27497 and MS27499.

26482, Class Z:

Souriau QPL'd in Nov 2010, MS3110, MS3111, MS3112, MS3114 and MS3116.

83513, Class M finishes A (Pure Al), K (ZiNi) and T (Ni-PTFE):

Glenair QPL'd to 83513/1 through /4, /10 through /33.

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