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WIRING COMPONENT DESIGN GUIDELINES

Scope:

This document gives general guidelines to be used during the connector design stage. Various guidelines may not apply in all situations. Therefore, sound engineering judgment must be used in their application. Consider these guidelines as the basis for connector and wiring DFMEA's. Items in this document are grouped by DFMEA functional requirements. Groups are as follows:

A. Non-functional Drawing Requirements
B. Electrical Continuity
C. Electrical Isolation/Sealing
D. Device Assembly
E. Harness Assembly
F. Vehicle Assembly
G. Serviceability

References:

SAE/USCAR-2 - Performance Standard for Automotive Electrical Connector Systems
SAE J1742 – Connections for High Voltage On-Board Road Vehicle Electrical Wiring Harnesses – Test Methods and General Performance Requirements
SAE J1344 – Identification of Plastic Material
ASME Y14.5M-1994 – GD & T
SAE/USCAR – 20 – Field Correlated Life Test Supplement to SAE/USCAR-2
SAE/USCAR-17 – Performance Specification for Automotive RF Connector Systems

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A. NON-FUNCTIONAL DRAWING REQUIREMENTS

1. Design all new connectors to Geometric Dimensioning and Tolerancing standard ASME Y14.5M-1994. Design connectors to meet the performance requirements of USCAR Standard for Automotive Connector Specification (SAE/USCAR-2).

2. Complete final design drawings, including models (dimension, material, notes, etc,) prior to release for manufacturing.

3. Include in the drawing the location and specification call-out for the terminal cavity identification system (see Appendix A), mold cavity identification, and vendor identification (and part number when possible). Include all individual parts listed by part number in the assembly drawing. Chrysler, Ford, and GM will use their own part numbering system.

4. When supplying a USCAR footprint CAD drawing, indicate the supplier name above "CAD" (approximately 1″ x 1.5″ in size).

   Example:

(Supplier) CAD

   Locate this supplier identification box to the left of the title block.

5. Review and obtain approval for any deviation from the USCAR/EWCAP footprint drawing(s) with all three USCAR/EWCAP partners.

6. Consider a graduated tolerance scale which could result in three or four tolerances based on size and importance of dimensions on new designs. To control critical or important dimensions, put the specific tolerance directly onto the dimension in question.

7. Assure dimensions used for SPC are measurable and indicative of process capability.

8. On new connector programs, include a detailed direct connect application ("footprint") drawing and any applicable gaging requirements as part of the quote package.

9. Make connector and terminal assembly design of the device receptacle "footprint" exactly the same as the in-line connector mating male (if one exists), unless otherwise specified on a direct connect application drawing.

B. ELECTRICAL CONTINUITY

1. Validate the connector system to the requirements of SAE/USCAR-2 (latest revision).

2. During the initial design of each new connector and terminal family, complete a layout study of the mated assembly showing minimum/maximum terminal insertion, seal compression tolerance stack-ups, and worst case connector-to-connector alignment at the point of initial terminal contact. This guideline ensures that connector lock over-travel and minimum terminal engagement length requirements are met. The supplier retains this information and makes it available to the OEM or tier supplier upon request.

3. Take connector and terminal misalignment during all stages of engage/disengage into account. Account for cocking of the fully mated connector due to wire bundle longitudinal and lateral stress. Provide for a minimum 1.0mm terminal engagement beyond the male terminal coined edge in all possible positions.

4. Design terminals and manufacturing tooling so as to prevent stamping burrs on interface mating and external surfaces.

5. Verify that all lubricants, cleaners, and mold release agents used in manufacture of the terminals and connectors are not harmful to the electrical performance for the life of the connection system.

6. Design the terminal so that it retains any pre-staged lubricant (if specified) in the contact area during all stages of shipping and processing through final assembly into the vehicle.

7. Design connector and terminal systems to meet the appropriate temperature, vibration, and sealing classes per SAE/USCAR-2.

C. ELECTRICAL ISOLATION/SEALING

1. Whenever possible, conduct product validation testing using mating part samples that are production intent. Document any modifications (such as sealing holes) made to a mating housing (header) in the test report and share this information with the component manufacturer.

2. In cases where power and ground are in the same connector and the existence of the opposite potentials is known during the initial design, locate the (+) and (–) pins as far from each other within the pin field as practical. Plastic isolating walls to increase the creepage distance may be used as an alternative.

3. Provide a wire strain relief feature so that the wire seal is unaffected by wire bending and handling. Allow for plugs to be inserted in individual terminal cavity openings in the cap after the end cap is installed. Provide for positive retention of seal plugs if used. Provide sealing when subcomponents (Christmas tree, wire guide, strain relief) attached to a connector are subject to a force or torque in any direction sufficient to separate the parts.

4. Design the terminal to prevent individual cable seals from moving along the wire and away from the terminal during assembly and handling.

5. Design connectors with a shroud to completely protect seals and connector seal surfaces. Design the peripheral seal as part of the female connector, not the male connector.

6. Design to prevent “bunching” rollover or excessive movement of the peripheral seal during mating and un-mating of connectors. Design connectors with a seal retaining feature.

7. When using a multiple rib peripheral seal, design so that shroud length and size incorporates full utilization of all functional ribs in the worst-case statistical dimensional stack-ups.

8. Design terminals and connectors so that there is at least 1 mm of plastic coverage between the back of the terminal and the back of the connector

9. Keep mold parting lines, steel match lines, and part decorations off of the sealing surfaces of the seals and the plastic connector housing.

10. Certify that any used combination of regrind and raw material meets the plastic manufacturer’s specification. Also certify that the “as molded” parts are not degraded beyond acceptable material limits.

11. Verify that all lubricants, cleaners, and mold release agents used in manufacture of the terminals and connectors are not harmful to the mechanical performance for the life of the connection system.

12. Consider automated assembly of connector, wedge, CPA (Connector Position Assurance), seals, cover, etc., in the design.

13. Design caps and covers for unused (option delete) connectors with positive retention to the covered connector.

14. Sealed Connectors validated under SAE/USCAR-2 are not subjected to high pressure spray testing. Consider additional validation testing when connector/cable seals are directly exposed to moving vehicle induced wind, road/wheel splash or spray.

15. Consider the pressure differential developed within connectors as the device is heated and quenched by road splash. A good practice is to not allow standing water/fluid to collect on the seal during vehicle operation which could be drawn into the connector as the device cools.

16. Isolate connectors and terminals from contamination emanating from within the component side of the connection (i.e. brake fluid, engine coolant, transmission fluid, etc.). If the risk of contamination is present, consider testing the connection system while flooded with the fluid of risk.

D. DEVICE ASSEMBLY

1. Verify that the connector assembly still meets all dimensional requirements after worst case processing (temperature and chemical exposure) of the device or module.

E. HARNESS ASSEMBLY

1. Reference wire size and type on all terminal drawings. Provide crimp dimensions for all applicable cable types and sizes either on the drawing or as a separate document. Make this information readily available to the harness supplier.

2. Fully disclose connector and terminal materials (alloy/temper) on all drawings supplied to end users for crimp analysis.

3. Specify the approved wire outer diameter ranges on all seal drawings.

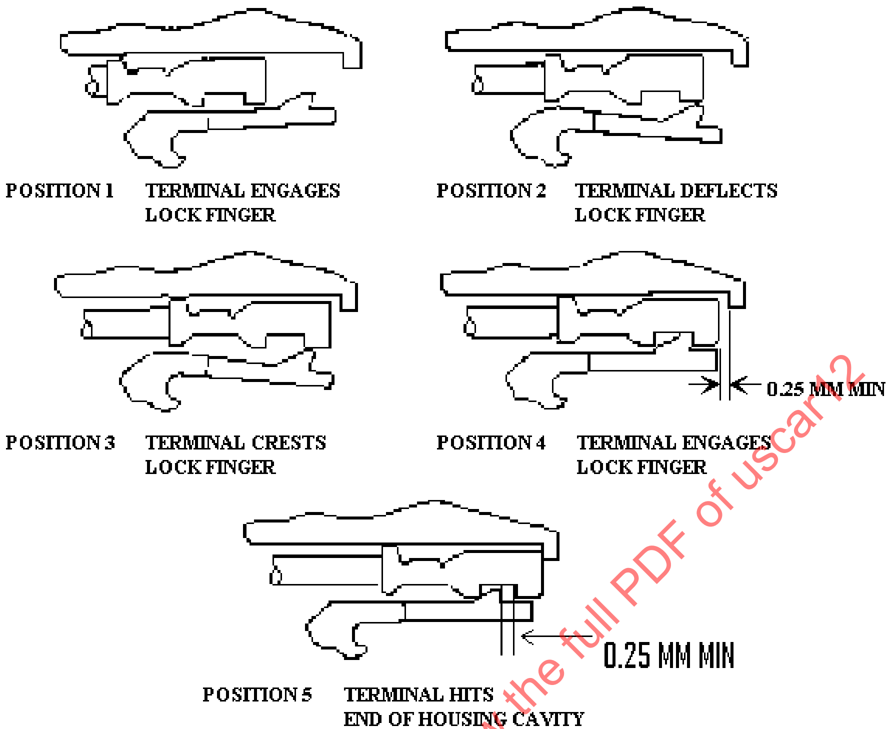
4. Make seal a contrasting color to the connector housing and TPA/PLR (if front loaded).

5. Design seals with features that will prevent them from sticking to each other before assembly.

6. Design each individual terminal cavity with lead-ins for rear seals.

7. Eliminate oval cable seals, with or without inserts. Round seals and oval cavities are permitted.

8. Provide at least 0.25mm clearance between the terminal lock surface and the cooperating terminal cavity locking finger retention surface. This is measured with the terminal against its forward stop and with the locking finger swung to a position where it's retention surface most closely approaches the terminal lock surface.



9. Design all connectors with lead-ins on all mating surfaces.

10. Design connectors with a feature to detect and/or correct partially seated terminals.

11. Design the connector with a terminal forward stop feature or alternative means to prevent terminals from pushing through during assembly and handling.

12. Avoid sharp projections on terminals which may cut operators' hands or damage mat seals.

13. Design the polarization features such that they can be detected by the harness build/test fixture and incorrect polarizations rejected.

14. Provide access for the harness fixture continuity probe in the connector housing assembly. Provide access for the probe through the front of the connector. Design the connector and probe so that contact is not made with the terminal mating surface.

15. Design the terminal and connector to prevent mis-orientation. For non-circular terminals, design the terminal:

    a. With an external terminal orientation insertion feature which is visually obvious
    b. To prevent full insertion of an incorrectly oriented terminal into the connector housing such that at least the terminal insulation grip protrudes from the rear of the connector housing.

TERMINALS

16. Design the female and male terminal with sufficient lead-in.

17. Use only rear carrier strips.

18. Design terminals to avoid snagging at harness assembly plants.

19. Design the female terminal with hoods, shrouds, or sleeves to protect the electrical contact(s).

20. Design terminal retention features with plastic locks rather than primary terminal locking tangs.

21. Identify special material terminals with a visible indicator.

SECONDARY TERMINAL LOCKS (Combs, Stuffers, TPA's [Terminal Position Assurance] and PLR's [Primary Lock Reinforcement])

22. Incorporate secondary locks and/or PLRs in all new connectors.

23. Design secondary locks and PLRs with ergonomically friendly surfaces for the operator to push on during handling and assembly.

24. The following is the preferred design of the PLR (in order of preference):

    a. Independent of the primary lock
        i. detects and corrects partially seated terminals,
        ii. detects partially seated terminals.
    b. Backs up locking finger (i.e., PLR)

25. Design the secondary lock and/or PLR with a snap fit (positive lock). Make the design to be removable without damage or the use of special tools.

26. If PLR is pre-assembled and shipped as a sub-assembly, make the design of the PLR so that it does not extend beyond the connector housing in the pre-loaded position.

27. Make the design of the secondary lock, so that the terminal is retained to connector housing independent of the primary lock, with an extraction force equal to or greater than the primary locks.

28. Avoid polarization of the secondary lock and PLR.

29. Design secondary locks and PLR's so that they are not capable of being fully inserted unless all terminals are fully seated.

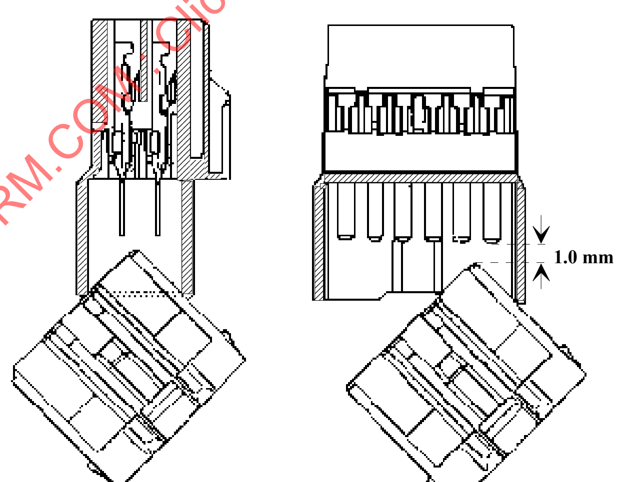
30. Make the secondary lock and PLR a contrasting color to the connector housing.

F. VEHICLE ASSEMBLY

1. Design all in-line connector systems with standard clip mounting provisions (tooling inserts) for a slide-on clip for sheet metal mounting. Consider direct connects (female connector) for clip provisions for future in-line applications. Provide for a positive retention feature for all un-used connectors (i.e. option delete). The retaining feature may be on the cap or on the connector body.

2. Provide for multiple polarizations with a minimum of four (design cannot allow miss-mating) in the design. Design tooling to support the potential of additional polarizations. Design polarizations to be visually distinguishable, preferably by color.

3. Design the connector shroud to provide proper alignment of the mating connectors before terminal engagement. This provides good terminal alignment and makes the connector "scoop proof." Design the female housing to come no closer than 1.0mm to the male terminals during worst case mis-insertion angle (see sketch below). A combination of CAD, SLA and prototype part studies may be required to demonstrate fulfillment of this guideline.



4. Design terminal blades with:

   a. Coining to ease insertion efforts and minimize the possibility of stubbing. The flat on the tip of the male terminal should not exceed 65% of the material or effective blade thickness (Refer to applicable USCAR drawing.)
   b. Blanked edges free of burrs.
   c. Straightness and flatness notes.

5. Quantify and provide (on demand) the insertion efforts of both the connector without terminals and each different terminal family used in the connection system so that specific application insertion efforts can be calculated.

6. Obtain approval of the respective OEM Manufacturing Ergonomics department prior to implementing any twist-lock mating connector system.

7. Include a radius as large as possible on all exposed connector edges to prevent injury and/or discomfort during handling and assembly.

8. Multi-cavity connectors with large pin fields require designed-in ribs, shipping covers, or other protective measures to prevent damage prior to assembly in the VAP.

9. Design eyelet/ring terminal teeth in the proper direction to provide anti-rotation per application (right-handed or left-handed screws). Provide an anti-rotation feature on ring terminals without teeth.

10. Call out the recommended torque and/or the torque specification on the assembly drawing of any connector using a fastener (i.e., nut, bolt, bushing, etc.).

11. Design the functional features of the connector assemblies to be robust or protected by the connector construction to withstand the normal packaging, shipping, and handling of the product. Avoid snag points.

12. Design connector halves with terminals so that there is no buzz, squeak, or rattle in either the mated or unmated condition.

CONNECTOR LOCKING FEATURE

13. Design the connector locking feature with anti-snag and inadvertent release protection to prevent inadvertent unlocking or permanent deformation during storage and shipping or after assembly in the vehicle.

14. Incorporate overstress protection in the design of the connector locking feature.

    a. Design to provide visual, audible, and tactile feedback.
    b. Design the connector housing lock to avoid a false indication of lockup.

15. Design the flexible lock member to be on the female connector half.

16. Design connector plastic locks with a statistical worst case minimum of 0.25 mm overtravel following full engagement.

CONNECTOR POSITION ASSURANCE (CPA)

17. Provide for CPA capability in the design. Include a CPA or secondary latch in the design of mechanical assist connectors (slide, lever, etc.). Bolt together designs do not require a CPA.

18. Design the CPA so that it cannot be engaged until the connector is completely mated.
19. Design the CPA so that it is capable of being preloaded on the connector housing.

20. Make the CPA of a contrasting color to the connector housing.

G. SERVICEABILITY

1. Use yellow and red connectors for safety and security systems. Use bright orange connectors only for high voltage systems (see SAEJ-1742 Connections for High Voltage On-Board Road Vehicle Electrical Wiring Harnesses – Test Methods and General Performance Requirements).

2. Use the standard terminal cavity identification schemes shown in Appendix A, on all connector housings. Space permitting, make the numbers no less than 1.5mm high.

3. Ensure that the terminal lock finger design does not reach its elastic limit when stressed to maximum open position. This may be accomplished by designing in an internal wall or stop.

4. Identify plastic parts with material identification symbols per SAE J1344.

5. Design the terminal and connector system so that terminals and the connector can be removed without the use of special tools.

6. Design wire routing guides to be capable of disassembly for service without functional damage to connector housing.

CONNECTOR LOCKING FEATURE

7. Design the connector locking feature so that it is ergonomically accessible and easily operated.

8. Avoid impeding of access to the connector lock by the location of any of the components attached to the connector housing (e.g., strain relief, locator, wire guides), except the connector secondary lock.

APPENDIX A
CAVITY NUMBERING GUIDELINES

These guidelines are intended to provide a standard system for designating connector cavities. This is not an all inclusive list or a substitute for common sense. It is to be used as a supplement to existing good design practices and standards.

1. Position the female connector with the locking or latching member pointed upward.

2. The rear of the connector (wire end) faces you.

3. A. For square or rectangular cavity spacings, start with number one, in the upper left corner and progress to the right. When the upper level is filled, continue the sequence on the next level starting at the left and so on.

   B. For circular or oval cavity patterns, start with number one in the uppermost cavity under the center of the locking/latching member. Continue the numbering in a clockwise direction, working toward the center of the connector.

   <u>NOTE</u>: **If the center of the lock/latch member falls between two cavities of equal distance and height, start with the cavity to the right of the center of the lock/latch. Always start with the uppermost cavity.**

4. Number the mating connector/part to the above connector so that cavity numbers match up (1-1, 2-2, etc.) when connected.

5. Where spacing allows connector make permanent terminal cavity identification visible from the rear of the connector.

- Several examples reflecting this procedure are shown on the following pages.

GUIDELINE EXAMPLES

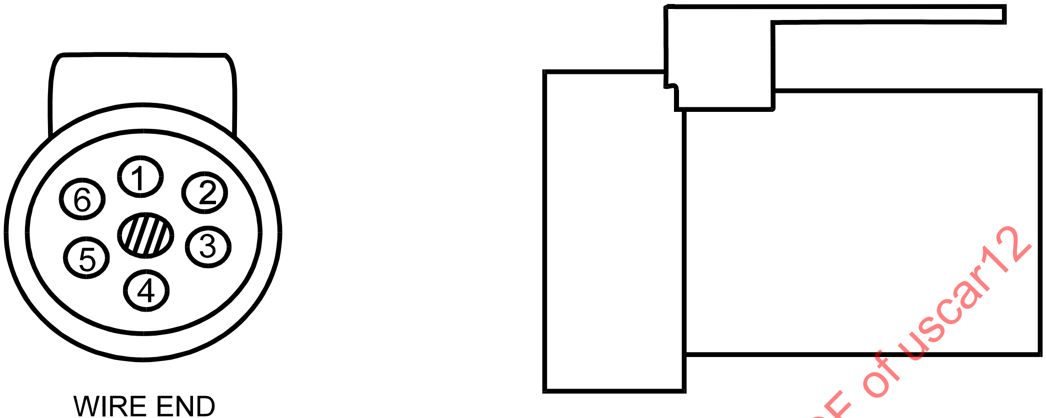


FIGURE #1

This example incorporates the guidelines for case 3(b), where the cavities are equally spaced and the first cavity is under the center of the latch.

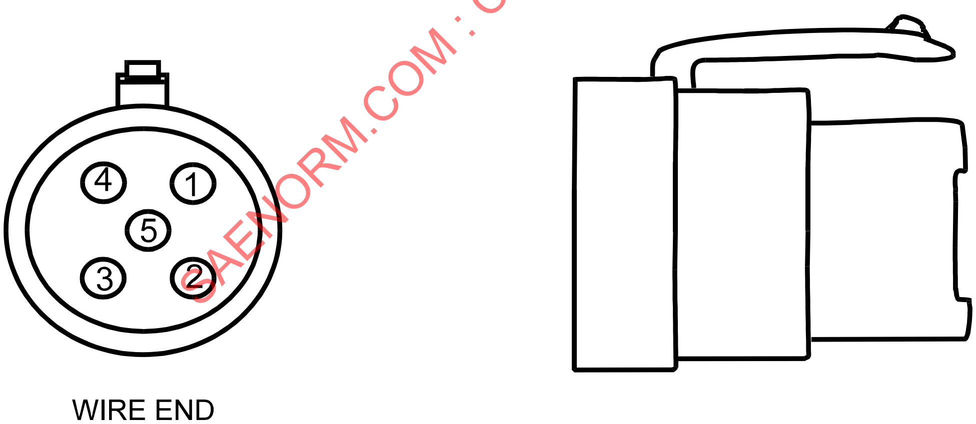


FIGURE #2

This example incorporates the guidelines for the noted case of 3(b), where two cavities are equally distant from the center of athe latch.