

Electrical Connector Design Requirements

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ELECTRICAL CONNECTOR DESIGN REQUIREMENTS

Notice about interim revisions: editorial updates or clarifications may be made as “interim revisions” if the EWCAP review team determines that a formal revision is not needed. Interim revisions are documented as “revision letters” and are available on the USCAR website, uscar.org.

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1. SCOPE

This document gives specific and measurable design requirements to be applied at a design review prior to tooling. The specification is formatted as a checklist to aid in its use. The requirements do not apply in all situations so engineering judgment must be used. This is a specification for design; applicable performance specifications (USCAR-2, etc.) must still be performed. Specific requirements in this document are grouped by component using a prefix as shown in Table 1 and are numbered by an item number following the prefix.

Table 1 - Organization of requirements

Category	Prefix Code Used
Terminals	T
Secondary terminal locks	STL
Connectors	C
Connector locking	CL
Connector position assurance	CPA
Connector seals	SE
Pin protection plate	PP
Serviceability	SV
Drawing/general requirements	DG

2. REFERENCES

- SAE/USCAR-2, "Performance Specification for Automotive Electrical Connector Systems"
- SAE/USCAR-21, "Performance Specification for Cable-to-Terminal Electrical Crimps"
- SAE/USCAR-25, "Ergonomics Specification for Electrical Connections"
- SAE/USCAR-37, "High Voltage Connector Performance Supplement to SAE/USCAR-2"
- USCAR/EWCAP-001, "Blade Drawings"
- USCAR/EWCAP-005, "Connector Clip Slot Drawings"
- USCAR/EWCAP P105, "Drawing Requirements for USCAR interface Drawings"

NOTE: SAE/USCAR specs are available from SAE International. USCAR/EWCAP drawings are available from the EWCAP section of the USCAR website.

3. USAGE

USCAR-12 is a design requirement for new terminals and connectors, when specified in an engineering statement of work from a customer. Compliance provides the following advantages:

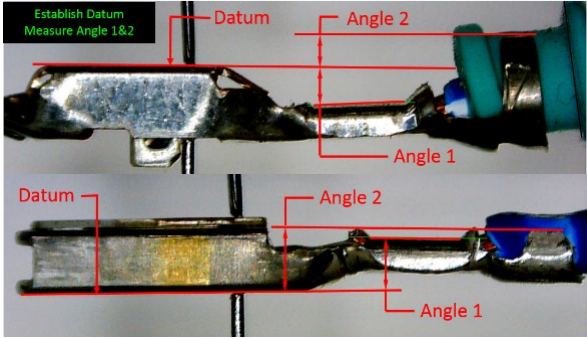
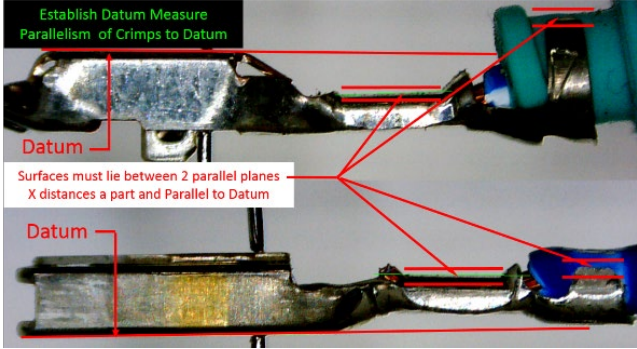
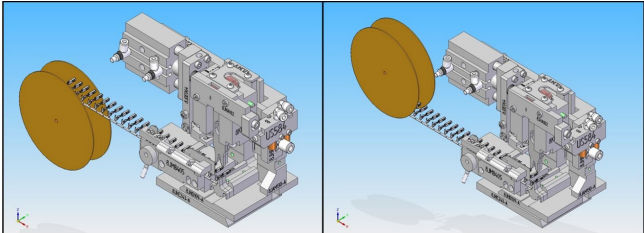
1. Common connector terminal blade sizes.
2. Common connector pitch (to facilitate similarity of USCAR footprints).
3. Common plating (to avoid material incompatibility or retesting).
4. Common minimum blade travel (to ensure complete mating).
5. Common terminology (naming parts, gender, additional parts, etc., the same).

6. Common ergonomic features to generate a common “look and feel” between connectors.
7. Common retention (clip slot) to allow for common clips.
8. Common drawing layout (to facilitate interpretation of drawings).
9. Common error-proofing methods (contrasting color, etc.) to allow for common assembly processes.
10. Common seal design requirements to (to allow for common seal suppliers).

4. DESIGN REQUIREMENTS

4.1 TERMINALS

#	Requirement	Confirmation Method	X																
T1	Design male terminals for headers per USCAR EWCAP-001 and inline male terminals per the table at right. (Tolerances on dimensions for both inline and header terminals must be per EWCAP-001.)	Confirm male header blades are per EWCAP-001. Confirm inline blades are per the table below. <table><tr><th>EWCAP-001 Blade</th><th>Related Inline Blade</th></tr><tr><td>050-T-001</td><td>0.5 X 0.40 mm</td></tr><tr><td>064-T-001&002</td><td>0.64 X 0.64 mm</td></tr><tr><td>120-T-001&002</td><td>1.2 X 0.60 mm</td></tr><tr><td>150-T-001</td><td>1.5 X 0.80 mm</td></tr><tr><td>280-T-001</td><td>2.8 X 0.80 mm</td></tr><tr><td>630-T-001</td><td>6.3 X 0.80 mm</td></tr><tr><td>950-T-001</td><td>9.5 X 1.20 mm</td></tr></table>	EWCAP-001 Blade	Related Inline Blade	050-T-001	0.5 X 0.40 mm	064-T-001&002	0.64 X 0.64 mm	120-T-001&002	1.2 X 0.60 mm	150-T-001	1.5 X 0.80 mm	280-T-001	2.8 X 0.80 mm	630-T-001	6.3 X 0.80 mm	950-T-001	9.5 X 1.20 mm	
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950-T-001	9.5 X 1.20 mm																		
T2	Design female terminals to avoid snagging (or assembler's hand damage) at harness assembly plants.	a. Confirm no sharp projections on terminals. b. Confirm no protruding features. (Protected tangs, rounded shark fins, etc., are acceptable.)																	
T3	Design the female terminal to protect the electrical contact using closed-box technology.	Confirm full metal closed box design.																	
T4	Design for robust terminal retention with: a. Plastic lock fingers (preferred), or b. Protected tangs.	Confirm use of robust plastic lock finger or protected tang. Note: OEM-specific requirements may not allow use of tangs, even if protected.																	
T5	Design female terminals with plated copper alloys. Disclose terminal materials including temper on drawings supplied to end users for crimp analysis. Plating must be compatible with mating device platings per EWCAP-001.	a. Confirm plating is compatible with EWCAP-001 drawing if for a device (header). b. Confirm thickness, method of plating, type of material are disclosed and documented on the part drawing.																	
T6	Silver-plated terminals must have anti-tarnish protection.	Confirm anti-tarnish protection is used.																	

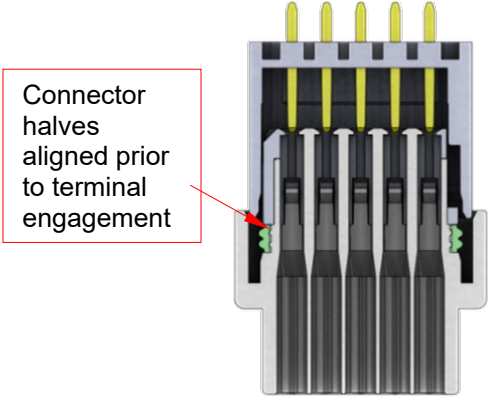
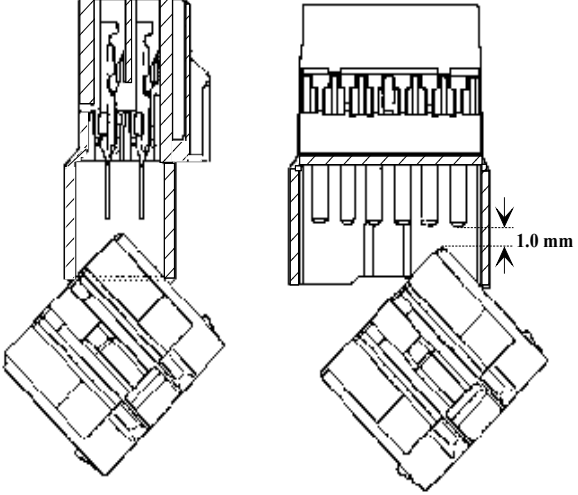
#	Requirement	Confirmation Method	X
T7	The terminal supplier must provide information needed to process or use the terminal.  Figure 1  Figure 2	Confirm drawing or handling manual shows applicable information for terminals: - Chart wire range and insulation diameter range. - USCAR-21 compliant crimp dimensions for all tested crimps applicable types and sizes either on the drawing or as a separate document. - Additional dimensional information: - Datum for measurement of crimp location and orientation as shown in Figures 1 and 2. - Crimp offset if applicable (not shown). - Parallel or angularity tolerance (not shown). - If the design assumes coaxial features note it in the specification.	X
T8	Any outside surface or blade-contacting surface of female terminal must be free of burrs.	Confirm that the tooling simulation predicts no burrs on the surface of a male blade terminal or blade-contacting surface of female terminal.	
T9	For designs that require polarization, design the terminal with an external terminal orientation feature which is visually obvious.	Confirm with a CAD study that: - Terminal orientation feature is obvious. - An incorrectly oriented terminal inserted into the connector housing will have terminal insulation grip fully protruding from the rear of the connector housing when fully pushed against orientation feature. - If a mat seal with a rear cap is used, the terminal insulation grip must be visible if orientation feature has stopped a terminal.	
T10	Terminal winding must be designed so the payout is left-to-right, when crimp wings are oriented up. (See Figure 3.)  Figure 3	Confirm the tooling is designed for payout from left-to-right.	

4.2 Secondary Terminal Locks

#	Requirement	Confirmation Method	X
STL1	All connector designs must include a secondary terminal lock. Known methods are: TPA, ISL, PLR.	Confirm secondary lock presence.	
STL2	Secondary lock must be effective. in meeting corresponding pull test values.	Ensure secondary lock is present. Verify design is mature carry-over or complete FEA or prototype test. Note: OEMs often have additional requirements for this category and design engineers are advised to recheck their statement of work.	
STL3	Make the secondary lock a contrasting color to the connector housing for separate piece designs.	Confirm contrasting color.	

4.3 Connectors

#	Requirement	Confirmation Method	X															
C1	All connectors with clip mounting provisions must use an applicable design per EWCAP-005.	Confirm the applicable EWCAP-005 clip slot design is used. Confirm slot is identified as conforming to EWCAP-005.																
C2	Provide unique key options and colors: a. Provide for multiple polarizations as requested with an ability to expand to four. (Intent of keys is to ensure design cannot allow mis-mating and is not to be used as an assembly aid to confirm wire harness level.) b. Design polarizations to be visually distinguishable. c. Polarizations and colors are to match these colors as a default: <table><tr><td>KEY</td><td>UNSEALED</td><td>SEALED</td></tr><tr><td>A</td><td>Black</td><td>Black</td></tr><tr><td>B</td><td>Lt. Gray</td><td>Lt. Gray</td></tr><tr><td>C</td><td>Dk. Gray</td><td>Dk. Gray</td></tr><tr><td>D</td><td>Black</td><td>Black</td></tr></table> Note: Due to the frequent need for deviations from this color chart, OEM's release engineer typically can easily approve variances. d. If using a non-standard color, do not use a "reserved color" listed below except for the use listed below: * Yellow = Restraint system * Orange = High voltage * Light blue = Intermediate voltage (>12 V and <60 V)	KEY	UNSEALED	SEALED	A	Black	Black	B	Lt. Gray	Lt. Gray	C	Dk. Gray	Dk. Gray	D	Black	Black	a. Confirm connector color is per the table and design polarizations are visually distinguishable and match the color option. Ensure no reserved colors are used. b. Confirm space for four polarization options that are effective and meet the criteria as defined in USCAR-2 using CAD studies and or SLA models. c. Confirm use of default colors unless directed to use different colors. d. Confirm no reserved colors are used incorrectly.	
KEY	UNSEALED	SEALED																
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D	Black	Black																

#	Requirement	Confirmation Method	X
C3	Housing alignment: Design the connector shroud to provide housing alignment of the mating connectors before terminal engagement. (This ensures terminal alignment.) (See Figure 4.)  Figure 4	A combination of CAD studies and SLA models must be reviewed to document housing alignment. Verify CAD data used for the studies is at the correct release level. Reconcile math model and documented rev levels.	
C4	Terminal Scoop Avoidance: Design the connector system so there is clearance (1.0 mm recommended) to the male terminals during worst case mis-insertion angle to provide “scoop proofing.” (See Figure 5.)  Figure 5	Review CAD studies and SLA models to document scoop proofing. Verify CAD data used for the studies is at the correct release level. Reconcile math model and documented rev levels. Rapid prototypes may be required to determine the worst-case scenario for misalignment of the connector pair.	
C5	Calculated connector mating effort must comply with applicable SAE/USCAR-25 criteria with a 10% design margin.	Confirm the computed mating force does not exceed 90% of the USCAR-25 limit. (Compute the insertion effort of the connection system, fully populated with all applicable terminals, using average force per terminal data from the terminal supplier. Include consideration for array factor, seal drag, lock engagement, and other factors in the calculations.)	
C6	Push surface areas must comply with SAE/USCAR-25 Section 4.2 for “CONTACT SURFACE CHARACTERISTICS.”	Confirm push surface areas comply to USCAR-25 Section 4.2 by meeting the minimum area requirements of Table 4.1.	