Electrical Connector Design Requirements

SAE/USCAR-12 REVISION 6
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SAE/USCAR-12 REVISION 6

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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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QUESTIONS REGARDING THIS DOCUMENT: (248) 273-2470 FAX (248) 273-2494
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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).

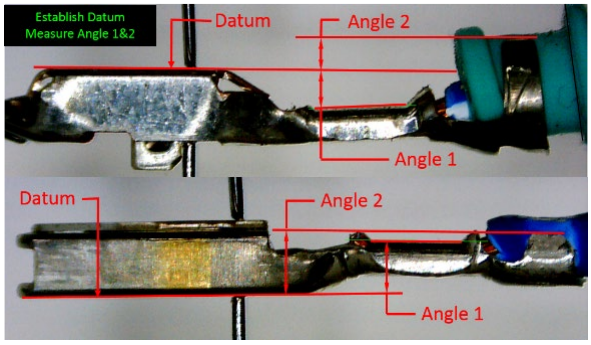
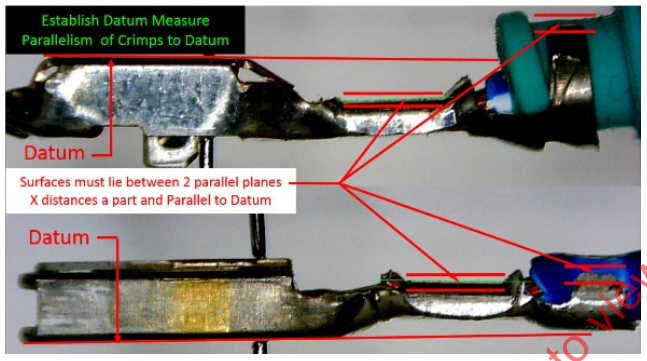
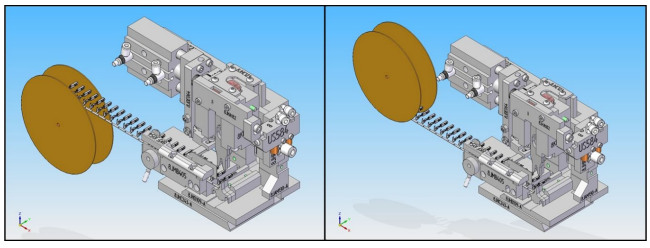
9. Common error-proofing methods (contrasting color, etc.) to allow for common assembly processes.

10. Common seal design requirements to (to allow for common seal suppliers).

4. DESIGN REQUIREMENTS

4.1 TERMINALS

<table>
<tr><th>#</th><th>Requirement</th><th>Confirmation Method</th><th>X</th></tr>
<tr><td>T1</td><td>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.)</td><td>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></td><td></td></tr>
<tr><td>T2</td><td>Design female terminals to avoid snagging (or assembler’s hand damage) at harness assembly plants.</td><td>a. Confirm no sharp projections on terminals.
b. Confirm no protruding features. (Protected tangs, rounded shark fins, etc., are acceptable.)</td><td></td></tr>
<tr><td>T3</td><td>Design the female terminal to protect the electrical contact using closed-box technology.</td><td>Confirm full metal closed box design.</td><td></td></tr>
<tr><td>T4</td><td>Design for robust terminal retention with:
a. Plastic lock fingers (preferred), or
b. Protected tangs.</td><td>Confirm use of robust plastic lock finger or protected tang.
Note: OEM-specific requirements may not allow use of tangs, even if protected.</td><td></td></tr>
<tr><td>T5</td><td>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.</td><td>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.</td><td></td></tr>
<tr><td>T6</td><td>Silver-plated terminals must have anti-tarnish protection.</td><td>Confirm anti-tarnish protection is used.</td><td></td></tr>
</table>

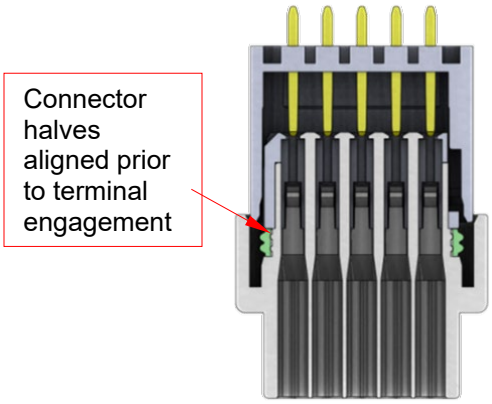
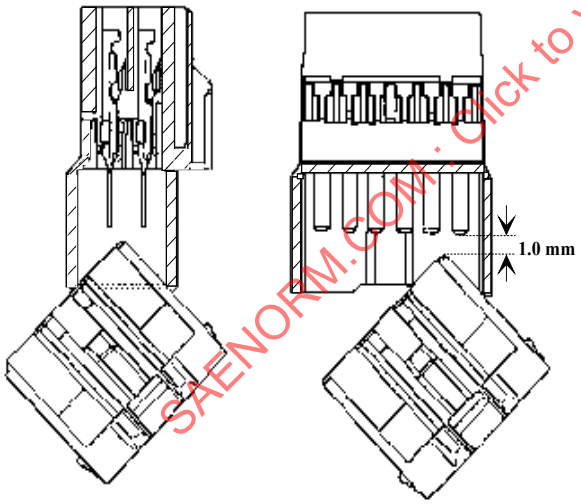
#	Requirement	Confirmation Method	X
T7	The terminal supplier must provide information needed to process or use the terminal.  ***Figure 1***  ***Figure 2***	Confirm drawing or handling manual shows applicable information for terminals: a. Chart wire range and insulation diameter range. b. USCAR-21 compliant crimp dimensions for all tested crimps applicable types and sizes either on the drawing or as a separate document. c. 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.	
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: a. Terminal orientation feature is obvious. b. 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. c. 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

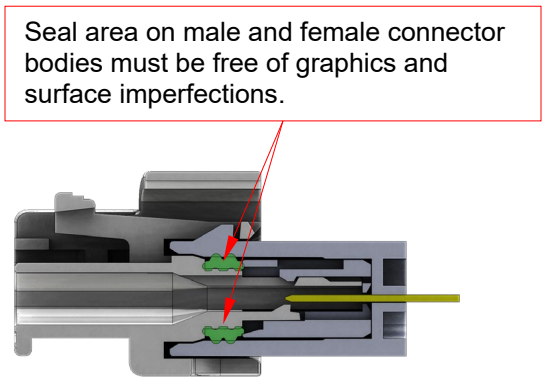
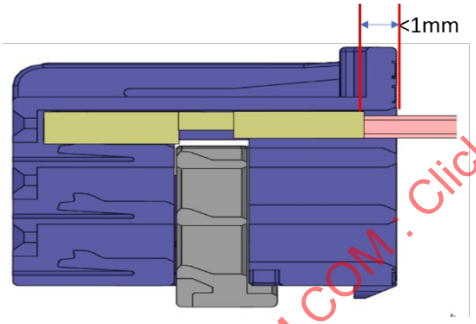
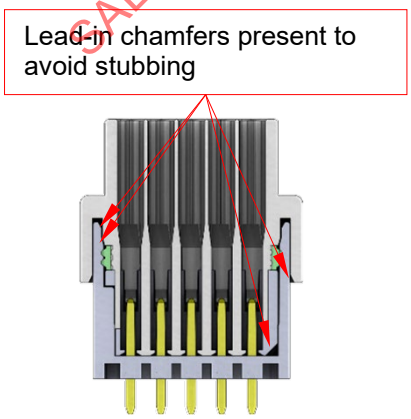
#	Requirement	Confirmation Method	X
STL1	All connector designs must include a secondary terminal lock. Known methods are: TPA, ISL, PLR.	Confirm secondary lock presence.	
STL2	Secondary lock must be effective. in meeting corresponding pull test values.	Ensure secondary lock is present. Verify design 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.	

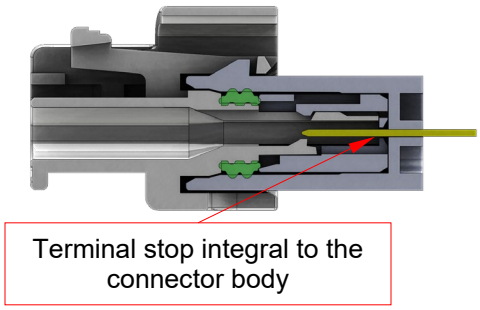
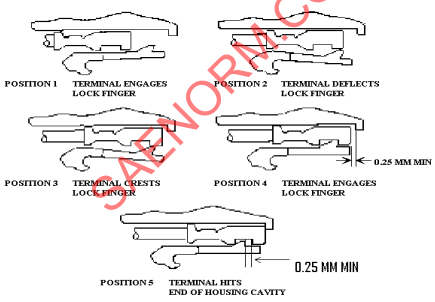
4.3 Connectors

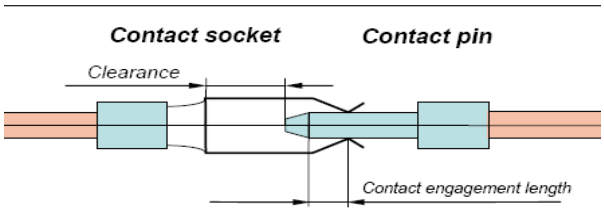
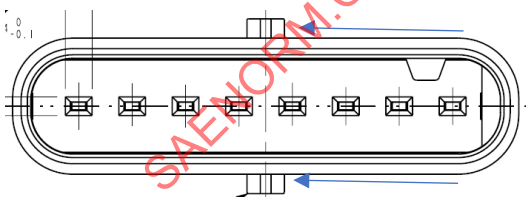
#	Requirement	Confirmation Method	X
C1	All connectors with clip mounting provisions must use an applicable design per EWCAP-005.	Confirm the applicable EWCAP-005 clip slot design is used. Confirm slot is identified as conforming to EWCAP-005.	
C2	Provide unique key options and colors: a. Provide for 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: KEY UNSEALED SEALED A Black Black B Lt. Gray Lt. Gray C Dk. Gray Dk. Gray D Black Black 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)	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.	

#	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.	

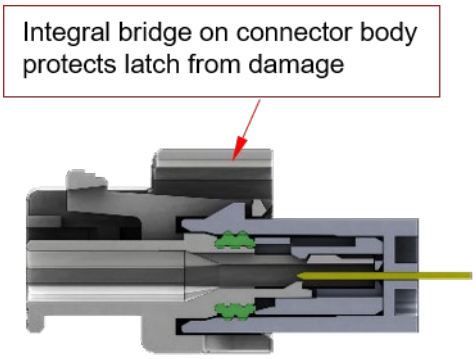
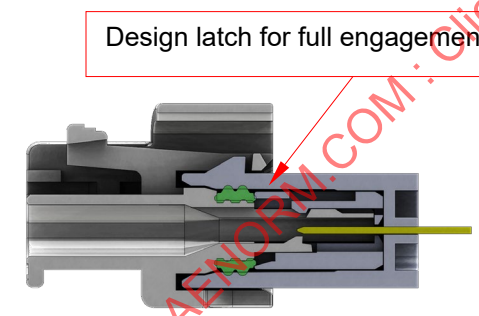
#	Requirement	Confirmation Method	X
C7	All exposed connector edges must contain radii per USCAR-25 requirements.	Confirm compliance with USCAR-25.	
C8	Mating connector method shall not require a twisting motion on the part of the operator.	Confirm assembly method does not require a twisting motion.	
C9	Design the connector to protect the terminals from damage and misalignment. Male connectors shall have features molded into the connector housing or TPA that act as an obstacle to finger/object contact. The requirement is based on terminal size since larger terminals have higher bend strengths and are more tolerant of finger contact. USCAR-12 item C9 does not need to be met if the male connector is supplied with an automatically resetting PPP. Requirement still applies for manual resetting designs. (See PP3.) Blade fields with mixed blade widths (hybrid. can use the criteria for the larger (wider) blade when the wider blade is also taller. Neighboring small terminals can be considered as part of the larger field when the distance from the bigger terminal is smaller than the height difference between terminals. Male connector designs with a long protective shroud (shroud depth > than connector width) should be evaluated by an expert to assess whether special (more tolerant) criteria are possible due to the protection from the shroud.	Using CAD simulation, a sphere must be virtually placed in all locations of the blade field and must comply per the table below: a. For male blade size <1.5 mm: a ball of 12.5 mm diameter must not contact the terminal blades. If a pin protection plate is utilized, the requirement is waived. b. For male blade sizes 1.5 to 2.8, inclusive, a ball of 18 mm diameter must not contact the terminal blades c. For male blade size >2.8 mm: a ball of 24 mm diameter must not contact the terminal blades.	
C10	Bolt-assist connectors shall have the following design features. 1. Connector must use only one bolt. 2. Connector design must consider the size of the socket-driver being used. Connector and cable shall have 2 mm clearance from socket. 3. Larger terminals shall be placed towards the center (for balanced terminal forces). 4. Bolt tip shall not protrude past the back of the connector when fully mated 5. Bolt shall have an unthreaded lead-in or other method to avoid cross threading (typically, chamfer of 1 mm x 45 degrees). 6. Bolt shall be designed to fail before the insert in the mating part moves or its threads strip.	Confirm bolt connection requirements meet customer expectations and given requirements. 1. Confirm single bolt located in the center. 2. Confirm 2 mm clearance (radial) from outside of socket tool. 3. Confirm design has larger terminals close to center. 4. Confirm bolt end does not protrude. 5. Confirm design does not cross-thread. 6. Verify design strength of the bolt is weaker than insert.	
C11	Ensure protruding features are designed to avoid snags.	Perform a CAD study to make sure a 1.5 mm diameter cylindrical shape is not able to get trapped or work its way in between geometry present on the connector to avoid snagging in a wire harness application.	
C12	Design connector half with terminals and other mating components so that there is no “buzz, squeak, or rattle” in the mated condition.	Complete a design review of the connection system. (Review tolerance stack-ups related to fit and function of TPA’s, CPA’s, clip slots, delete caps, and back caps.) Use crush ribs to engineer line-to-line fits and absorb tolerance to increase system immunity to BSR.	

#	Requirement	Confirmation Method	X
C13	Sealing surfaces on the connector housings must be free of surface imperfections (including the surface located under the peripheral seal). (See Figure 6.)  ***Figure 6***	Apply a note on the part drawing that states “entire surface no mold parting lines, steel split lines, and part decorations allowed on these surfaces. This area of tool to be Ra 0.4 µm max. Verify the seal area has been maximized to accommodate multiple seal glands. Peripheral seal design is preferred. Surface finish requirements described above also apply to areas of the housing that provide nests for cable and matte seals.	
C14	Design connectors so that there is at least 1 mm of plastic coverage between the back end of the terminal and the back end of the connector. (See Figure 7.)  ***Figure 7***	Complete design analysis (considering worst case tolerances) and confirm terminal is embedded in the connector at least 1 mm (to avoid electrical shorting of terminals).	
C15	Design all connectors with lead-ins on all mating surfaces. (See Figure 8.)  ***Figure 8***	Confirm presence of lead-ins. A chamfer is allowed if it does not defeat keyways (polarization).	
C16	Design the rear surface of the connector housing with lead-ins for rear seal installation.	Ensure chamfer or radius is present (to aid in seal installation).	

#	Requirement	Confirmation Method	X
C17	Design the terminal cavity with a forward stop. The stop feature needs to be part of the initial connector housing, not in the front loaded TPA/PLR. (See Figure 9.)  ***Figure 9***	Confirm design is compliant and utilizes a forward stop in the connector housing.	
C18	Provide access for the harness fixture continuity probe in the connector housing assembly. Provide access for the probe through the front of the connector so that top of spring member cannot be contacted. If this is not achievable, probing the throat of the terminal is acceptable provided the terminal retains its design intended performance.	Confirm the connector and probe is designed so that contact is not made with the terminal mating surface.	
C19	Provide at least 0.25 mm overtravel of terminal which leaves 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 its retention surface most closely approaches the terminal lock surface. (See Figure 10.)  ***Figure 10***	Confirm with CAD and swing studies and tolerance stack ups. Verify CAD data used for the studies is at the correct release level. Reconcile math model and documented revision levels.	
C20	Design in an internal wall or stop, to prevent overstress of the terminal lock finger.	Ensure that the terminal lock finger design does not reach its elastic limit when stressed to maximum open position. Review engineering studies.	
C21	Certify that any used combination of regrind and raw material meets the plastic manufacturer's specification. Ensure selected material or its content is not restricted or prohibited for use by government agency.	Certify that the "as molded" parts are not degraded beyond acceptable material limits. DFMEA to include material processing parameters as cause for failure mode this failure mode needs to be transferred to the PFMEA and the manufacturers control plan.	
C22	Empty (item was removed, but to keep numbering consistent between revisions, it is now blank).		

#	Requirement	Confirmation Method	X
C23	Removed.		
C24	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. (See Figure 11.)  ***Figure 11*** 1 mm minimum contact engagement length shall be met for terminal families larger than 0.5 mm. For 0.5 mm, contact engagement shall be 0.7 mm, min.	This guideline ensures that connector lock over-travel and 1 mm minimum contact engagement length requirements are met for all terminal families except the 050 connector family. The 050 family allows 0.7 mm engagement. The supplier retains this information and makes it available to the OEM or tier supplier upon request. Review engineering studies, verify CAD data used for the studies is at the correct release level.	
C25	Removed.		
C26	Ensure cavities are numbered per EWCAP rules in Appendix A, Section A1.	Confirm by design review.	
C27	Make terminal spacing (pitch) per the recommendations of Appendix D.	Confirm compliance to Appendix D.	
C28	Design shall have a single lock (rather than a dual lock that is difficult to engage, see Figure 12 for example of a dual lock that does not meet this requirement).  ***Figure 12***	Confirm a single lock is designed. (Interface drawings can note that older designs may have them.)	

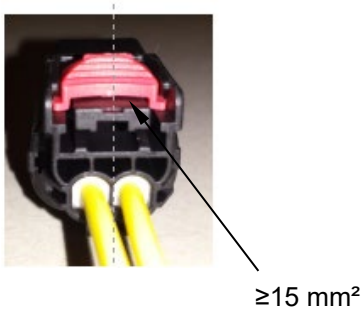
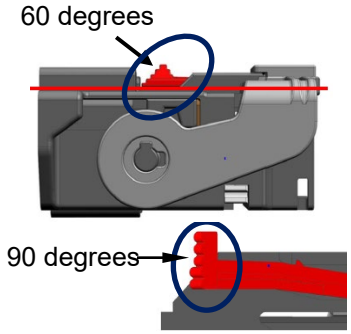
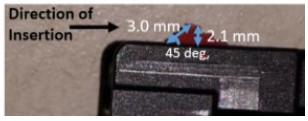
4.4 Connector Locking

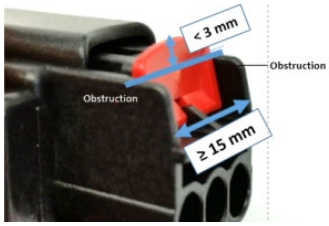
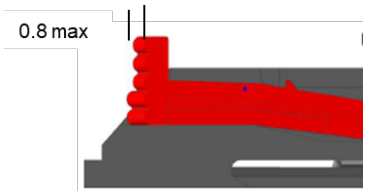
#	Requirement	Confirmation Method	X
CL1	Design the locking feature with anti-snag and lock release protection to prevent inadvertent unlocking or permanent deformation during storage and shipping or during assembly in the vehicle. (See Figure 13.)  ***Figure 13***	Analyze the design to ensure latch is adequately protected with side rails or a bridge or other features that protect latch.	
CL2	Ensure that the connector external latch feature is robust.	Connector supplier to perform predictive analysis to ensure latch has adequate flexibility.	
CL3	Design the locking feature to provide full engagement with face of shark fin and includes a back angle of at least 5 degrees. (This ensures a true lock up condition between the mated pair.) (See Figure 14.)  ***Figure 14***	Review CAD studies and design analysis to ensure full engagement or utilize predictive tools. Verify CAD data used for the studies is at the correct release level. Reconcile math model and documented rev levels.	
CL4	Design the flexible lock member to be on the connector half not on the device.	Confirm latch is not on the device.	
CL5	Design connector locks with clearance for beam motion.	Review CAD studies and tolerance stack-ups to ensure connector to connector plastic locks with a minimum of 0.25 mm over travel and a maximum of 0.80 mm following full engagement.	
CL6	When designing for mechanical assist (lever, bolt, or slide), connectors are to have no electrical continuity when the connector is in the pre-lock position. Also, the mechanical assist shall not unlock until the connector has reached the pre-lock condition.	Review connector design studies to ensure the pre-lock connector does not allow electrical continuity between connector halves. Review connector design studies to ensure the lever is locked in the pre-lock position per USCAR-2.	

#	Requirement	Confirmation Method	X
CL7	When the connector is properly aligned for mating completion on a mechanical assist lever design, the lever shall release from the pre-stage position, providing a visual indication the connector is ready to seat.	Verify through CAD studies and rapid prototypes the connector assist lever releases and moves 10 to 35 degrees and an arc length of 10 mm min.	
CL8	Color of mechanical assist is at OEM discretion.	Connector supplier shall contact OEM to determine the requirement.	

4.5 Connector Position Assurance (CPA)

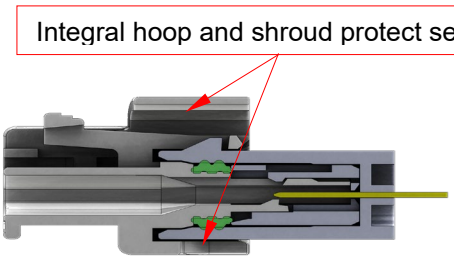
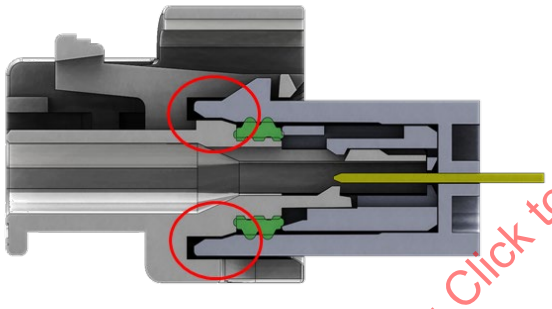
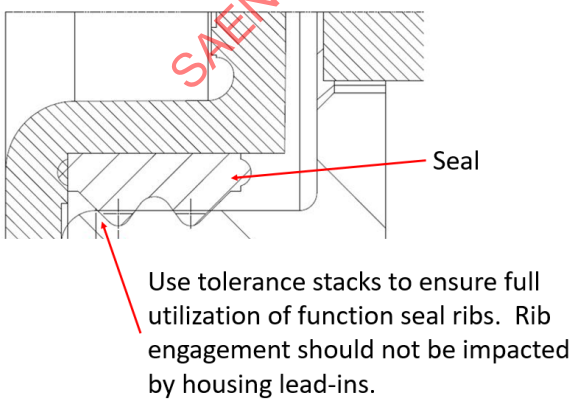
#	Requirement	Confirmation Method	X
CPA1	Provide for CPA capability in the connector housing (or secondary latch for mechanical assist connectors).	Complete a design review to confirm the connection system is a CPA-capable design.	
CPA2	Design the CPA so that it is capable of being preloaded on the connector housing.	Confirm no loose-piece or tethered CPA's are used.	
CPA3	Make the CPA of a contrasting color to the connector housing. The color will be determined by the sourcing OEM.	Confirm contrasting color to the connector housing.	
CPA4	The CPA shall: a. Provide audible and tactile feedback of proper closure in the final/seated position b. Not produce a sense of false locks or double clicks.	a. Use test data from a part that meets the OEM's specific performance criteria for audible feedback and carry over the design or perform FEA analysis to predict the frequency range and sound pressure level of the new geometry when actuated and compare to test data. b. Use FEA to predict the force versus travel curve of the CPA when actuated. A continuous increase in engagement effort as the CPA travels to lock followed by a distinct decrease in assembly effort combined with over travel past lock prior to reaching the CPA seated position with peak engagement effort and 0 travel.	
CPA5	Design the CPA to be "active," meaning that it cannot be engaged until the connector is completely mated.	Verify through CAD studies of the design to ensure the CPA cannot be engaged until the connector is completely mated.	
CPA6	The CPA shall provide readily identifiable visual indication that the CPA is Closed. Examples of visual indication include, but are not limited to, designing the push surface to be flush with the surrounding connector surface, designing the CPA push surface to have a shoulder that rests on the surrounding connector surface.	Review the CPA design in the seated position to ensure the CPA position relative to adjacent connector geometry can be visually detected. Requirement source: USCAR-25.	
CPA7	The CPA shall be designed to prevent activation of the connector lock and disconnecting the connector halves when it is positioned in its final position to avoid an accidental "bump and release" of the connector lock during vehicle assembly.	Review the CPA design in the seated position to ensure the CPA protects the connector lock from inadvertent release.	

#	Requirement	Confirmation Method	X
CPA8	Make the minimum contact surface area at least 15 mm² with a minimum dimension of 3 mm, not including the edge radius. (Any surface measuring less than 3 mm in width or length cannot be considered as part of the contact surface area.) Larger surfaces are preferred if possible. (See Figure 15.)  ***Figure 15***	Use CAD to verify available actuation area. Source: USCAR-25.	
CPA9	Angled contact surface is acceptable. Contact surface areas should be optimally angled between 30 degrees and 90 degrees (perpendicular) from the direction of force insertion. Angles greater than 90 degrees negative slope are not allowed. Concave spherical and compound radii are also acceptable contact surface shapes. The actual area will be included in the calculation if the operator can contact the surface during actuation.	Use CAD to verify actuation angles and compare to Figure 16. Evaluate function with rapid prototype parts. Source: USCAR-25.  ***Figure 16***	
CPA10	Design the CPA with engagement force to meet applicable specifications. (See Figure 17.)	Measure the force on prototype parts or predict with FEA.  ***Figure 17***	
CPA11	No sharp edges or hard contact points are allowed on the CPA push surfaces or along its actuation path. An edge radius less than 0.8 mm is unacceptable.	Evaluate CAD model to ensure no hard contact points exist on the CPA actuation surface or along its actuation path. Source: USCAR-25.	

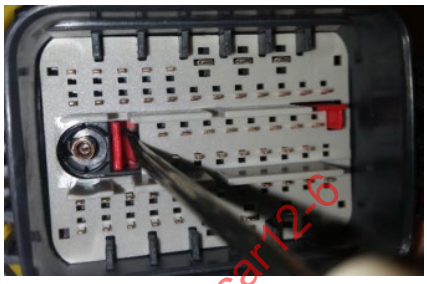
#	Requirement	Confirmation Method	X
CPA12	A fully seated unobstructed CPA push surface must be either flush or protruding above the surrounding surface of the connector. Flush includes a surface that is even with or recessed beyond the surrounding surface a maximum of 1 mm. A minimum of 3X5 mm push surface must remain unobstructed by the connector body and wires through the length of travel. If the CPA is obstructed, recessed, or shrouded between opposing surfaces or sides, maintain 15 mm minimum between opposing sides for CPA travel ≤7 mm, 19 mm minimum between sidewalls for travel >7 mm and for CPA's starting in a recessed and obstructed travel position, provide 19 mm minimum between sidewalls. (See Figure 18.)	Use CAD to verify seated position and required actuation clearance. Evaluate function with rapid prototype parts.  ***Figure 18 - Examples of obstructed CPA*** Source: USCAR-25.	
CPA13	Serrations, knurls, ridges etc. are permissible and if used must have a maximum height of 0.8 mm. (See Figure 19.)  ***Figure 19***	Evaluate CAD model to ensure serrations, knurls and ridges meet the maximum height requirement. Source: USCAR-25.	
CPA14	Removed.		

4.6 Connector Seals

#	Requirement	Confirmation Method	X
SE1	Make seal presence visually detectable by using a contrasting color.	Confirm contrasting color to the connector housing.	
SE2	Make a continuous smooth surface (no tooling marks) in all seal areas (including peripheral, individual cable, and mat seals).	Confirm mold parting lines, split lines, and part decorations are placed off sealing surfaces. Tool steel roughness to be Ra 0.4 µm, max.	
SE3	Design for cable seal retention so that USCAR-21 criteria will be met. Include design feature for retention (example, mushroom tops).	Design individual cable seals to have retaining feature to prevent it from moving along the wire and away from the terminal during assembly and handling.	
SE4	Design protective covers, when required, for unused (option delete) connectors with positive retention to the covered connector.	Maintain sealing capability as required and meet BSR performance.	
SE5	Design the connector, so that the mat seal is unaffected by wire bending and handling. Provide for positive retention of seal plugs if used. Other alternatives are end cap with integral hard plugs that are removed according to circuit loading. Flashed over cavities in the connector or mat seal.	Include a back cap with a wire strain relief feature. Allow for plugs to be inserted in individual terminal cavity openings in the cap after the end cap is installed.	

#	Requirement	Confirmation Method	X
SE6	Peripheral seals shall be designed as part of the female connector. The connector must have a shroud to completely protect the peripheral seal. Design must include a peripheral seal retention feature. (See Figure 20.)  ***Figure 20***	Complete a design review of the connectors to ensure the design includes a peripheral seal retaining feature and a shroud to protect the peripheral seal from damage.	
SE7	Design lead-in chamfer on connector housing to prevent "bunching" rollover or excessive movement of the peripheral seal during mating. (See Figure 21.)  ***Figure 21***	Confirm with design review of CAD studies to ensure the design meets the intended performance requirement.	
SE8	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 dimensional stack-up. (See Figure 22.)  ***Figure 22***	Complete design review of CAD study. Verify CAD data used for the studies is at the correct release level. Reconcile math model and documented rev levels.	
SE9	All sealing methods must be designed for two terminal insertions and one terminal extraction from the connector cavity without compromising the sealing properties.	Supports terminal design requirement having friendly edges and surfaces to avoid cutting seals. Confirm matches spec.	

4.7 Pin Protection Plate

#	Requirement	Confirmation Method	X
PP1	Male connectors (in-line and headers) must have a PPP if the customer requests that feature.	Confirm PPP is included when requested.	
PP2	PPP shall be a contrasting color to the connector housing. It shall also contrast with any nearby components such as TPA/PLR/ISL if that component needs to be moved in the assembly process. An example of contrasting housing, TPA, and PPP is shown in Figure 23.	Confirm contrasting colors are present.  ***Figure 23***	
PP3	PPP designs are to be “automatically resetting” (which reset to the shipping position during female connector disengagement).	Confirm required type is in the design. Note that customer often provides a different requirement.	
PP4	If PPP has a manual reset, the reset process must be accomplished without needing special tools and the component shall have easily identifiable and accessible service features.	Confirm using expert assessment/design review to verify reset features are acceptable.	
PP5	Exposed blades extending beyond the PPP in shipping position shall comply with all dimensions of Figure 27.	Confirm maximum exposed blade lengths conform to the table to ensure PPP is effective. Note: This requirement is to enable access for test probes.	
PP6	Removal of terminals for in-line connectors must be possible (for service) without removal of PPP. In cases where customer allows the PPP to be removed, a procedure must be added in the connector handling manual for PPP removal and re-installation with terminals loaded.	Verify terminals can be accessed with service tools either in pre-set or seated position.	

4.8 Serviceability

#	Requirement	Confirmation Method	X
SV1	Design the terminal and connector system so that terminals and the connector can be removed without the use of “special tools.”	Confirm nothing other than typical terminal picks are required.	
SV2	Design the connector locking feature so that it is ergonomically accessible, easily operated, and does not require the use of any tools.	Confirm compliance unless use of tools is specified by the design objective for a special application (i.e., high voltage connector).	
SV3	Do not block access to the connector lock with other components attached to the connector housing, except the secondary lock (CPA).	Confirm add-on features (i.e., strain relief, locator, wire guides) do not block the lock.	
SV4	Design wire routing guides (rear covers, or wire dress covers) to be capable of disassembly for service.	Confirm ability to disassemble.	

4.9 Drawing/General Requirements

#	Requirement	Confirmation Method	X
DG1	If creating a USCAR header drawing, the drawing must conform to the “EWCAP P105-Drawing Conventions” document available online.	Confirm compliance to EWCAP P105 Drawing Conventions, as applicable.	

APPENDIX A - CAVITY NUMBERING

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. Position the female connector with the locking or latching member pointed upward. The rear of the connector (wire end) faces you.

a. For square or rectangular cavity spacing, 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. (See Figure A1.)

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. (See Figures A2 and A3.)

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

Where spacing allows, make permanent terminal cavity identification visible from the rear of the connector. If numbers cannot be physically fit on the connector housing, they must be identified on the component drawing. Several examples reflecting this procedure are shown in Figures A1, A2, and A3.

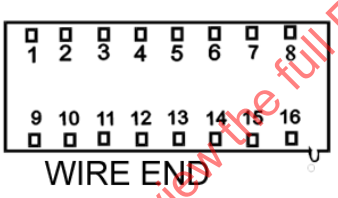


Figure A1

Figure A2

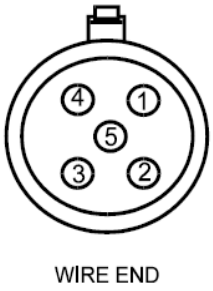


Figure A3