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Part must comply with VCC Restricted Substance Management Standard (RSMS) VCS 5036,5	

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DESIGN PREREQUISITES

FRONT LIGHTING 728B
SuperEcho
728B

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

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0 CHANGE LOG

ChangeLog summary

Document Revision	001	002
SystemWeaver version	2	3
SystemWeaver Id	x0400000005649511	x0400000005654843

	Same	New	Updated	Summary	Deleted
Number of requirements	270	+ 0	+ 2	= 272	(0)

0.1 New requirements

No new requirements.

0.2 Updated requirements

REQ-53561 v5 Configuration EOL
REQ-426373 v2 System Block Diagram – Supply

0.3 Unchanged requirements

REQ-163605 v2 Legal compliance for lighting components
REQ-148687 v1 2k Outer Lens
REQ-139428 v2 730 MFG AUXILIARY LAMPS PLUG & PLAY
REQ-3952 v3 730 MFG EXTRA LIGHT: NO ADJUSTMENT
REQ-7267 v3 730 MFG HEADLAMP ADJUSTING EQUIPMENT
REQ-23768 v4 730 MFG HEADLAMP ADJUSTMENT FEATURE IN LIGHT PICTURE
REQ-98263 v2 730 MFG HEADLAMP KINK SLOPE ANGLE
REQ-23766 v6 730 MFG HEADLAMP LIGHT PICTURE CUT-OFF QUALITY
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REQ-6206 v3 730 MFG MASKING OF HEADLAMP IN DARKROOM PROCESS
REQ-7269 v3 730 MFG TESTING OF DETACHED HEADLAMP
REQ-55647 v3 AEC - Q102 RV level
REQ-53657 v3 Aftermarket management
REQ-4989 v10 Ageing in Humidity Low Temperature, 38°C/95%RH
REQ-44417 v4 Ageing requirement for plastic electrical components
REQ-85925 v7 Allowed derating due to high temperatures, front lights
REQ-30325 v4 Attributes requirement headlamp
REQ-101107 v1 Bad Weather Light
REQ-61051 v3 Beam pattern horizontal cut off
REQ-199200 v3 Chemically recycled material certification need
REQ-60102 v6 China NCAP
REQ-30256 v6 China Type Approval
REQ-4987 v19 Climate Variation
REQ-33461 v3 Complete Vehicle tests
REQ-129367 v3 Component Condensation Test - Front Lighting
REQ-61108 v4 Conformity of Production Korea
REQ-25562 v11 CORCAR - Complete vehicle corrosion test
REQ-101111 v4 Cornering Illumination
REQ-61106 v5 Cut off position stability after digital aiming
REQ-61057 v4 Cut off position stability after reference run

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REQ-61056 v3	Cut off stability after tests
REQ-30624 v3	Cyclical dust test
REQ-430077 v1	DI ASIL A HW Exterior Front Light
REQ-198209 v1	Digital aiming resolution
REQ-426485 v1	Dimming table Delivery
REQ-31259 v4	Dividing lines on lens
REQ-33180 v2	Documentation
REQ-60035 v2	Double testing
REQ-30254 v5	ECE Type Approval
REQ-1043 v8	ELECTRIC MOTOR OVERLOADING AND STALLING EFFECT
REQ-30651 v3	Electrical feed at crash
REQ-456934 v1	ELP- Second source requirement for discrete components
REQ-8768 v6	ELP-Automotive grade qualification
REQ-595 v9	ELP-Conformal coating of printed circuit boards
REQ-596 v10	ELP-Connections in the electrical system
REQ-600 v6	ELP-Design requirement for wiring components
REQ-549 v7	ELP-Electric energy consumption requirement on component
REQ-686 v6	ELP-Electrical component - internal short circuit
REQ-687 v5	ELP-Electrical component - substrates and leadframes
REQ-31688 v4	ELP-Electrical component operational time
REQ-601 v7	ELP-Electrical component orientation
REQ-598 v7	ELP-Electrical components positioned under the wading line
REQ-602 v10	ELP-Endurance requirements for electrical components in complete vehicle
REQ-562 v13	ELP-Environmental conditions and testing for electrical and electronic equipment
REQ-603 v13	ELP-Fault propagation to class B and C functions
REQ-213158 v2	ELP-FMEA Guideline
REQ-118827 v1	ELP-Inrush current
REQ-697 v8	ELP-Insulation of live parts and structures
REQ-615 v8	ELP-Mean time between failure prediction on electronic components
REQ-613 v8	ELP-Overloading or stalling of electrical motors
REQ-124932 v1	ELP-PCB Water retention
REQ-57133 v2	ELP-Reliability requirements for capacitors
REQ-609 v6	ELP-Reliability requirements for power semiconductors
REQ-610 v8	ELP-Soldering requirements for electrical components
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REQ-104570 v5	EMC - CE3 Conducted current requirement, current probe
REQ-104571 v4	EMC - CI3 Conducted current requirement, BCI
REQ-367801 v2	EMC - CI7 Conducted current requirement, fallback mechanisms
REQ-104557 v5	EMC - Emission requirements introduction
REQ-104575 v3	EMC - ESD1 Handling tests requirement
REQ-104576 v3	EMC - ESD2 Handling tests (conditional) requirement
REQ-104577 v5	EMC - ESD3 Powered tests, direct discharges requirement
REQ-104578 v4	EMC - ESD4 Powered tests, indirect discharges requirement
REQ-104561 v3	EMC - ESD requirements introduction
REQ-104558 v3	EMC - Immunity requirements introduction
REQ-104556 v5	EMC - Introduction and applicability
REQ-104562 v4	EMC - RE1 Magnetic field requirement, close proximity
REQ-104563 v3	EMC - RE2 Magnetic field requirement, ALSE
REQ-104564 v3	EMC - RE3 Electric field requirement, ALSE, legal
REQ-104565 v4	EMC - RE4 Electric field requirement, ALSE, coexistence
REQ-104566 v3	EMC - RI1 Magnetic field immunity requirement
REQ-104567 v4	EMC - RI3 Electromagnetic field requirement, ALSE
REQ-104568 v3	EMC - RI4 Portable transmitters requirement

REQ-367805 v3	EMC - RI7 Electromagnetic field requirement, fallback mechanisms
REQ-104572 v5	EMC - TE1 Transient emission requirement
REQ-104573 v6	EMC - TI1 Transient immunity on Power lines requirement
REQ-104574 v3	EMC - TI2 Transient immunity on Signal lines requirement
REQ-417649 v1	EU Critical Raw Materials Act (CRMA) – Reporting Requirements for Permanent Magnets
REQ-40860 v3	Evaluation of appearance for exterior lights after test
REQ-30264 v2	Exterior lighting clearance to radiant heat sources
REQ-24091 v2	Exterior lightning - Corrosion: Design requirements of aluminium material
REQ-20666 v4	Exterior lightning - Corrosion: Exterior lightning
REQ-458884 v1	Exterior Lights Power Consumption 728B
REQ-33189 v5	FEM simulation fixation system
REQ-33188 v2	Flow simulations of injection moulded plastic parts
REQ-59723 v6	Forward visibility
REQ-101146 v1	Front Lamp Power Consumption
REQ-30648 v2	Functional Importance Classification of electrical functions
REQ-33158 v4	Functional safety standard ISO26262
REQ-30653 v4	Functional Status Classification
REQ-31280 v3	GDV (Allianz) Insurance Classificaion
REQ-94237 v6	General - Corrosion: Surface treatment of components and fasteners
REQ-13748 v2	General - Corrosion: Transportation
REQ-34300 v5	General Deliverables, Technical Input
REQ-4988 v10	General Testing and Appearance Evaluation
REQ-31241 v5	Guidelines for delivery of headlamp measurements (and IIHS calulation) to Volvo Cars
REQ-53654 v2	HCM interface condensation
REQ-53642 v1	HCM Left/Right detection
REQ-61107 v2	Headlamp aimability
REQ-58775 v6	Headlamp and bumper lamp hard coating requirements
REQ-34646 v2	Headlamp beam pattern evaluation
REQ-151189 v3	Headlamp fault
REQ-53653 v3	Headlamp HCM fastening
REQ-459250 v1	Headlamp performance
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REQ-53650 v2	Headlamp to HCM orientation
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REQ-97768 v1	Headlight HCM
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REQ-129429 v2	Headlight unit NVH - Component requirement
REQ-5300 v8	High pressure wash Exterior and Engine Compartment Components
REQ-34194 v3	IES Files – Supplier Data Delivery Guideline
REQ-34621 v2	IES files for Volvo, front, special pixel and HD
REQ-31239 v6	IIHS light performance
REQ-30258 v4	India type approval
REQ-105055 v1	Input for CFD Condensation Simulations at Volvo, Front and Rear Lamps
REQ-34186 v5	Input for Light Visualisations at Volvo
REQ-30259 v6	Installation tolerance requirement for light functions
REQ-404612 v2	Internal Airflow for Condensation Prevention
REQ-33243 v17	ISO 16750 Code Allocation
REQ-33154 v4	Joint Procedure for Headlamp Performance Approval
REQ-30261 v4	KMVSS self certification
REQ-53662 v2	LED brightness calibration
REQ-426381 v1	LED controller addressing
REQ-53672 v3	LED controller diagnostics
REQ-53674 v3	LED controller thermal management
REQ-53658 v2	LED diagnose
REQ-30635 v5	LED ELP requirement
REQ-30268 v4	Light leakage between functions

REQ-60034 v2	Light picture homogeneity
REQ-30650 v3	Limp Home
REQ-30652 v2	Long term loading
REQ-426375 v2	Low beam flat - safety level of light output
REQ-254457 v1	Low beam flat minimum light output
REQ-316658 v3	Marking on parts
REQ-5994 v7	MATERIAL QUALIFICATION; EXTERIOR TPE/TPV materials
REQ-458881 v1	Maximum headlamp weight
REQ-33161 v3	Maximum Illumination Loss For ASIL Classified Functions
REQ-53598 v2	Maximum stray light
REQ-33185 v5	Measuring
REQ-64209 v2	MFG 100% geometrical verification/documentation
REQ-5085 v3	MFG Assembly feedback
REQ-82044 v2	MFG el harness fixing method
REQ-3925 v7	MFG Error proofed assembly
REQ-3920 v3	MFG- fault detection for not connected electrical component
REQ-3932 v2	MFG guiding principle
REQ-3921 v5	MFG harness connection to component
REQ-86202 v1	MFG mating force electrical connector
REQ-3908 v5	MFG No added refinement on parts in Final Assembly
REQ-3915 v2	MFG No adding of glue on parts in the Final Assembly Shop
REQ-3916 v2	MFG No contamination on delivered parts in the Assembly Shop
REQ-3938 v3	MFG no function tests of delivery units allowed
REQ-3922 v2	MFG no tools for connecting el. connectors
REQ-3909 v2	MFG restriction assembly direction for rigid part
REQ-3939 v5	MFG restrictions for process equipment
REQ-3923 v3	MFG space for connecting connectors
REQ-3934 v2	MFG third hand solution
REQ-3935 v4	MFG tolerance calculation
REQ-58967 v7	Mission profile for different functions
REQ-195351 v3	Monitoring
REQ-33940 v5	Motorway light
REQ-31275 v3	Mounting and dismounting requirements
REQ-30255 v9	North American Self Certification
REQ-30339 v2	Number of DUTs for testing
REQ-33179 v2	Performance and follow-up
REQ-433038 v1	Photometric Maximum Measurement
REQ-59382 v5	Photometry documentation
REQ-33144 v2	Photometry requirements for Signalling functions, front
REQ-11096 v13	PQ APPEARANCE EXECUTION- 39 CAVITIES
REQ-11056 v16	PQ APPEARANCE EXECUTION - 01 SCREWS
REQ-11061 v13	PQ APPEARANCE EXECUTION - 04 ENGINEERING CLIPS & CLAMPS
REQ-11062 v15	PQ APPEARANCE EXECUTION - 05 CABLES & CONNECTORS
REQ-11070 v13	PQ APPEARANCE EXECUTION - 13 ADHESIVE DECALS
REQ-11073 v14	PQ APPEARANCE EXECUTION - 16 TEXT & PRINTS
REQ-11077 v12	PQ APPEARANCE EXECUTION - 20 CROSS-SECTION SURFACES
REQ-11078 v14	PQ APPEARANCE EXECUTION - 21 STRUCTURE & FEATURES
REQ-11080 v13	PQ APPEARANCE EXECUTION - 23 DEPRESSIONS & BULGES
REQ-11081 v14	PQ APPEARANCE EXECUTION - 24 PROCESS HOLES
REQ-11082 v13	PQ APPEARANCE EXECUTION - 25 RAW METALLIC SURFACES
REQ-11086 v11	PQ APPEARANCE EXECUTION - 29 SEALING EXECUTION
REQ-11089 v16	PQ APPEARANCE EXECUTION - 32 ADHESIVES
REQ-11091 v13	PQ APPEARANCE EXECUTION - 34 TOOL PARTING LINES
REQ-11092 v13	PQ APPEARANCE EXECUTION - 35 EJECTOR MARKS
REQ-11095 v12	PQ APPEARANCE EXECUTION - 38 HOLES
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REQ-10743 v6	PQ ILL ARCH Designed light behavior per component
REQ-13768 v5	PQ ILL ARCH Rampable lights resolution
REQ-425645 v2	PQ ILL Illuminated SML homogeneity
REQ-318947 v2	PQ ILL Syncronized LED ramping tolerance
REQ-20714 v4	PQ ILL SYS Color homogenity on distributed light
REQ-6621 v7	PQ ILL SYS Color Rendering capabilities of light
REQ-44824 v12	PQ ILL SYS Exterior colored light target 1.1
REQ-39923 v10	PQ ILL SYS Exterior white light target
REQ-20706 v10	PQ ILL SYS Glare & visual comfort
REQ-20713 v6	PQ ILL SYS Intensity homogenity on distributed light
REQ-44769 v11	PQ ILL SYS Light leakage
REQ-17289 v6	PQ ILL SYS Sequential light resolution
REQ-307918 v2	PQ ILL SYS Signature Lit Surface Intensity Homogeneity 1.2
REQ-395366 v3	PQ ILL SYS Volvo Word Mark lit appearance
REQ-6205 v14	PQ PF Paint Finish - Component Requirement
REQ-6299 v12	PQ PF Paint Systems for Painting Classes A, B and C - Component Requirement
REQ-6227 v8	PQ SF Substrate Finish Plastics
REQ-297392 v2	PQI Clean surface guideline
REQ-33184 v2	Process Input Variables
REQ-61054 v3	Relation between different beams
REQ-33178 v3	Reliability program
REQ-5320 v14	RESISTANCE TO CHEMICALS, EXTERIOR
REQ-6015 v5	RESISTANCE TO CHEMICALS, EXTERIOR LIGHTING
REQ-6014 v1	RESISTANCE TO FOGGING IN EXTERIOR LIGHTING DEVICES
REQ-5307 v18	Resistance to Heat Ageing
REQ-92817 v3	Resistance to Impact in Cold
REQ-5302 v9	Resistance to peak Temperature Exterior
REQ-5317 v9	RESISTANCE TO UV-LIGHT, EXTERIOR COMPONENTS
REQ-6631 v2	RESISTANCE TO UV-LIGHT, EXTERIOR LIGHTING COATINGS
REQ-55330 v3	Resulting forces on headlamp from hood overslam
REQ-55452 v3	Robustness requirement
REQ-139574 v5	Safety requirement - Headlamp Leveling failure
REQ-426380 v1	Sattelite module LED diagnose
REQ-426379 v1	Sattelite module LED thermal management
REQ-5993 v8	scratch resistance, exterior high gloss surfaces
REQ-53660 v4	Segments, switches, and MLCs
REQ-31283 v3	Spare parts
REQ-30649 v2	Special cases: Diagnostic sessions
REQ-415939 v1	Spectral Intensity Distribution files for Volvo, general
REQ-4957 v16	Sun Simulation Complete Vehicle
REQ-316686 v3	Supplier marking
REQ-50395 v6	Swivelling and levelling
REQ-426374 v1	System Block diagram with Bus Interface
REQ-310327 v1	Tactile stiffness front lamps
REQ-393864 v1	Tactile stiffness requirment generic part
REQ-30257 v4	Taiwan type approval
REQ-34413 v3	Text marking on parts
REQ-31281 v3	Thatcham Insurance Classification
REQ-53556 v2	Thermal design
REQ-33163 v3	Tooling preparation for trimming possibility
REQ-31323 v3	Tourist function
REQ-101109 v1	Town Light
REQ-316685 v5	VCS 5051,4 Parts marking with bar codes and 2-D symboligies

REQ-316660 v6	VCS 5051,17 Text marking on parts
REQ-30272 v4	Visibility of red and white light
5	VMR 0167 EXTERIOR LIGHTING VIBRATION ENDURANCE
3	VMR 0173 RESISTANCE TO IMPACT FOR FRONT LIGHTING DEVICES
3	VMR 0175 NON-HEADLAMP EXTERIOR LIGHTING DEVICE DEFLECTION RESISTANCE
3	VMR 0176 HEADLAMP DEFLECTION RESISTANCE
3	VMR 0177 EXTERIOR LIGHTING RESONANT FREQUENCY
3	VMR 0682 SQUEAK AND RATTLE AVOIDANCE
REQ-62923 v3	VOC Outgassing and Contamination Resistance
REQ-316657 v3	Volvo Cars Mandatory Standards
REQ-6012 v1	WARPAGE TEST, EXTERIOR LIGHTING
REQ-6910 v9	WATER TIGHTNESS CONDENSATION IN EXTERIOR LIGHTING
REQ-6911 v11	WATER TIGHTNESS IN EXTERIOR LIGHTING
REQ-53646 v3	Wiring for CAN
REQ-53647 v2	Wiring for stepper motors

0.4 Deleted requirements

No deleted requirements.

1 GENERAL INFORMATION

The Design Prerequisites (DPR) document is established by persons within VCC, at the product development organization. The purpose of the DPR is to serve as a base for creating design solutions and the issuance of engineering design documentation related to a product.

The Design Prerequisites (DPR) document constitutes part of the purchasing agreement between VCC and the Supplier when purchasing product development services.

The system and component design must fulfill the explicit requirements stated in this DPR. The design must also take into consideration the implicit requirements in this DPR (e.g. the environment, etc.). The Supplier must, without delay, notify VCC of any deviation from fulfillment of these requirements.

1.1 Purpose of this DPR

The purpose of this document is to describe prerequisites and requirements for development.

1.2 Revision history

Ver	Date	Author	Description
1	2026-02-26	PKLUSEK	DPR First Issue

1.3 Requisite documents

1.3.1 Volvo Cars documents

The Following VCS references are included in requirement from this Design Prerequisites DPR.

1.3.2 Document References

ISO/IEC and other international standards have to be retrieved by supplier
DPR/TR/SWRS documents are stored in TeamCenter document portal and will be transferred to supplier by VCC.

1.4 Customer needs/wants. Problem orientation

1.5 Terminology

1.5.1 Abbreviations

Abbr.	Stands for	Description
AFS	Adaptive Front-lighting System	The system that dynamically adjusts headlight beam direction and range based on steering input, vehicle speed, and road conditions to enhance night-time visibility and driving safety.
AHBC	Adaptive High Beam Control	Automatic control of high beam. Either turns high beam on or off or adapts the beam shape according to other vehicles.
BEV	Battery Electric Vehicle	Electric vehicle that uses a battery as main source of power.
DPR	Design Prerequisites	Design prerequisites, Konstruktionsförutsättningar, text-based document containing property and function descriptions, conceptual solutions, process requirements, etc. with the main purpose to serve as a base for the production of final engineering-design documentation. (according to VCS 5001,119).
ICE	Internal Combustion Engine	
N/A	Not Applicable	
VCC	Volvo Car Corporation	

1.5.2 Definitions

Definition	Description
corrosivity position	**Corrosivity positions** When exposing materials and components to the generic corrosion load in a chamber (cyclic climate procedure) the acceptance criteria must be adjusted to the expected local vehicle service environment of the tested object. If this corrosion load is not pre-formatted in the requirement conditions, *an assessment of the expected corrosivity in the component position has to be agreed between the test requestor and the subject matter expert on corrosion*. The component/assembly is then classified into either of four standard corrosivity positions: 1. Low corrosivity position: Used when the position is not affected by macro wetness, mud/ dirt, road (deicing) salts, or significant amounts of marine saline deposits air pollutants. The position may be affected by humidity, some dust and by anthropogenic (human) pollutants from touching and exhaling. (Most interior components in the passenger and luggage compartments are situated in this low corrosivity position. Clean areas in engine compartment "cold zone" and in closed or semi-closed plastic casings may also be included into this category.) 2. Medium corrosivity position: Used when the position is at most moderately affected by macro wetness, mud/ dirt, road (deicing) salts or by significant amounts of marine saline deposits air pollutants, or their combinations. (Examples of positions usually belonging to this category are the upper, rear area of the engine compartments, well protected underbody areas in the inner part of front floor and interior cavities of closures. 3. High corrosivity position,: Default for all exterior positions affected by road spray. Bottom of door cavities and lower and/or rear part of engine compartment belong to this category. 4. Very high corrosivity position: Seldom-rinsed positions accumulating salt and dirt, typically including wheel housings and their installation components, the wheel arch rims, underbody positions along the sill, behind the rear wheels and in the rear wheel suspension area, including adjacent body positions. NOTE 1: The corrosivity of a position can be dramatically reduced by correctly designed (plastic) protections.

Definition	Description
	NOTE 2: A corrosivity class does not correspond to a fixed time of testing in e.g. VCS 1027,1449. The test time is dependent on the type of corrosion aspect that is tested for.

1.5.3 Concepts

The requirement tag is generated from SystemWeaver, e.g. REQ-1931 and it is uniquely defined with an version e.g. REQ-1931v5

2 PRODUCT DESCRIPTION

The headlamp component provides front lighting functions, including:

- Position Light
- Day Running Light
- Direction Indicator
- Low Beam
- High Beam/ADB (Adaptive Driving Beam)
- Side Marker Light (SAE)
- Reflex reflector (SAE)
- Cornering (Static bending)

and other AFS functions.

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3 REQUIREMENT FOR PRODUCT REGULATIONS

Acc to PMGTC, Responsible business (section 21 as of 2022), each supplier shall comply with all applicable laws and regulations related to their delivery.

Responsible Design department will here inform in which countries and regions the parts and replacement parts are to be sold. See Supplier Portal for different type of suppliers and their obligations. For Build to Print suppliers, responsible Design department is responsible for communicating applicable laws and regulations.

Countries and regions
ECE
US / CDN
UK
China
India
Taiwan
Korea

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4 Front Lamps 728B



Figure: Details for Component Front Lamps 728B version (4).

Attributes:

Component ID: C-33367

Description

Below are the artefact requirements listed.

4.1 Component Requirements

4.1.1 Legal Requirements and Type Approval

REQ-163605 v2 Legal compliance for lighting components

The design must ensure that all current and known future demands for all countries to which VCC cars are sold, will be met.

Below is a list of the most commonly applicable legal demands per market. Please note that this list is for information purposes only!

Market	Type of demand	Title	Regulation
ECE	**General**	Replaceable Bulbs	ECE R 37
		Installation of lighting and light-signalling devices for vehicle	ECE R 48
	Component	Reflex reflectors	ECE R 3 / R150
		Rear registration plate lamps	ECE R 4 / R148
		Direction indicators	ECE R 6 / R148
		Stop lamp	ECE R 7/ R148
		Centre High Mounted Stop Lamp	ECE R 7/ R148
		Position lamps	ECE R 7/ R148
		Front fog lamp	ECE R 19/ R149
		Reversing lamp	ECE R 23/ R148
		Rear fog lamp	ECE R 38/ R148
		Daytime running lamps	ECE R 87/ R148
		Side marker lamps	ECE R 91/ R148
		Headlamp for asymmetrical passing beam or a driving beam or both and equipped with filament lamps and/or light emitting diod(LED) modules.	ECE R 112/ R149
		Cornering lamps	ECE R 119/ R149

		Adaptive Front lighting Systems (AFS)	ECE R 123/ R149
US / CDN	**General**	Federal Motor Vehicle Safety Standard	FMVSS 108
		NHTSA	PART 581 (low speed impact)
		Canadian Motor Vehicle Safety Standard	CMVSS 108
		Canadian Motor Vehicle Safety Standard	CMVSS 215 (low speed impact)
		SAE standards	
		Test Methods	SAE J575
		Plastic Material	SAE J576
		Colour specification	SAE J578
		LED	SAE J1889
	Component	Centre High Mounted Stop Lamp	SAE J186
		Position lamp	SAE J222
		Front fog lamp	SAE J583
		Stop lamp	SAE J586
		Rear registration plate lamps	SAE J587
		Side marker lamps	SAE J592
		Reversing lamp	SAE J593
		Reflex reflectors	SAE J594
		Front & Rear Direction indicator Lamps	SAE J588
		Front Cornering Lamps	SAE J852
		Side Direction Indicator Lamps	SAE J914
		Rear fog lamp	SAE J1319
		Daytime Running Lamps	SAE J2087
		Flammability of interior materials *Applies for Units assembled in or close to passenger compartment*	FMVSS 302 CMVSS 302
China	**General**	Prescription for installation of the external lighting and light-signalling devices for motor vehicles and their trailers	GB 4785
		Safety specifications for Power-driven vehicles operating on roads.	GB 7258
	Component	Headlamps	GB 4599
		Front fog lamp	GB 4660
		Front and Rear position lamps, end-outline marker lamps and stop lamps	GB 5920
		Rear fog lamps	GB 11554
		Retro Reflector	GB 11564
		Reversing lamps	GB 15235
		Direction indicators	GB 17509
		Side-marker lamps	GB 18099
		Rear registration plate lamp	GB 18408
		LED (No AFS)	GB 25991
		LED AFS	GB-T 30036
		Cornering Lamp	GB-T 30511
		Daytime Running Lamp	GB 23255
	Certification	Automotive Exterior Lighting and Light Signal Devices	CNCA-C11-07: 2014
		Retro Reflectors	CNCA-02C-056

Taiwan		Requirements equal those valid for ECE. The ECE test reports are used for Taiwanese certification. Please note that the ECE Test house must be approved by Taiwanese authorities.	See ECE.
India	**General**	Installation	AIS-008
	Component	AUTOMOTIVE INDUSTRY STANDARD Performance Requirements of Lighting and Light-Signalling Devices for Motor Vehicle having more than Three Wheels, Trailer and Semi-Trailer	AIS-012
		AUTOMOTIVE INDUSTRY STANDARD Performance requirements for retro-reflecting devices for power-driven vehicles and their trailers	AIS-057
		Headlamps	AIS-010
		AFS	AIS-127
Korea			KMVSS

REQ-30254 v5 ECE Type Approval

Requirement

Component supplier is responsible for all applications of component approval at the applicable authorities. The component supplier has the legal responsibility for applying for type approval. The component supplier shall apply for official approval in accordance with the appropriate ECE regulation.

Homologation report

- Copies of all official approval documents (electronic copy) shall be sent before the first production delivery (TT milestone) to the department at Volvo Cars that is responsible for the product.
- Volvo Cars will not accept production deliveries of components without approval marking.

Failure management

Volvo Cars and lamp supplier shall agree on failure management for each lighting / signaling function by ESOW3 sign-off with a final confirmation at FDJ. The failure management agreement shall include the following aspects:

- Lamp/function activations, including combined or partially combined function.
- Failure detection according to Volvo recommendations.

Low beam and high beam failure provision – Volvo recommendation

- ”Failure” feedback as soon as failure is detected, light shall be kept ON for all other LEDs in case of LED short circuit, LED open circuit, channel output short circuit, complete PCB in short circuit.
- If it is not possible to detect a LED failure (short circuit); the function shall be compliant with minimum legal requirements in all cases of short circuit (one or more LEDs in short circuit), or supplier shall guarantee that only open circuit will happen (with test results required in REQ-55647 and risk analysis of other risks such as cable hardness, IC, etc.).

Turn indicator – Volvo recommendation

- It is recommended to follow the N-1 requirement. If this not possible, a 2 light source system, keeping 50% of the flux in case of failure is accepted. 1 fail all fail strategy (1 light source concept) is not preferred.
- ”Failure” feedback as soon as failure is detected, maximum number of LEDs shall be kept ON.
- If it is not possible to detect a LED failure (short circuit); the function shall be compliant with minimum legal requirements in all cases of short circuit (one or more LEDs in short circuit), or supplier shall guarantee that only open circuit will happen (with test results required in REQ-55647 and risk analysis of other risks such as cable hardness, IC, etc.).

All other lighting and signaling functions – Volvo recommendation

- ”Failure” to be reported if below the minimum legal requirement (N-x, 1 fail all fail ..).
- ”Warning” only in case of N-x when above minimum legal requirement.
- It is recommended to fulfill the N-1 requirement (100% of minimum legal required flux, or 80% of minimum legal required flux for DRL) in case of open circuit and short circuit on the complete function (incl. both body and trunk lamps).

/!\ Above recommendations may be difficult to follow on front signature components when there is more than one channel. If it is not possible to follow, below is recommended by Volvo:

- “1 fail all fail” strategy in case of short circuit and open circuit failure.
- If it is not possible to detect LED in short circuit (only one or two in short circuit in a long row of 10 LEDs for example), the function shall be compliant with minimum legal requirement until the failure is possible to detect, or supplier shall guarantee that only open circuit will happen (with test results required in REQ-55647 and risk analysis of other risks such as cable hardness, IC, etc.).

REQ-30256 v6 China Type Approval

Requirement

Component supplier is responsible for all application of component approval at the applicable authorities. The component supplier has the legal responsibility for applying for type approval. The component supplier shall apply for official approval in accordance with the appropriate GB regulation.

Homologation report

- Copies of all official approval documents (electronic copy) shall be sent before the first production delivery (TT milestone) to the department at Volvo Cars that is responsible for the product.
- Volvo Cars will not accept production deliveries of components without CCC-marking.
- Supplier shall create a Cert code in VSIM for the homologation report.
- For vehicles produced in China: MIIT reports are required.
- For imported vehicles: CCC component test report and CCC certificate, or self declaration or voluntary certificate are required.

Authorized Test Center for Vehicle/Components Certification

No.	Abbreviation	Test Centre	MIIT-EIDC	CNCA (CCC)	MEP	BJEPA	Authorized No. of Compulsory Test report(MIIT format)	Comments
1	TATC (CATARC)	国家轿车质量监督检验中心 National car quality supervision and inspection center	√	√	√	√	QA**********	
2	CMVIC	国家机动车质量监督检验中心（重庆） National motor vehicle quality supervision and inspection center (Chongqing)	√	√	√	√	QD**********	
3	CATC	国家汽车质量监督检验中心（长春） National automobile quality supervision and inspection center	√	√	√	√	QB**********	
4	SMVIC	国家机动车产品质量监督检验中心 National motor vehicle product quality supervision and inspection center	√	√	√	√	QM**********	
5	NAST	国家汽车质量监督检验中心（襄阳） National automobile quality supervision and inspection center (xiangyang)	√	√	√	√	QC**********	
6	CVTRI	国家客车质量监督检验中心 National passenger vehicle quality supervision and inspection center	√	√	√	√	QE**********	

Failure management

Volvo Cars and lamp supplier shall agree on failure management for each lighting / signaling function by ESOW3 sign-off with a final confirmation at FDJ. The failure management agreement shall include the following aspects:

- Lamp/function activations, including combined or partially combined function.
- Failure detection according to Volvo recommendations.

Low beam and high beam failure provision – Volvo recommendation

- ”Failure” feedback as soon as failure is detected, light shall be kept ON for all other LEDs in case of LED short circuit, LED open circuit, channel output short circuit, complete PCB in short circuit.
- If it is not possible to detect a LED failure (short circuit); the function shall be compliant with minimum legal requirements in all cases of short circuit (one or more LEDs in short circuit), or supplier shall guarantee that only open circuit will happen (with test results required in REQ-55647 and risk analysis of other risks such as cable hardness, IC, etc.).

Turn indicator – Volvo recommendation

- It is recommended to follow the N-1 requirement. If this not possible, a 2 light source system, keeping 50% of the flux in case of failure is accepted. 1 fail all fail strategy (1 light source concept) is not preferred.
- ”Failure” feedback as soon as failure is detected, maximum number of LEDs shall be kept ON.
- If it is not possible to detect a LED failure (short circuit); the function shall be compliant with minimum legal requirements in all cases of short circuit (one or more LEDs in short circuit), or supplier shall guarantee that only open circuit will happen (with test results required in REQ-55647 and risk analysis of other risks such as cable hardness, IC, etc.).

All other lighting and signaling functions – Volvo recommendation

- ”Failure” to be reported if below the minimum legal requirement (N-x, 1 fail all fail ..).
- ”Warning” only in case of N-x when above minimum legal requirement.

- It is recommended to fulfill the N-1 requirement (100% of minimum legal required flux, or 80% of minimum legal required flux for DRL) in case of open circuit and short circuit on the complete function (incl. both body and trunk lamps).

/!\ Above recommendations may be difficult to follow on front signature components when there is more than one channel. If it is not possible to follow, below is recommended by Volvo:

- “1 fail all fail” strategy in case of short circuit and open circuit failure.
- If it is not possible to detect LED in short circuit (only one or two in short circuit in a long row of 10 LEDs for example), the function shall be compliant with minimum legal requirement until the failure is possible to detect, or supplier shall guarantee that only open circuit will happen (with test results required in REQ-55647 and risk analysis of other risks such as cable hardness, IC, etc.).

REQ-30257 v4 Taiwan type approval

Requirement

Component manufacturer is responsible for all application of component approval at the applicable authorities.

Supplier is responsible to arrange all relevant homologation activities with applicable authorities and send certificates/approval documents to Volvo Cars before production delivery (TT milestone).

The documents shall be sent (electronic copy) to the department at Volvo Cars that is responsible for the product.

NOTE: ECE R148-01 and R149-01 may not be accepted yet in Taiwan. Lamp supplier must check with Taiwan test house which legal requirement they have to fulfil. This evaluation has to be done at different steps during the project since it may change during the course of the program.

REQ-30258 v4 India type approval

Requirement

Component manufacturer is responsible for all application of component approval at the applicable authorities.

Supplier is responsible to arrange all relevant homologation activities with applicable authorities and send certificates/approval documents to Volvo Cars before production delivery (TT milestone).

The documents shall be sent (electronic copy) to the department at Volvo Cars that is responsible for the product.

NOTE: ECE R148-01 and R149-01 may not be accepted yet in India. Lamp supplier must check with Indian test house which legal requirement they have to fulfil. This evaluation has to be done at different steps during the project since it may change during the course of the program.

REQ-30255 v9 North American Self Certification

Requirement

Component supplier is responsible to provide proof that the requirements in the appropriate Federal Motor Vehicle

Safety Standard (FMVSS), Canadian Motor Vehicle Safety Standard (CMVSS) and/or applicable SAE standard have been met, tests at an accredited lab listed by NHTSA need to be conducted and approved.

The accredited lab that the component supplier intends to use shall be approved by Volvo Cars.

The component supplier shall send a copy of the test reports (separate reports referring to FMVSS and CMVSS, or SAE standard if applicable) from the laboratory to Volvo Cars before production delivery (TT milestone). The documents shall be sent (electronic copy) to the department at Volvo Cars that is responsible for the component.

Volvo Cars will not accept production deliveries of components without relevant marking.

Failure management

Volvo Cars and lamp supplier shall agree on failure management for each lighting / signaling function by ESOW3 sign-off with a final confirmation at FDJ. The failure management agreement shall include the following aspects:

- Lamp/function activations, including combined or partially combined function.
- Failure detection according to Volvo recommendations.

Low beam and high beam failure provision – Volvo recommendation

- One fail all fail strategy in case of LED failure. The switching off of all LEDs may occur at the end of the driving mission as defined by Volvo safety requirements.
- If it is not possible to detect a LED failure (short circuit): the function shall be compliant with minimum legal requirements in all cases of short circuit (one or more LEDs in short circuit), or supplier shall guarantee that only open circuit will happen (with test results required in REQ-55647 and risk analysis of other risks such as cable hardness, IC, etc.).

Turn indicator

- Tell-tale feedback as soon as there is a LED failure.
- If it is not possible to detect a LED failure (short circuit); the function shall be compliant with minimum legal requirements in all cases of short circuit (one or more LEDs in short circuit), or supplier shall guarantee that only open circuit will happen (with test results required in REQ-55647 and risk analysis of other risks such as cable hardness, IC, etc.).
- 1 fail all fail if the turn indicator is considered as a "1 lighted section lamp" (in case of open circuit).
- If the turn indicator is considered as a "multi section lamp", the maximum number of LEDs shall be kept ON and tell tale activated.

All other lighting and signaling functions

- It is recommended to fulfill the N-1 requirement (100% of minimum legal required flux required) in case of open circuit and short circuit on the complete function. In case of trunk lamp, it shall be considered as an auxiliary lamp.
- Tell-tale if the function is below the minimum legal requirement (N-x, 1 fail all fail).
- DTC shall be set only in case of N-x, when above the legal required flux.
- If one lighted section with multiple PCBs: 1 fail all fail is requested (1 light source requirement) and tell-tale shall be activated (for open circuit). In case of short circuit, failure detection shall be agreed between supplier and Volvo Cars (n-1 or tell-tale).
- Supplier shall provide the % of LED failure in open circuit and short circuit mode (with test results required in REQ-55647v1).

REQ-30261 v4 KMVSS self certification

Requirement

Component manufacturer is responsible to provide proof that the requirements in the appropriate KMVSS (Korean Motor Vehicle Safety Standard) article, test protocols and/or applicable KMVSS standard has been met. Tests at a third party test house need to be conducted and approved.

The component supplier shall provide copies of the KMVSS official test protocols including their relevant forms in accordance with the appropriate KMVSS regulation. These documents shall be sent before the first production delivery (TT milestone) to the department that is responsible for the product at Volvo Cars.

Volvo Cars will not accept production deliveries of components without relevant marking.

Supplier shall apply KC marking on visible areas of the headlamp (low beam, high beam) and rear retro-reflexes as requested by Korean authorities.

REQ-61108 v4 Conformity of Production Korea

Requirement:

All produced lighting devices that are sold on the Korean market must fulfill the legal values (CoP rule with margin +/- 20% apply, but at least one out of four samples shall meet the luminous intensity requirements).

For KMVSS self certification requirement, see REQ-30261.

The component supplier shall provide Volvo Cars with measurements proving that at least 25% of the parts fulfil 100% of the minimum requirement on a yearly basis.

In case measurements are requested by KATRI, the component supplier shall provide all needed information including an “operating box” to switch ON each function (if needed), to enable KATRI to do official photometric measurements.

REQ-30259 v6 Installation tolerance requirement for light functions

General
Due to the fact that the installation requirements are measured on the car, a tolerance must be added to the legal installation requirements regarding heights, in all countries.

Purpose
The installation has to be legal for all chassis heights.

Scope
All lamps.

Requirement
The car must be legal for all chassis heights, in all countries within tolerance ± 40 mm.
It also has to be checked that component installation rules are respected in all driving conditions including 4x4 mode.

Verification method
Engineering judgment.

REQ-30272 v4 Visibility of red and white light

General
Vehicles detected by both humans and automatic systems makes conclusions on the direction of a vehicle by the appearance of the lights. White light indicates a vehicle directed towards the viewer, red light the opposite.

Purpose
No unintended light should give rise to confusion.

Definition
The requirement is valid for all functions in front and rear lamps.

Requirement
No red light which could give rise to confusion shall be emitted from a lamp or reflex reflector in a forward direction and no white light which could give rise to confusion, other than from the reversing lamp shall be emitted from a lamp or reflex reflector in a rearward direction.

Requirement according to:

- The §5.10 of last series and the last supplement of Regulation UNECE R48 valid for this development.
- The last GB4785 requirement in §4.10.

Verification
To be verified by supplier virtually by CAD and if needed by Photometrical simulation before FDJ. To be verified by supplier physically through visual judgement in VP, TT and PP if needed.

Verification method

1. CAD verification (mandatory). Analysis result should explain definition of the apparent surface in order to check compliance with Annex connected to UNECE R48 (annex 4) and GB4785 (annex C).

2. Photometrical simulation (if needed).

3. Physical test by visual judgement (if needed).

4.1.2 General Requirements

4.1.2.1 Supplier Collaboration and Compliance Guidelines

The DPR defines what Volvo expects from the supplier. In the case other documents, e.g. commercial agreements, ESOW have been supplied by Volvo to the supplier together with this document or at some previous time and those commercial documents contains wording that contradict the requirements in this section, then those commercial documents take precedence over these requirements.

These requirements are only applicable if other agreements on the supplier's responsibility have not been reached. In case of ambiguous requirements or difficulties in interpreting the requirements the supplier is expected to without undue delay contact Volvo for a clarification.

4.1.2.1.1 Supplier deliverables, general

REQ-59382 v5 Photometry documentation

Purpose

To ensure that the photometric performance of the front lighting system is thoroughly documented and validated against both internal and legal requirements throughout the development and verification phases.

Scope

This requirement applies to the photometric documentation of low beam, high beam, AFS and AHBC functions for both left- and right-hand headlamps, and includes simulation, measurement, nominal setup, and variation analysis.

Requirements

a) Photometric documentation shall be created and presented at least 1 week prior to each defined milestones: TI2, TI3, TI4, FTI, UPV2 and 2 weeks prior to VP DWG (FDJ).

b) Photometric documentation shall provide guidance on required actions during early phases and prove compliance with all Volvo Cars' internal and legal photometric requirements by the FTI gate review.

c) Photometric documentation shall describe the optical concept used for low beam, high beam, AFS and AHBC.

d) Photometric documentation shall define a nominal arrangement of optical modules. Nominal arrangement shall give information about correct adjustment of Front-Lighting System to have matching configuration for photometric simulation, photometric measurements, and End-of-Line inspection.

e) Nominal arrangement shall represent position and orientation of each optic in reference to optical module, which forms kink element of cut-off profile. Optic projecting kink is set as master to adjust other optical modules producing portions of low- and high beam light distribution to its nominal arrangement, respectively.

f) The optical module set as master shall define the reference position for the adjustment of other optical modules, ensuring their alignment relationship to the master is maintained when the master is adjusted. Furthermore, the master allows the operator to adjust the headlamp in its designed position within the vehicle environment.

g) Each master module shall define one particular center of reference for each side. Center of reference coincides with projection of illuminating surface midpoint along axis of reference on outer lens. Vehicle three-dimensional reference system determines X, Y and Z coordinates of center of reference.

h) Photometric documentation shall represent nominal arrangement of left- and right-hand side headlamps separately.

i) Photometric documentation shall include IES files light distributions generated by simulation and, when applicable, by measurements. The required type of data (simulation or measurement) and its delivery timing shall be agreed according to project gates.

j) Light distributions shall follow REQ-31241 Guidelines for delivery of headlamp measurements (and IIHS calculation) to Volvo Cars.

k) Supplier shall present to Volvo 1 week prior to FTI and 2 weeks prior to VP DWG (FDJ) the detailed analysis of the factors that could make variation of the photometry from the nominal arrangement, with the impact of Isolux and flux. Volvo may request IES files at its discretion.

l) The analysis shall include, but is not limited to, the following factors:

- Digital adjustment range
- Leveling Dynamic range
- LED position tolerance in relation to focal length of optical system
- LED BIN (flux, forward voltage)

REQ-33154 v4 Joint Procedure for Headlamp Performance Approval

Purpose

To define and safeguard the minimum photometric performance of the front lighting prototype, ensuring its optimization and validation through collaboration between Volvo Cars and the supplier.

Scope

This requirement applies to the specification, optimization, and validation of low and high beam performance for lighting prototypes and test samples produced using production tools.

Requirements

a) A specification which is jointly defined by Volvo Cars and the supplier for the low and high beam shall be set up to serve as the minimum performance requirement and guarantee the performance of the lighting prototype prior to prototype production kick-off. Any performance exceeding these requirements is acceptable and does not constitute non-compliance.

b) The performance of the lighting prototype shall be optimized through joint effort between the supplier and Volvo Cars. Two optimization cycles are expected.

c) The performance of the optimized lighting prototype shall serve as the benchmark requirement for the light test samples from production tools.

d) The performance of the light test samples shall be further optimized in coordination between the supplier and Volvo Cars prior to the delivery of initial samples.

e) Following the delivery and evaluation of the initial samples, the front lighting component shall be subject to approval by Volvo Cars.

REQ-34300 v5 General Deliverables, Technical Input

Background:
"TI" milestones mark the time when "Technical Input" is needed regarding the latest design/styling input at the preceding "DSM" milestone (DSM= Digital Shape Model).
"FTI" = Final Technical Input, usually after DSM5.

Requirements:
- Technical Input and status reports must be provided to Volvo Cars at least at every TI / FTI milestone but also upon request (WIP (Work in Progress), AA1, AA2 etc.) for being able to secure aligned progresses and results.

- The following content is at least expected:

1. **Time plan - Complete**
   - Based on Volvo Cars VPP time plan & Technical Logic Base Plan (Provided by Volvo Cars) supplier needs to show how to reach (example, all Volvo Cars milestone needs to be fulfilled):
     - TI & DSM milestones
     - Toolmaker sourcing and TOB (Toolmaker On Board)
     - FDJ
     - Timing for Tool Orders to meet VP MRD & VP build (Parts within tolerances measured in VCC MSA approved gauges)
     - PPAP0+
     - TT build
     - PPAP1
     - PP build
     - PPAP2/3
     - PSW
     - SOP

2. **Time plan - Electronic Hardware development (El-HW)**

- How to meet E-series, EIDB, PCB development loops, breadboards, VP/TT/PP builds, series PCB supplier sourcing etc.
- HW joint review (HWJR) by checklist, ISO 26262

3. **Time plan - Software development (SW)**
   - How to meet E-series, EIDB, SWJR, SSJR, breadboards, VP/TT/PP builds etc.
   - SW joint review (SWJR) by checklist, ISO 26262

4. **Time plan - Styling Prototype (incl. electronics)**

5. **Time plan - Detailed DV & PV-testing plan**
   - Which requirement will be tested in DV-testing & which requirement in PV-testing. Planned start & finish date needed.

6. **Development work & technical solutions based on latest (design) input**

7. **3D CAD data based on design models/input**
   - Including interior and exterior surfaces; CAD data shall be sent to Volvo Cars every second week; CATIA V5 compatible data shall be provided; including injection points, split lines, slider directions

8. **From TI2 and onwards: Input to visualizations according to REQ-34186**

9. **Packaging studies and technical input on styling questions**

10. **Photometric validation: Legal, performance, homogeneity, light leakage**

11. **Thermal predictions on design feasibility**

12. **Cost analysis after each release is required**

13. **Bill of Material**
    - One list for all variants (e.g. low and high spec, ECE, SAE etc), incl. complete material spec (detailed commercial name), weight, dimensions, picture, surface treatment (mention production method and material for metallization), amount and type of recyclate material used; state if it is a "standard part", "carry over part" or "new part".

14. **Tooling list**
    - Specify for tooling:
      - Toolmaker sourcing plan (to meet FDJ tooling input and kick-off and VP build according to DCP)
      - Manufacturing country and number of cavities for each part
      - Process information
      - Tool produced in-house or purchased
      - Dimensions of part in main tooling direction (cube)

    - Specify for PCBs:
      - Dimension and rough geometry, technology, class, thickness, Cu-thickness
      - Number of PCBs/panel, colour, number and type of LEDs/PCB incl. binning classes, single/double sided mounting, SMT/THT, other processes, production country

    - Specify for electrical harnesses:
      - Detailed information regarding connectors, Pin OUT proposal, wires, manufacturing country

15. **Bill of electronics for all PCBs (incl. components on PCB)**
    - For PCBs: Dimensions, colour, technology, number and type of LEDs.

16. **Electrical interface design proposals**

17. **Schematics of electrical components/harness on complete lamp level and interface towards dedicated ECU and vehicle**

4.1.2.1.2 Supplier deliverables: Input for visualisations and simulations

REQ-105055 v1 Input for CFD Condensation Simulations at Volvo, Front and Rear Lamps

General
For the customer to perform internal CFD calculations regarding condensation simulations specific information is needed for calculation and potential improvement work.

Purpose
The purpose of this requirement is to enable an effective work process for CFD condensation simulations.

Definition
The requirement is valid for lamps with encapsulated volumes.

Requirement
Information required:

1. Maximum inlet pressure flow through vents.
2. Recommended alternative ventilation positions.
3. Fan information:
    a. Maximum fan speed
    b. Minimum fan speed
    c. Fan performance curve
    d. Rotation direction
4. Recommended alternative fan position with regards to ventilation position.
5. Statement regarding purpose of fan position. Is fan position optimized for cooling of electronics or for deicing//defogging.
6. Specification of varnish/coating on lens.
7. Heat emitting
8. Specified Heat flux surfaces (3D model) density (Watt/m^2) for heat emitting surfaces
9. Specification for thickness and weight of lens, housing and internal components
10. Temperatures on LEDs, PCBs, bezels, heat sinks and other heat generating parts in the headlamp at winter and summer conditions

REQ-34186 v5 Input for Light Visualisations at Volvo

Background

Volvo Car collaborates with exterior illumination suppliers using virtual prototyping. This iterative approach enables early identification and resolution of visible issues, supporting high product quality while minimizing investment in physical prototypes. Virtual simulations are conducted using Ansys SPEOS or equivalent tools, and suppliers are expected to deliver validated and complete data to support both the Exterior Lighting, and Perceived Quality (PQ) departments.

Purpose

To ensure reliable and efficient virtual prototyping, suppliers must provide accurate and complete input data for all exterior lighting components. This enables early detection of perceived quality issues, verification of styling intent, and supports simulation accuracy across both functional and visual domains.

Scope

This requirement applies to all exterior lighting and signaling functions delivered by suppliers for virtual simulation using Ansys SPEOS or equivalent tools. It includes:

- Standard CAD data deliveries
- SPEOS Light Box component deliveries
- Material and surface treatment documentation
- Light source specifications
- Rayfile usage (if applicable)
- Submission timing and content for both the Exterior Lighting and PQ departments

Instructions and Required Deliverables

a) Submission timing

- All required data shall be delivered at least 1 week prior to each defined milestones: TI2, TI3, TI4, FTI, UPV2 and 2 weeks prior to VP DWG (FDJ).
- Additional deliveries may be requested for intermediate visualization or simulation loops where both the supplier and Volvo cars are allowed to initiate the need for additional simulation loops to ultimately solve critical issues.

b) SPEOS Light box delivery (if applicable)

- If SPEOS Light Box components are used, they shall replace all or part of the CAD, material, and surface treatment data.
- The supplier shall ensure that all included CAD geometry, material definitions, and surface treatments are accurate and complete.
- Light source data shall still be delivered separately.
- The delivery shall include:
    - All Light Box files with clear documentation of their contents.
    - CAD geometry and light source information.
    - A separate presentation detailing the inputs, CAD materials, and surface treatments applied to the Light Box component.

c) Standard CAD delivery

- CAD data shall be clearly identified for the applicable variant (e.g., base, option, ECE, SAE).
- Transparent components shall be free from geometric clashes, including tangent surfaces between clear and opaque materials in multi-material designs.
- All optical elements and surfaces for lighting and signaling functions shall be included, such as reflectors, light guides, lenses, and micro-optics.
- Fixation and clipping systems shall be represented.
- Surface details indicating grain and surface treatment areas shall be included.

- LED light sources shall be modeled with defined light-emitting surfaces, placed correctly in the optical system, and linked to the light source description.
- Tooling and process-related features such as tooling radius, injection points, tool split lines, and ejector marks shall be represented in the CAD model between DSM5 and FDJ deliveries.

d) Material information

- A separate document shall be provided describing all materials used in the components.
- Each material shall be specified by type and grade (e.g., PC, PMMA, PBT-GF30).
- Material color codes shall be included for all components.
- Applicable for materials that are not yet included in Volvo Cars simulation library:

  Physical sample plaques (minimum 2×2 cm, flat surface) shall be provided, showing the intended grain, material, and surface treatment.

  These samples shall be used for BRDF/BSDF characterization to support simulation accuracy.

e) Surface treatment information

- Surface treatments shall be described in a separate document or combined with the material description.
- Graining shall be clearly specified either in the CAD model or documentation, using standardized references (e.g., VDI or MT codes).
- Paint, print, and metallized surfaces shall be defined as separately selectable surfaces by CAD geometry.
- Applicable to surface treatments that are not yet included in Volvo Cars simulation library:

  Sample plaques shall be provided, or BRDF/BSDF files shall be submitted.

  If applicable, data describing refractive index, absorption characteristics across the visible spectrum, and scattering behavior (e.g., Gaussian, Lambertian, specular mix) shall be included.

f) Light source information

- A separate light source description document shall be provided for each delivery.
- Each LED shall be specified by manufacturer and type code.
- Luminous flux values shall be defined for all light sources and functions included in the simulation.
- Applicable for light sources that are not yet included in Volvo Cars simulation library:

  Datasheets shall be provided for any LED types not previously known to Volvo Cars, including color BIN-specific spectral distribution data.

g) Rayfile usage (if applicable)

- Rayfiles may only be used in exceptional cases and must be approved via the ESOW/DPR Compliancy Matrix. If rayfiles are used:
- They shall be included in the delivery package.
- Spectral information shall be correctly represented.
- The axis system used to generate the rayfile shall be included and correctly positioned in the CAD model.
- LED flux values shall be either embedded in the rayfile or documented separately.

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

Background

To enable a realistic assessment of light distribution on the road and to support early performance evaluations. Therefore, Volvo Cars conducts its own independent visualizations, not limited to any specific supplier or project, in addition to those provided by the supplier.

Purpose

To ensure accurate and consistent photometric data is available for all lighting functions throughout the project, supporting both internal and supplier-led visualizations.

Scope

This requirement applies to all exterior lighting functions requiring photometric IES files for visualization and simulation purposes during all relevant project phases.

Requirements

a) Photometric IES files shall be provided 1 week prior to each defined milestones: TI2, TI3, TI4, FTI, UPV2 and 2 weeks prior to VP DWG (FDJ) for all lighting functions.

b) IES files must comply with IESNA:LM-63-2002 or IESNA:LM-63-1995 standards.

c) Minimum angular resolution: 0.01 degrees.

d) Vertical Field of View: -90° to +90°.

e) Horizontal Field of View: -90° to +90°.

f) Separate IES files are required for each module and function.

g) IES files shall be generated considering all sub-components that may influence the light output, including bezel, outer lens etc.

h) For matrix/pixel-based systems:

   Separate IES files for each pixel at 100% intensity, measured with the same grid.

i) For HD modules:

   Field of view, resolution, and intensity requirements for individual controllable pixel IES files to be agreed upon based on program content.

j) The minimum number of rays shall be jointly specified by Volvo Cars and the supplier, and documented before the start of the relevant development or verification activities.

REQ-415939 v1 Spectral Intensity Distribution files for Volvo, general

Purpose

To define the requirements for providing spectrally resolved luminous intensity distribution data for each lighting module and function, ensuring timely and accurate data delivery to support project milestones and validation activities.

Scope

This requirement applies to the provision of spectrally resolved intensity distribution data for all modules, module functions, and controllable light sources throughout the development process, from early project stages through to final design and validation milestones.

Requirement

a) Spectrally resolved intensity distribution data shall be provided for each module, each module function, and/or each controllable light source.

b) The data shall be supplied at early project stages and at every Technical Input (TI) milestone (beginning with DSM2 → TI 2) up to and including FDJ, as well as for AA1 and AA2.

c) If simulation loops are necessary between or after milestones, the relevant data shall be provided upon request.

d) The data shall include spectral photometric intensity for each angular direction of emitted light, as observed from the module position along its optical axis, in degrees. Angular directions shall be sampled from -90° to 90°, both horizontally and vertically, at 0.01-degree increments.

e) The data shall include spectral photometric intensity for six wavelengths, evenly spaced between 390 nm and 652 nm.

f) The specified sampling parameters are generic and may be adjusted if requested by Volvo Cars or mutually agreed upon with the supplier.

g) The data shall be delivered in a non-encoded file format or another proprietary format as agreed upon with Volvo Cars.

REQ-34621 v2 IES files for Volvo, front, special pixel and HD

Background:
Addition to REQ-34194

Requirements:
Matrix/ pixel modules:
Separate ies-files for each pixel at 100% intensity. All pixels should be measured with the same grid.

HD:
Ies-file for HD-module with all pixels at maximum intensity. Resolution should be at least 0.01 degrees.

REQ-31241 v5 Guidelines for delivery of headlamp measurements (and IIHS calulation) to Volvo Cars

Scanning of beam pattern

Minimum measurement window

Horisontal: +/-50deg

Vertical: +/-15deg

File type: .ies

Resolution: Minimum 0,1 deg within H +/-10deg V+/- 5deg. Minimum 0,2 deg outside H +/-10deg V+/- 5deg.

Purpose of the resolution is to have high accuracy in the area which is important for IIHS simulation and cut off gradient assessment.

Multiple chambers

If the headlamp has multiple reflectors or other units that together form the total beam pattern, these beam patterns shall be measured separately. Typically this would be the case for Kink, flat, HBwide, HBspot. The position and aim of multiple reflectors shall be stated. Se example:

Cavity	Height	Spacing	Aim LB	Heading	Declared as optical center	Aim en HB

Kink	0.913	1.58	0	DBL ON	X	+1.14 en HB
Flat	0.836	1.5	+0.16	-		+1.30 en HB
HB	0.899	1.308	0	-		

IIHS demerit calculation

IIHS demerit calculation in early phases should normally be performed at the minimum flux level the supplier can guarantee during running production, unless otherwise agreed with Volvo Cars. It shall be stated which level of flux is used for the calculation. For example “Calculation is made at Emax=75lux, representing 75% of the nominal 100lux”

However, if a set of headlamps to be used for rating test on a vehicle is measured, it is expected that supplier make the IIHS demerit calculation on the actual measured flux and not on the minimum flux level.

If the bending angles are known and used for demerits calculation, they shall also be stated. See example:

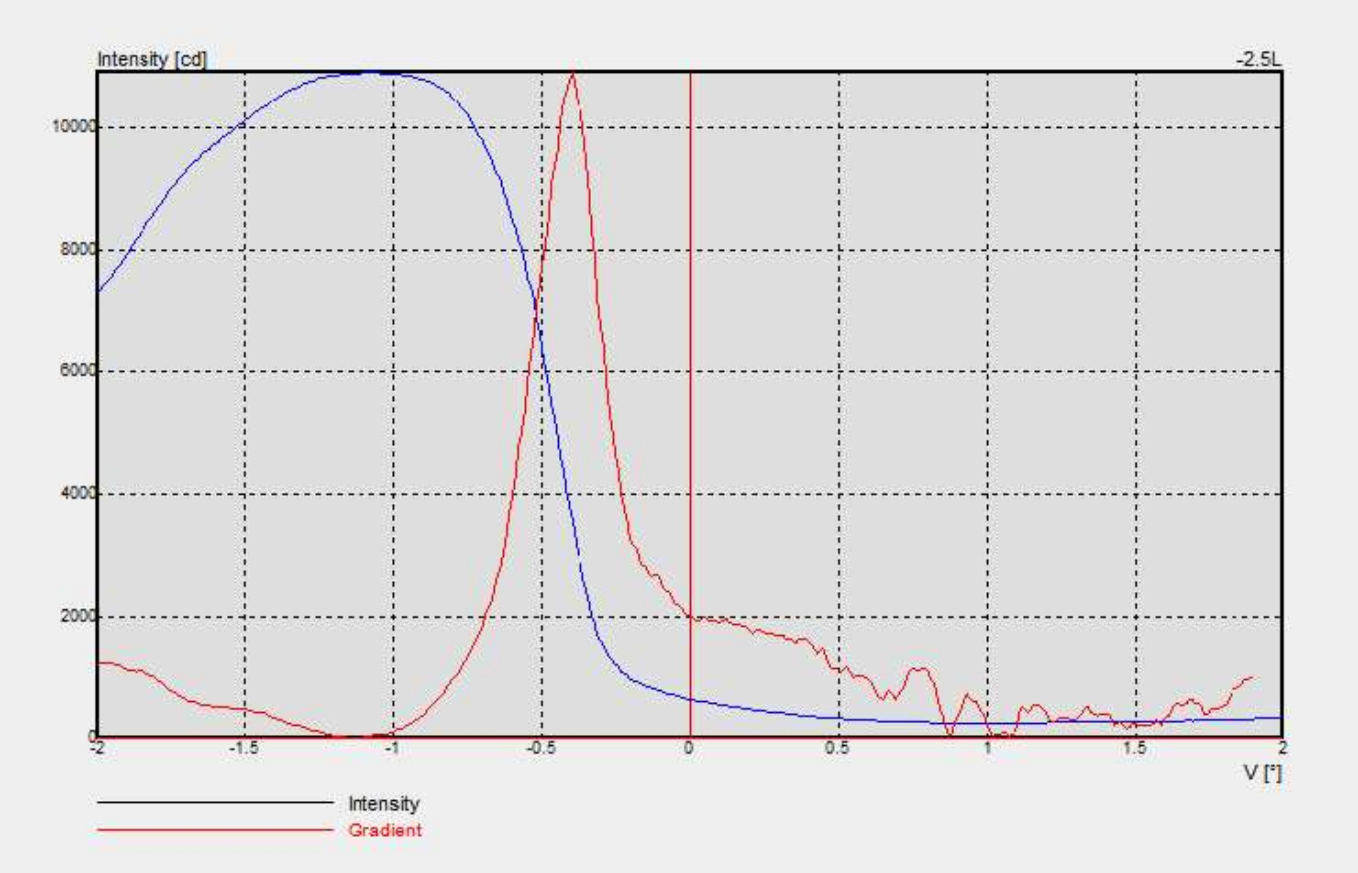
		Straight	250R	250L	150R	150L
Angles	Right HL	0	2.9	-2.2	5.9	-3.9

Suppliers IIHS demerit calculation shall include glare as percentage of maxlimit for 5-10m range and as percentage of maxlimit for glare exposure for longer distances than 10m. See example:

Beam (HB/LB)	Scenario	Visibility Left edge	Visibility Right edge	Glare within 10m	Glare exposure	Visibility demerits	Vis. demerits with HBA (if equipped)	Glare demerits	Total demerits	Total demerits with HBA
Offsets (horizontal, vertical):		-0,20	0,00							
High beams	150L	75,10	81,70	N/A	N/A	0,00	0,00	N/A	0,00	0,00
High beams	250L	88,90	88,50	N/A	N/A	0,00	0,00	N/A	0,00	0,00
High beams	150R	71,00	65,20	N/A	N/A	0,24	0,24	N/A	0,24	0,24
High beams	250R	81,10	75,10	N/A	N/A	0,25	0,25	N/A	0,25	0,25
High beams	Straight	164,00	163,00	N/A	N/A	0,00 0,00	0,00 0,00	N/A	0,00	0,00
Low beams	150L	74,60	59,20	-0,57	-0,39	0,12	0,08	0,00	0,12	0,08
Low beams	250L	75,00	51,30	-0,63	-0,46	2,81	1,87	0,00	2,81	1,87
Low beams	150R	68,70	63,80	-0,72	-0,75	0,00	0,00	0,00	0,00	0,00
Low beams	250R	70,10	69,20	-0,71	-0,67	0,12	0,08	0,00	0,12	0,08
Low beams	Straight	55,60	77,50	-0,67	-0,52	1,98 6,75	1,32 4,50	0,00	8,73	5,82
						12,26	8,34	0,00	12,26	8,34

Cut off gradient measurement

Should normally be performed at 2.5L for VOL and 2R for VOR SAE market. Maximum gradient and gradient curve shall be measured. To get a representative curve it is important to use a high resolution. Typically 0,01deg. (when we study gradient curve in the ies files we use the existing 0,1deg resolution. But when making a separate measurement of gradient we want to make it as accurate as possible. Therefore a higher resolution than 0,1deg is required) A graph similar to below example shall be provided. The purpose is to have intensity and gradient value in the same graph. Preferably the axis shall have tick marks for every 500cd and every 0,1deg. The graph shall be made at 2.5L (VOL) or 2R (VOR) for the beam intended for aiming of the low beam.



4.1.2.1.3 General Testing and Validation Procedures

REQ-30325 v4 Attributes requirement headlamp

The supplier is responsible to set up a test specification, complete test cycle and plan the tests for the product. This shall be done in co-operation with VCC testing and design department. The specification shall be preliminary at Sourcing Agreement, SA, and approved by VCC design department at Commercial Program Agreement, CPA (or as agreed in time plan).

The exterior lighting shall function under the following climate conditions:

Headlamps

Working temperature	-40°C to +105°C
Storage temperature	-40°C to +85°C
Relative humidity	up to 100 %

General test conditions

If nothing else has been prescribed, the test should be carried out under the following conditions:

Ambient temperature	+ 23°C± 2°C

Pressure	80 kPa - 106 kPa
Relative humidity	45% ± 15%
Electric connections	13,0V ± 0.2 V

For stated temperature and humidity, following tolerances are valid:

Tolerance for temperature:	0-100°C	±1°C
	>100°C	±2°C
Tolerance for humidity:	0-50%	±2%
	>50%	±5%

The component shall be visually inspected, fully tested and then all internal parts analysed. For all versions, a function test shall also consist of an ocular inspection and a check to ensure that all electrical and mechanical requirements are met. A functional check shall be done before, during and after test (reference: REQ-30653 Functional Status Classification) containing levelling system and all lighting functions. After the tests, solder joints shall show no deformation. Furthermore, no mechanical deformation, no internal damage are allowed and colour, gloss and surface structure shall be in accordance with the master specimen. No visible change is accepted. After the tests, no red corrosion on external metallic parts, including galvanic corrosion and fretting corrosion is allowed. Ear human evaluation of any unusual noise: comparison between new and tested lamp.

REQ-33461 v3 Complete Vehicle tests

All components are required to fulfill complete vehicle tests.

REQ-60035 v2 Double testing

Supplier can propose to remove double testing between "Reliability Requirements, Testing" chapter and ISO-16750 testing by including respective assessments into the ISO testing sequence. Test plan and conditions to be planned and agreed with VCC representative in project.

REQ-30339 v2 Number of DUTs for testing

Background
The number of devices under test (DUTs), for each requirement test, is determined by the experience from earlier tests and from calculations, if not stated in the requirement itself. The specific number of DUTs is defined through collaboration between Volvo Car Corporation and the supplier with the purpose of finding the quantity needed for reliable testing.

Scope
Exterior lights.

Purpose
Defining the amount of DUTs to be used if not stated elsewhere.

Requirement
If nothing else is stated, each part number must be tested minimum one time, i.e. minimum 1 DUT per part number.

Verification method

To be presented in the DV and PV plan.

REQ-195351 v3 Monitoring

Background

The Volvo Cars supplement (31822854) to ISO 16750 defines the requirement for monitoring the lamps during the tests included in the aforementioned documents. The supplement is a generic document. As the supplement is applied to lamps, the monitoring chapter needs a complementary requirement (Volvo Cars supplement (31822854), ISO 16750-1, 7.2 Monitoring).

The light intensity value of illuminated lamps has to be monitored as detection of light intensity variations can't be guaranteed with current monitoring. This way a derating or a short circuit could be detected that otherwise would have gone undetected with current monitoring.

Scope

Rear lamps and front lamps.

Purpose

The purpose of this requirement is to find non-intended light intensity variations during tests.

Requirement

The light intensity value of illuminated lamps has to be monitored with light intensity monitoring devices for all tests included in the DPR, also including the ISO 16750 testing that requires illuminated lamps.

4.1.2.1.4 Quality Assurance

REQ-33163 v3 Tooling preparation for trimming possibility

The target is to have all components on the car nominal. This is however not always possible. To enable trimming of components to fit with other, non nominal, components to achieve a good fit and finish on the complete vehicle level, the supplier must present and include tooling preparation for trimming in the initial bid. This means that fixing and reference points shall be possible to modify.

REQ-33185 v5 Measuring

General

Parts shall be positioned in Car Position in measurement fixture / gauge.
Measurement points are to be evaluated normal to surface (perpendicular to surface) unless otherwise specified.
Measurement system is to be qualified by MSA (Gauge R&R), using one of below described methods:

AIAG Capability study and Gauge R&R requirements , 4th edition methods;

ANOVA Preferred *
X-bar Range Acceptable.*
Range method NOT Acceptable.
Note: * 10 parts / 3 op / 3 measurements per part is preferred (and 5 parts / 2 op / 3 measurements is bottom line acceptable, to be agreed with VCC

Acceptance level - GR&R % of total Tolerance:
< 10% = Accepted
10 -30 % = Conditional - Requires customer approval
>30 % = Rejected - Requires supplier improvements

Note:
The GR&R % of the total variation should ideally be well below 10%
Number of Distinct Categories (NDC) >5
GR&R study should be done in all the MP points. If supplier wants to run GR&R study with reduced points customer approval is required.
If other important points beside the MP drawing is to be measured then a GRR study should be performed. according to agreement between Supplier and Volvo Car R&D.

In case of question or customer approval please contact Volvo Car Site SQM.

Measuring performance

VCC requirement is to have all parts delivered to any pre-series build or running production to be 100% inside specification. For TT-delivery parts from R@R fulfilling PPAP Ph0+ is required.

It is expected that supplier perform tuning of tools, processes and equipment continuously during development phase in order to reach PPAP Ph0+ in time. All modifications of tools need to be communicated and agreed with VCC, after approved R@R also all process changed need to be approved by VCC according to the SRICA process.

Measuring report, DMIS

All points included in Draw-Dime document, or defined measurement points in Draw-Prod / 3D-PMI documents / models shall be reported according to Dimensional Control Plan (DCP).

Measuring results shall be sent to VCC in the form of DMIS-files in accordance with Dimensional Control Plan (DCP). These files are fed in to VCC statistical software where all data are stored and available to VCC employees. If any discrepancies occur when evaluating Cmk/Cpk/Ppk between VCC and supplier, VCC calculations are the base.

See Specification of DMIS-OUT files. VCC STD 5036,9.

Control fixtures

Measurement fixtures design shall follow VCC STD 5919,1.
The fixture/gauge design must be approved by VCC prior to start of manufacturing of fixture/gauge.
Prior to first of tool parts are available, measurement fixture/gauge shall be available and preferably qualified with Gauge R&R/ MSA.

REQ-33189 v5 FEM simulation fixation system

General
Thermal expansion might have a damaging effect on lamps due to tensions that occur when the material gets heated or cooled. The extremes of the tolerances together with the extremes of the temperature are crucial to test with the fixations to determine the feasibility of the fixation system.

Purpose
To secure that no overload is forced into the lamp that can cause warping that results in cracks from tensions.

Definition

The requirement is valid for headlamp-, rear lamp- and CHMSL systems.

Requirement
FEM simulation shall be carried out and approved.

Verification
Conducted by the supplier during UPV2.

Verification method
The simulation shall be carried out with body (reference points and supporting attachments) and headlamp/rear lamp/CHMSL (reference points and supporting attachments) in all tolerance areas (worst case) +50% and in temperature intervals -40/+23/+85°C.

REQ-34413 v3 Text marking on parts

Labels and Text marking of parts/delivery/variant units have to be compliant with Volvo mandatory standard VCS 5051,17.

REQ-33184 v2 Process Input Variables

Setting of parameters

An established method of setting the parameters shall be used, documented and reported to VCC. Design of experiment evaluation technique shall be used, including a factorial test (see § 2.4) with all applicable parameters. The parameters may be chosen from the Process-FMEA. The outcome of the test will give information how to adjust the parameters and get details within tolerances. The test result establishes "the process window".

Applicable parameters (typical)

- Pressure used in the injection moulding machine
- Temp at the melted polymer in the injection moulding machine
- Temp in the mould

REQ-33188 v2 Flow simulations of injection moulded plastic parts

To be able to secure early verification of injection moulded plastic parts we require flow simulations of those parts. Which parts that shall be included shall be decided by the cross-functional team in "Analysis and Verification Needs (AVB)" for the system (also included in "generic AVB"). Presentations of the simulations are divided in at least four different stages.

1. First Design Review together with the supplier. {Design review 1 or equal}
   In this stage the styling models vary a lot, this makes detailed simulations difficult. However, simple simulations can give fruitful indications (feasibility confirmation). The input to first design review can be based on a) Simple simulations or b) Earlier simulations or experience of similar components. It is important to discuss number of gates. Their locations should be identified to enable identification of possible problem areas. If there is a lack of knowledge from earlier experience of similar parts or configurations, a simple simulation should be performed. This shall be part of the technical input to VCC regarding different styling releases.

   If new technical solutions are used or new potential problem areas can be suspected, a simplified simulation shall be performed. The responsible person for simulations shall be appointed and take active part in technical discussions.

This stage will result in a report to VCC regarding number of gates, rough indications of gating locations, effect from holes, possible problem areas and hard points to styling etc. A report of this kind shall include a plan for further simulations in the project. Guidelines to secure a large processing window for the part shall be included.

2. Design review 2 (Before Gate 1)
A simulation based on NUFO models shall be performed for technical input. The surfaces and gating positions are critical. Very soon there will be too late to do any changes. When important changes are presented by styling, it should be followed by simplified simulations.

   The report at Design Review 2 shall include results from (simple) simulations and calculations. Proof for a large processing window for the part must be presented.

3. Design review 3 (Before Gate 2)
In this stage there shall be detailed mould filling simulations. This stage shall end with release of technical documentation to the tool-maker.

   The intentions with the simulations are to decide type of gates, dimensions and number of gates as well as define processing parameters (see Appendix 4). An important result is to verify the intended processing parameters to secure a processing window large enough to permit adjustments when running in the tool, etc.

   The target is to prove, on a numerical, simulation level that the part is OK regarding all attributes and properties, such as surface properties, warpage, dimensions etc. (see Appendix 4).

   A final report for the development stage shall be presented in Design Review 3.

4. Series 3.x and following
The purpose of this stage is to get feed-back from the real injection moulding to the simulations that were carried out prior to Design Review 3.

   The processing parameters used in the real injection moulding shall be compared to the ones used in the simulations. The quality status of the first-shot material shall be considered in the presentation.

   The feed-back shall be provided latest two weeks after delivery of first-shot material.

   After this, the simulations from Design Review 3 should be base for introduction of QOP.

   Feed-back from the final result in the injection moulding process compared to the simulations in Design Review 3 shall be provided after start of production.

4.1.2.1.4.1 FMEA, Reliability program

REQ-33178 v3 Reliability program

Background

A program ensuring proper reliability will be worked out and agreed upon between VCC and the supplier.

Scope

Front and rear lamps.

Requirement

This program should include the following:

a) Making use of customer feedback

VCC takes account of the type of faults and problems, which are experienced by our customers in the field. Our aim is to prevent these faults in new and modified systems/components.

b) Design-FMEA on system level is performed jointly by VCC and the supplier (if the supplier is responsible for the entire system).

Based upon the results of the FMEA, a plan of action will be developed. The aim of this plan is to eliminate weaknesses in the system.

This plan of action will be developed jointly by VCC and the supplier.

See related document in ESOW: ESOW – Failure Mode Avoidance (FMA)

c) Design-FMEA on component level performed by the supplier in close co-operation with VCC. Based upon the results of the FMEA, a plan of action will be developed. The aim of this plan is to eliminate weaknesses in the system.

This plan of action will be developed jointly by VCC and the supplier.

d) Production process-FMEA performed by the supplier in close co-operation with VCC.

Based upon the results of the FMEA, a plan of action will be developed. The aim of this plan is to eliminate weaknesses in the system.

This plan of action will be developed jointly by VCC and the supplier.

e) Logistic-FMEA performed by the supplier in close co-operation with VCC. This FMEA covers the supplier's responsibilities with regard to handling, storage, packaging and transportation.

Based upon the results of the FMEA, a plan of action will be developed. The aim of this plan is to eliminate weaknesses in the system.

This plan of action will be developed jointly by VCC and the supplier.

f) System FMEA performed by the supplier in close co-operation with VCC. This FMEA is the basis for a system and identifies potential system failure modes.

Based upon the results of the FMEA, a plan of action will be developed. The aim of this plan is to eliminate weaknesses in the system.

This plan of action will be developed jointly by VCC and the supplier.

See related document in ESOW: ESOW – Failure Mode Avoidance (FMA)

g) Clash analysis of internal components in lamp shall be made to secure that no conflicts, wear of harness or electrical shortcuts can occur.

REQ-33179 v2 Performance and follow-up

The before mentioned program must be carried out. Since the FMEA will be a living document and will reflect the current design/process situation, it will be continuously updated during the product development process. Thus each

FMEA will be assigned a follow-up date which time the FMEA will be updated and new solutions will be evaluated against the plan of action specified in the FMEA.

Changes to all points agreed upon in the plan of action will be made immediately. This means that all weaknesses are to be repaired well before the start of production and that the changes must be approved/verified by both VCC and the supplier.

REQ-33180 v2 Documentation

FMEA analyses, in which plans of action have been decided upon, must be documented and made available to both VCC and the supplier.

There may be cases where it is necessary to deviate from this. However, an unequivocal requirement is that a documented FMEA summary with plan of action must be issued to VCC.

4.1.2.2 Mandatory Standards

REQ-316657 v3 Volvo Cars Mandatory Standards

All Volvo Cars Mandatory Standards have to be followed. The supplier needs to make sure to follow these standards for all final products and documentation.

Volvo Cars Mandatory Standards can be found and downloaded from Volvo Cars Supplier Portal, in section Supplying to Volvo Cars → Engineering Standards → Mandatory Standards

4.1.2.3 Marking Requirements

REQ-316658 v3 Marking on parts

Applicable Requirements on text, symbols and colour-marking according to Volvo Cars standards.

All parts that are technically possible to mark shall be marked in accordance with VCS 5051,17. Reduced marking is allowed but must contain one of the Volvo, SPACMA or Polestar logotypes if technically possible and available space exists.

Exceptions are vehicle glass, tubes, hoses, profiles, etc., which should be marked in accordance with VCS 5052,219 and 5052,319.

REQ-316660 v6 VCS 5051,17 Text marking on parts

Our marking standard VCS 5051,17 includes different marking ingredients/content (trademarks and markings without trademarks, reduced marking, etc.). In addition, there are several marking methods. Therefore, the DPR must be specific about these items.

Text marking requirements on headlamps shall be expressed as a code.
If the DPR covers several parts or systems, a marking code must be given for each part covered.

The marking requirements on the headlamps are found in section **VCS 5051,17 Text marking on parts** of this DPR.

For more details regarding text marking on parts see section 2 in VCS 5051,17.

REQ-316685 v5 VCS 5051,4 Parts marking with bar codes and 2-D symboligies

Marking with bar codes and 2-D symbologies (Datamatrix/DMC) is required on parts subject to traceability requirements, see VCS 5032,3.

Parts marking with bar codes and 2-D symboligies requirements on the headlamps shall be expressed as codes.

The bar codes and 2-D symboligies requirements on the headlamps can be found in section **VCS 5051,4 Parts marking with bar codes and 2-D symboligies** of this DPR.

For more details regarding bar codes and 2-D symboligies see section 2 in VCS 5051,4.

REQ-316686 v3 Supplier marking

The general rule is that a manufacturer's/supplier's trademark/logotype, or any other information, shall not be placed on Volvo-branded parts. Exceptions can be made but require approval by the Volvo Cars Brand Protection department, see section 2.1 in VCS 5051,17. All primary documents such as drawings, TREGs, etc., shall be checked for markings and are rejected if supplier information without valid approval is found.

4.1.3 Function Requirements

4.1.3.1 Levelling and swivelling general

REQ-50395 v6 Swivelling and levelling

Information:
Swiveling (also known as Bending light, or Active Bending Light, ABL) shall provide enhanced illumination in curves by moving light left and right. Levelling compensates for the pitch angle of the car by moving light up and down. Signals for performing these functionalities are sent by the CEM/BLPC and HCM.

Digital adjustment compensates for cars assembly/geometrical tolerances.

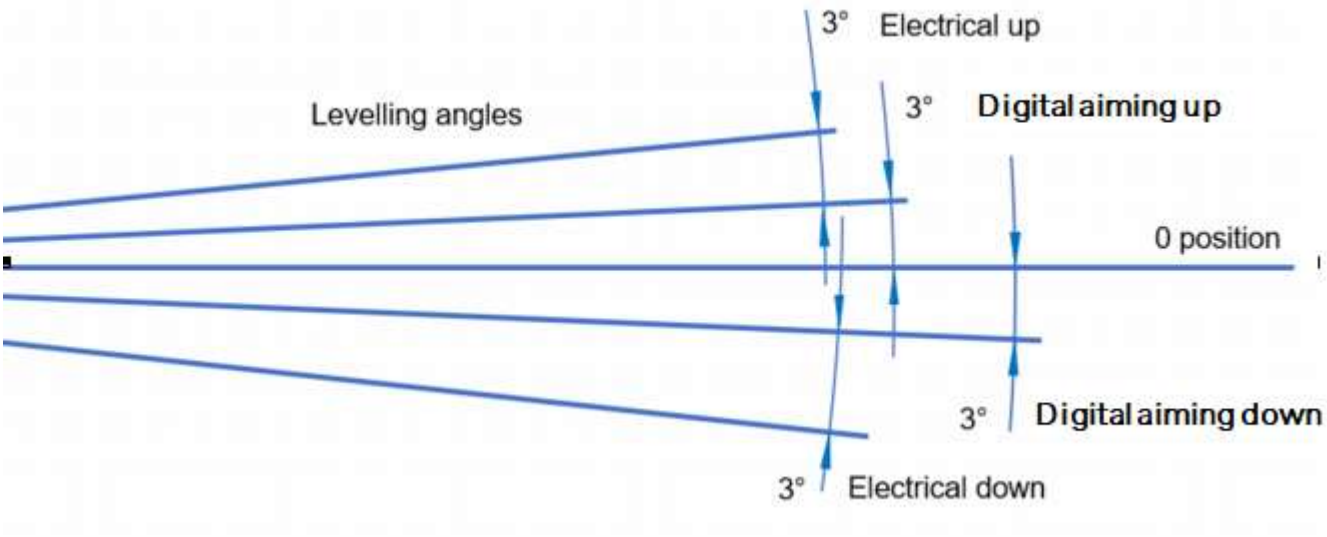
Definition
The requirement is valid for both low beam and high beam.

Requirement:
At least the following **swiveling, levelling** and **digital adjustment angles** need to be kept free in the headlamp for mechanical movement. The light cones need to be clear of bezels in manual adjustment zone range. In dynamic range, simulations need to be reviewed before approval.

The bending behavior shall be perceived as controlled, with constant and smooth acceleration without jerks, and soft retardation in end positions. In case of bending light created by switching light segments on and off, the light segment intensity shall be dimmed up and down to make the sequence look smooth.

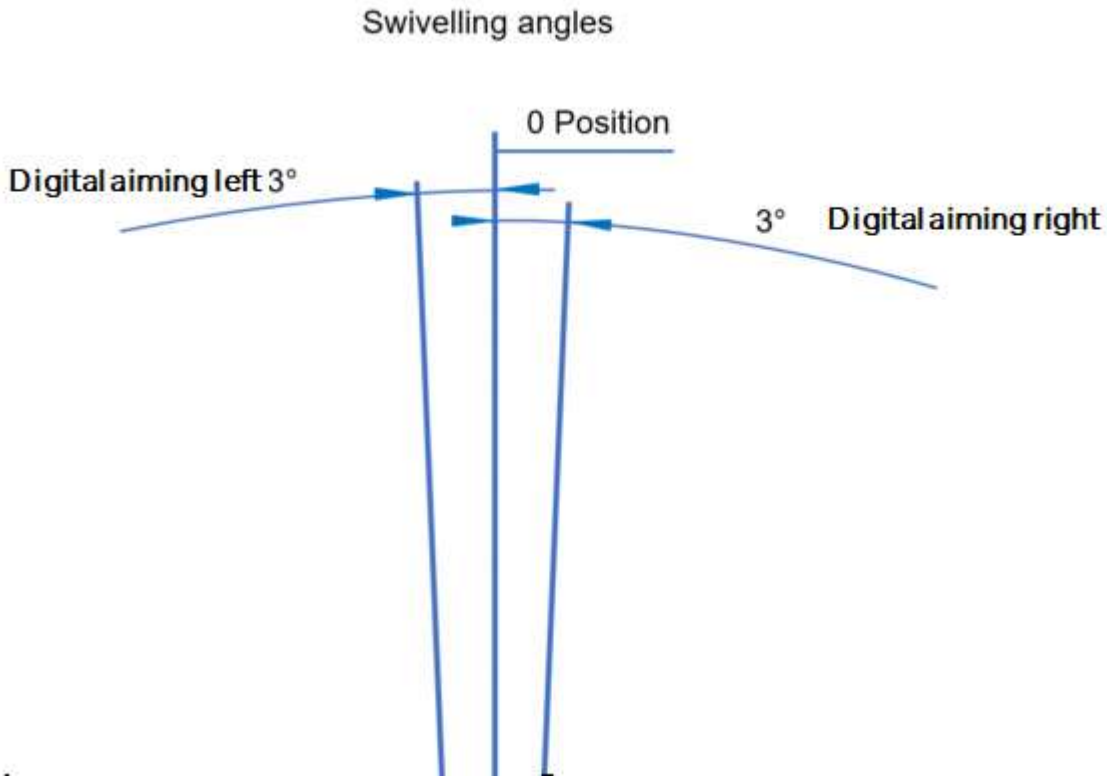
Levelling angles:

Digital aiming Up Including supplier tolerances	3°
Digital aiming Down Including supplier tolerances	3°
Electrical Up For load, acceleration and breaking and AHBC2/3	3°
Electrical Down For load, acceleration and breaking and AHBC2/3	3°



Swivelling angles:

Digital aiming left Including supplier tolerances	3°
Digital aiming right Including supplier tolerances	3°



The angles should be stated on the assembly drawing.

Verification:
Before FDJ - review of simulations in 4 corners.
In DV and PV, 1 DUT set (L and R) of each headlamp variant that has a difference in the mechanics

Headlamp mounted as in car and with low beam on 10m wall.

Mechanics in the lamp has to be able to reach all extreme positions. Controlled by measuring the LB movement on the wall, documented with pictures.
Manual, dynamic and manual+dynamic.

4.1.3.2 Tourist function

REQ-31323 v3 Tourist function

For or all LED headlamps: Low beam light pattern shall be tourist compliant when driving from a left-hand traffic to a right-hand traffic country and vice versa. If the technology permits, the light pattern shall be mirrored to provide optimal visiblity for respective markets.

Tourist regulation shall be respected for all AFS classes.

If needed, there shall be means to adapt the beam pattern to stay complaint. If it is not possible to conform (e.g. Motorway Light), supplier shall inform Volvo Car Corporation in order to implement correct measures when tourist mode is activated.

Markets were tourist solution is not applicable are: USA, Canada and may not be used for Japan.

4.1.3.3 Motorway light

REQ-33940 v5 Motorway light

Motorway light is an AFS passing beam pattern, class E.

Reference:
Europe:
- R48

China:
- GB4785-2019, §5.22.7.4.3
- GBT30036

Purpose
To improve visibility for the driver when driving on motorway, by raising passing beam level.

Requirement
- For markets with ECE/CCC regulation Motorway light shall be used.
- For markets with SAE regulation Motorway light shall not be used.

Realization
Motorway light shall realize by raising passing beam level and if necessary, adapt beam shape, see table below.

Table: Motorway light realization

Passing beam level adjustment [degrees]	Beam shape adaptation according to dimming table
+0,3	To be Agreed in Development

4.1.3.4 Bad Weather Light

REQ-101107 v1 Bad Weather Light

Purpose:

-Improve visibility in bad weather like fog and snow by better illumination of the roadside close to the car and the area just below the cutoff.

-Improve visibility in bad weather like fog and snow by reducing light that is reflected by the snow/fog back towards the driver.

-Reduce road surface glare towards oncoming vehicle.

Definition:

Bad weather light is expected to be realized with lighting units already existing in the lamp for country light/HB/Corner lights etc. No unique lighting unit for bad weather light.

BWL shall only be available in option lamp.

BWL shall not be available in SAE version.

Shall meet legal requirements (ECE+CCC) for Class C.

Shall be activated by the driver with a separate button

Typically, BWL can be realized with the normal low beam Class C together with the corner light dimmed to [50%]. Ideally the corner light shall be installed in the same carrier frame as LB to avoid aiming differences.

If the main lighting units are variable, for example with pixel or HD technology, the beam pattern shall be adopted in order to reduce road surface glare towards oncoming vehicles. Typically, this can be done by reducing light in:

a) segment 10 and below.

b) segment 20 and below.

If the main lighting units are variable, for example with pixel or HD technology, the beam pattern shall be adopted in order to increase visibility just below the cutoff. Typically, this can be done by increasing light in:

c) Point Emax

d) Point 75R

e) Point 50V

f) Point 50L

If the main lighting units are variable, for example with pixel or HD technology, the beam pattern shall also be adopted in order to reduce light that is reflected by the snow/fog back towards the driver. Typically, this can be done by reducing light in the “sign light” area.

The development of BWL shall follow REQ-33154v1 Procedure for joint work between suppliers and Volvo Car Corporation in establishing approved headlamp performance and REQ-59382v1 Photometry documentation.

Requirement:

BWL Point 2.5D 80L shall have minimum 560cd

BWL Segment 10 shall be lower than LB Segment 10

BWL Segment 20 shall be lower than LB Segment 20

BWL Point Emax shall be higher than LB Point Emax

BWL Point 75R shall be higher than LB Point 75R

BWL Point 50V shall be higher than LB Point 50V

BWL Point 50L shall be higher than LB Point 50L

BWL S50+S50LL+S50RR shall be lower than LB S50+S50LL+S50RR

BWL S100+S100LL+S100RR shall be lower than LB S100+S100LL+S100RR

Verification:

To be verified by supplier on simulated beampatterns when photometry documentation is presented according to REQ-59382v1 and verified on measured beampatterns from light prototype and initial samples.

4.1.3.5 Town Light

REQ-101109 v1 Town Light

Purpose:

-Reduce discomfort glare.

-Increase LB width to better illuminate sidewalks and crossings.

-Reduce power consumption.

Definition:

Town light is expected to be realized with lighting units already existing in the lamp for country light/HB/Corner lights etc. No unique lighting unit for Town Light.

Town Light for base lamp.

Shall meet legal requirements (ECE+CCC) for Class V and fulfill one or more of the purposes with town light. Town Light shall not be available in SAE version.

Typically, this can be done by reducing/dimming kink and thereby reducing glare and power consumption.

Width of beam pattern shall be maintained also when power consumption is reduced.

Town Light for option lamp.

Shall meet legal requirements (ECE+CCC) for town light and fulfill all or most of the purposes with town light. Town Light shall not be available in SAE version.

Typically, this can be done by reducing/dimming kink and thereby reducing glare and power consumption. Beam width can be increased by using corner lights dimmed to [50%] as part of the town light beam pattern. Power consumption shall not be higher than country light even if dimmed corner lights are used to increase beam pattern width. Balancing power between light sources used for town light may be used to reach power consumption target.

The development of Town Light shall follow REQ-33154v1 Procedure for joint work between suppliers and Volvo Car Corporation in establishing approved headlamp performance and REQ-59382v1 Photometry documentation.

Requirement:

Town Light Point 2.5D 80L shall have minimum 560cd

Verification:

To be verified by supplier on simulated beampatterns when photometry documentation is presented according to REQ-59382v1 and verified on measured beampatterns from light prototype and initial samples.

4.1.3.6 Cornering Light

REQ-101111 v4 Cornering Illumination

Purpose:

-To improve side visibility in sharp curves, crossings and parking areas.

Definition:

Cornering Illumination is expected to be realized inside the headlamp either with a separate lighting unit or included in the LB/HB unit.
Cornering Illumination shall extend the low beam pattern out to +/-80deg and 5lux at 15m. The boundary between LB and Cornering Illumination shall be well integrated to show no visible inhomogeneity. The outside edge of the beampattern shall have a gradual fade out without distractions. The Cornering Illumination itself shall show no visible inhomogeneity.
If Cornering Illumination is provided by a separate lighting unit it shall be located on the same carrier frame as LB in order to prevent visible aiming differences or steps between CL and LB cut off.

Typically, Cornering Illumination shall have 150-200lm.

Cornering Illumination shall be able to do a linear ramp up and ramp down to enable activation/deactivation without distraction. To be defined between supplier and Volvo Cars Corporation if CEM can supply PWM.

Requirement:

Cornering Illumination Point 2.5D 80L shall have minimum 1125cd.
Cornering Illumination minimum flux 150lm.

Verification:

To be verified by supplier on simulated beampatterns when photometry documentation is presented according to REQ-59382v1 and verified on measured beampatterns from light prototype and initial samples.

4.1.3.7 Functional Safety

REQ-33158 v4 Functional safety standard ISO26262

The functional safety standard ISO 26262 is valid for all components.

REQ-33161 v3 Maximum Illumination Loss For ASIL Classified Functions

For all ASIL classified function, realized by the front lamps, no more than 50% deration/loss in illumination is acceptable.
Necessary values shall be configured in the parameter file for the HCM.
For all ASIL classified functions realized by the rear lamps, a warning value shall be sent when deration results in a loss of 50% light output or more.

REQ-139574 v5 Safety requirement - Headlamp Leveling failure

ASIL: A
Purpose: To avoid that aiming on both headlamps goes to an unsafe position while vehicle is moving, due to internal failure in headlamp module or signal failure.

The headlamp module shall ensure that both level actuators follow requested angle.

Monitoring component(s) shall make end check(s) on input signal(s) and actuator status. In the event of failure, the following safe strategy applies:

- If the actuator is below defined safe position, its position is unknown, or it is unable to move, fault detection shall happen and the actuator shall freeze in its current position within 1500 ms.

- If the actuator is above defined safe position, fault detection shall happen and the actuator shall go to defined safe position within 1500 ms.

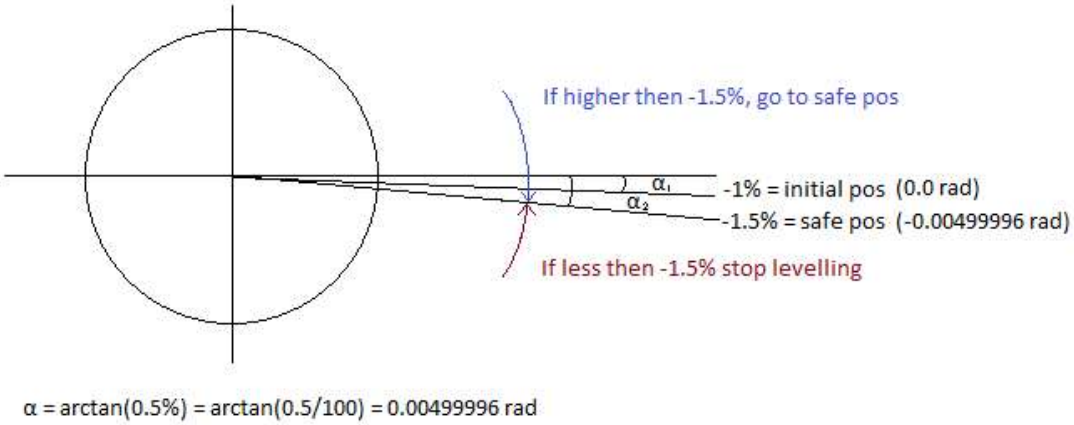


Figure: Illustration of safe state concept. Safe position: -0.005 rad.

REQ-151189 v3 Headlamp fault

ASIL: B

Purpose: To ensure that the headlamp hardware do not cause any systematic failure that lead to both passing beams being deactivated.

Safe State: Passing Beam on.

A headlamp fault shall not cause both left and right passing beam to turn off.

Safe state: Passing beam on.
FHTI: N/A

REQ-430077 v1 DI ASIL A HW Exterior Front Light

ASIL: A

Light Exterior Front hardware that provide Direction Indication functionality shall comply with ASIL A requirements according to ISO 26262. The hardware shall be designed to support ASIL A.

REQ-254457 v1 Low beam flat minimum light output

ASIL: Not Applicable

Scope:

Headlamp.

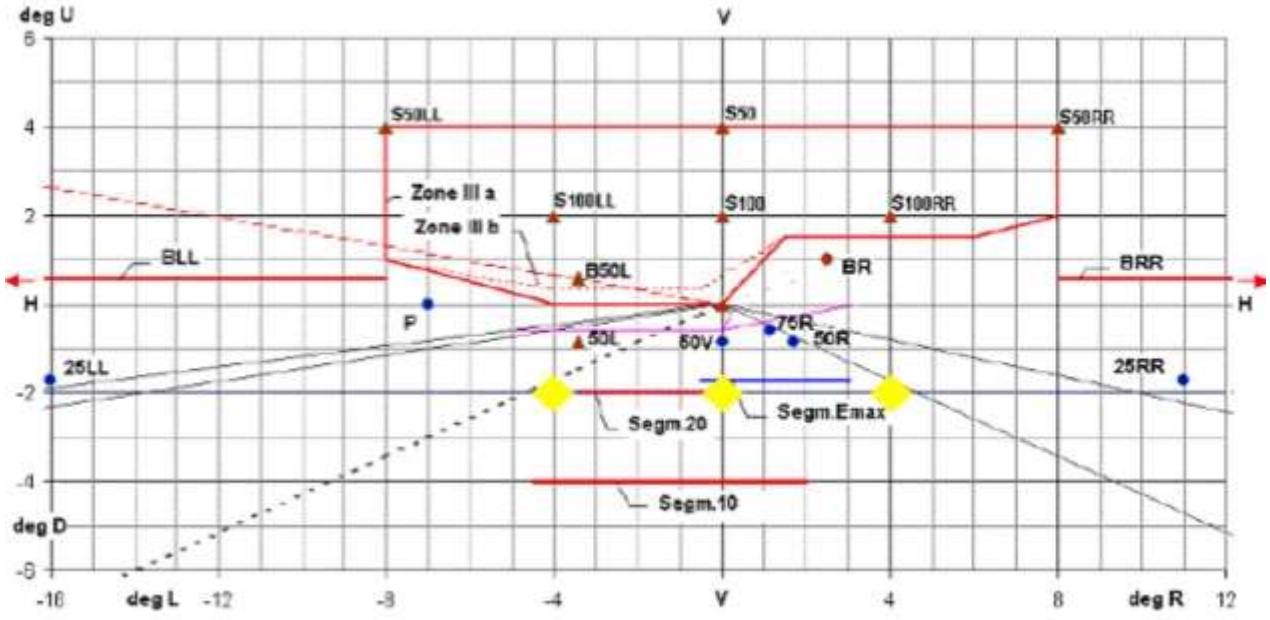
Purpose:

In case of Headlamp Control Module hardware or software failure, providing enough light on the road for driver to reach a safe stop or to a workshop.

Requirement:

Minimum 3000 cd at the points marked yellow on R123 Table below (H-4, V-2 / H 0, V-2 / H 4, V-2) and shall be fulfilled by channel 1 (Low Beam Flat) with all other light outputs Off.

Requirement is valid for single lamp at nominal aiming. Minimum current to fulfill the requirement should be defined by headlamp supplier.



Headlamp supplier shall ensure to configure Headlamp Control Module SWP2 parameter LB_Flat_MinPwr to corresponding level, defined as percentage of nominal current.

Verification:

Review of light simulations and .ies files during development.
Physical verification during Pre-Series builds.

REQ-426375 v2 Low beam flat - safety level of light output

ASIL: B
Purpose: To ensure that low beam flat provides a safe light output.

IF the bypass switch is defective, THEN the LED configuration for channel 1 (low beam flat) SHALL ensure the lowest safe light output intensity meets defined level as stated in requirement "Low beam flat minimum light output".

4.1.4 Product Attribute Requirements

4.1.4.1 Active safety - supervised Drive

4.1.4.1.1 AS Rating and Grading

4.1.4.1.1.1 IIHS

REQ-31239 v6 IIHS light performance

Info

Result of IIHS light rating is very sensitive to correct light adjustment. The process at Volvo Cars factories for adjusting the light on a car has a certain tolerance which is agreed for each project between Manufacturing Engineering and R&D and then communicated to suppliers, but general starting point is +-0,2% vertical and +-0,4% horizontal cut-off shift.

Another light adjustment related influencer is the position of mechanical adjustment system in the lamp. For example, if the car chassis tolerances and lamp attachment point tolerances together result in a 2 degree deviation of the lamp position compared to the ground plane, and then this deviation is compensated with the mechanical adjustment system, the light cones most likely hit the styling bezels and hence reduce performance or generate glare. In order to commit to this requirement, supplier needs to analyse and run simulations based on the latest available styling data.

When demerits are calculated it shall be taken into account that the vehicle will have a small inclination, roll, in curves. Roll= rotation around vehicle x-axis. Roll is normally somewhat different for std. chassi compared to air suspension and has a small influence on visibility distance and a large influence on glare values. 0,8 degree shall be used as a starting point for IIHS demerit calculations, representing all chassis and all curves.

Requirement:

Applicable to all SAE variant headlamp.

- Light adjustment in nominal position: max 2 demerits
- Light adjustment with a cut-off shift according Volvo Cars factory process tolerance (lamps mechanical adjustment in center): max 5 demerits
- Light adjustment in nominal position (no cut-off shift in vehicle coordinates), full range of mechanical adjustment: max 5 demerits
- Combined cut-off drift according to Volvo Cars factory process tolerance and full mechanical adjustment range: max 7 demerits.
- The supplier shall provide to Volvo a calculation of the variation in demerits of delivered headlamps

4.1.4.1.1.2 C-NCAP

REQ-60102 v6 China NCAP

Requirement:

CNCAP Protocol 2027 shall be used for evaluation, however final scores will be evaluated according to the CNCAP protocol applicable at the time of car production start.

Headlamp socore: 94% (without bonus points, potential penalty to be included)

4.1.4.2 Ageing Polymer Materials

REQ-58775 v6 Headlamp and bumper lamp hard coating requirements

Requirements:

Paint tests and requirements according to VCS 5751,6.
Painting classes B is valid for the coated exterior surfaces of the Front lights.

Paint finish requirement according to TR31826779.
Surfaces classes II is valid for the coated exterior surfaces of the Front lights.

Test material
Before testing, the painted/coated test objects shall be conditioned in accordance with VCS 1021,19. The test objects shall be representative of the product to be tested. Prior to moisture resistance test and weathering ageing tests, the test objects must fulfil the following to be valid as verification:

Surface texture for surfaces intended for verification of change of texture due to exposure, must not be lower than grade 7 when assessed in accordance with the 10 grade scale for subjective rating in TR-31826779 issue 17. These surfaces must be agreed with responsible test engineer.

VCS 5751,6 requirements that need to be tested on all front lighting components are as below;

102 Adhesion, scrape test

104 Adhesion, cross-cut test

105 Stonechip

106 Adhesion, water spraying under high pressure

111 Moisture resistance

*113a light exposure 3000h

*401 Scratch resistance

*501 Chemical resistance

Tests marked with * can be skipped in a specific project in case a test report for previous Volvo Cars Corporation headlamp/bumper lamp from the same factory, with the same clear coat and with same plastic is shown and included in test documentation.

If it is a new coating that has not been used with Volvo Cars Corporation project before, also 701a = Light exposure 5000h needs to be performed.

4.1.4.2.1 Complete Vehicle

REQ-4957 v16 Sun Simulation Complete Vehicle

Attribute: Ageing Polymer Materials
Requirement Intermediate

Classification:

Change classification: Editorial

Design Target : False

Is Generic : Yes

Purpose

Determine how the complete vehicle will handle high UV and heat load, corresponding to approximately;
3 years in dry markets e.g. Arizona, with respect to *deformations*
2 years in humid markets e.g. Florida, with respect to *colour changes and adhesion*
1,5 years in significant markets e.g. US and southern EU with respect to *theoretical UV load*

Test method (Performed by VCC)

The complete vehicle shall be tested in a sun simulation rig according to Volvo Test Method TM-1775.

Test duration 1680h (total time: 10 weeks) performed in continual cycles of 6h daytime and 2h nighttime.

Interior Climate condition is set to 2-weeks dry, 6-weeks humid, followed by 2-weeks dry for the total test duration. Interior relative humidity level is set to achieve Dew point 40°C during humid daytime cycles.

Nighttime cycles are set to 25°C dry Ambient for both Exterior and Interior.

The artificial global radiation system fitted in the Sun Simulator is configured to achieve uniformed irradiance level at the front vehicle surfaces, top vehicle surfaces, left hand side vehicle surfaces and rear vehicle surfaces.

The uniformed irradiation level are set to 1090 W/m2 with the spectral composition of air mass AM 1.5 Global i.e., with summarized UV 6.8%, VIS 55.4% and IR 37.8%. The overall tolerance at target surfaces is ±10%, but also set to comply within spectral tolerance of UV ±5%, VIS ±10% and IR ±10%

The Sun Simulator shall be calibrated to give uniformed irradiation throughout the exterior volume of the complete vehicle, one cycle to equal one day of solar load during mid-summer at mid-latitude locations, spectral distribution according to AM 1.5.

The Sun Simulator shall be calibrated to give correlated heat load throughout the volume of the complete vehicle for each daytime cycle i.e. each surface zone of the vehicle shall not be exposed to higher heat load than measured in significant markets e.g Arizona.

Requirements

*Function:
All parts must be fully functional during and after completion of the tests.
Parts/materials may not become sticky.

*Colour change/appearance change:
Grey Scale grade is assessed as the total result of the change in colour including hue, depth, brightness, haze and gloss. Colour change, according to grey scale, minimum class 4 (class 5 corresponds to ”no change”) is acceptable as compared to the un-aged components in accordance with VCS 1026,82019 and VCS 1026,51729. No change in colour tone, with the exception of a slight yellowing that might be acceptable by VCC.

Visible surfaces must not become blotchy or show any surface or injection mould imperfections such as, tiger stripes, mould flow lines, sink marks, changes to surface structures/grain etc. A subjective assessment shall also be made to ensure that there is no colour variation between adjacent components.

Visual assessment is the final judgement, and if colour measurements are used, the data should be considered only as support.

*Deformation:
No value higher than grade 1 may be accepted as defined by VCS 1026,11229 covering ageing. No visible deformation and no cracks are accepted. Metal plated parts to be evaluated according to *Detection of defects in metal plated parts, REQ-6041*.

*Adhesion:
No loss of adhesion on adhesive, tape, paints/lacquer/coatings**,** foil or fabric etc nor any degradation of foam backing affecting surface material adhesion, is accepted after completion of the test (subjective assessment).

*Odour:
There shall be no unpleasant odour after completion of the test (subjective assessment).
Assessment according to Volvo VCS 1027,2729 may be used.

*Resistance to impact:
Evaluate by following REQ-92817 *Resistance to Impact in Cold*

REQ-5300 v8 High pressure wash Exterior and Engine Compartment Components

Attribute:	Ageing Polymer Materials
Requirement Classification:	Intermediate
Change classification:	
Design Target :	True
Is Generic :	Yes

Purpose
Ensure that the car withstands high pressure wash.

Test Method
The high pressure cleaning is defined as;

- Spray nozzle 2506
- Water temperature +50 ± 5°C
- Spraying distance 10 cm (guiding value) for parts and 20 cm for labels, the machine's water pressure is set to 120 bars, 15 l/minute. The cleaning is done with a sweeping motion.
- Sweep length 50 cm
- Number of sweeps back and forth = 20
- Duration 60s ± 10s (this gives an approximate speed of 1m/s)
- Angle of water jet: Along the Normal of the materials surface plane ± 45°

Requirements
Exterior parts and parts in the engine compartment that are likely to be exposed to high pressure cleaning, should not come loose from their fixing points and not show any surface damages. The parts shall not crack or deform, no value higher than grade 1 may be accepted as defined by the VCS 1026,11229 covering ageing (this corresponds to no visible deformation). Labels shall be readable from minimum 0.5 meters distance after test.

4.1.4.2.2 General Ageing Requirements

REQ-4988 v10 General Testing and Appearance Evaluation

Attribute: Ageing Polymer Materials
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes
TCreqID: REQ-001263

Conditioning
The test object shall be conditioned at 23 ± 2°C and 50 ± 5% relative humidity for at least 24 hours before testing as well as prior to evaluation after test, if not specifically stated otherwise in the Technical Regulations (TR).

If the parts have been stored in extreme environmental conditions (i.e. the manufacturing process or heat storage) it may be necessary to increase the duration of the conditioning period.

General testing conditions and functional requirement

- Unless specified, ageing tests are to be carried out with the part mounted as in a vehicle.
- Heat ageing cabinets must have an air exchange rate corresponding to 3-10 times of its volume per hour, see for instance ISO-188.
- All parts must be fully functional during and after completion of the tests**.** The only exception to full function during testing is if the conditions are accelerated beyond temperature levels that could be expected during vehicle life.

If a system or part is not visible (during normal usage of the car), appearance requirements are not applicable.

Evaluation of changes in appearance
Overall appearance including colour and surface structure after testing shall be judged against untested material from the same part and batch. The evaluation shall be made according to VCS 1026,51729 and VCS 1026,82019, if nothing else is specified in the test method. Conditioning shall be carried out according to section *Conditioning*.

REQ-5307 v18 Resistance to Heat Ageing

Attribute: Ageing Polymer Materials
Requirement Classification: Intermediate
Change classification: Editorial
Design Target : True
Is Generic : Yes

Purpose:

Determine how components will handle long time heat ageing, corresponding to approximately 3 years in hot markets, such as Arizona. (In order to simplify testing, the interior and exterior long term heat requirements have been partially combined).

Method:

The tests refer to complete parts assembled as in a vehicle. Heat ageing cabinets must have an air exchange rate corresponding to 3-10 times of its volume per hour, see for instance ISO-188.

Ageing conditions, Exterior:
80 ± 2° C for 1 000 h for components mounted vertically and 2 000 h for components mounted horizontally. Remark: If the chosen materials have sufficient temperature stability (as evaluated by VCC Materials Centre), ageing can be performed at 10 °C higher temperature using half the above stated test durations.

Ageing conditions, Interior:
80 ± 2° C for 1 000 h.
Components exposed to sunlight and/or high cabin temperature are instead subject to *Heat Ageing for Highly Exposed Interior Areas, REQ-4985.*

Components in engine compartment must be aged at corresponding service temperature according to Thermodynamics measured mean temperature during 98% of service time. Ageing time to represent customer driving spectrum.

Requirements:

*Function:
All parts must be fully functional during and after completion of the tests.
Parts/materials may not become sticky.

*Colour change/appearance change:
Grey Scale grade is assessed as the total result of the change in colour including hue, depth, brightness, haze and gloss. Colour change, according to grey scale, minimum class 4 (class 5 corresponds to ”no change”) is acceptable as compared to the un-aged components in accordance with VCS 1026,82019 and VCS 1026,51729. No change in colour tone, with the exception of a slight yellowing that might be acceptable by VCC.

Visible surfaces must not become blotchy or show any surface or injection mould imperfections such as, tiger stripes, mould flow lines, sink marks, changes to surface structures/grain etc. A subjective assessment shall also be made to ensure that there is no colour variation between adjacent components.

Visual assessment is the final judgement, and if colour measurements are used, the data should be considered only as support.

*Deformation:
No value higher than grade 1 may be accepted as defined by VCS 1026,11229 covering ageing. No visible deformation and no cracks are accepted. Metal plated parts to be evaluated also according to *Detection of defects in metal plated parts, REQ-6041*.

*Adhesion:
No loss of adhesion on adhesive, tape, paints/lacquer/coatings**,** foil or fabric etc nor any degradation of foam backing affecting surface material adhesion, is accepted after completion of the test (subjective assessment).

*Odour:
There shall be no unpleasant odour after completion of the test (subjective assessment).
Assessment according to VCS 1027,2729 may be used.

*Resistance to impact:
Evaluate by following REQ-92817 *Resistance to Impact in Cold*

REQ-4987 v19 Climate Variation

Attribute:	Ageing Polymer Materials
Requirement Classification:	Intermediate
Change classification:	Editorial
Design Target :	True
Is Generic :	Yes
TCreqID:	REQ-023275

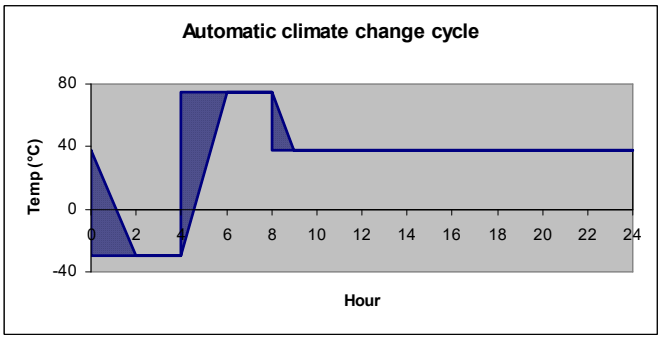
Purpose:
Determine how components will handle temperature fluctuations and combination of humidity uptake followed by low temperature. This generates movements in parts, high forces in sandwich constructions, interactions between components and forces to attachments points, glue, tape etc.

Method:
The part shall be assembled as in vehicle with surrounding parts. After conditioning, the whole assembly shall be subjected to the below 24 hour cycle, 10 times. For chrome plated parts, taped and glued parts the test length is instead 20 cycles. In addition, when a statistically secured number of test parts are needed, as in the case of chrome plated parts, these may be tested unmounted.

Test cycle:

4h (-30)°C -> 4h 75°C -> 16h 38°C & 95% RH

The test cycle with allowed ramp times is depicted below. Note that air temperature in the chamber should be within the marked areas.



Requirements:
*Function:
All parts must be fully functional during and after completion of the test.
Parts/materials may not become sticky.

*Colour change/appearance change:
Grey Scale grade is assessed as the total result of the change in colour including hue, depth, brightness, haze and gloss. Colour change, according to grey scale, minimum class 4 (class 5 corresponds to ”no change”) is acceptable as compared to the un-aged components in accordance with VCS 1026,82019 and VCS 1026,51729. No change in colour tone, with the exception of a slight yellowing that might be acceptable by VCC.

Visible surfaces must not become blotchy or show any surface or injection mould imperfections such as, tiger stripes, mould flow lines, sink marks, changes to surface structures/grain etc. A subjective assessment shall also be made to ensure that there is no colour variation between adjacent components.

Visual assessment is the final judgement, and if colour measurements are used, the data should be considered only as support.

*Deformation:
No value higher than grade 1 may be accepted as defined by VCS 1026,11229 covering ageing. No visible deformation and no cracks are accepted. Metal plated parts to be evaluated also according to *Detection of defects in metal plated parts, REQ-6041*.

*Adhesion:
No loss of adhesion on adhesive, tape, paints/lacquer/coatings**,** foil or fabric etc nor any degradation of foam backing affecting surface material adhesion, is accepted after completion of the test (subjective assessment).

*Odour:
There shall be no unpleasant odour after completion of the test (subjective assessment).
Assessment according to Volvo VCS 1027,2729 may be used.

*Resistance to impact:
Evaluate by following REQ-92817 *Resistance to Impact in Cold*

REQ-4989 v10 Ageing in Humidity Low Temperature, 38°C/95%RH

Attribute:	Ageing Polymer Materials
Requirement Classification:	Intermediate
Change classification:	Editorial
Design Target :	True
Is Generic :	Yes
TCreqID:	REQ-022262

Purpose:
Determine how components will handle high moisture at 38°C. Valid for all materials and components in the vehicle. Below description of interior and exterior cases are guidelines for testing.

Interior
Examples: To be tested for leather and other parts that contain natural materials, as well as for materials that are hygroscopic (absorb water) e.g. polyamide, to ensure that the swelling does not cause functional problems. Must also be tested for carpets with backing, other laminated materials, paints etc. The test is also to be used for materials/parts where additives or fillers can be suspected to be affected by humidity.

Exterior
Examples: To be tested for taped, PUR rim and glued parts as well as when the material is known to be hygroscopic. Also used for materials/parts where additives or fillers can be suspected to be affected by humidity.

Test method:
If relevant, test can be performed on loose parts/materials after agreement with responsible VCC test engineer. The system is to be aged in an humidity chamber at 38 ± 2°C and 95 ± 5%RH for 1000h.

Requirements:

*Function:
All parts must be fully functional during and after completion of the tests.
Parts/materials may not become sticky.

*Colour change/appearance change:
Grey Scale grade is assessed as the total result of the change in colour including hue, depth, brightness, haze and gloss. Colour change, according to grey scale, minimum class 4 (class 5 corresponds to ”no change”) is acceptable as compared to the un-aged components in accordance with VCS 1026,82019 and VCS 1026,51729. No change in colour tone, with the exception of a slight yellowing that might be acceptable by VCC.

Visible surfaces must not become blotchy or show any surface or injection mould imperfections such as, tiger stripes, mould flow lines, sink marks, changes to surface structures/grain etc. A subjective assessment shall also be made to ensure that there is no colour variation between adjacent components.

Visual assessment is the final judgement, and if colour measurements are used, the data should be considered only as support.

*Deformation:
No value higher than grade 1 may be accepted as defined by VCS 1026,11229 covering ageing. No visible deformation and no cracks are allowed.

*Adhesion:
No loss of adhesion on adhesive, tape, paints/lacquer/coatings**,** foil or fabric etc nor any degradation of foam backing affecting surface material adhesion, is accepted after completion of the test (subjective assessment).

*Odour:
There shall be no unpleasant odour after completion of the test (subjective assessment).
Assessment according to VCS 1027,2729 may be used.

*Biological degradation
There must not be any biological degradation or growth of fungus, mould etc. after completion of test.

REQ-5302 v9 Resistance to peak Temperature Exterior

Attribute:	Ageing Polymer Materials
Requirement Classification:	Intermediate
Change classification:	
Design Target :	True
Is Generic :	Yes

Purpose:
Determine how components will handle peak temperature loads and/or paint repair oven.

Test Method:
The test refers to complete parts assembled as in a vehicle. Oven ageing with air circulation according to SS-ISO 188 (3-10 times/hour).
All parts below waistline and vertical surfaces above waistline: Ageing time 2 h at 95 ± 2°C.

Parts above waistline with a significant horizontal surface: Ageing time 6h at 95°C ± 2°C in a heat chamber.

Should the component during usage, under any circumstances, be exposed to higher peak temperatures than the above mentioned temperature, the ageing temperature should be exchanged to the real peak temperature.

NB I: All instances when an exterior part cannot withstand at least 2h of 95°C must be logged and reported to Manufacturing (due to possible paint touch up consequences).

NB II: components in engine compartment must be tested at corresponding peak temperature according to Thermodynamics representing the 2% time at the highest part of the temperature interval.

Requirements: No change of appearance, loss of adhesion or any odour is accepted. All parts must be fully functional during and after completion of the tests.

REQ-44417 v4 Ageing requirement for plastic electrical components

Attribute:	Ageing Polymer Materials
Requirement Classification:	Soft
Change classification:	Editorial
Design Target :	
Is Generic :	No

Purpose
This requirement aims to secure ageing polymer properties for plastic parts and housings of electrical components, but not related to electrical performance.

Information
Ageing requirements for plastic is applicable on all polymer components, including electrical components. However ISO 16750 surpasses the general ageing requirements for components that aren't visible and not subjected to abnormal loads. Therefore testing and certification against ISO 16750 is sufficient for most applications. Contact the owner of this requirement if uncertainties arise.
Components that are part of interior and exterior styling and have electrical components need to be tested with all ageing requirements regarding surface finish. Requirements are to be taken from surrounding ARTs

Test method
ISO 16750

Requirement
Parts without visual exposure to customer during normal use, that fulfill ISO 16750 are verified OK for Ageing Polymer Materials.
Parts that can be exposed to customer scrutiny under reasonable use of product need to add visual assessment, after ISO 16750 test and fulfill colour change and deformation requirements in addition to ISO 16750 evaluation.

*Colour change/appearance change:
Grey Scale grade is assessed as the total result of the change in colour including hue, depth, brightness, haze and gloss. Colour change, according to grey scale, minimum class 4 (class 5 corresponds to ”no change”) is acceptable as compared to the un-aged components in accordance with VCS 1026,82019 and VCS 1026,51729. No change in colour tone, with the exception of a slight yellowing that might be acceptable by VCC.

Visible surfaces must not become blotchy or show any surface or injection mould imperfections such as, tiger stripes, mould flow lines, sink marks, changes to surface structures/grain etc. A subjective assessment shall also be made to ensure that there is no colour variation between adjacent components.

Visual assessment is the final judgement, and if colour measurements are used, the data should be considered only as support.

*Deformation:
No value higher than grade 1 may be accepted as defined by VCS 1026,11229 covering ageing. No visible deformation and no cracks are accepted. Metal plated parts to be evaluated according to *Detection of defects in metal plated parts, REQ-6041*.

This is applicable for the following tests in ISO 16750-4:
- Storage in heat test
- Rapid climate variation

And the tests in ISO 16750-5

REQ-92817 v3 Resistance to Impact in Cold

Attribute: Ageing Polymer Materials
Requirement Classification: Intermediate
Change classification: Editorial
Design Target : True
Is Generic : No

Purpose

Evaluate both unaged and aged polymer parts possibility to withstand impact in cold.

Requirement

Interior passenger and luggage compartment and frunk;
Tests shall be carried out at -30°C according to TM-958 Impact in cold. The part shall be fully functional after the impact and no visible cracks shall appear. Taped and/or laminated parts may not exhibit any loss of adhesion. Scratches due to unevenness or rough surface of the impactor can be disregarded, but paints and lacquers shall not crack.
[+/- 10% impact energy is acceptable for testing]

Area	*Impact energy*	*Impactor*
Luggage compartment floor and vertical areas below window level	5 J	1000 g solid steel ball
Frunk inner sides, floor and lid	2 J	1000 g solid steel ball
”Kick area*” of the interior	2 J	1000 g solid steel ball
Other areas in the interior	1 J	1000 g solid steel ball

** Kick area of interior is defined as entire passenger compartment from door panel armrest level and below*

Exterior and under the hood;
Tests shall be carried out at -30°C according to TM-958 Impact in cold. The part shall be fully functional after the impact and no visible cracks shall appear. Taped and/or laminated parts may not exhibit any loss of adhesion. Scratches due to unevenness or rough surface of the impactor can be disregarded, but paints and lacquers shall not crack. At 15-20J a minor deformation of the surface is allowed.
[+/- 10% impact energy is acceptable for testing]

Area	*Impact energy*	*Impactor*
Exterior of the car, at and above the waistline.	2 J	255g solid steel ball, 40mm diameter
Exterior of the car, below waistline	5 J	1250g solid steel mandrel, 40mm diameter
Exterior Lights above bumper and Traditional Grille	1 J	255g solid steel ball, 40mm diameter
Exterior Lights, Smart-zone Grille and reflexes in Bumper	3 J	1250g solid steel mandrel, 40 mm in diameter
Cheater panel protected by Rear view mirror	1 J	255g solid steel ball, 40mm diameter
Bumper cover, rear and front upper area	15 J	3250 g solid steel mandrel, 40 mm in diameter
Bumper cover, rear and front lower area	20 J	3250 g solid steel mandrel, 40 mm in diameter
Under the hood, on parts exposed when hood is open	1 J	255g solid steel ball, 40mm diameter

4.1.4.2.3 Unique system requirements

4.1.4.2.3.1 Exterior Requirements

REQ-6631 v2 RESISTANCE TO UV-LIGHT, EXTERIOR LIGHTING COATINGS

Attribute: Ageing Polymer Materials
Requirement Classification: Intermediate
Change classification:
Design Target : True
Is Generic : Yes

Method:

Samples cut out from parts are subjected to ageing according to VCS 1027,339 for 3000 h.

Requirements:
Maximum change in grey scale class 4 (class 5 corresponds to "no change") as compared to the reference sample in accordance with VCS1026,82019 and VCS 1026,51729. A subjective assessment shall also be made to ensure that

there is no visible whitening, degradation, crack formation of the clear coat layer etc. Visible surfaces must not become blotchy or show any surface or injection mould imperfections such as, mould flow lines, etc. Master samples must be available for comparison.

NB:
After UV exposure the tested surface may be washed lightly with a sponge, using a 10% car shampoo and water solution. Maximum three strokes. Rinse with tepid water and dry gently with soft paper tissue

REQ-6012 v1 WARPAGE TEST, EXTERIOR LIGHTING

Attribute: Ageing Polymer Materials
Requirement Classification: Intermediate
Change classification:
Design Target : True
Is Generic : Yes

Method:
The test is based on a modification of SAE J575e (WARPAGE test).
The lamp is placed in an oven and in a similar position as in the vehicle.
Before the test begins, the lamp should have reached the correct temperature level:
Headlamps +60°C
Other lamps +60°C

The air speed in the heat chamber should be between 1-1.5 m/s. During the test time, 60 minutes, the lamp's bulbs should be lit with the following light characteristics for the lamp functions listed below:
Low beam continually lit
High beam continually lit
Front fog lamp continually lit
Position lamp continually lit
Reversing lamp 10 minutes lit -> 10 minutes off, and so on
Rear fog lamp continually lit
Stop lamp continually lit
High mounted stop lamp continually lit
Direction indicator continually blinking, frequency 90 flashes/minute
Side marker lamp continually lit
Rear registration plate lamp continually lit

The lamp function shall be connected according to the information below (4 cases) during the testing of various functions in the same lamp unit.

Case	Position lamp	Reversing lamp	Stop lamp	Direction indicator lamp	Rear / Front fog lamp	Side marker lamp	Low beam	High beam
1	X	X				X		
2	X				X	X		
3	X		X	X		X		
4(Headlamp)	X			X	X	X	X	X

Requirements:

Requirement after testing according to FMVSS 108. The requirements according to ECE-regulation no. 38 and EEC-directives 77/538 and 89/518 are applicable to fog lamps.
After testing no visible change or loss of function are accepted.

REQ-6014 v1 RESISTANCE TO FOGGING IN EXTERIOR LIGHTING DEVICES

Attribute: Ageing Polymer Materials
Requirement Classification: Intermediate
Change classification:
Design Target : True
Is Generic : Yes

Method:
The lamp shall be exposed to a test cycle in +23 °C and 50%RH. The test cycle is 3 hours with all functions on in the lamp and 1 hour with everything off. Total number of test cycles shall be 165.

Requirements:
After the test a comparison with a non aged lamp shall be made. Lamps shall be judged in car position and from ca 1 m distance with the light turned on.
Requirement: No visible change. (For example deposit on the inner side of the lens)

The target is to have no fogging from materials on any visible part of the lamp for any environmental condition and customer during the first 5 years. This shall be achieved by choosing materials suitable for the environment in the lamp. For example materials with softeners shall be avoided.

REQ-6015 v5 RESISTANCE TO CHEMICALS, EXTERIOR LIGHTING

Attribute: Ageing Polymer Materials
Requirement Classification: Intermediate
Change classification: Editorial
Design Target : True
Is Generic : Yes

Purpose
To secure exterior lighting resistance to aggressive chemical agents.

This test was introduced after cracks were found on head lamps. Method and requirement reproduces field issue but on relevant versions whereas proper parts pass the test.

Requirement
No cracks or crazing is allowed on any part.
No release of surface coating is allowed.

Test Method

Front Lightning:

To test the resistance to environmental cracking, a cycle of heat exposure followed by spraying the chemical is performed in six loops. The cycle consists of heating the part in 60°C for 1 hour, followed by spraying of the chemical (listed below) over the part when the part is still warm and finally starting the second cycle (keeping the part at 60°C for 1 hour again). After 6 loops of this cycle, the part should be heated again finally for 1 hour at 60 degrees before eventually finishing the test.

The chemical is sprayed thoroughly over the part, so that the whole part is covered with the chemical.
Total test consists of 7 hours in 60°C and 6 exposures to the chemical.

The evaluation of the part for cracks should be done every time before spraying the chemical on it. The part is evaluated by naked eye for cracks after every loop. And microscopic analysis is done of the part and the cracks after the test is finished.

Rear Lightning:
The complete lighting is wrapped in soft paper and placed in a plastic bag. The covered lighting is sprayed with the chemicals listed below. The plastic bag is then immediately sealed and the lighting is in an airtight surrounding for 72 hours at room temperature. After 72 hours the plastic bag is opened and the soft paper shall be removed. Make an initial assessment for cracks and then let the test object dry for 4 hours at room temperature and thereafter rinsed with water. After further 168h conditioning at 23°C and 50%RH (1 week) the lamp shall be inspected.

Test fluids below in accordance with VCS 1027,61329:

a) White spirit (C13)

b) Alkaline Degreaser (Engine cleaner) (C6)

c) Alkaline Car Shampoo (C5) 10% solution

d) Washer fluid (C1) or (C2), ethanol/isopropanol-based (European-type), concentrated and diluted (10% and 33%)

e) Washer fluid (C3), methanol-based (US-type, 95%methanol and 5%water) concentrated and diluted (10% and 33%)

REQ-40860 v3 Evaluation of appearance for exterior lights after test

Attribute:	Ageing Polymer Materials
Requirement Classification:	Soft
Change classification:	Editorial
Design Target :	True
Is Generic :	No

To be evaluated after:
Resistance to heat ageing, exterior REQ-5307
Resistance to peak Temperature Exterior REQ-5302
Climate variation REQ-4987
Sun Simulation Complete vehicle REQ-4957

Requirements: No change of appearance, no deformation or loss of adhesion allowed. All parts must be fully functional during and after completion of the tests. Colour change on part LIT OFF and LIT ON are to be assessed and compared to a reference part (or before and after pictures in dark room), judgement is made according to 1026,51729 were grade 7 and above is OK. Colour and temperature before and after test with lit on is to be measured and compared. No noticable change in colour teperatyre and hue is allowed and lenses and light guides are not allowed to become yellow.

If subjective assesment is disputed then the following applies: No larger colour change than 600 Kelvin is allowed in any given point, before and after test. Colour can not move away or towards black body line more than 0,03.

4.1.4.2.4 UV Resistance

REQ-5317 v9 RESISTANCE TO UV-LIGHT, EXTERIOR COMPONENTS

Attribute: Ageing Polymer Materials
Requirement Classification: Intermediate
Change classification: Editorial
Design Target : True
Is Generic : Yes

Valid for exterior plastics and polymers

Method:
Samples cut out from parts are subjected to ageing according to VCS 1027,3379 for 1500h (components mounted vertically) or 2000 h (components mounted horizontally), equivalent to 3 years in Arizona climate.

Requirements:
Colour change, according to grey scale, minimum class 4 (class 5 corresponds to ”no change”) is acceptable as compared to the un-aged components in accordance with VCS 1026,82019 and VCS 1026,51729. No change in colour tone, with the exception of a slight yellowing that might be acceptable by VCC. Grey Scale grade is assessed as the total result of the change in colour including hue, depth, brightness, haze and gloss.

Visual assessment is the final judgement, and if colour measurements are used, the data should be considered only as support.

Surfaces must not become blotchy, sticky or show any surface or injection mould imperfections such as, tiger stripes, mould flow lines, sink marks, changes to surface structures/grain etc.

Note: After UV exposure, the tested surface may be washed lightly with a sponge using a 10% car shampoo (without wax) and water solution. Maximum three strokes. Rinse with tepid water and dry gently with soft paper tissue.

REQ-5994 v7 MATERIAL QUALIFICATION; EXTERIOR TPE/TPV materials

Attribute: Ageing Polymer Materials
Requirement Classification: Intermediate
Change classification: Editorial
Design Target : True
Is Generic : Yes

Test Method:
Thermoplastic elastomer materials (TPE, TPV) intended for use in exterior applications must be thoroughly evaluated before implementation. If a successful application in a previous Volvo model cannot be shown by long term field data from hot as well as hot and humid markets, the supplier must show that the material passes at least the following two criteria to qualify:

3500h according to VCS 1027,3379, 65°C BST, 50± 5%RH
1500h according to VCS 1026,82429 at 100°C BST

Tests shall be performed on plaques with a maximum thickness of 2mm.

Requirements:
Maximum change of mechanical properties 30%.
No significant weight change (+/-5%)
No tendency for surfaces cracks/ whitening when folded/bended.
Evaluation shall be made by VCC materials centre

In addition to the qualification requirements, the material must fulfill the requirement "RESISTANCE TO UV-LIGHT, EXTERIOR COMPONENTS".

4.1.4.2.5 Resistance to chemicals, soiling and cleanability

4.1.4.2.5.1 Exterior Requirements

REQ-5320 v14 RESISTANCE TO CHEMICALS, EXTERIOR

Attribute:	Ageing Polymer Materials
Requirement Classification:	Intermediate
Change classification:	Editorial
Design Target :	True
Is Generic :	Yes

Purpose

Secure that exterior materials can resist common automotive used fluids and chemicals.

Test Method:

Fluids and chemicals to be used are specified in the list and pictures below. All used fluids must be documented with name, brand, part number and preferably a photo.

Procedure 1: 2,5 ± 0, 5 ml of appropriate chemical solution is applied with a pipette or another suitable tool on a section of a part or a sample. The part or the sample shall be placed in such a way that the test surface is horizontal. The test object shall self-dry for four hours, followed by wash with hot tap water prior to evaluation. With certain fluids, such as anti-rust oil, it's allowed to use degreasing agent in the wash procedure. The test shall be carried out at 23 ± 2°C. A new sample or an untested section of a part shall be used for each fluid.

Procedure 2: The part shall be fixed as in vehicle when the test is carried out. The whole part is washed with appropriate solution using a foam sponge. The amount of fluid shall be sufficient to wet the whole part. With certain materials and parts, it is of importance that possible unpainted reverse side is wetted with the chemical. The part shall self-dry for 24 h before evaluation is conducted, with reference to deformation and crack formation. The test shall be carried out at 23 ± 2°C. A new sample or an untested section of a part shall be used for each fluid.

All parts should sustain treatment by the following fluids:

A) White spirit (C13)

B) Alkalic Degreaser (C6)

C) Alkaline Car Shampoo (C5) 10% solution

D) Washer fluid (C1) or (C2), ethanol/isopropanol-based (European-type), concentrated and diluted (10% and 33%)

E) Washer fluid (C3), methanol-based (US-type, 95%methanol and 5%water) concentrated and diluted (10% and 33%)

Q) Plastic cleaner (any commercial with below composition)

Alcohol, C9-11, Ethoxylated 1-5%
Alkylglycoside 1-5%

R) Car wash shampoo (C4)

S) Insect Remover (C11)

Parts situated in marked areas illustrated in figures below shall ALSO sustain spill from or spray by following fluids:

F) Unleaded petrol from local tap (May be excluded for BEV only components)

G) Diesel fuel from local tap (May be excluded for BEV only components)

H) Cooling Liquid (B10), glycol, concentrated and diluted (50%)

I) Engine oil (B1) (May be excluded for BEV only components)

J) Anti Corrosion Oil (B3)

K) Lock Lubricant

L) Isopropanol 99.7% (de-icing lock lubricant)

M) E85 (May be excluded for BEV only components)

N) Engine wash fluid

O) Rim Cleaner (C12)

P) Ad-Blue (Urea) (B13) (May be excluded for BEV only components)

T) Brake fluid (B11)

Additionally if the part will ever be washed with or come in contact with Heptane (Cleaner H) during production or normal use the part should sustain treatment from that as well.

Z) Heptane >95%, CAS# 142-82-5

Fluids are Specified in VCS 1027,61329, contact VCC Material Centre if any questions.



Requirements:
COLOUR CHANGE: Maximum colour change grey scale class 4/5. (class 5 corresponds to "no change") as compared to reference in accordance with VCS 1026,82019 and VCS 1026,51729. Visible surfaces must not become blotchy or show any surface or injection mould imperfections such as, tiger stripes, mould flow lines, sink marks etc.

DEFORMATION: Grade 1 as defined by VCS 1026,11229 covering ageing. This corresponds to no visible deformation and no cracks. Adhesive or other underlying material must not be visible after test, i.e. spill of glue etc

ADHESION AND DELAMINATION: No loss of adhesion, release of adhesive, tape, paints, foam, glue, foil or any other surface material etc nor any degradation of foam backing, causing release of surface material, after completion of the test.

4.1.4.2.6 Scratch Resistance

REQ-5993 v8 scratch resistance, exterior high gloss surfaces

Attribute: Ageing Polymer Materials
Requirement Classification: Intermediate

Change classification:
Design Target : True
Is Generic : Yes

Valid for incoloured high gloss plastics.

Method:
Scratch resistance ungrained (high gloss) incoloured plastics:
Mar resistance of top coats in brush-type car wash (AMTEC-Kistler)
The scratch resistance test is performed according to VCS 1024,369

Requirement:
Gloss ratio after recovery ("reflow") (Glr/Gli) ≥ 85%

4.1.4.3 Clearance

REQ-30264 v2 Exterior lighting clearance to radiant heat sources

Design clearance shall be provided between radiant heat sources (e.g. radiator, A/C lines, trans-cooler, oil cooler, etc.) and lighting devices so that the lamp components never exceed their respective heat warpage temperatures. Supplemental heat shielding may be used to ensure compliance to this requirement.

4.1.4.4 Component NVH

REQ-129429 v2 Headlight unit NVH - Component requirement

Attribute: Operational Sound Quality
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

Description of requirement
These system level requirements on the headlight units are meant to ensure fulfillment of complete vehicle requirement given that the installation in car is suitable for NVH.

Load case or/and Use case
The headlight shall be operated with the same conditions as in vehicle regarding voltage supply etc. Care for having sufficiently low background noise.

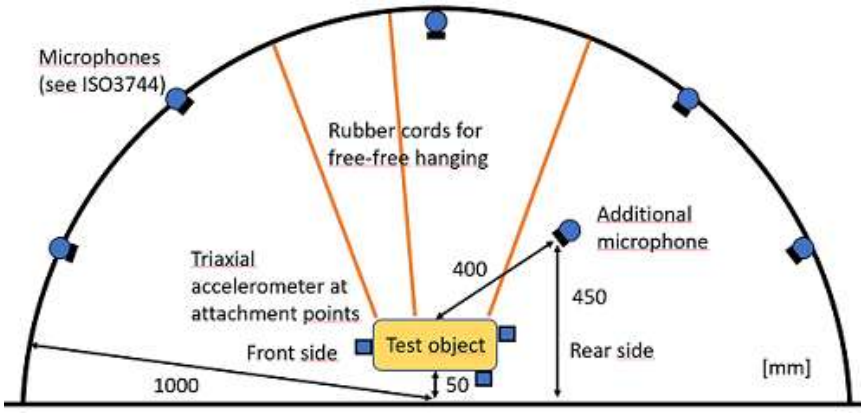
Max fan
All fans in the headlight unit (one side) running at the highest speed that can occur in vehicle for a duration of ≥40 seconds.

Reference run and other actuator movements

Operate the reference run and all other actuator events at least 3 times with ≥1 second pause with no operation between each run.

Test setup

System shall be measured in a semi-anechoic environment according to standard ISO3744 plus an additional microphone at 450 mm height above floor and 400 mm on the rear side from middle of the test object. Use at least 48 kHz sample rate for microphone acquisition.
The test object shall be hanging free-free in rubber cords or similar, 50 mm above the floor, in leveled angles (as when installed in car).
Triaxial accelerometers shall be placed at all attachment points. Use at least 12,8 kHz sample rate for accelerometer acquisition.



Test setup

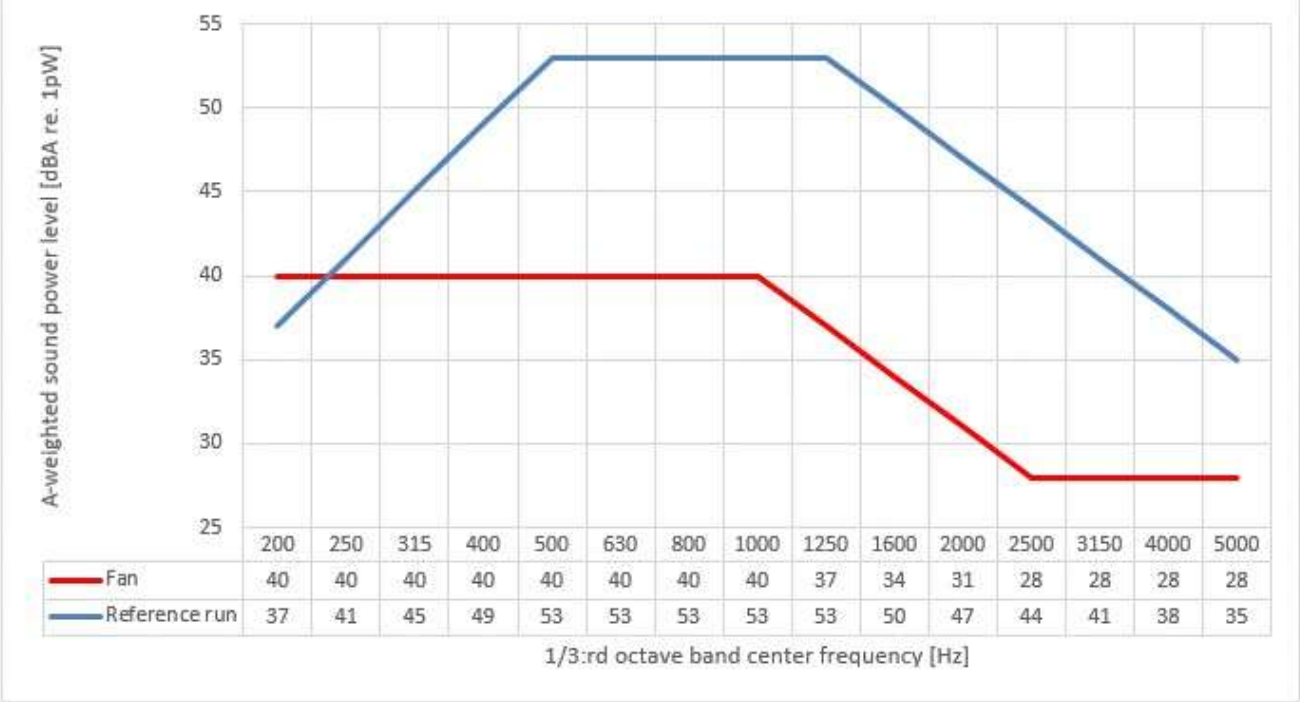
Levels and Variants that target apply to

Each load case should be analyzed separately. Requirement levels for any other actuator movements is the same as for "Reference run".

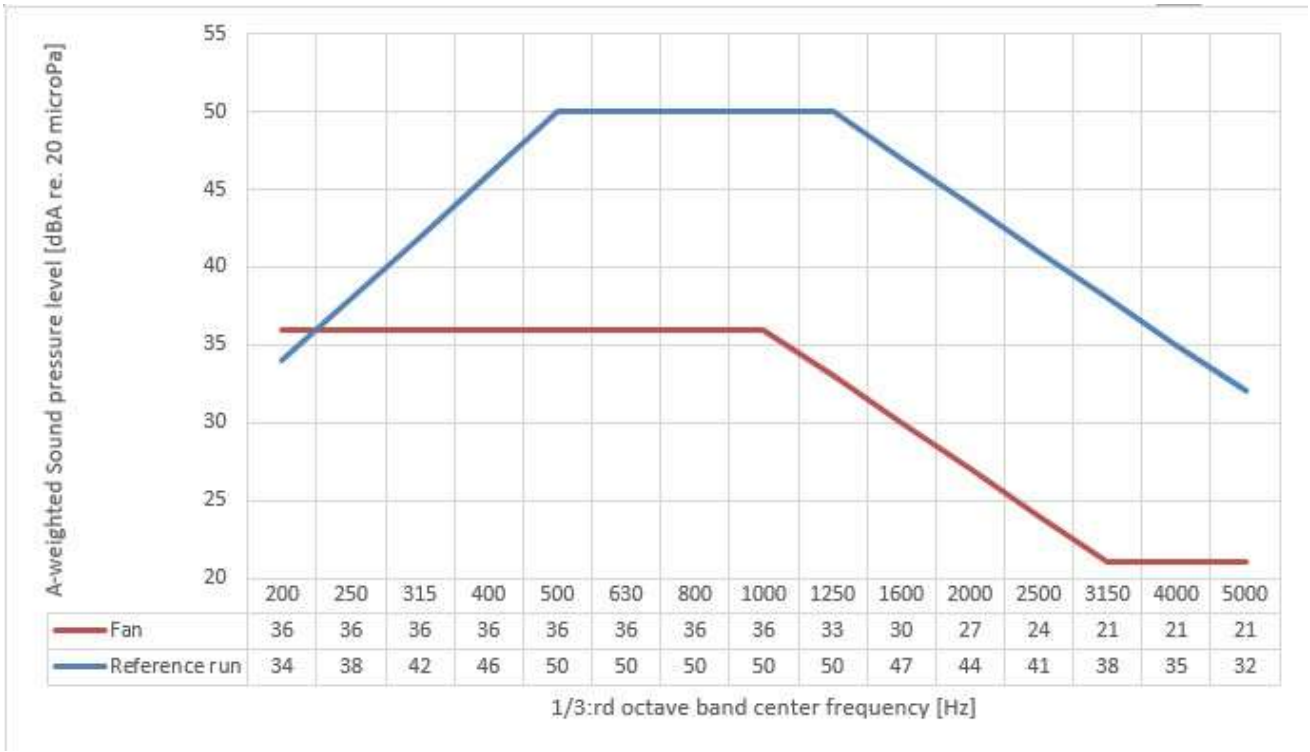
Air-borne noise

Analysis settings for microphones shall be Peak-hold, 48 kHz sample rate, 4096 spectrum size, Hanning 50%, A-weight-filter. For the additional microphone, also include narrow band (FFT, 4096 spectrum size, Hanning 50%, A-weight filter) result in the same plot.
For reference run and actuator movements, the max of at least 3 runs shall be taken.

Sound power level values according to ISO3744 but using peak-hold over time instead of average may not exceed these limits:



Peak-hold sound pressure level of additional microphone must not exceed these limits. Furthermore, tonal levels in narrow band spectra (FFT, 4096 spectrum size, Hanning 50%, A-weight filter) must be at least 3 dB below respective 1/3:rd octave band level:



Structure-borne noise

Analysis settings for accelerometers shall be 1/3:rd octave band, peak-hold, 12,8 kHz sample rate, 4096 spectrum size, Hanning 50%.
The square-root sum of all directions peak-hold accelerations squared $\sqrt{X^2 + Y^2 + Z^2}$, averaged for all attachment points must not exceed:



	20	25	31,5	40	50	63	80	100	125	160	200	250	315	400	500	630	800	1000	1250	1600	2000	2500	3150	4000	5000
Fan	70	70	70	70	70	70	70	70	70	70	70	70	70	70	75	80	85	90	90	90	90	90	90	90	90
Reference run	80	80	80	80	80	80	80	80	80	80	80	80	80	80	85	90	95	100	100	100	100	100	100	100	100

Blocked force
System shall be measured in a blocked force setup where forces is measured at all attachment points. Provide blocked force data up to 3 kHz and map of eventual resonances in the setup.

Beating effect from multiple fans

In order to avoid noticeable beating effect that can happen e.g. when multiple fans run at almost same rpm these requirements applies to tonal components:
There should be no noticeable tones with less than 6 Hz difference (entails e.g. that rpm of fans needs to be separated by at least 360 rpm).
Analyze frequency content of "additional microphone" and accelerometers for fan measurements by narrow band FFT with resolution of at least 0,1 Hz (at least 480 000 spectrum size for 48 kHz sample rate, Hanning 50%, A-weight for microphone / no weight for accelerometers) to detect close tones.

- If a tone is higher than 10 dB below any of above requirement levels, any other tones within
  - 6 - 10 Hz difference, the level difference between the tones must be at least 10 dB
  - 10 - 20 Hz difference, the level difference between the tones must be at least 6 dB

Requirement responsible: Henrik Törnqvist

4.1.4.5 Contamination

REQ-62923 v3 VOC Outgassing and Contamination Resistance

Is Generic : No
Requirement Classification: Soft

Purpose

To verify that the headlamp maintains its optical and functional performance when exposed to VOCs released from its own internal materials under high temperature and humidity.

Scope

All exterior front lamp assemblies with LEDs.

Requirement

This test is designed to assess the reliability of the lamp assembly under accelerated high temperature and high humidity conditions, simulating the potential release and impact of volatile organic compounds (VOCs) originating from internal materials. The following test conditions shall be applied:

Climatic Test Sequence

- 16 hours at 85°C and 95% relative humidity.
- 3 hours at -20°C.
- 6 hours at 85°C.
- Repeat for 7 cycles

Functional test

- 1 hour ON (low beam, high beam and turn indicator light)
- 5 hours OFF
- Repeat throughout climatic test

Acceptance Criteria

- Functionality: All functions shall operate as intended after the test.
- Light Output: Less than 10% reduction compared to initial measurement.
- Visual Inspection: No discoloration, haze, deposits, or other degradation shall be observed either on external or internal components after the headlamp is opened for inspection.

REQ-30624 v3 Cyclical dust test

The unit’s interior should be free of dust after the test. The unit is placed in a dust chamber according to SAE J575e/ASTM C150-84 but with open draining holes. If there is a sealing casing against the luggage area, it must be ventilated with air outside the test chamber. There shall be negative pressure (0.95 bar) in this area for 10% of the period, according to the following test cycle:

21.5 h normal air pressure

5 h negative

21.5 h normal air pressure

Requirement: The unit's interior should be free of dust after the test.

4.1.4.6 Corrosion

4.1.4.6.1 Systems and Module Requirements

4.1.4.6.1.1 General Requirements

REQ-94237 v6 General - Corrosion: Surface treatment of components and fasteners

Attribute: Corrosion
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

Corrosion requirements for surface treatment of metal components and fasteners

Do not hesitate to contact the corrosion team for assistance as this requirement is very important.

Target background

To ensure that supplied surface treatment is meeting expected function and quality levels on metal parts, included in complete assembly, or attached separately.

NOTE 1: Below standards are based on test method VCS 1027,1449 and *are preferably evaluated in parallel with the general component testing according to the same corrosivity class*. Evaluation of different materials can be at different test time during the complete test.

Scope

There are four different standards applicable for corrosion protection. Which one to be used depends on the type of surface treatment, finish requirement and friction requirement on fasteners.

VCS 5751,6 Paint systems for painting classes A, B and C
VCS 5751,7 Paint systems for painting classes D and E
VCS 5737,19 Cathodically protective surface treatment with requirement on friction Y 100
VCS 5737,29 Cathodically protective surface treatment without requirement on friction Y 200

Painted parts

Select appropriate paint class using chapter 2.1 as guidance in the VCS 5751,6 or VCS 5751,7. Paint class depends on corrosivity and finish requirement on the part. Use test method, test duration and acceptance criteria according to standard VCS 5751,6 or VCS 5751,7.

For high corrosivity- and very high corrosivity positions, steel sheet with dimensions under 1,5 mm must always be pre-coated with minimum GI50/50 or equal (e.g., ZM35/35), and sheets with dimensions above 1,5 mm shall be assessed in consultations with corrosion team. Neither shall painting systems be used for threaded parts as only surface protection in these corrosivity positions.

Non-painted, cathodically protected steel parts <u>without</u> friction demand
Surface treatment class depends on the corrosivity position.
Select appropriate surface treatment class using corrosivity position in DGL-723. Use test method, test duration and acceptance criteria according to standard VCS 5737,29.

In the table below you find minimum requirement level for each corrosivity position:

	Corrosivity position			
	Low	Medium	High	Very high
General for steel and iron	**Y 200-1**	**Y 200-3**	**Y 200-4**	**Y 200-4**
If risk for galvanic corrosion (in contact to aluminum alloys)	**Y 200-1**	**Y 200-4**	**Y 200-4**	**Y 200-4**

<u>NOTE 2:</u> In high and very high corrosivity position use stainless steel or painted parts, in contact with stainless steel, instead of the information in the table.

<u>NOTE 3:</u> In very high corrosivity position, do not use magnesium (Mg). In high corrosivity position, use painted Mg with inert washer and aluminum (Al) fastener. In medium corrosivity position, use Mg with or without paint together with Al fasteners. In low corrosivity position, no corrosion problem with Mg.

<u>NOTE 4:</u> If conductivity is required, this shall be indicated in the design-engineering documentation using the suffix C, e.g., Y 200-3 C.

Non-painted, cathodically protected steel parts <u>with</u> friction demand, i.e., fasteners for assembly in VCC plants
Surface treatment class depends on the corrosivity position.
Select appropriate surface treatment class using corrosivity position in DGL-723. Use test method, test duration and acceptance criteria according to standard VCS 5737,19.

In the table below you find minimum requirement level for each corrosivity position:

	Corrosivity position			
	Low	Medium	High	Very high
General for steel and iron	**Y 100-1**	**Y 100-3**	**Y 100-4 /4B***	**Y 100-4 /4B***
If risk for galvanic corrosion (in contact to aluminum alloys)	**Y 100-1**	**Y 100-4/4B**	**Y 100-4 /4B***	**Y 100-4 /4B***
Grounding	**Y 100-2****	**Y 100-2**	**Y 100-2**	**N/A*****

* Y 100-4B must not be applied to light metal without special testing
** Y 100-1 can be used as long as the surface treatment is conductive
*** Grounding joint must not be positioned in very high corrosivity position

<u>NOTE 4:</u> For complicated mix metal joints in high and very high corrosivity position, discussion with corrosion team is needed before choosing solution.

<u>NOTE 5:</u> In high and very high corrosivity position use stainless steel or painted parts, in contact with stainless steel, instead of the information in the table.

<u>NOTE 6:</u> In very high corrosivity position, do not use magnesium (Mg). In high corrosivity position, use painted Mg with inert washer and aluminum (Al) fastener. In medium corrosivity position, use Mg with or without paint together with Al

fasteners. In low corrosivity position, no corrosion problem with Mg.

REQ-13748 v2 General - Corrosion: Transportation

Attribute: Corrosion
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

Transportation corrosion requirement

Target: The purpose of the test is to verify resistance to corrosion during transport (shipping).

Test Method: The parts are stored in a humidity chamber with temperature 38 ± 2°C and humidity 95 ± 5%RH

Test duration: 168 h (1 week).

Acceptance Criteria: No corrosion is allowed after completed test, except for slight corrosion on edges.

Alternative transportation requirement:
The above testing requirements can be excluded if special attention of protecting the parts during transportation is taken. The requirement is that the parts are free from corrosion when arriving to the assembly plant.

4.1.4.6.1.2 Visibility & Cleaning

REQ-20666 v4 Exterior lightning - Corrosion: Exterior lightning

Attribute: Corrosion
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

Corrosion function requirements for exterior lightning

Purpose: To evaluate the corrosion resistance of exterior metal parts, i.e. on the outside / back of the lamp house. E.g., aluminum heat exchangers, fasteners, bushing inserts. Internal corrosion (i.e. inside the lamp house) is not tested / evaluated for compontents with non-metal sealing surfaces (e.g. lamp houses consisting of two plastic halves).

Test method: Accelerated Corrosion Test, ACT II, according to VCS 1027,1449

For materials and sealing solutions known from previous projects, an Engineering Judgement may reduce the need of testning. Contact the Attribute Corrosion for consultion in this matter.

Test duration: 6 weeks

Test object preparation:

The unit shall be exposed in an orientation/angle representative to its service condition in the vehicle.

Connections should be made at original connectors.

Acceptance criteria:
Exterior metal parts: No base metal corrosion on steel parts.
Aluminium parts may show surface corrosion.

For sealing surfaces including at least one metal part *
No corrosion inside lamp house.
No interior corrosion is accepted in electrical components. Corrosion may not have passed the center of the sealing surface in any position or bypass O-ring sealing's.
No formation of any type of visible corrosion products on contacting surfaces.
No malfunction of the lamp functionality including headlamp adjustment is allowed.

** Note: A lamp house consisting of two plastic parts is not included in this Acceptance critera.*

REQ-24091 v2 Exterior lightning - Corrosion: Design requirements of aluminium material

Attribute:	Corrosion
Requirement Classification:	
Change classification:	
Design Target :	
Is Generic :	Yes

Material design requirement for aluminium components

Aluminium alloys with higher copper content than 0,25% shall not be used in high or very high corrosivity position.
Deviation from this requirement must be consulted with the corrosion team (91390) and judged from case to case.

4.1.4.6.2 Complete Vehicle Corrosion

REQ-25562 v11 CORCAR - Complete vehicle corrosion test

Attribute:	Corrosion
Requirement Classification:	Hard
Change classification:	
Design Target :	

Is Generic : Yes

Complete vehicle corrosion test

This requirement is aimed at verifying the corrosion of the complete vehicle.

Volvo is responsible to perform the complete vehicle corrosion test, CORCAR, and to verify that all components and systems are to comply with *Volvo Cars Corrosion Mandatory Requirements* (VMR-000461). In case of deviations from VMR, the suppliers are responsible/obligated to resolve the issue. The corrosion requirements are generic for all markets and all variants. A short version of the VMR and PG test is attached under "Attachment", and is available for suppliers.

When tested in laboratory and in complete vehicle testing, acceptance criteria must be met in both tests, unless an explicit exemption has been agreed. Complete vehicle corrosion testing is targeted for all components and systems during some stage in the product development program, but can usually not cover all variants or development stages.

4.1.4.7 Electrical Performance

REQ-30635 v5 LED ELP requirement

Requirement
It's forbidden to use a LED with silver lead frame in an exterior lighting application

It's not recommended to use passive or resistive driver technologies for functions using LED. Depending on type of function and electrical performance demand for each function, a more refined driver technology/ies shall be used.

Drivers for LED-functions
LED functions require a minimum linear driver or similar to manage the variation in voltage in all cars.

For the functions below, supplier has to respect the §5.27 of UNECE R48 with the usage of an electronic light source control gear to maintain the Voltage at 13,5V +/-3%

- Driving-beam (main-beam) headlamp
- Passing-beam (dipped-beam) headlamp
- Principal passing-beam (principal dipped-beam)
- Stop lamp
- Front position lamp
- Rear position lamp

Printed Circuit Boards (PCB)
Shall fulfill requirements according to Volvo Cars Corporation STD 1218,29 with service temperature according to the specific application, according to chapter 2.3 Attributes requirements / attribute requirements. Minimum PCB quality FR4 or CEM3.

Other substrates such as ceramic or metal substrates (IMS, DCB etc.) may also be used.

REQ-33243 v17 ISO 16750 Code Allocation

Purpose: Reliability - Ensure compliance with ISO 16750

ISO16750 code must be defined by Volvo Cars.

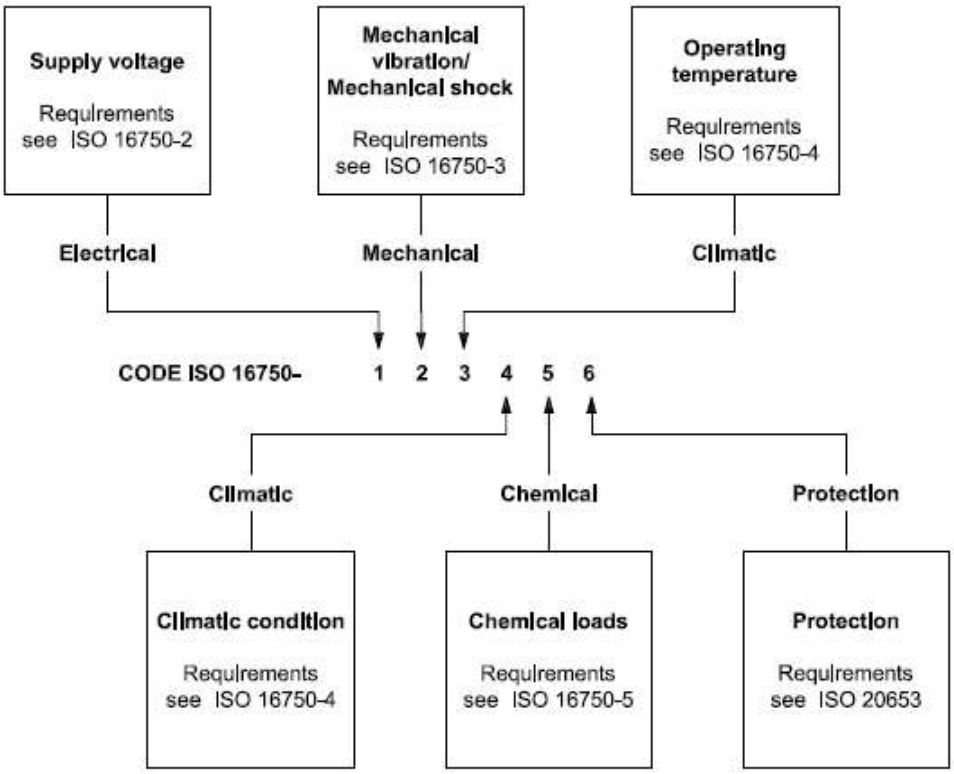


Figure 1 — Code allocation

Volvo Cars requires all electrical components to be compliant with ISO 16750. The concept of ISO 16750 is to assist its user in systematically defining and/or applying a set of internationally
accepted environmental conditions, tests and operating requirements, which are based on the anticipated actual environment in which the equipment will be operated in and exposed to during its life cycle.

For Volvo Cars the environmental conditions, required tests and operating requirements are defined in ISO 16750 together with the supplement Volvo Car Corporation Supplement to ISO 16750 (doc no. 31822854).

Additional requirements, information and guidelines on how to interpret and use ISO 16750 could also be found in document Volvo Car Corporation Supplement to ISO 16750 (doc no. 31822854). The definition of designation coding could be found in ISO 16750-1: General

Front Lamps (Including Headlamps, Bumper Lamps, Front Side Markers, etc.)
ISO 16750-C-E-K-Z-A/D-IP6K4K/IP6K7/IP6K9K
C = Supply Voltage 9-16V,
E = Rigid point,
K = Temperature interval -40°C to +105°C,
Z = Yes, Yes, Yes, Yes, 400 cycles, Yes, According To Corrosion Test VCS 1027-1449, Yes, (2,3), Yes, Yes, Yes,
A/D = Engine compartment/exterior,
IP-Classification: splashed water with increased pressure (IP6K4K), wading (IP6K7), high pressure / steam-jet cleaning (IP6K9K), 6K = dust-tight.

ISO
ISO 16750-2 Electrical loads (Supply voltage)

ISO 16750-3 Mechanical loads (Mechanical exposure)
ISO 16750-4 (Operating Temperature)
ISO 16750-4 (Climatic test)
ISO 16750-5 Chemical loads (Chemical loads)
ISO 20653 Road vehicles Degrees of protection (IP-Code) (Protection against dust and water)

REQ-30650 v3 Limp Home

A defined Limp-home behavior is to be applicable for functions / sub-functions in Functional Importance Class C and B.

The object is to provide a back-up function to replace ordinary functions in case of not operating, for example to allow the car to be driven to a work-shop, without exposing anyone inside or outside the car to danger.

If any function / sub-function have changed to limp-home status, the driver shall be made aware of an obvious reduction in the function, or by a warning light or display indication.

A design FMEA shall establish if a limp home function is necessary for the specific system in order to avoid unnecessary inconvenience for the customer.

Limp-home for functions / sub-functions in Functional Importance Class C and B are as listed in table: Functional Importance Classification of Electrical Functions

Limp Home is a fail safe mode which shall be activated when a serious error occurs in the MCU's HW or SW and shall be independent from the main logic voltage regulator.

REQ-30651 v3 Electrical feed at crash

In an accident situation the electrical feed to safety related functions as hazard, motorized seats, brake lights, position lights, cabin light shall not malfunction

In an accident situation the electrical feed to following systems shall be turned off:

Exterior light, except hazard and position lights if there is no vehicle speed or that vehicle speed signal is missing. Crash level >= 1

Wiring to devices, activated under or after a crash mode has been set, must be installed in known zones of minimum deformation.

REQ-55647 v3 AEC - Q102 RV level

Requirement

The reliability validation for LED-s according to appendix 7a in AEC - Q102 has to be done as stated below:

- For DRL, front position light, rear position light and side marker LED-s, according to RV-level 1 "long life exterior"
- For all other LED-s, according to RV-level 0 "interior and normal life exterior"

LED-s with RV-level 0, 1 and 2 has to be complimented with over-stress test that is recommended in appendix 7a.

As a result of the over-stress test, Supplier shall confirm the failure mode of each LED.

REQ-30648 v2 Functional Importance Classification of electrical functions

Each Electrical Function is classified in accordance with the definitions defined in the FRD Complete Vehicle:

The electrical functions in the vehicle shall be classified by importance during normal operation according to:

Functional importance Class C: Any feature/function that is essential to the safe operation and control of the vehicle.

Functional importance Class B: Any function that enhances but is not essential to the operation or control of the vehicle.

Functional importance Class A: Any function that provides a convenience (e.g., comfort, entertainment).

The consequences for the customer of functional faults occurring in the electrical system determine the Functional Importance Classifications. The fault may cause complete functional failure, “incorrect” or unintended function, or incorrect timing of functions. Functional Importance Classifications are determined by the most severe customer consequences.

Electrical classification of electrical functions, see table below:

Electrical Function Integration	Functional Importance class
High Beam	C
Low Beam	C
Front Position Light	C
Front Fog Light	B
Front Direction Indicator	C
Front side marker	C
Cornering lamp	B
Separate daytime Running Light	B
Side Direction Indicator	B
Puddle Light/approach light	A
CHMSL	C
Reverse Light	B
Rear Position Light	C
Rear Direction Indicator	C
Rear Fog Light	C
Stop Light	C
Number Plate Illumination	B

Bulb failure warning	B
Bending Light	B
LWR	B
Home safe light	A
Rear side marker	C

REQ-30649 v2 Special cases: Diagnostic sessions

When running Diagnostic Services, exceptions from the normal requirements can be necessary regarding fault effects links between Functional Importance Classifications.

In these cases attention must be paid to the increased risk for: personal injury in, for example, automatic closing of windows in case of anti-trap protection. abnormal loading due to duration, switching time, or frequency, e.g. extremely short activation of relays, or high activation frequency with heavy electrical load.

REQ-30652 v2 Long term loading

Environmental factors (with the exception of electrical functional environment), are established for each electrical component, depending on its location.
Water, salt or dust particles may not exist inside electrical installations where corrosion can result in increased risk for overloading or function failure.

E.g. Junction boxes in the engine bay must be sealed that salt water or snow may not enter. Cable protection hoses must be installed that water can exit before grommets and housings to components.

REQ-30653 v4 Functional Status Classification

This element describes the functional status of a Device Under Test during and after a test.

The minimum functional status shall be given in each test. An additional test requirement may be agreed between device supplier and vehicle manufacturer.

Vehicle manufacturer and device supplier shall specify operations that are not allowed.

(These classes correspond to Functional status classification A-E according to ISO 16750-1:200**6**)

Class A

All functions of the device/system perform as designed* during and after the test.

Class B

All functions of the device/system perform as designed* during the test. However, one or more of them may go beyond the specified tolerance. All functions return automatically to within normal limits after the test. Memory functions shall remain class A.

Class C

One or more functions of a device/system do not perform as designed* during the test but return automatically to normal operation after the test. Levelling and swivelling may go to limp-home mode.

Class D

One or more functions of a device/system do not perform as designed during the test and do not return to normal operation after the test until the device/system is reset by simple “operator/use” action.

Class E

One or more functions of a device/system do not perform as designed during and after the test and cannot be returned to proper operation without repairing or replacing the device/system.

*) shall fulfil VCC photometry requirements. The light intensity may vary up to 30% in voltage conditions up to the upper and lower limit of the working area. Levelling and swivelling system shall have full functionality.

For all lighting and signaling function excepting puddle light: This photometry requirement is applicable also for the REQ-58884 about derating light output.

Only for puddle light, the photometrical requirement -30% does not apply during derating test (REQ-58884).

REQ-433038 v1 Photometric Maximum Measurement

Scope

Front lighting functions equipped with LED light sources.

Instructions

Measurements of the photometric maximum shall be conducted in accordance with SAE J1889.

4.1.4.7.1 ELP Motor/pumps (Actuators)/ Motor & Actuator drivers

ELP Motor/pumps (Actuators)/ Motor & Actuator drivers

This category shall be chosen if the component/system is an, or is related to, electrical motor/s or pump/s.

Note that this category is not valid for
* Control electronics such as stepper motor controllers.
* Electrical coils and solenoids.

REQ-613 v8 ELP-Overloading or stalling of electrical motors

Attribute: Electrical Performance
Requirement Classification: Intermediate
Change classification: Editorial
Design Target :
Purpose (rich text): The purpose of this requirement is to prevent that electrical motors break down, degrade or cause thermal events, due to blocking that can occur during normal operation of the system.
Scope: All electrical motors in the vehicle.

Valid for	Yes/No/Support	Comment
Architecture	No	

Function	No	
System	Yes	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.
- Verification according to actual DVM shall be performed .
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfilment of this requirement.

Requirement:

Overloading or stalling of electrical motors due to e.g. increased friction or temporary blocking in mechanical system, shall not result in damage or degradation to any electrical system components, including fuses or other protection devices in the electrical system.
The power dissipation must be controlled in the system by limiting current and/or activation time.

Note 1: The electric motor's design FMEA may impose additional performance constraints on the electric motor.

Note 2: For systems where the motor have more than one direction of movement (i.e. electrical power windows, power operated tailgate, etc.), all directions of movement must be considered.

DVM:

Method type: Engineering judgement

Design review of drawing/s, CAE model/s and physical layout. An analysis of the system to determine the critical operating conditions concerning supply voltage, ambient temperature and load shall be done (note: maximum current is not necessarily the worst case).

Method type: Physical test - Laboratory

Stall and overload test shall be performed, with measurement of the current, temperature and other relevant parameters, to ensure that the system don't degrade or break down due to increased friction in mechanical system or temporary blocking.
The current and temperature shall not exceed the maximum designated values for the system, including but not limited to fuses, cables, drivers and connectors.

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

An analysis of the system to determine the critical operating conditions concerning supply voltage, ambient temperature and load shall be done (be aware of that maximum current is not necessarily the worst case). The result shall be used as basis for the test setup. Details of the test setup and operating conditions shall be described in the test plan.

The system shall be activated in all modes that a customer can utilize. If the system is current limited the measurement shall continue until a stable temperature is achieved. If the system is turned off due to for example overcurrent or time, the possibility of multiple restarts should be taken into consideration and their effect measured. After the test, the system shall have full function and no signs of degradation are allowed.

Note: During snow packing test for wiper motors, shut down due to thermal overload is not allowed and the system shall have function during the whole test.

Guidelines:

Example of system and factors that can affect the system are given below. There might be other systems or factors that can affect the system, than those mentioned below.

System	Factors/exposures to take into consideration
Electrical cooling fan	Snow packing, deep water wading, mechanical seizure, etc.
Electrical power window	Snow, ice, ageing, dust, etc.
Electrical sun-roof	Mechanical seizure, frozen water, etc.
Electrically foldable mirrors	Mechanical seizure, frozen water, etc.
Power operated seats	Low temperatures, mechanical seizure, blocking by random objects, etc.
Power operated tailgate	Mechanical seizure, frozen water, etc.
Retractable roof	Mechanical seizure, frozen water, etc.
Washer pump	Frozen fluid, ice-slush, contamination in the washer fluid, etc.
Wiper motors	Snow-packing, frozen wiper blades, other mechanical blocking, etc.

REQ-1043 v8 ELECTRIC MOTOR OVERLOADING AND STALLING EFFECT

Attribute: Electrical Performance
Requirement Classification: Hard
Change classification: Editorial
Design Target :

VMR 0448 ELECTRIC MOTOR OVERLOADING & STALLING EFFECT

Mechanical overloading or stalling of the electric motor due to increased friction in the system or blocking shall not cause:

(a) Visible thermal or physical damage to the electric motor or the electric motor's interfaces (connectors, terminals, wiring, etc), or

(b) Permanent degradation to the functional performance of the electric motor's interfaces.

Devices specified for the overcurrent, overload or over temperature protection of the electric motor (such as internal and external fuses) are excluded from the scope of this requirement, but must meet the start-up and speed change transient current requirements specified for the motor.

Note: The electric motor's design FMEA may impose additional performance constraints on the electric motor.

DVM:

Method Type: Physical Test - Laboratory

An analysis of the system to determine the critical operating conditions concerning supply voltage, ambient temperature and load shall be done (note: maximum current is not necessarily the worst case). The result shall be used as basis for the test setup.

The system shall be activated in all modes that a customer can utilize. If the system is current limited the exposure shall continue until a stable temperature is achieved. If the system is turned off (for example due to overcurrent or time), the possibility of multiple restarts should be taken into consideration and their effect measured.

Acceptance criteria:

Post testing, the motor shall not exhibit:

(a) Visible thermal or physical damage to the electric motor or the electric motor's interfaces (connectors, terminals, wiring, etc), or

(b) Permanent degradation to the functional performance of the electric motor's interfaces.

Details of the test setup and operating conditions shall be described in the test plan. The test report shall include test setup, operating conditions and detailed test results.

4.1.4.7.2 General electronics

REQ-600 v6 ELP-Design requirement for wiring components

Attribute: Electrical Performance
Requirement Classification: Intermediate

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

Change classification: Editorial

Design Target :

Purpose (rich text): Main reason for this requirement is electrical reliability.
The standard gives general guidelines to be used during the connector design stage. The standard shall be considered as a guideline for connectors and wiring.

Scope: Valid for all design of electrical connectors and wiring.
The standard is grouped in:
Electrical continuity
Electrical isolation/sealing
Device assembly
Harness assembly
Vehicle assembly
Materials
Serviceability
Environmental requirements
High voltage (> 60V) application requirements

Valid for	Yes/No/Support	Comment
Architecture	Support	
Function	No	
System	Yes	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.
- Verification according to actual DVM shall be performed .
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfilment of this requirement.

Requirement:

Wiring components shall be designed in accordance with Wiring component design guidelines, SAE/USCAR-12 revision 3.

Deviation from this standard shall be discussed and evaluated with the appropriate Volvo Cars Corporation Subject Matter Expert before the final design is selected .

DVM:

Method type: Engineering judgement

Verify that requirements and appropriate verification method are included in the technical descriptions/documents.
Engineering judgement performed by a team including at least one Volvo Cars Corporation Subject Matter Expert.
Special attention must be taken to campaign prevention history.

REQ-609 v6 ELP-Reliability requirements for power semiconductors

Attribute: Electrical Performance
Requirement Classification: Intermediate
Change classification: Editorial
Design Target :
Purpose (rich text): Main reason for this requirement is electrical reliability.
All power semiconductors shall be selected to meet or exceed the required vehicle service life without any degradation.
Scope: All power semiconductors including smart semiconductors.

Valid for	Yes/No/Support	Comment
Architecture	No	
Function	No	
System	Yes	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.
- Verification according to actual DVM shall be performed.
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfilment of this requirement.

Requirement:

All power semiconductors shall be selected to meet or exceed the required vehicle service life without any degradation.

Any combination of singular or repeated overload conditions or short circuits predicted to occur over vehicle service life shall not cause residual damage or shorten the life of the semiconductor device.

A protection strategy with a combination of SW and HW is normally needed to limit the number of attempts to switch externally induced excessive current or shorted load.

Power semiconductor integrated temperature protection functionality is not allowed to serve as replacement for a fuse.

Standard design parameters such as switching losses et cetera needs to be included in dimensioning where Pulse Width Modulation (PWM) or other types of high frequency switching is used.

DVM:

Method type: Engineering judgement

Documented Life expectancy simulation including any single or repeated overload or short circuit condition that can be predicted to occur in the application over vehicle service life.
Note: Worst case stress conditions for semiconductors may occur due to combinations of load and temperature that are not necessarily the extreme predicted values. Temperature gradients shall be considered.

Method type: Engineering judgement

Confirmation by semiconductor supplier that application is safely inside the semiconductor specification under all environmental conditions given by the application.

Method type: Physical test - Laboratory

Test with actual load (including pulses, in-rush currents, back emf , inductive kickback and overload conditions) under worst case environmental conditions according to specification. In case the real load of the device cannot be used for this test a synthetic load with equal characteristics shall be specified.

Guideline:

Long term steady state high temperature but also temperature gradients has major effect of the life time of the semiconductor, both internal heat up and environmental temperature must be considered. A semiconductor that is exposed to harmful temperatures will gradually be destroyed and the electrical properties will be degraded in time.

Cooling strategy is of major importance and there are many ways to cool the semiconductor as cooling flange or via PCB. Fan shall be avoided.

Release of inductive loads and electrical motors can cause high reverse voltage and high reverse

current peaks that might need extra protection for the semiconductor. A stalled electrical motor will cause an increased current.

Slow rise and fall times of PWM can cause extra heat generation.

Resistance in lamps, motors, heaters etc. are low directly at activation and can cause a significant inrush current, but also capacitor initial charge can cause a significant inrush current . This can cause harmful initial heat up and residual damage of the semiconductor but also self-protection output turnoff.

Current limitation in circuit can cause heat generation, as for example soft start function in smart semiconductors.

Floating gates on FET's shall be avoided. Body diodes in FET might destroy the ECU during reverse voltage.

REQ-8768 v6 ELP-Automotive grade qualification

Attribute: Electrical Performance
Requirement Classification: Intermediate
Change classification: Editorial
Design Target :
Is Generic : No
Purpose (rich text): To ensure that electrical components are robust towards automotive harsh environment.
Scope: All internal electrical components

Valid for	Yes/No/Support	Comment
Architecture	No	
Function	No	
System	No	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.
- Verification according to actual DVM shall be performed.
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfillment of this requirement.

Requirement

Components used shall be qualified according to automotive standard. Compliance with the following documents are mandatory whichever is applicable:

- AEC - Q100: Failure Mechanism Based Stress Test Qualification For Integrated Circuits
- AEC - Q101: Failure Mechanism Based Stress Test Qualification For Discrete Semiconductors
- AEC - Q102: Failure Mechanism Based Stress Test Qualification for Discrete Optoelectronic Semiconductors in Automotive Applications
- AEC - Q103: Failure Mechanism Based Stress Test Qualification for Sensors in Automotive Applications
- AEC - Q104: Failure Mechanism Based Stress Test Qualification For Multichip Modules (MCM) In Automotive Applications
- AEC - Q200: Stress Test Qualification For Passive Components

This requirement applies to all projects, including but not limited to SREA(Supplier Request Engineering Approval), VPC(Volvo Part Change), and similar initiatives.

Note 1: Sub Integrated Circuits, Discrete Semiconductors, Discrete Optoelectronic Semiconductors, and Passive components on Multichip Modules (MCM) shall also be qualified according to AEC-Q for each respective field.

Note 2: For MEMS(Micro Electro-Mechanical System) components other than pressure sensors, applicable standards beyond AEC-Q (such as ZVEI ARRA Handbook) should be referenced where relevant.

Note 3: For DC-Link Capacitors, relevant qualification standards beyond AEC-Q (such as ZVEI Basic Qualification of DC-Link Capacitors for Automotive Use) should be identified and referenced as applicable.

Note 4: If the components belong to power electronic modules, refer to ECPE guideline AQG 324 (Qualification of Power Modules for Use in Power Electronics Converter Units in Motor Vehicles).

DVM

Engineering judgement

Confirmation that only automotive grade quality components are used. If there is any deviation from above qualification requirements, supplier need to confirm that counter measures to achieve automotive business qualification on par with AEC-Q standard and other guidelines mentioned above are met. Supplier shall create a comparison of what qualifications are done vs what are required above and shall act to close the gap.

BOM(Bill Of Materials) template:

A standard BOM Template can be found in the HWSOW (Hardware Statement of Work) package. It includes an automotive qualification check for each MPN (Manufacturer Part Number), which shall be completed to comply with this requirement. The document is titled "Volvo Cars ECU BOM Template" and prepared by procurement team.

REQ-549 v7 ELP-Electric energy consumption requirement on component

Attribute: Electrical Performance
Requirement Classification: Intermediate
Change classification: Editorial
Design Target :
Purpose (rich text): Minimize electrical energy consumption.

Scope: Network connected components.

Valid for	Yes/No/Support	Comment
Architecture	No	
Function	No	
System	No	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.
- Verification according to actual DVM shall be performed.
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfillment of this requirement.

Requirement

Component design shall be made to always minimize its electrical energy consumption in all given situations , this includes following aspects:

- Preparation for minimal component electrical energy consumption:
  - Minimize/consider number of included parts/blocks.
  - Consider internal usage and power supply strategy to allow actuators to normally be in sleep/standby while sensor objects more often in active state.
  - I/O ’s possible to be active only when needed.
  - Regulated power usage to obtain minimum energy consumption.
  - etc.
- Secure that your surrounding support low electrical energy consumption:
  - Identify and communicate to your and adjacent systems to secure low electrical energy consumption on your component.
  - etc.

Current consumption shall be specified for all relevant use cases, e.g. quiescent current, alive without any customer function, prepared for customer function, etc.

Requested energy consumption data shall be inserted in EiDB
(Electrical Interface Database).

The components shall, as a minimum requirement level, meet Electrical System Architecture/Vehicle Mode Management current consumption requirements.

Note: Waiting for a button push or a specific input signal shall not be interpret as “Active”, it shall be regarded as a Standby-state.

DVM

Engineering judgement

Carry over HW solution:
Optimized SW solution and/or other changes to decrease energy consumption shall be documented.

Carry over solution design from previous project with any updates done on the component:
Optimized HW/SW solution and/or other changes to decrease energy consumption shall be documented.

New solution and new component compared with previous project:
State design effort made to minimize energy consumption.

Physical test on component:

Verify that the components meet of MEE specified current consumption levels for all relevant use cases.

Physical test complete vehicle

Verify that the components meet of MEE specified current consumption levels for all relevant use cases.

Guideline

- On state time for internal HW peripheral and microcontroller functional blocks (for example SPI, IO's, ADC etc.) shall be minimized. Sampling frequency, internal prescaler for clock frequency, polling etc. shall be set to minimum.

REQ-686 v6 ELP-Electrical component - internal short circuit

Attribute:	Electrical Performance
Requirement Classification:	Hard
Change classification:	
Design Target :	
Is Generic :	Yes

Purpose (rich text): An internal short-circuit in a (non-EDS) component causing an over-current must not result in thermal damage to the electrical component or its interfaces.

Scope: All non-EDS electrical components.

Valid for	Yes/No/Support	Comment
Architecture	Support	
Function	No	
System	Yes	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.
- Verification according to actual DVM shall be performed.
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfilment of this requirement.

Reference:
IEC 62368-1: 2020

Requirement:
Internal short-circuit in a (non-EDS) component causing an over-current must not result in thermal damage to the electrical component or its interfaces.

All electrical components shall be internally short-circuit protected to fulfill the IEC 62368-1: 2020, chapter 6.

If this design is not feasible and the component relies on an external over-current protection device (OCPD) to fulfil this requirement. A short-circuit not tripping the OCPD must not result in thermal damage to the electrical component or its interfaces. The rating or the logic of the OCPD must be evaluated and risk assessed. The OCPD maximum rating and device type or the logic description shall be included in the component drawing or documented (technical descriptions/documents or similar primary documentation).

DVM:
Method type: Virtual assessment, physical test according to IEC 62368-1:2020 chapter 6.

Critical areas, regarding internal short circuit, in the component shall be included in the D-FMEA.

Verify that requirements and appropriate verification method are included in the technical descriptions/documents.

Engineering judgment performed by a team including at least one Volvo Car Corporation Subject Matter Expert.
Special attention must be taken to campaign prevention history.

Guidelines:
Some examples of things causing a short circuit are:

- *Failure in a capacitor or other components*
- *Electrochemical migration*
- *CAF*
- *A piece from a copper wire*
- *High current, overheating / Overloading of components*
- *Arching of components*
- *Loose joints/connections*

REQ-687 v5 ELP-Electrical component - substrates and leadframes

Attribute: Electrical Performance
Requirement Classification:
Change classification: Editorial
Design Target :
Purpose (rich text): This requirement is to ensure no harmful effects, causing a thermal event, from material or change of material property.
Scope: All components.

Valid for	Yes/No/Support	Comment
Architecture	No	
Function	No	
System	No	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.
- Verification according to actual DVM shall be performed.
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfilment of this requirement.

Requirement:
Substrate and lead frames materials shall be chosen in such a way that the available energy cannot initiate or maintain combustion.

Failure modes must be minimized if they can lead to a change of the properties of chosen substrate and lead frames materials in such a way that displacement of conductors leading to uncontrollable arcing can occur.

The possibility for conductive anodic filaments (CAF) and other electrically driven corrosion processes leading to unwanted conductive paths shall be taken into consideration.

Special attention must be taken to campaign prevention history.

DVM:
Method type: Engineering judgement

Verify that requirements and appropriate verification method are included in the technical descriptions/documents.
Engineering judgement performed by a team including at least one Volvo Car Corporation Subject Matter Expert.
Relevant parts of the requirements in the campaign prevention mandatory check list must be considered.

REQ-628 v7 ELP-Substrates for mounting of electrical components

Attribute: Electrical Performance
Requirement Classification: Intermediate
Change classification: Editorial
Design Target :
Purpose (rich text): The purpose of this requirement is to ensure that the PCB's in electrical and electronic equipment can withstand the environment in the vehicle.
Scope: All electrical and electronic equipment containing PCB's (Printed Circuit Boards).

Valid for	Yes/No/Support	Comment
Architecture	No	
Function	No	
System	No	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can

most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.

- Verification according to actual DVM shall be performed.
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfilment of this requirement.

Requirement:

The substrate for mounting of electronic components (e.g. ceramic, flexible PCB's, rigid PCB's) shall be selected to withstand the electrical and environmental factors in the specific application and position.

DVM:

Method type: Engineering judgement

Documented design inspection. The design inspection shall be performed by a team including at least one Volvo Cars Corporation engineer.

REQ-595 v9 ELP-Conformal coating of printed circuit boards

Attribute: Electrical Performance
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes
Purpose (rich text): Main reason for this requirement is electrical reliability, and to protect electronic equipment from degradation, malfunction or breakdown, due to humidity or other contamination in the vehicle.
Scope: All electrical and electronic equipment containing PCB's (Printed Circuit Boards).

Valid for	Yes/No/Support	Comment
Architecture	No	
Function	No	
System	No	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can

most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.

- Verification according to actual DVM shall be performed.
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfilment of this requirement.

Requirement:

For electronic modules supplied by relay or other switching component (not powered at all times) a full PCB conformal coating is strongly recommended.

For electronic modules supplied by continuous power supply, i.e. powered (with e.g. 48V, 12V, 5V, 3.1V) at all times, conformal coating is mandatory.

In case a full conformal coating is not possible with respect to physical design, component properties[1], solder joint reliability concerns[2], process constraints[3], or material compatibility limitations, selective conformal coating that fully covers all components, solder joints and circuit tracks which are powered at all times shall be applied.

If full conformal coating is not possible, for the reasons mentioned above, or any other reason, this must be reviewed by and agreed with Volvo Car Corporation subject matter expert.

In case electronic modules supplied by continuous power supply cannot be coated, for the reasons mentioned above, or any other reason, mitigation measure shall be taken to achieve appropriate protection level, this must be reviewed by and agreed with Volvo Car Corporation subject matter expert.

For all electronic modules, exposure to humidity shall not cause any residual damage or increase in quiescent current.

Note: Be aware that the coating process, coating properties, as well as the properties of the PCBA (geometry, placement, component packages, etc.) plays a major part in the fulfillment of the coating coverage intention. For instance, sharp corners on a component together with too low viscosity in the applied coating can at worst lead to bad coating coverage and over time also intrusion of humidity.

[1] e.g. non-sealed relays, IGBT, electrolytic capacitors with vent holes covered by the coating, connector, LED, CMC, etc.
[2] e.g. BGA, flipchip, CSP, D/QFN, etc.
[3] e.g. clear-out area between connectors.

DVM:

Method type: Engineering judgement

The module supplier must supply a circuit board layout drawing showing copper and component placement. The layout shall also identify the conformal coating coverage.

Method type: Engineering judgement

Verification according to IPC-A-610 rev.H, 10.8 Conformal Coating; Class 3
Deviation from this standard shall be discussed and evaluated with the appropriate Volvo Car Corporation subject matter expert before the final design is selected.

Method type: Physical test

It shall be proven by testing that the unit does not exhibit any residual damage or increase in quiescent current by exposure to humidity. The required test sequence, visual inspection and quiescent current acceptance criteria is given by latest valid revision of ‘SUPPLEMENT TO ISO 16750’ doc. no. 31822854.

REQ-596 v10 ELP-Connections in the electrical system

Attribute: Electrical Performance
Requirement Classification: Hard
Change classification: Editorial
Design Target :
Purpose (rich text): To ensure that all connections/inter-connections and the corresponding mating connector in the electrical system are chosen with respect to the voltage/current level and environmental factors given by the actual installation (e.g. vibrations, temperature, humidity).

Scope: Connectors in the electrical system including mating connectors on components (ECUs, sensors, actuators). Connectors internally inside an ECU.

Valid for	Yes/No/Support	Comment
Architecture	No	
Function	No	
System	No	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level

(Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.

- Verification according to actual DVM shall be performed .
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfilment of this requirement.

Requirement:
All connections/inter-connections in the electrical system shall be chosen with respect to the voltage/current level and environmental factors given by the actual installation (e.g. vibrations, temperature, humidity…).

All electrical connections (connectors including terminals and sealing, or related component) need to fulfil latest revision of SAE/USCAR-2.

High voltage connections (connectors including terminals and sealing, or related component) also need to fulfil latest revision of ISO20076.

- Amendment 1 of ISO20076:
  4.18 Connection resistance (voltage drop). This test shall also be preformed before and after the Environmental test sequence 1 described in the latest valid revision of ‘SUPPLEMENT TO ISO 16750’ doc. no. 31822854.
- Amendment 2 of ISO20076:
  4.27 Current cycling at environmental temperature. This test shall be performed for 1008 cycles instead of 500 cycles.

All connections/inter-connections (e.g. Connectors, terminals and seals) in the electrical system need to be approved by connector specialist(s) at Volvo Car Corporation’s EDS-department. This includes sealing, vibration and temperature classification according to SAE/USCAR-2 and ISO20076.

Note 1:
The SAE/USCAR-2 and ISO20076 covers all the classifications (tightness, vibration, temperature…), technical requirements, tests to be performed and DVPR.

Note 2:
The requirements and procedures in ISO20076 are also valid for connections in subassemblies e.g. the HV battery assembly.

Note 3:
Connectors and corresponding mating connector can be for example connectors or pin headers located inside ECUs or mating connectors located on a harness.

DVM:
Method type: Engineering judgement
Method type: Physical test
Tests according to SAE/USCAR-2. For High voltage connections: also tests according to ISO20076.

Test report to be approved by connector specialist(s) at Volvo Car Corporation's EDS-department.

REQ-695 v8 ELP-Wiring harnesses and electrical component separation from flammable fluids

Attribute: Electrical Performance
Requirement Classification: Hard
Change classification: Editorial
Design Target :
Purpose (rich text): To prevent a thermal event due to flammable fluids (including fuel, washing fluid, coolant fluid, etc) coming in contact with a powered electrical circuit during electrical failure
Scope: All electrical components and wiring.
Electrical system and components which are in direct physical contact to flammable media (e.g. fuel pumps, washer fluid pumps, cooling water pumps) have a separate requirement.

Valid for	Yes/No/Support	Comment
Architecture	Support	
Function	Yes	
System	Yes	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.
- Verification according to actual DVM shall be performed.
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfilment of this requirement.

Requirement:
Wiring harnesses and electrical components must be installed well separated (e.g. more than 10cm, by cable duct or metal wall) from lines or containers with flammable fluids (including fuel, washer fluid, coolant fluid, etc).

If wire harness cannot be well separated appropriate measures shall be taken to fulfil safety issues and service life with no degradation during all driving conditions. Each routing not well separated shall be risk accessed, well documented and approved by the department responsible for Electrical Distribution Systems components and a team including at least one Volvo Car Corporation (Volvo Cars) Subject Matter Expert. A wire not well separated from flammable fluid lines shall fulfil requirements in applicable Volvo Cars' crash tests e.g. fuel in contact with an exposed powered electrical circuit is not allowed.

DVM:
Method type: Engineering judgement

Design review of drawing/s, CAE model/s and physical layout performed by a team consisting of subject matter experts from Volvo Cars like robustness to fire, ELP, etc.

Routing Quality Assessment
Verify that the wire harnesses are routed well separated from fuel lines and other lines or containers with flammable gases or liquids.

Method type: Engineering judgement – Wires not well separated from lines with flammable fluids

Wires not well separated from lines with flammable fluids shall be included as a separate item in all design reviews
e.g. Routing Quality Assessment, EDS FMEA, Design review of drawings and 3D CAD-models.
Parameters that shall be considered in addition to those stated above: e.g. the crossover interaction shall be well controlled and rigidly clipped in a way that vibration or motion shall not lead them closer together than designed or lead to chafing.
Wires not well separated from lines with flammable fluids shall also be included as a separate item in the FMEA for those line routings. The department responsible for Electrical Distribution Systems components is responsible to put this requirement on department responsible for flammable fluid line routing.

Method type: Physical test - General
Define appropriate verification method to fulfil requirement including applicable vibration tests and brand specific durability test cycles. These shall be included in the technical descriptions/documents.
Details of the test setup and operating conditions shall be described in the test plan. The test report shall include test setup, operating conditions and detailed test results. All special attentions and parameters mentioned above shall also be considered.
Visual inspection of material from vibration test. Volvo Cars' long term vibration test. Visual inspection of installation in vehicle on all variants in each vehicle series.

Method type: Physical test - Wiring not well separated from lines with flammable fluids
Wiring not well separated from fuel lines shall be included as a separate item in all applicable tests and test reports.
Visual inspection after tests shall be made, no sign of wear, chafe, dislocated fixation or other relevant failure are allowed.

Wires not well separated from lines with flammable fluids shall be tested in applicable crash tests. Requirements in applicable crash tests shall be fulfilled e.g. no potential risk of failures where the flammable fluid comes in contact with a potentially powered electrical circuit is allowed.

REQ-601 v7 ELP-Electrical component orientation

Attribute: Electrical Performance
Requirement Classification: Intermediate
Change classification: Editorial
Design Target :
Purpose (rich text): Main reason for this requirement is electrical reliability.

This requirement is to ensure that liquid (e.g. water, coffee , washer fluid) cannot enter the component or connector resulting in electrical failure or electrical degradation (e.g. short circuit or corrosion).

Scope: All components with openings leading in to electrical components or circuit boards , including sealed connectors.

Valid for	Yes/No/Support	Comment
Architecture	Support	
Function	No	
System	Yes	If analysis show that the system protects the component, otherwise support.
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.
- Verification according to actual DVM shall be performed.
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfilment of this requirement.

Requirement:

Electrical component orientation shall be positioned to divert liquid (e.g. water, coffee, washer fluid) away from the connector and component openings.

No liquid is allowed to accumulate in the connector or component openings during vehicle

operation or service.

If the requirement is not fulfilled on component level, the component, surrounding and/or system solution shall take measures to divert liquid or to make it equally safe from liquid intrusion.

DVM:

Method type: Engineering judgement

Design review of drawing/s, CAE model/s and physical layout

REQ-632 v7 ELP-Worst case circuit analysis

Attribute: Electrical Performance
Requirement Classification: Intermediate
Change classification: Editorial
Design Target :
Purpose (rich text): To evaluate mathematically, circuit performance attributes against performance tolerance limits under simultaneous existence of all the most unfavourable conditions being at realizable limits. Sources of variations can be drift due to aging, component quality level, environmental stress, other electrical influences.
Scope: All electronic components

Valid for	Yes/No/Support	Comment
Architecture	No	
Function	No	
System	No	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.
- Verification according to actual DVM shall be performed.
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfillment of this requirement.

Requirement:

A WCCA(Worst Case Circuit Analysis) shall be completed and submitted to the Volvo Cars Corporation for each circuit block. The sign-off on the WCCA shall be done by approving a summary matrix showing percent margins for all parameters of interest (e.g. junction temperature considering operating temp and self-heating, power ratings, logic levels, leakage current, etc.)

This document shall include the following:

Functional block diagram, circuit description, schematic, bill of materials, theory of operation, description of functionality provided by each component, environmental conditions (temp, voltage, EMC, ground shifts, interface), assumption table*(component specifications/assumptions), analysis schematic (with and without parasitics), worst case analysis, stress analysis, A/C analysis (if required), transient analysis, summary, peer review comments and bench test results.

*Assumption table: The assumption table shall include all key component values to be varied or evaluated. This table shall be included at the beginning of the document and include two columns:

1) Component values (e.g. $R8_{min}$ = 920 Ω , $R8_{nom}$ = 1kΩ , $R8_{max}$ = 1.080 kΩ)

2) Source of the assumption (e.g. supplier data, test data, etc.)

The preferred format for this report is a Mathcad document. P-spice or Saber simulation tools are acceptable. However, if a simulator is used, Worst Case models must be verified and provided upon request. All equations must be visible in the document.

Peer Review Process : It is highly recommended that the Tier 1 Supplier institutionalize a Peer Review Process, using the supplier's Subject Matter Experts, to review assumptions and key models/equations for each circuit block. The Peer review process shall be conducted before submitting the WCCA to Volvo Cars Corporation.

Marginal Result Deep Dive : If the %margin is less than 5%, for any analysis, there must be a Peer Review conducted at the supplier. The team must conduct a deep dive of all assumptions, models and equations. The Summary Matrix must list the members of the Peer Review Team for each Marginal Result Deep Dive in the comment field. The supplier shall keep meeting minutes of Deep Dive Reviews and shall take appropriate actions as identified by the team.

If the circuit does not meet Extreme Value Analysis, a Monte Carlo analysis shall be conducted. Depending on the results of the Monte Carlo analysis, a Volvo Cars Corporation engineering and management decision will be made regarding the usage of this circuit.

Additionally, any device that has results within 10 % of the parts temperature rating shall be thermo-coupled during DV/PV testing and verify the temperature of the device is acceptable.

Note1: Regardless of the temperature stated for the EMC test plan, all circuits must be designed and analyzed for all known transients, over the entire operational range of the module.

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Template GRS 10.03 Security Class: Proprietary

Additionally, if the EMC specification calls out any tolerances or ranges for transients, the module must be designed and analyzed for the worst-case condition.

Note 2: For outputs that are PWM'd, make sure to include switching losses in the output driver analysis.

Note 3: make sure to include reverse battery power dissipation in the output driver analysis. Reverse battery is to be done over the entire temperature range.

DVM:

Method type : Engineering judgement

Sign-off on WCCA summary matrix shall be done.

REQ-615 v8 ELP-Mean time between failure prediction on electronic components

Attribute: Electrical Performance
Requirement Classification: Intermediate
Change classification: Editorial
Design Target :
Purpose (rich text): The electronic components shall be designed without having any degradation, intermittent or permanent loss of function for the complete environmental range of conditions. As a method to conduct reliability prediction on electronic components, MTBF(Mean Time Between Failure) shall be used.

Scope: All electronic components

Valid for	Yes/No/Support	Comment
Architecture	No	
Function	No	
System	No	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.
- Verification according to actual DVM shall be performed.
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfillment of this requirement.

Requirement:

MTBF(Mean Time Between Failure) shall be calculated by suppliers on electronic component level according to MIL HDBK 217F notice 2, Siemens Norm 29500, IEC 61709 or similar.

The calculation shall be yielded based on various thermal mission profile from the actual position in the vehicle considering its on/off operating phase, permanent working phase under continuous power feed, storage or dormant phase. Operating profile for component shall be defined in DPR.

Reliability predictions contain numerous assumptions and different standards gives a different calculation result. Therefore, it’s recommended to use the given data to secure reliable design rather than only focusing on given MTBF figure.

Examples of activities to secure reliable design:

- Identification of highest failure contributors e.g. components with highest FIT(Failures In Time) rate and focus on improvement, scrutinizing their working stress factors
- Identification of potential design weaknesses
- Evaluation of alternative designs or selection of components
- Assessment of overall quality assurance program of suppliers

Reference documents to evaluate e.g. schematic, layout drawing, BOM(Bill Of Material) including FIT rate and etc. shall be provided by suppliers. The document shall be reviewed by component owner.

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Note: Technically MTTF(Mean Time To Failure) should be used for electronic components since they're referenced to non-repairable items, however, MTBF is used as a reliability term since it's more commonly used for both repairable and non-repairable items.

DVM:

Method type: Engineering judgement

The highest failure contributors shall be shown with initial FIT rate, what has been done to mitigate the FIT rate and the final FIT rate by suppliers.

REQ-602 v10 ELP-Endurance requirements for electrical components in complete vehicle

Attribute: Electrical System Attributes
Requirement Classification: Intermediate
Change classification: Editorial
Design Target :
Purpose (rich text): Ensure that all parts of the electrical system are designed to withstand applicable environmental factors.
Scope: All designs that direct or indirect are included in the complete electrical system, e.g. architecture-, system- and component level.

Valid for	Yes/No/Support	Comment
Architecture	Support	
Function	No	
System	Yes	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.
- Verification according to actual DVM shall be performed.
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfilment of this requirement.

Requirement:
All parts of the complete electrical system shall be designed to withstand all environmental factors (e.g. vibrations, temperature, humidity, chemicals and customer usage) in the whole operating

voltage range for the required service lifetime of the vehicle without intermittent or permanent loss of function.
For serviceable parts (e.g. light bulbs, batteries) specific service life requirements may apply.
Volvo Cars Corporation has to provide to the supplier all the details regarding the environment where the component will be installed (e.g. temperature mission profile, humidity, vibration levels, packing models, etc.). Installation guidelines shall be provided by the supplier.

DVM:
Method type: Physical test - Road

The component shall take part in applicable Volvo Cars Corporation standard durability tests such as VPT1, VPT2, VPT3, CORCAR (previously named LPK), LPH, LPD, LVA, Full Vehicle Body rig (Skak-rigg), Chassie-rig, MUPP-rig etc.
Before starting the testing, all components and their installation shall be reviewed together with Supplier to comply with the design requirements.
The component shall have full functionality during and after the testing according to the component specification.
After test all components of the electrical system shall be analysed regarding functionality, and then visually inspected externally and internally according to the visual inspection criteria in latest valid revision of ‘SUPPLEMENT TO ISO 16750’ doc. no. 31822854.

Note:
This requirement shall not be sent directly to Supplier since the tests described are Volvo internal tests, but for matters herein which requires support, participation or cooperation from Supplier side, it befalls the component owner to formulate and plan those activities together with Supplier.

REQ-697 v8 ELP-Insulation of live parts and structures

Attribute: Electrical Performance
Requirement Classification: Intermediate
Change classification: Editorial
Design Target :
Purpose (rich text): Ensure personal safety - protect unintentional contact with the electrical system and reduce the risk for thermal events
Scope: All electrical components.

Valid for	Yes/No/Support	Comment
Architecture	Yes	ED to refine and cascade to EDS.
Function	No	
System	Yes	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can

most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.

- Verification according to actual DVM shall be performed.
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfilment of this requirement.

Requirement:
Insulation of live parts and structures

No uninsulated live parts or structures are to be used in the electrical system in order to prevent accidental short circuit by the customer and to protect the customer against unintentional contact with the electrical system.

This requirement is also valid during exchange of customer serviceable parts (e.g. light bulbs, fuses).

DVM:
Method type: Physical test - Laboratory

ISO 20653, IPXXC. Refer section “Requirements and tests for degrees of protection against

foreign objects and access” and additional letter C for test conditions and requirements.

REQ-31688 v4 ELP-Electrical component operational time

Attribute: Electrical Performance
Requirement Classification: Hard
Change classification: Critical
Design Target :
Is Generic : No
Purpose (rich text): To ensure the availibility and reliability of the electrical system in the vehicle for the vehicles required life time.

Scope: All electrical and electronic equipment in the vehicle.

Valid for	Yes/No/Support	Comment
Architecture	Support	

Function	No	
System	Support	
Component	Yes	

Note:

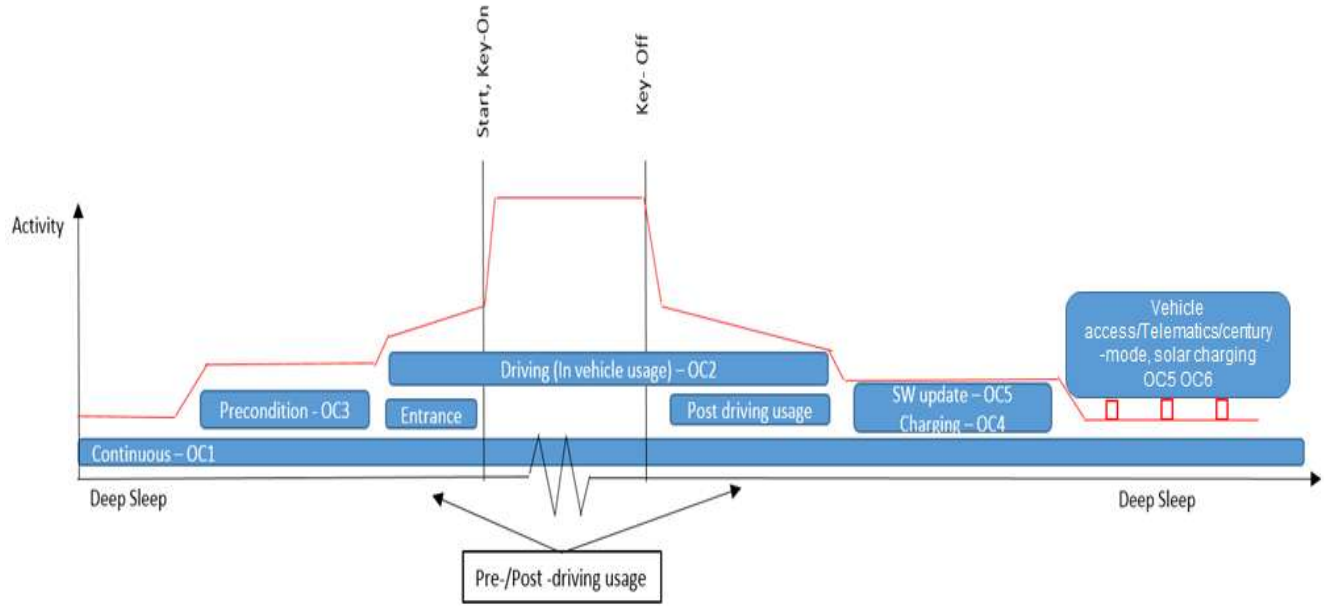
- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.
- Verification according to actual DVM shall be performed.
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfilment of this requirement.

Requirement:

All the electrical and electronic equipment in the vehicle shall have an operational lifetime and operating hours to ensure the required life time of the vehicle.
Required life time and operating hours will differ depending on Functional Importance Classification (FIC) and functional Operation Condition (OC).
Minimum life time and operating hours for each Operation Condition are specified in the table 1 below. Note that OC1 refers to the total operating hours with voltage supply to the component (OC2-6 are subsets of OC1).

Table 1 Operation condition

Operation state	Operation Condition	Operational time
Life time (regardless of operation condition)		≥ 15 years FIC C functions (300.000 km) ≥ 10 years FIC A/B functions (240.000 km)
Continuous feed or activity	OC1	≥ 131,500 h FIC C functions ≥ 88,000 h FIC A/B functions
Driving, (In vehicle usage)	OC2	≥ 20,000 h FIC C functions, ≥ 13,500 h FIC A/B functions available. Loads may be restricted.
Preconditioning only	OC3	≥ 6,000 h
Traction battery vehicles “Plugged in”, Charging / Preconditioning	OC4	≥ 40,000 h
Connected functionality and SW updates in non driving states	OC5	≥ 1,500 h
Solar charging	OC6	≥ 24,000 h (14000 h if active mutual with OC2-4)
Other functionalities active in non-driving states		Not specified



Note:

- Operational time is not quantified for all functionality in non-driving states.
- OC2 + OC3 is valid for components active in both Driving and Preconditioning.
- OC2 + OC4 is valid for components active in both Driving and “Plugged in” Charging & Preconditioning.
- The driving duration during OC2 is the result of an expected average speed of 15 km/h and required 15 years lifetime, and with two additional assumptions;
    - For a total driving distance of 300,000 km, that will give a duration of 20,000 h (FIC C functions).
    - For a daily usage of 2.5 h, that will give a duration of 13,500 h (FIC A/B functions).
- If the mileage is reached within 3 years (instead of 15 years) and with a daily usage of 18 h, this will also give a duration of 20,000 h.
- Connected functionality, 2 h/week is based on assumed vehicle connected interaction in non driving states including SW, settings updates and diagnostics.
- Charging duration increased to cover bidirectional use-cases 30,000h to 40,000h
- OC6 include duration for vehicle in sun exposure with charging

DVM:

Method type: Engineering judgement:

Review of Technical Regulation and Reliability analysis report.
For ECUs, BoM breakdown of component life expectancy shall be made, with consideration given

to which Operating Condition applies for the different blocks in the ECU (e.g. if an ECU is constantly supplied from KL30, that doesn't necessarily mean that the whole of the ECU has constant supply, some blocks may be turned on only during Driving for instance).

REQ-603 v13 ELP-Fault propagation to class B and C functions

Attribute: Electrical Performance
Requirement Classification: Hard
Change classification: Editorial
Design Target :
Purpose (rich text): Main reason for this requirement is electrical reliability and to limit unwanted fault propagation.
Scope: Ensure accessibility and safe usage of the vehicle with regards to mitigate fault propagation.

Valid for	Yes/No/Support	Comment
Architecture	Yes	
Function	Yes	
System	Yes	
Component	Yes	

-
- Note:
- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.
- Verification according to actual DVM shall be performed.
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfilment of this requirement.

Requirement:

Identify critical use cases considering FIC C (Functional Importance Class C) functions in the area of accessibility and safe usage, i.e. FIC C main function, Customer Function (CF) or Product Function (PF).

A fault in any function independently if it’s Class A, B or C must not lead to loss of or degradation of any other FIC C main function. S-FMEA shall be done to show this.

DVM:

Specify critical use cases and evaluate that any propagating failure will not jeopardize accessibility, drivability and safe usage of the vehicle.

Specify critical use cases and evaluate that the function behaves according to requirement.

Evaluate that a failure in a FIC A function does not lead to critical loss in FIC C main function.

Evaluate that a failure in a FIC B function does not lead to critical loss in FIC C main function.

Evaluate that a failure in a FIC C function does not lead to critical loss in another FIC C main function.

All cross system interactions shall be included in the analysis. Document the result in the S-FMEA.

Guidelines:

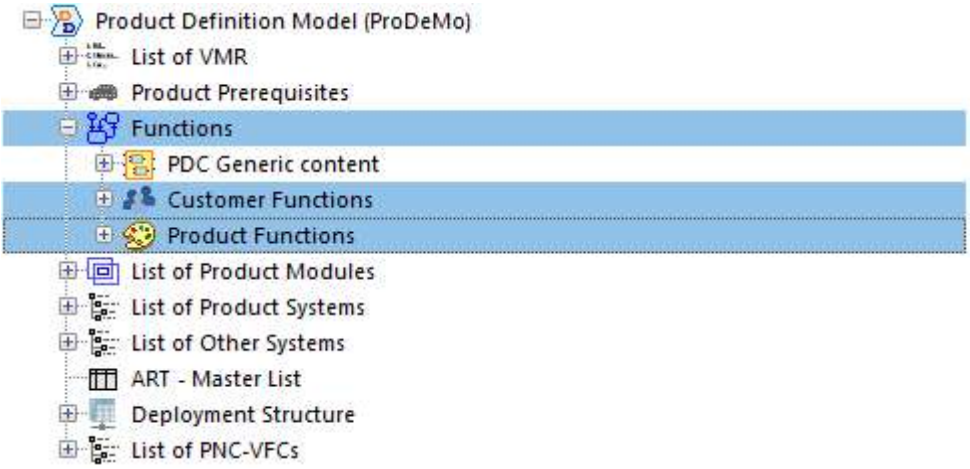
Design actions to mitigate or prevent the loss of FIC C main function can range between (as for example) :

- Allocation of functions on different components (signaling/signaling path, hardwire signals) .
- OCPD (Over-Current Protection Device) in electrical distribution system
- OCPD inside components
- Smart clustering of functions
- Redundancy and/or robustification .
- Reduced performance mode
- …

“ The classes are:
Functional importance Class C - Any function that may be essential to the safe operation and control of the vehicle.
Functional importance Class B - Any function that enhances but is not essential to the safe operation or control of the vehicle.
Functional importance Class A - Any function that only provides a convenience ”

FIC level for specific Customer or Product Functions can be found under "Functions" in Product Definition Model (ProDeMo) in CarWeaver.

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary



REQ-562 v13 ELP-Environmental conditions and testing for electrical and electronic equipment

Attribute: Electrical Performance
Requirement Classification: Intermediate
Change classification: Editorial
Design Target :
Purpose (rich text): Main reason for this requirement is electrical reliability.
Scope: Environmental conditions and testing for all electrical and electronic equipment.

Valid for	Yes/No/Support	Comment
Architecture	Yes	ED: Load dump, jump start, reverse polarity, over voltage
Function	Support	
System	Yes	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.
- Verification according to actual DVM shall be performed.
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfilment of this requirement.

Requirements for components using secondary regulated feeds:
Requirements (i.e. electrical and environmental) valid for a main ECU are normally also valid for any connected sensor/actuator regardless of the voltage feed rating of the sensor/actuator, however voltage levels must be refined according to the main ECU regulator output characteristics.

Example: A 5V sensor/actuator connected to a 12V system supplied main ECU may be subjected to electrical disturbances that pass through the main ECU 5V regulator.

Requirement:

General
All electronic and electrical equipment in the vehicle shall be designed to comply with the mechanical, climatic, and chemical loads described in ISO 16750 and valid revision of 'SUPPLEMENT TO ISO 16750' doc. no. 31822854, (hence referred to as 'the Supplement').
The requirements and guidelines in the Supplement (e.g. reporting, test procedures, pre- and post testing validation and inspection, etc.) shall be met by the supplier.

12V
For all electronic and electrical equipment fed from a 12V power line (or lower, if a component using a secondary regulated feed is considered), design shall comply with the electrical loads described in the Supplement and ISO 16750-2.

48V
For all electronic and electrical equipment supplied from or supplying a 48V power line, the design shall comply with the electrical loads described in the ISO 21780:2020.

High Voltage (>60VDC or >30VAC (RMS))
See specific High Voltages electrical requirements, internal and external, regarding function and voltage levels.

For equipment with multiple voltage feeds, the relevant electrical requirements and tests from above shall apply to the respective part of the equipment (i.e. for a 48V/12V ECU, the 48V electrical requirements are applicable for the 48V part and the 12V electrical requirements are applicable for the 12V part, and so on).

Note that the various environments specified in these above requirements may in vehicle appear simultaneously. The component shall under these circumstances be fully operational (fit for use), for the entire service life of the vehicle.

DVM:

Method type: Physical test - Laboratory

Testing shall be done according to the Supplement and/or ISO 21780:2020 chapter 10 (if relevant) to verify that the requirements are met.

Method type: Engineering judgement

Review of the test plan.

REQ-57133 v2 ELP-Reliability requirements for capacitors

Attribute: Electrical Performance
Requirement Classification: Intermediate
Change classification: Editorial
Design Target :
Is Generic : Yes
Purpose (rich text): All capacitors shall be selected to meet or exceed the required vehicle service life without any degradation.
Scope: All capacitors including AC or DC capacitors.

Valid for	Yes/No/Support	Comment
Architecture	No	
Function	No	
System	Yes	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.
- Verification according to actual DVM shall be performed.
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfilment of this requirement.

Requirement:

All capacitors shall be selected to meet or exceed the required vehicle service life without any degradation.

Any combination of singular or repeated electrical stress predicted to occur over vehicle service life shall not cause residual damage or shorten the life of capacitors.

Suppliers shall consider a reliability-oriented design for selected capacitors. Type of capacitor choice shall be made considering the placement/packaging of the component and application in the vehicle to withstand environmental, mechanical and electrical stressors. See below guideline for more information.

It is required that the capacitances shall be optimized to achieve high efficiency and high reliability.

DVM:

Method type: Engineering judgment

Confirmation by subject matter expert that the application is safely inside the capacitor specification and application notes under all environmental conditions given by the application and meet the service life time.
Capacitor specifications shared must include impedance characteristic versus frequency, capacitance versus temperature profiles, over-voltage and short circuit tests.

Method type: Physical test – Laboratory
Test with actual load and different electrical stresses under worst case environmental conditions according to the specifications.

Guideline:

The selection of other components also affect the sizing of the capacitors. For example, the choice of the input side inductor in an ac drive has significant impact on the life time of dc-link capacitor.

It shall be noted that cable impedances can magnify/attenuate voltage/current harmonics which affect the degradation of capacitors.

It shall be noted that for the emerging applications such as photovoltaic systems, solar irradiance profile with ambient temperature profile have significant impact on the ripple current stress of dc capacitors.

It shall be noted that degradation of dc capacitors and other components could in turn affect the ripple currents flowing through the capacitors.

Hybrid design solutions composed of different type of capacitors or active ripple reduction circuits can be applied to increase reliability of the capacitors.

It shall be noted that for components such as an ac drive and electrical machine which are connected to the power line directly, dc-link capacitors are stressed even when switching devices of the inverter/converter are turned OFF.

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A high capacitance will reduce voltage ripples but it results in high inrush current meantime which decrease life time of other components in the circuit such as power switching devices.

Table 1 lists a summary of the failure modes, failure mechanisms, and corresponding critical stressors of three types of capacitors.

Table 1

Cap. type	Failure mode	Critical failure mechanisms	Critical stressors
Al-Caps	Open circuit	Self-healing dielectric breakdown	V_c, T_a, i_c
		Disconnection of terminals	Vibration
	Short circuit	Dielectric breakdown of oxide layer	V_c, T_a, i_c
	Wear-out	Electrolyte vaporization	T_a, i_c
		Electrochemical reaction	V_c
MPPF-Caps	Open circuit	Self-heating dielectric breakdown	V_c, T_a, dV_c/dt
		Connection instability by heat contraction of a dielectric film	T_a, i_c
		Reduction in electrode area	Humidity
	Short circuit	Dielectric film breakdown	V_c, dV_c/dt
		Self-heating due to overcurrent	T_a, i_c
		Moisture absorption by film	Humidity
	Wear-out	Dielectric loss	V_c, T_a, i_c, humidity
MLC-Caps	Short circuit	Dielectric breakdown	V_c, T_a, i_c
		Cracking; damage to the capacitor body	Vibration, mechanical shock, CTE mismatch and board flexure
	Wear-out	Oxide vacancy migration; dielectric puncture; insulation degradation; micro-crack within ceramic	V_c, T_a, i_c, vibration

AL-caps: Aluminium Electrolytic capacitors, MPPF-caps: Metallized Polypropylene Film Capacitors, MLC-caps: Multi-layer Ceramic capacitors, CTE: coefficient of thermal expansion

V_c : capacitor voltage stress, i_c: capacitor ripple current stress, T_a: ambient temperature

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Template GRS 10.03 Security Class: Proprietary

Attribute: Electrical Performance
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes
Purpose (rich text): Main reason for this requirement is to ensure reliability of solder joints.
Scope: All solder joints.

Valid for	Yes/No/Support	Comment
Architecture	No	
Function	No	
System	No	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.
- Verification according to actual DVM shall be performed .
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfilment of this requirement.

Requirement:

Electrical and electronic components shall fulfil IPC/EIA J-STD-001H, class 3.

Hand soldering and/or rework of solder joints is not allowed.

DVM:

Fulfilment of acceptance criteria according to ANSI/IPC-A-610H, class 3.

REQ-118827 v1 ELP-Inrush current

Attribute: Electrical Performance
Requirement Classification: Intermediate
Change

classification:

Design Target :

Is Generic : Yes

Purpose (rich text): To limit current transients in the unit supplying power and to avoid unnecessarily costly electronics (e.g. High Side Driver with to “high” specification)

Scope: All electrical components (e.g. ECU´s , actuators, sensors, electrical motors etc.)

Requirement

Inrush current at Power On of capacitive load (such as ECU)
Inrush current at Power On shall be maximum 7 times the maximum SSC (Steady State Current) for the load itself.
Inrush duration at power on (S1) shall be as short as possible but maximum 3 ms.
Inrush duration definition is described in Figure 5.

Power on current, at function activation (for example activation of inductive load, such as a DC-motor)
Peak current shall be maximum 5 times the maximum SSC (steady state current) for the inductive load itself.

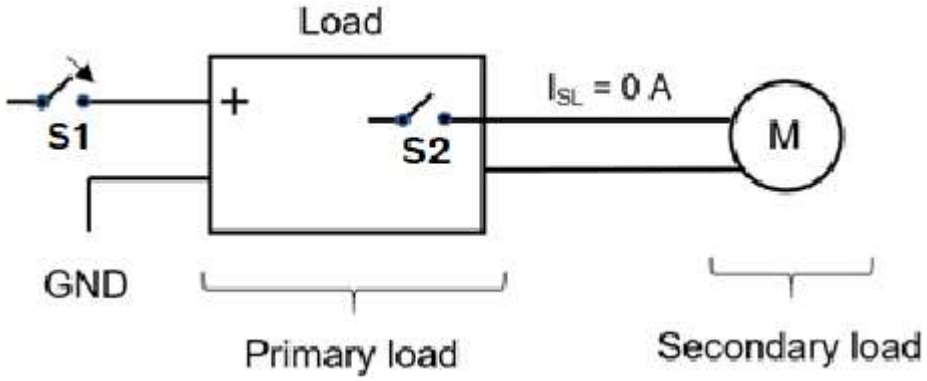


Figure 1. Power On of a primary load.

Inrush current at power on of a primary load when S1 is closing and S2 remains open
When this occurs, supply to a potential secondary load (S2) is assumed to be disabled (Off)
A primary load can be either a capacitive load (e.g. ECU) or inductive load (e.g. DC-motor) but it can also be a non linear resistive load (e.g. PTC heating element)

Note! If a motor (or other type of actuator) is supplied directly from a central power distribution box, then the motor is defined as the primary load.

Inrush current at Power On, of a secondary load, S1 closed and S2 is closing
In case the primary load supplies additional loads, these are here named secondary load(s). A secondary load is often an inductive motor load, but could also be a capacitive load.

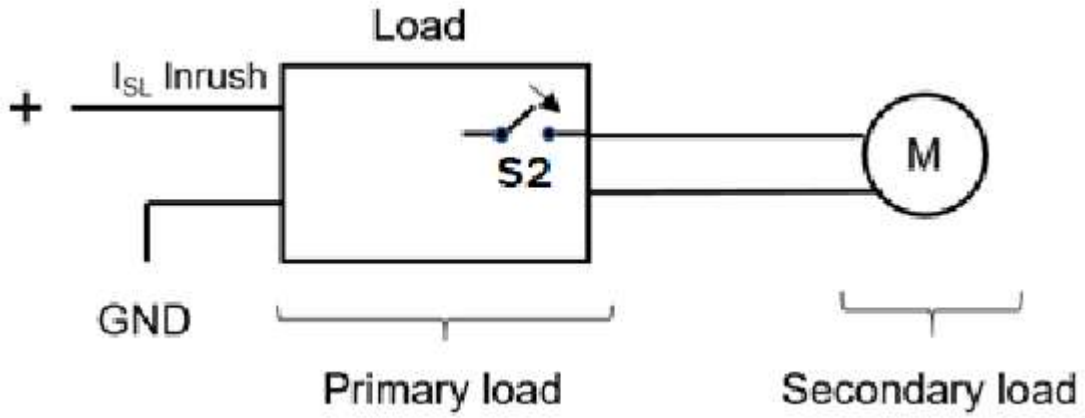


Figure 2. Power On of secondary load S2

See also Chapter 3 in NOTE-DESG-31868272-02-08.

If the inrush value or inrush duration need to be higher than the limits set in this requirement, this need to be requested and agreed with Volvo Cars' Product development team who is responsible for the unit supplying the power.

DVM

Wire area to be used to fulfill this requirement shall be according to table 1.

Max SSC [A]	Wire cross section area [mm^2]
≤ 5	0,5
5 - 12	1,0
12 - 20	1,5
20 - 35	2,5
≥ 35	4.0

Table 1. Wire cross section area, to be used and documented when verifying/testing this requirement

Wire lengths shall be total 2m including both on "+"-side and "-"-side. See figure 3. below.

Test methods according to Chapter 3 in NOTE-DESG-31868272-02-08 with the following corrections:

- Physical measurement Method 1 according to Chapter 3 in NOTE-DESG-31868272-02-08
  Wires shall be lifted minimum 3 cm from the ground plane.
- Wire dimensions according to Table 1
- Harness lengths according to Figure 3
- Harness between Primary load and secondary load shall be according to production intended.

- Inrush limits according to requirement above.
- Power supply U_S = 14 +/- 0.1 V > 5 A with an additional battery in parallel
- Battery charged to 14 +/- 0.1 V with CCA > 400 A
- Simulation and/or theoretical calculation based on WCCA / MonteCarlo analysis Method 3 according to Chapter 3 in NOTE-DESG-31868272-02-08

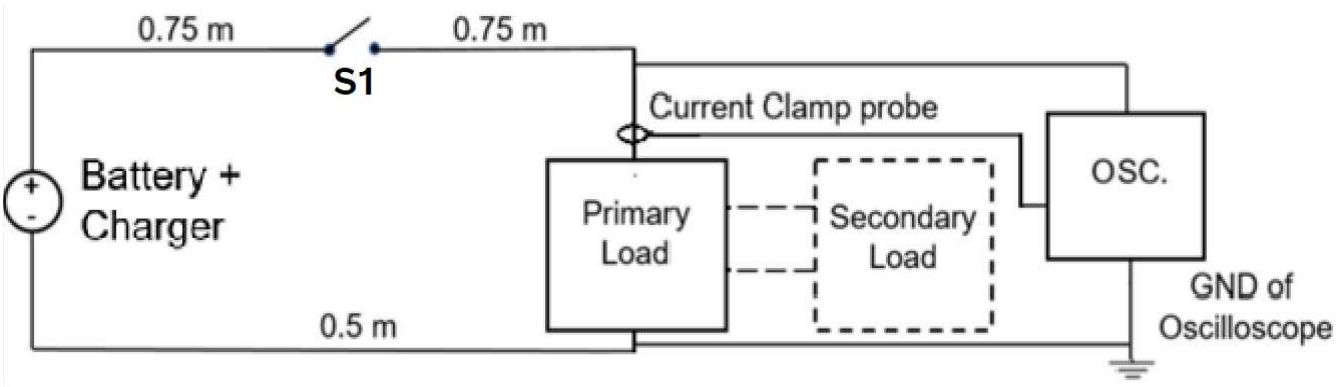


Figure 3. Principal test setup and harness definitions for inrush measurements.

Guideline

Value at <u>worst case</u> situation, (probably) U_S max, min temperature, spreading over individuals, etc. Inrush current at Power On is in relation to max SSC for the component supplied from “power distribution unit” e.g. not the max SSC for a secondary load supplied via the component.
Inrush at activation of secondary load is in relation to “max SSC” when secondary load is active.
See figure 3

<u>Description of a capacitive load.</u>

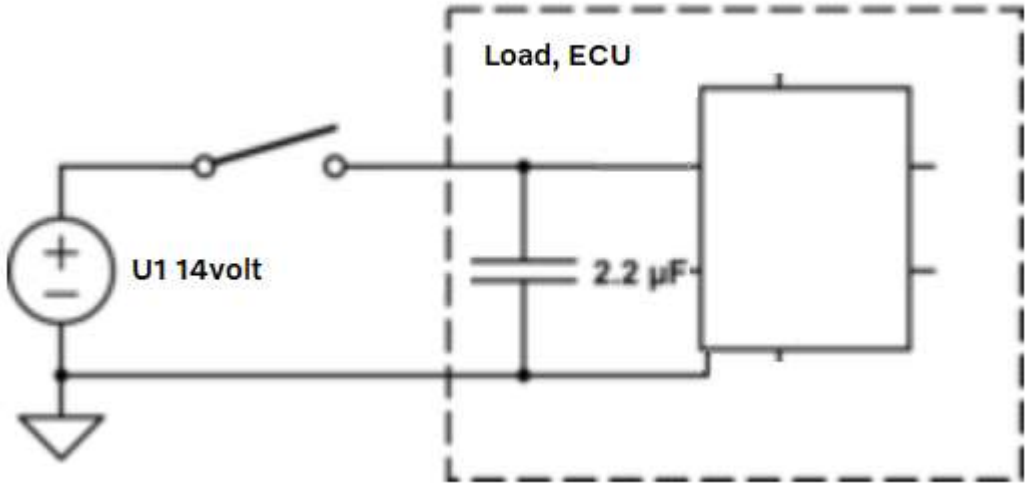


Figure 4. Capacitive load

Capacitors "acts" as batteries that can be charged and discharged.

Before Power On, the capacitor is usually fully discharged or "empty" so the capacitor voltage is zero.
At Power On a current will flow into the capacitor, and charge it up to the supply voltage U1, this current is defined as Inrush current. The duration of the inrush current is defined in Figure 5

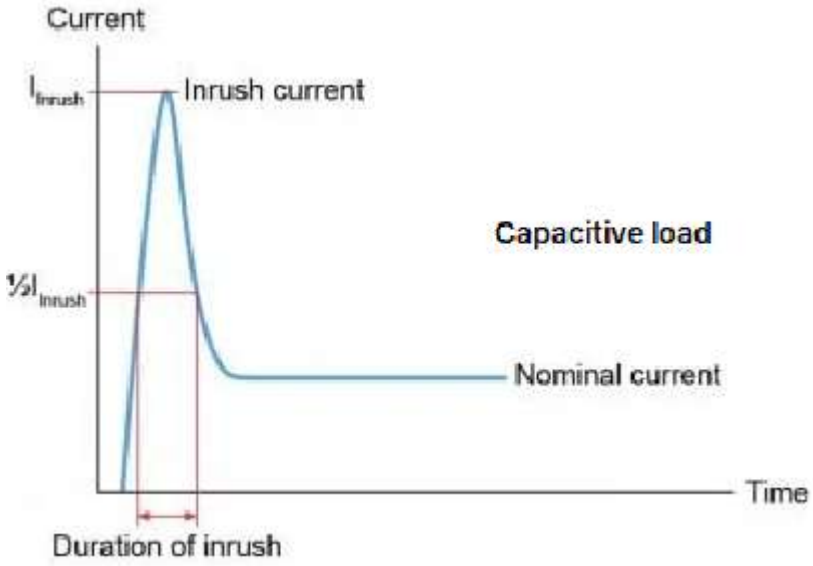


Figure 5. Inrush Current description

The inrush current can be high in the beginning and gradually decrease when the capacitor is charged or "filled up". This requirement is defining the maximum allowed inrush current in relation to the nominal current also defined as SSC (Steady State Current)

REQ-124932 v1 ELP-PCB Water retention

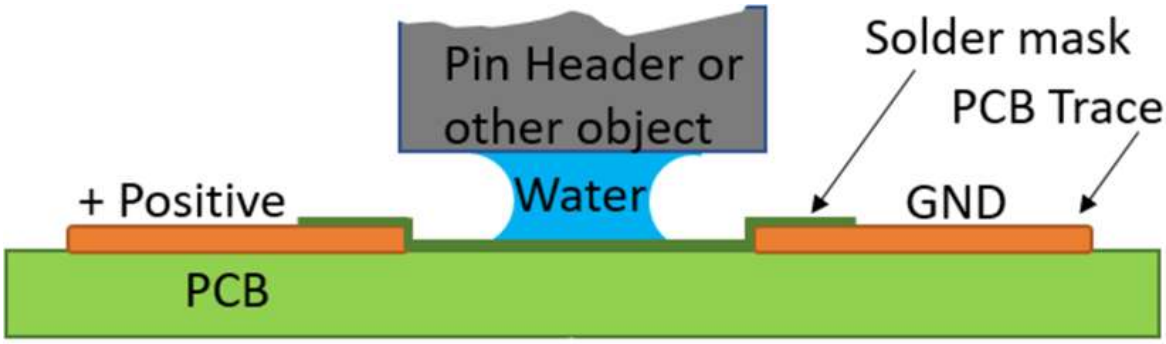
Attribute:	Electrical Performance
Requirement Classification:	Intermediate
Change classification:	New
Design Target :	
Is Generic :	Yes
Purpose (rich text):	In order to mitigate the risks of electrochemical migration and the formation of conductive anodic filaments (CAF) in PCBs, it is imperative to address water retention on the PCB surface. Water retention leads to absorption of moisture by the solder mask, which in turn increases the likelihood of dendrite formations.
Scope:	All electrical components that contains a PCB

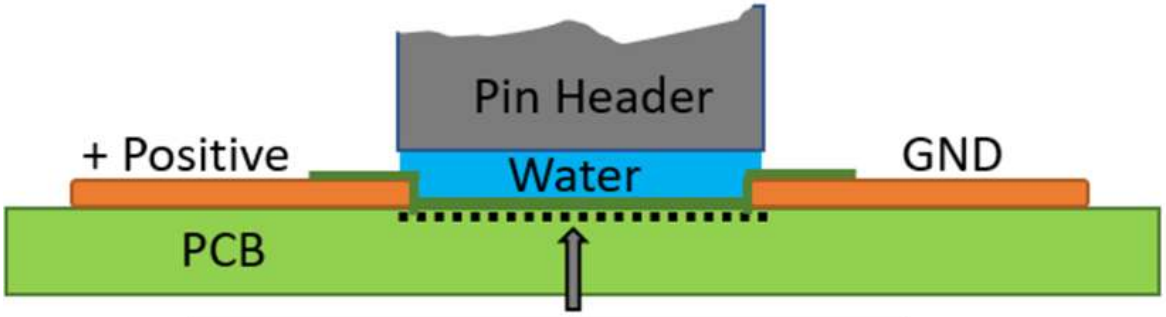
Requirement

Prevent water retention on the PCB surface to inhibit electro chemical migration.

1. No centering pin leaned on the PCB surface between two neighbor powered lines is permitted to prevent water retention. This restriction ensures that no additional contact points are created that could potentially exacerbate water retention and subsequent moisture related issues.

2. Maintain a distance of >1.5 mm between the PCB surface and any objects placed in close proximity, such as pin-header, housing parts, component brackets. This distance serves to prevent water retention caused by surface tension.





Electro chemical migration, below and above solder mask.

Water retention leads to absorption of moisture by the solder mask, which increase dendrite formations. In order to mitigate the risks of electrochemical migration and the formation of conductive anodic filaments (CAF) in PCBs, it is imperative to address water retention on the PCB surface.

DVM

Method type (s) :

Virtual and physical verification (i.e design phase)

Design review of drawing for centering pins between two neighbor powered lines.
Design review of drawing for clearance distances through any CAD/CAM/PCB layout measurement tool, there must be >1.5 mm between PCB surface and any objects placed in close proximity, such as pin-header, housing parts, component brackets.
The PCB layout with component placement (document reference HW SOW, section 3.6.1) to be reported in HWJR3.

Physical test :

After DV/PV test, the PCB assembly is analyzed regarding function and then by visually inspection, according to the visual inspection acceptance criteria in VCC supplement ISO 16750 (Doc No.) 31822854

REQ-456934 v1 ELP- Second source requirement for discrete components

Attribute: Electrical Performance

Requirement Classification: Hard

Change classification:

Design Target :

Purpose (rich text): To secure production continuity by reducing the risk of component shortage. Establishing a list of discrete components from a second source strengthens supply chain, and minimizes dependency on a single source. This requirement also aims to foster greater awareness of the importance of proactive risk management.

Scope: This requirement is applicable to all the electronic components.

Valid for	Yes/No/Support	Comment
Architecture	NO	
Function	NO	
System	NO	
Component	YES	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.
- Verification according to actual DVM shall be performed.
- No: Requirement is not valid for your design role.

- Support: Your design shall not prevent other design responsible to achieve fulfilment of this requirement.

Requirement:

To mitigate the risk of components shortages, at least one alternative source for discrete components must be established to ensure uninterrupted production. The alternative components shall be equivalent to the original.
When selecting alternative components, technical compatibility, supplier diversity and geographical distribution, etc. must be taken into consideration.
The BOM template provided by Volvo Cars' procurement team shall be completed in full and submitted for approval.

The following components are covered by this requirement:

Discrete component	**AEC-Q standard**	**Examples**
Active semiconductor discretes	AEC-Q101	Diodes (rectifier, Schottky, Zener, TVS, switching), BJTs, Power transistors, MOSFETs, JFETs, IGBTs, SCRs, Triacs.
Optoelectronic discretes	AEC-Q102	LEDs (visible & IR), Laser diodes, Photodiodes, Phototransistors / APDs, Optocouplers / photocouplers, IR emitters/receivers.
Passive discretes	AEC-Q200	Resistors (thick film, thin film, wirewound, shunt), Capacitors (ceramic, electrolytic, tantalum, film), Inductors & magnetics (chip, power, ferrite beads, transformers), Varistors (MOVs), Thermistors (NTC/PTC), Fuses, Crystals & resonators.

DVM:

Method type: Engineering judgement

Review the BOM and conduct the technical evaluation in collaboration with the subject matter expert.

Method type: Physical test

Physical validation shall be performed as per VCC supplement to ISO 16750 (Doc. No. 31822854). Sample size shall be chosen based on section 7.3 of the same document.

REQ-213158 v2 ELP-FMEA Guideline

Attribute: Electrical Performance
Guideline ID: DGL-147

Purpose:

FMEA is a mandatory tool within Failure Mode Avoidance (FMA) process to theoretically identify potential issues, define corresponding actions and define risk priority number.
General requirements for FMEA can be found:
* For function, architecture and system FMEA in BMS
* For component FMEA in ESOW.

Scope:

This requirement shall be used in all project phases including concept according to Volvo Cars working procedures.

Valid for	Yes/No/Support	Comment
Architecture	Yes	
Function	Yes	
System	Yes	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if n ew design or changes are made.
- Verification according to actual DVM shall be performed.
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfilment of this requirement.

Notes:

Current design control prevention must not violate Electrical Performance requirements. Potential cause/mechanism of failure caused by environmental factors as electrical loads, mechanical loads, climatic loads, and chemical loads must be evaluated. FMEA must not contradict electrical reliability, electrical safety (personal safety, fire safety etc.) and electrical energy requirements.

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

Actual vehicle physical installation and in-vehicle interaction must be reflected.

Special attention must be taken to campaign prevention history.

When performing FMEA all failure modes that violate any Electrical Performance requirements shall be evaluated.

Guideline:

Attached to this guideline (attachment can be found in the tool) is an excel sheet with an example FMEA.
Attached design/component example is mainly focused on electrical performance related topics.
The example will act as a guiding rule of what sort of Electrical Performance related content that is among others expected to be included in D-FMEA and P-diagram .
Rating and actual content in example must not be considered as correct for the actual component/system. Other areas (non ELP) must not be excluded.

Note! There is no example for Architecture, Function and System-FMEA

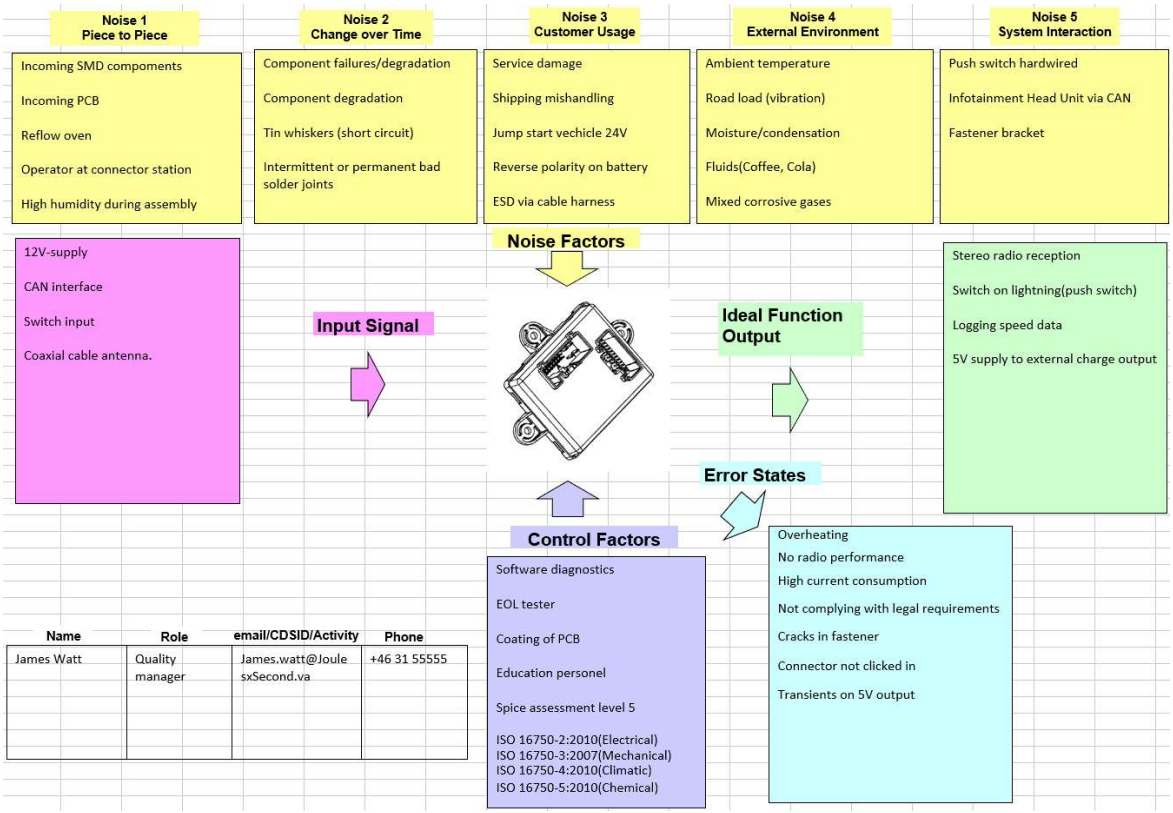
Pictures below are extracts from the example FMEA. The source can be found in the attachment to the guideline.

VOLVO
Volvo Car Corporation

POTENTIAL FAILURE MODE AND EFFECTS ANALYSIS (DESIGN / Process FMEA)

Model Year(s)/Vehicle(s): V526 | Design / Process Responsibility: Electrical, switches and comfort, 94222 | FMEA Number: 1
System/Subsystem/Component: Example ECU | FMEA completed to Date: 12w20 | Prepared by: Joseph Henry
FMEA titel: Example ECU supplier FMEA | Date (Orig.): 11w11 | Date (Rev.): 12w11

No Nr	Item/Function Funktion	Potential Failure Mode Feltyp	Potential Effect(s) of Failure Feleffekt	Sev	Class	Potential Cause(s)/ Mechanism(s) of Failure Felorsak	Occur	Current Design Controls Prevention Planerade förebyggande åtgärder	Current Design Controls Detection Planerade verifieringsaktiviteter	Detec	R.P.N.	Recommended Actions Rekommenderad åtgärd	Responsibie Ansvarig	DE Detection Event Tidpunkt för DE [format 09w15]	Action Results Resultat efter beslutad åtgärd Actions Taken Beslutad åtgärd	Sev	Occ	Det	R.P.N.
1	SRS warning lamp.	No function	Customer not aware of SRS failure (input from S-FMEA)	10	YC	Short circuit caused by water intrusion in connector	5	Connectors pointing downwards according to VCC requirement "REQ-023789/1 Electrical	Testing according to ISO 16750-4:2010 chapter 7 and VCC supplement 31822854	3	150	*change to sealed connectors*	*Alessandro Volta*	12w10	Sealed connector implemented 12w40	10	1	3	30
2				10	YC	Short circuit caused by electrochemical migration on PCB	2	~~Partial polyurethane conformal coating.~~ 12w10. Full polyurethane conformal coating according to VCC req "REQ-023783/1 Conformal coating of printed circuit boards", occurance lowered from 4	Confirm compliance with supplier internal guidelines according to IPC A-610 and IPC-CC-830	6	120	*Full Parylene C conformal coating*	*Gustav Kirschoff*	12w47					
3				10	YC		2	Analysis of flux (to be adressed to P-FMEA)	Summarize field result from ECU X,Y and Z using the same flux and present for	2	40	*Change flux*	*Michael Faraday*	12w47					
4				10	YC		3	Design with creepage distance > x mm on PCB according to supplier guidelines	Confirm creepage distance > x mm on PCB	3	90	*New PCB layout.*	*Anders Celsius*	12w47					
5	Window functionality	Partial function	No automatic opening or closing of windows possible	8	YS	No electrical connection in connector for positioning sensor caused by fretting corrosion	8	Terminal plating analysis	Analyse parts from test complete vehicle on Hällered.	6	384	*Change to gold plating in connector*	*Svante Arrhenius*						
6	Larm sensor	No function	Drained battery after long time parking.	8		Quiescent current >100uA	3	Implement sensor electrical interface according to sensor supplier data sheet.	Measure steady state current(<1% tolerance) at 14V -40°C.	1	24	*Change sensor.*	*Georg Ohm*						
7	Supply	No function	Local internal thermal event will burn off copper track to supply.	8	YS	Internal short circuit in ceramic and tantal capacitors caused by mechanical stress.	5	Put two capacitors in series as a robustification.	Tolerance stackup study to be presented to VCC.	3	120	*Use capacitors that opens on fail.*	*Michael Faraday*						



4.1.4.7.3 Wading line

REQ-598 v7 ELP-Electrical components positioned under the wading line

Attribute: Electrical Performance

Requirement Classification: Intermediate

Change classification: Editorial

Design Target :

Purpose (rich text): Electrical components positioned under the wading line shall withstand immersion in water according to METH-000668/1-Wading in deep water during complete life time.

Scope: All electrical components outside of the passenger compartment that are positioned below the wading line. Wading line level is dependent on vehicle type, model and physical position.

Note! This requirement is not intended for connectors in the electrical distribution system but will include those connectors that are an integral part of the component.

Valid for	Yes/No/Support	Comment
Architecture	No	
Function	No	
System	Yes	
Component	Yes	

Note:

- Yes: Requirement is valid for your design role. For more than one level (Architecture, Function, System or Component) the requirement can most likely be fulfilled at any of these level but all involved are still responsible for fulfilling this requirement if new design or changes are made.
- Verification according to actual DVM shall be performed .
- No: Requirement is not valid for your design role.
- Support: Your design shall not prevent other design responsible to achieve fulfillment of this requirement.

Requirement:

No sign of water intrusion is allowed in component or it’s connector interfaces.

DVM:

Physical verification:
According to ISO 20653 rev. 2013 IPx7 with packaging orientation as in vehicle. Immersion depth shall be chosen with regards to in vehicle installation but shall be at least 0.15m measured from highest housing location irrespectively of housing size.

Both new components and aged components shall be tested . Ageing shall be performed according to IEC 60068-2-2, Test B for duration of 168 h at the maximum value of the ambient temperature at which the components can be operated continuously.

4.1.4.7.4 Headlamp compatability with HCM

REQ-426485 v1 Dimming table Delivery

Purpose: To ensure that function mapping and LED segment duty cycle information is compatible with HCM SW.

Headlamp supplier is responsible to deliver a dimming table which is needed to configure correct duty cycle and segment mapping in the HCM software. This dimming table format must be in accordance to the guideline below

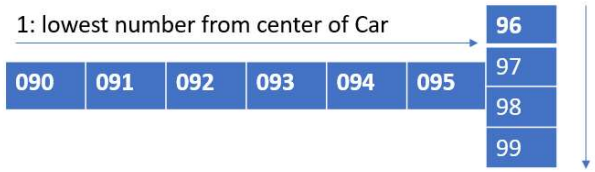
To reduce complexity in the use of segments in SW, functions shold follow below mapping pattern (all variants and markets). Note that it could be that a headlamp uses more number of segments available for below range. In those cases it should be aligned with Volvo on how to carry out the mapping.

Function	Mapped to parameters Segxxx
Low beam flat	001 (hard coded in HCM SW)
HB Spot	002
Cornering Light	003
Low Beam	004 to 027
Low Beam and High Beam*	028 to 057
High Beam	058 to 087
SML	089
Position Light / DRL	090-119
Turn Indicator	120-149

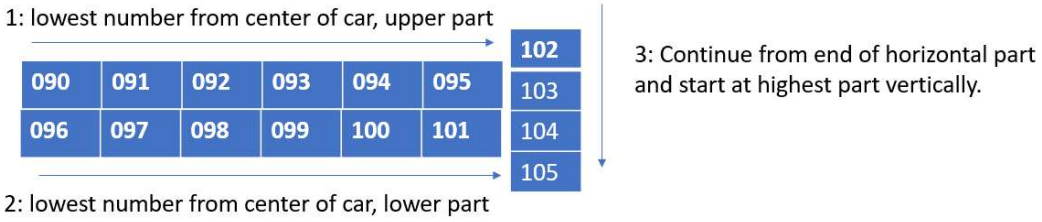
*This would only be used in lamp setups where high beam function and low beam function share LED segments, e.g. the middle row in a 3 row pixel 84 module configuration

Segment order with geometry DRL/POS/TI

Example DRL/PO/TI left headlamp



Example DRL/PO/TI left headlamp with two horizonal parts



Segment order with geometry High Beam

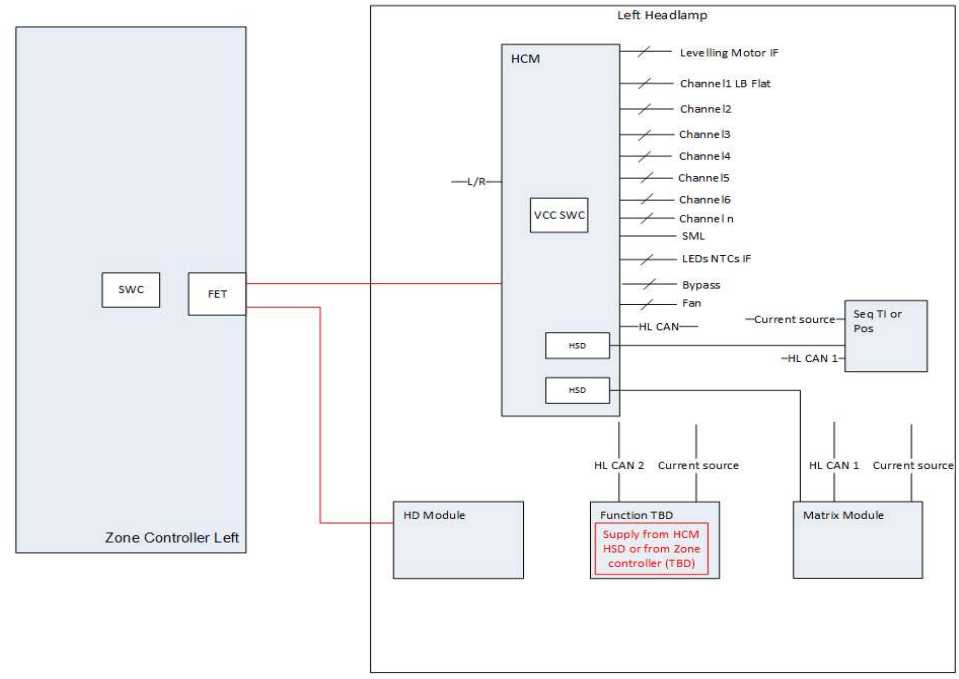
Example High beam/Low Beam left headlamp

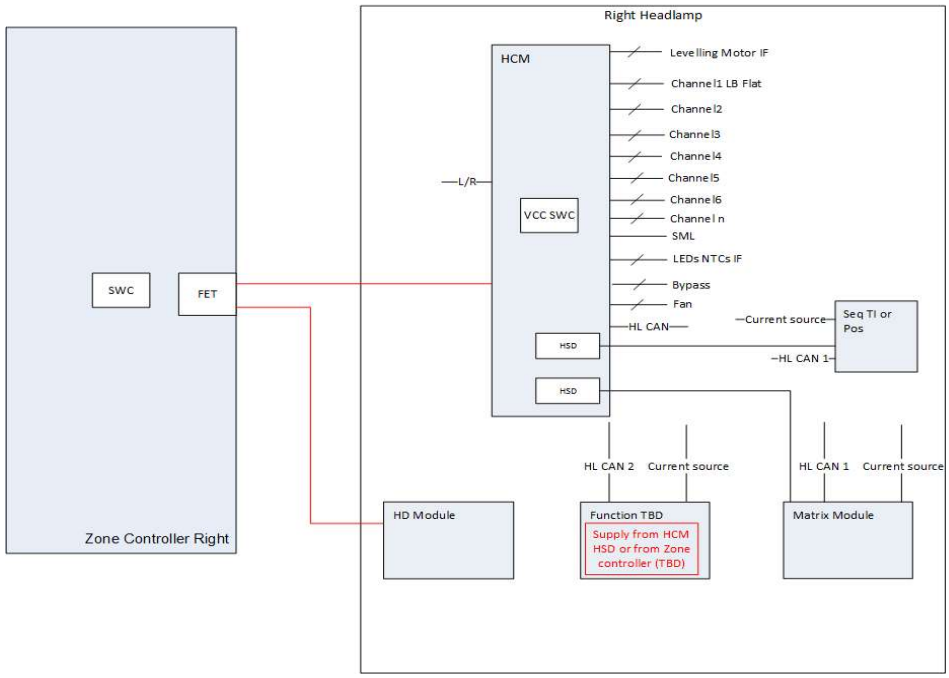


Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

Purpose: To describe the power supply interface between headlamp and vehicle.

The supply of the satellite for Matrix/Pos/TI can be a HSD in the HCM (like in picture) or via a switched battery supply).

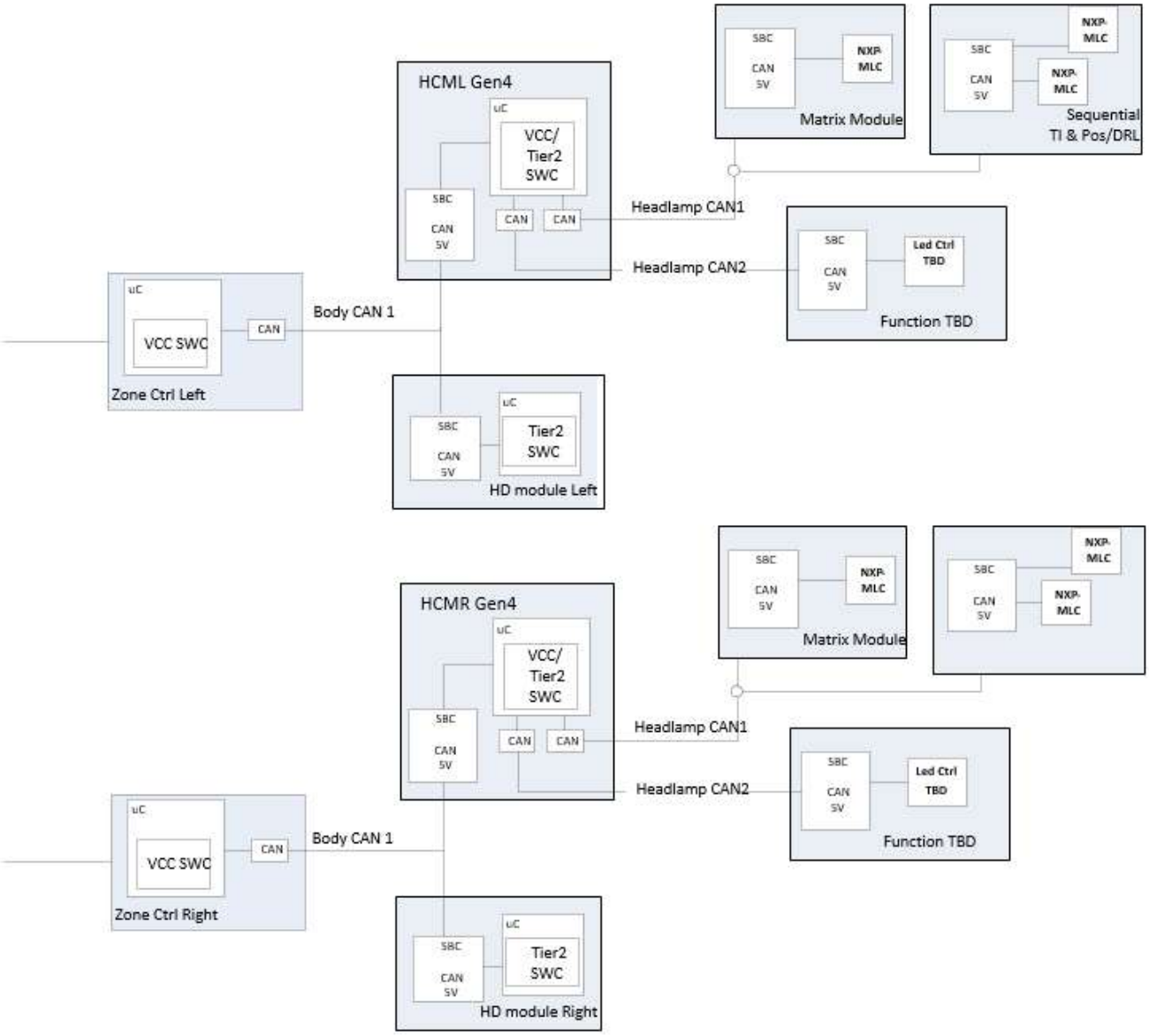




REQ-426374 v1 System Block diagram with Bus Interface

Purpose: Description of the newtwork interface bewtween the headlamps and the vehicle.

Example of an configuration with both HCM and HD modules.



REQ-426380 v1 Sattelite module LED diagnose

Purpose: Ensure that light modules connected over CAN to HCM provides correct level of diagnostic information.

A sattelite module with LED matrix managers shall be able to detect individual faults (open circuit, short circuit) on LEDs and shall send this information over CAN to HCM.

The sattelite module shall be able to detect if there is any other failure (e.g. short or open circuit on the LED current source input or a fault related to the matrix manager(s) that can affect the functionality of the LEDs and send this information over CAN to HCM.

REQ-426379 v1 Sattelite module LED thermal management

Purpose: Thermal management of sattelite modules.

A sattelite module with LED matrix manager shall evaluate its LEDs temperature and provide information over CAN to HCM such that the HCM can adapt LED channels correctly.

REQ-426381 v1 LED controller addressing

Purpose: To ensure correct LED matrix manager configuration.

The LED controllers (MLCs) for each function will have predefined addresses (same between projects).
E.g. one channel can have MLCs configurations for 12 or 12+9 switches. 9 and 9+9 can be used instead but has to be decided for first project, since addresses are predefined.

REQ-53662 v2 LED brightness calibration

If any LED brightness calibration is required, then this shall be done in the MLC by the headlamp supplier without the HCM.

REQ-53658 v2 LED diagnose

LEDs shall not fail in short circuit mode. The HCM cannot detect one or several LEDs short circuited in a string of several. However parameter will be provided for low voltage detection.

Only LEDs failed in open circuit (so that all LEDs will be off) can be detected. Otherwise, detection cannot be guaranteed.

REQ-53672 v3 LED controller diagnostics

Purpose: To ensure that the LED Controller have sufficient diagnostic capabilities.

The LED Controller shall be able to detect individual faults (open circuit, short circuit) on LEDs and shall send this information over CAN to HCM.

The LED Controller shall be able to detect if there is any other failure - e.g. short or open circuit on the LED current source input or a fault affecting the functionality of the LEDs and send this information over CAN to HCM.

REQ-53674 v3 LED controller thermal management

Purpose: To ensure that the LED Controller have sufficient temperature monitoring capabilities.

The LED controller shall evaluate its LEDs temperature and provide information over CAN to HCM, such that the HCM can provide correct current to Pixel Module LEDs.

REQ-53556 v2 Thermal design

The HCM will derate several outputs in high temperature. This shall be considered by the headlamp supplier for the headlamp design/light output/parameter setting for HCM.

REQ-53642 v1 HCM Left/Right detection

One wire shall be used to inform the ECU (HCM) if it is on the left or right headlamp.

Input:	Side of vehicle (headlamp):
Grounded	Left
Open circuit (left open)	Right

Note that HCM use NVRAM value as main input. HW input is used when no NVRAM value is available and for diagnose.

REQ-53660 v4 Segments, switches, and MLCs

Purpose: To ensure that headlamp hw is compatible with HCM system.

Switches reserved for each function:

Turn Indicator (TI): Not more than **30** switches.

DRL/Position light: Not more than **30** switches.

If a LED channel is used without any switches, then this is calculated as one switch.

E.g: 3 channels are used for sequential TI. 2 of them are combined with switches (MLCs*) and one is not combined with switches. Then the channel without switches are calculated as one switch and it remains 29 switches for the other channels.

The following rules shall be followed (deviation to these rules shall be agreede with Volvo):

- TI and DLR/Position shall not be combined in the same MLC.
- TI and DLR/Position shall not be combined with other functions in the same MLC.
- MLCs shall not be shared between channels.

*Matrix Led Controller

REQ-53646 v3 Wiring for CAN

Scope

Headlamps with internal ECUs including HCM.

Purpose

Guideline for headlamp internal CAN wiring.

Requirement

The headlamp internal wires for CAN networks shall provide daisy chain solutions when more than 1 ECU is present.

The sequence of the daisy chain connections (which ECU is last and carries the termination, and the order of the previous ones) must be agreed with VCC.

Headlamp internal CAN wires must be twisted due to EMC reasons.

Verification

Engineering judgement, Block Diagram or Drawing review.

REQ-53561 v5 Configuration EOL

Purpose: For HCM to know which headlamp it is fitted in. HCM need info for each LED channel the set current. It also needs information on which headlamp it is fitted in for e.g. stepper motor information etc.

Requirement (Please refer to lates:

HCM configuration shall be done at headlamp supplier with diagnose command. Diagnose command shall be based on binning/side detection number on Headlamp/Pixel Module.

Binning matching shall be done with number on the headlamp/Pixel Module. No Bin code resistor electrical interface exists on the HCM.

The information of number/diagnose command will be found in HCM TR.

HCM parameter files SWP1, SWP2, and SWP3 shall be downloaded at headlamp supplier EOL.

Matrix/Pixel/DLP Module side detection shall be programmed EOL at the Headlamp supplier. Up until the HCM is configured with left/right info, there shall be a DTC set, which is automatically cleared upon first correct configuration.

One command is needed for each side of vehicle.

The following information shall be part of diagnose command (programming):

Type of information:		Value description:
Side of vehicle	2 bits (four values)	0: Not configured 1: Left Headlamp 2: Right Headlamp
LED 1 Current	11 bits (2048 values), resolution 1mA, range 0-2047mA	LED set current for each channel.
LED 2 Current	-“-	-“-
LED 3 Current	-“-	-“-
LED 4 Current	-“-	-“-
LED 5 Current	-“-	-“-
LED 6 Current	-“-	-“-
LED 7 Current	-“-	-“-
LED 8 Current	-“-	-“-
LED 9 Current	-“-	-“-
LED 10 Current	-“-	-“-
LED 11 Current	-“-	-“-
LED 12 Current	-“-	-“-
Market (ECE/SAE)	2 bits (four values)	0: Not configured 1: ECE 2: SAE 3: Not configured

Steering wheel position	2 bits (four values)	0: Not configured 1: Left 2: Right 3: Not configured
Headlamp variant	2 bits (four values)	0: Not configured 1: Base 2: Mid 3: High

The list above shall be a number combination available on the headlamp for HCM configuration. E.g. this will be used on aftermarket when broken headlamps are exchanged or if broken HCM is exchanged. The number shall be possible to read for the service life of the vehicle. It shall be accessible (possible to read) when the headlamp is mounted on the car. All Headlamps shall have the same layout of this number on the headlamp so that it is easy for the service technician to find it.

The HCM shall maintain this data after a SW download.

In VCC factory, configuration information and parameter file for each side shall be uploaded to traceability system connected to VIN (Vehicle Identify Number). On aftermarket it shall be possible to either download information from database or read new barcode/barcode number on headlamp and launch diagnose command.

REQ-53647 v2 Wiring for stepper motors

Headlamp internal stepper motor wires must be twisted. Reason is EMC.

Exception from this requirement will be given only if the supplier can prove that the Headlamp system will comply with all EMC requirements without twisted wires in physical test results provided by the headlamp supplier.

See REQ-53646, "wiring for CAN", for references on twisting that shall be fulfilled.

REQ-53657 v3 Aftermarket management

1. Headlamp/light sources broken
   - Read binning/side detection number on new headlamp
   - Diagnose command to write the binning info to ECU

2. ECU broken (new HCM)
   - Load parameter files from PIE AND
   - download binning info from PIE

4.1.4.7.5 Mechanical Integration HCM

REQ-53649 v2 Headlamp to HCM sealing concept

Sealing concept between headlamp and headlamp ECU (HCM) shall be radial sealing.

Accepted tolerance (on new and aged parts) on the lamp sealing interface diameter is maximum 0.1 mm.
The mechanical interface including sealing shall support the IP classification of the ECU/Headlamp.

From Outside headlamp:

IP6K6K / IP6K7 / IP6K9K

REQ-53650 v2 Headlamp to HCM orientation

Headlamp ECU (HCM) shall be positioned on the side of the headlamp, not on top or below. The final position proposed by headlamp supplier shall be approved by Volvo Car Corporation.

REQ-53653 v3 Headlamp HCM fastening

The ECU (HCM) will be assembled at headlamp supplier.

The aim is to keep the HCM (Headlamp Control Module) weight as low as possible. Its initial required weight is to be below 400g but in case of e.g. thermal issues it may be heavier (up to 600g). The headlamp design must consider this extra weight.

The ECU shall be screwed to headlamp. Preliminary, 3 screws will be used. Screws shall be chosen with aspect to the HCM. Recommended screw type to be found in HCM drawing doc nr 33853572. The screws are not part of the delivery unit HCM.

REQ-53654 v2 HCM interface condensation

No water is allowed to drop onto/into the ECU/ECU connector due to condensation inside the headlamp.
No water is allowed to flow onto/into the ECU/ECU connector. Water shall be lead away from the ECU/connector.
Wire routing shall be done in a way to not lead water to the connector.

4.1.4.8 EMC

4.1.4.8.1 General EMC Components Requirements Ver 3.1

REQ-104556 v5 EMC - Introduction and applicability

Attribute:	EMC
Requirement Classification:	Hard
Change classification:	Critical
Design Target :	True
Is Generic :	No

Purpose:

This specification covers Electromagnetic Compatibility (EMC) requirements at system and component level. They have been developed to

- assure compliance with the present specified legal requirements for all markets,
- ensure coexistence between components in the vehicle, and
- meet customer satisfaction regarding EMC. The customer satisfaction requirements are generated from risk analysis performed by the Volvo Cars EMC department.

This specification also covers limits for the personal exposure to ElectroMagnetic Field (EMF) requirement at complete vehicle level. They have been developed to

- assure compliance with present and anticipated regulations.
- meet customer satisfaction regarding EMF.

Scope of requirements

These EMC requirements and test methods have been developed for electrical and electronic systems and components to be fitted to a Volvo Car Corporation vehicle. The requirements are designed to reduce the number of interference issues during vehicle integration and to secure test builds (e.g. VP) and homologation.

The purpose of component testing is the qualification of EMC in order for the system/component to be allowed into a test vehicle for final verification.

In addition to meeting the requirements specified herein, components shall comply with the vehicle EMC requirements when installed in the vehicle. Vehicle verification testing is performed by Volvo Cars. Failure to meet the requirements may result in redesign and revalidation with full support from the supplier.

The final EMC performance of the components is verified as installed in the complete vehicle. Note that vehicle level analysis and testing are not a substitute for component/subsystem conformance to this requirement.

The EMC part of vehicle homologation is based on the availability of EMC Component test reports. This is because not every I/O will be exercised and monitored during homologation.

The requirements and test methods are based on international standards wherever possible. If suitable international standards do not exist, Volvo Cars specifications are used.

In the event of a conflict between the content of documents, the following order of priority applies unless a specific exemption has been obtained:

1. applicable laws and regulations
2. the text of these Volvo Cars requirements
3. referenced standards in these requirements

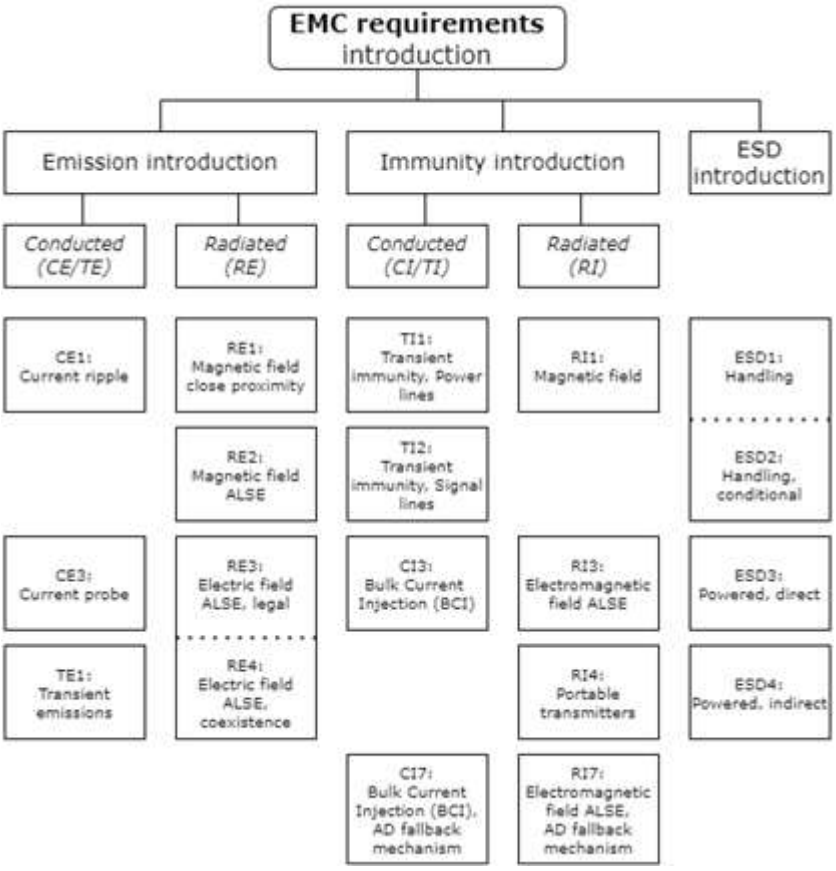


Figure of requirement structure with relation to the introduction parts

Requirement applicability

All requirements are deemed applicable by default. This is because the requirement set is created to be technology-neutral.

A table of requirement applicability is given below as a guide in the first instance to show the applicability of requirements against the used technology in a given DUT.

Requirement applicability shall be further detailed in the EMC test plan.

Table of requirement applicability versus technology

Req	**Used technology within the DUT**				
	Passive (resistors and capacitors)	*Diodes* and thermistors*	*Solenoids, relays and electromechanical horns*	*Electric motor*	*Transistor IC:s and uC*
RE1				X	X
RE2				X	X
RE3				X	X
RE4				X	X
RI1		X			X
RI3		X			X
RI4		X			X
RI7		X			X
CE1			X**	X	X
CE3				X	X
CI3		X			X
CI7		X			X
TE1			X	X	X
TI1					X
TI2					X
ESD1	X	X			X
ESD2	X	X			X
ESD3	X	X			X

ESD4	X	X			X

*Note that diodes include transient suppressors, LEDs, and regulation (e.g. Zener) diodes

**Applicable to electromechanical horns

All requirements have applicability modifiers within them.

Observe that specific versions of some of these requirements exist. These are to be used in certain cases such as short duration manually activated devices, components packaged near high magnetic fields or packaged in very close contact with humans.

Electro explosive devices (e.g. inflator/initiator/squib) are exempt from the EMC requirements; they are covered by other specifications e.g. SAE/USCAR.

Virtual verification

Virtual verification can be used as a substitute for physical testing in certain cases. Virtual verification takes the form of simulations, circuit analysis, engineering judgements and logical arguments. The goal shall be to show that a component cannot under any circumstance violate each respective requirement.

The EMC test plan shall be used to detail which requirements are selected for virtual verification and the proposed verification method. This is subject to review and negotiations with the Volvo Cars EMC team.

Virtual verification results shall be submitted in an engineering report, including prerequisites, method, analysis and the final outcome. In addition, there should be a review and argumentation of the validity of the result (synthesis). The report shall be delivered at the same time as the EMC test reports.

Volvo Cars reserves the right to request physical testing to support virtual verification conclusions or in case no agreement can be reached on the validity of the virtual verification.

Test port definitions

- Enclosure =
  the mechanical boundary of a component, including connectors

- Vehicle Power =
  system voltage for vehicle-internal Low Voltage (LV) DC power distribution (e.g. 12 VDC)

- Activation Input =
  power lead used for activation using non-stabilized supply voltages derived from Vehicle Power (e.g. ignition – KL15, KL56). This definition applies to input(s) that are only used for activation and/or signaling, not for power supply of the component.

- Load Output =
  any DUT power output that provides electrical power to a load
  Electrical loads include, but are not limited to actuators, heaters and lights.
  Note that load outputs can be considered constant or varying with respect to time (e.g. PWM).

- Local Power =
  a locally regulated power source that is dedicated to a specific component or a few components. It is characterized by being decoupled from Vehicle Power by a regulator or isolator such that disturbances on the vehicle power net

do not propagate to and from the local power net.
Note: Local Power is excluded from Vehicle Power and is treated as a Signal in the relevant tests

- Signal =
  any DUT input or output of commands or telemetry information

- HV, High Voltage =
  system voltage for class "B" according to ISO 6469-3: working voltage is > 60 V and ≤ 1500 V DC or > 30 V and ≤ 1000 V AC root mean square (rms)

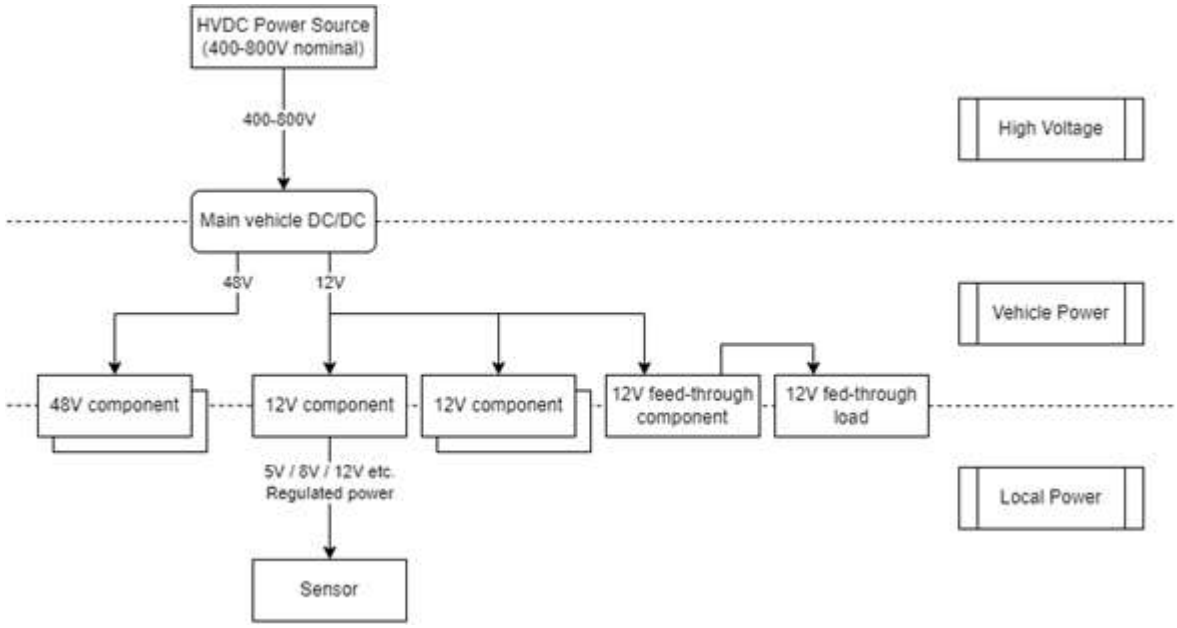


Figure showing used power definitions and their relations

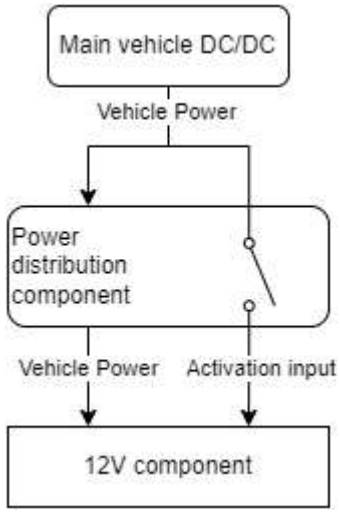


Figure on Activation Input and its relation

Management of Change

Re-verification according to this specification is required whenever any circuit, PCB or software design change occurs within the DUT (e.g. component replacement, die shrinks, new PCB layout). This is done to ensure EMC requirements are continually met.

The re-verification plan shall be documented in a Management of Change (MoC) document. The template for the MoC document can be obtained from the Volvo Cars EMC department upon request.

The MoC document shall be approved by the Volvo Car EMC team before start of test.

Work packages and Documentation

The following steps shall be taken by the Volvo Cars Design engineer and the supplier to assure EMC compliance of their component:

1. Obtain a list with applicable EMC tests, requirements, limits and interface data from the system owner.
2. Volvo Cars Design engineer to send the EMC test plan template to the supplier.
3. Supplier to complete the EMC Test Plan and obtain approval from Volvo Cars Design Engineer and EMC team before start of test. Approval is given after all parties accept the content of the EMC test plan and is signified by signatures and a tracking number (given by the Volvo Cars EMC team) on the test plan cover page.
4. Supplier to perform testing at an accredited test facility, see Test Facility.
5. EMC DV Testing shall be completed, and the test report approved by Volvo Cars no later than the start of Vehicle Integration.
6. Compliance to the EMC requirements shall be determined by the Volvo Cars EMC department and Design engineer after review of the test results submitted by the test laboratory.
7. EMC PV testing is required if the design tested during DV has been changed, the timing shall support the PPAP process.
8. To accommodate EMC simulation activities at Volvo Cars, it is essential that the supplier and the component owner cooperate and adhere to the CAE process outlined in the ESOW: Hardware Statement of Work (HWSOW). This includes providing measurement data files as well as the component noise source characteristics and/or interface impedance. For further details, please refer to the HWSOW.

Definition of Done

The sourcing of EMC requirements in each DPR shall be approved by the Volvo Cars EMC team.

The EMC Test plan shall be approved by the Volvo Cars EMC team before start of test.

The EMC Test report shall be approved by the Volvo Cars EMC team before vehicle integration.

Immunity Pass/Fail criteria

The purpose of the EMC immunity test is to verify that the DUT can perform its intended functional performance in the vehicle and its electromagnetic environment.

All of the DUT I/O and/or designed functions must be stimulated during all tests and monitored during the immunity tests. Each I/O and/or designed function shall operate as defined during all immunity tests. The Pass/Fail criteria for each I/O shall be documented in the test plan.

Functions that are related to vehicle AD fallback mechanisms will have unique requirements and pass/fail definitions depending on the assumed DUT response in that vehicle mode.

FPSC, Function Performance Status Classification

The FPSC Status I - IV definitions given in ISO 11452-1:2025 shall be interpreted as given below.

Status I

The function performs as designed during and after the test.

Interpretation:

The input or output under test performs as designed during and after exposure to disturbance. The pass/fail criteria is based on the hardware design, see 1 below, or a vehicle based criteria can be used, see 2 below.

1. An input or output is considered to have passed the test if its value remains within the designed tolerance during and after the test. Communication interfaces are not allowed to generate communication errors or transmit false messages.

2. Actual tolerance requirement can be determined from system/function simulations where the function with the most stringent tolerance requirement sets the pass/fail criteria for each I/O. This shall be defined in the TR/DPR.

During Transient Immunity transient and ESD testing, the value may deviate but must return to its designed value immediately after the transient. Resets are not allowed. One communication error or data message corruption is allowed for each transient occurrence or transient burst sequence (pulse 3a and 3b test in ISO 7637-2 and ISO 7637-3).

Status II

The function does not perform as designed during the test but returns automatically to normal operation after the test.

Status III

The function does not perform as designed during the test and does not return to normal operation without a simple driver/passenger intervention such as turning OFF/ON the DUT or cycling the ignition switch after the disturbance is removed.

Note: Removing and reattaching vehicle power or signal connectors is not allowed in the power up cycle. Re-initialization of parameters that are part of normal start-up behavior that is reflecting driver/passenger intervention (i.e. setting of parameters to go into active mode) is allowed.

Status IV

The function does not perform as designed during and after the test and cannot be returned to proper operation without more extensive intervention, such as disconnecting and reconnecting the battery or power feed. The function shall not have sustained any permanent damage as a result of the testing.

Note: DUT shall return to Status I on the first power up cycle after each test sequence.

Operating mode definitions

General

The DUT shall conform to the requirements in the worst-case operating conditions. All interfaces and functions shall be exercised during testing. For immunity tests, this means the most susceptible operating mode. For emission tests, this means the most active operating mode. More than one operating mode may be necessary to cover all functionality.

Sleep mode

DUTs that have a permanent power feed and are therefore powered when the vehicle is in a low power state shall additionally be tested in sleep mode for Immunity requirements. The acceptance criteria shall be that the DUT does not leave sleep mode during exposure (e.g. “wake up”, increase power consumption), and maintains functional performance after test.

Applicability of this requirement as well as operating mode(s) and acceptance criteria details shall be documented in the test plan.

Operating voltage range

The DUT shall conform to the requirements in its defined operating voltage range (e.g. 10,5 to 16 Volts for a 12 Volt component).

Emission requirement conformity can be shown by testing either:

- full envelope of the operational voltage range by selecting the maximum, nominal and minimum voltages, or
- at the worst-case operating voltage(s) with due justification.

Immunity requirement conformity, including powered ESD, can be shown by testing only at the nominal voltage unless the operating voltage has a significant impact on the DUT behavior.

The selection of operational voltage levels shall be made individually for each requirement. Observe that some EMC tests have specified set operating voltage(s) in the standard.

Test Sample selection

A minimum of two samples of each part number shall be tested against each requirement. Both samples must pass the test.

A reduction of the number of samples must be accompanied with an analysis showing the rationale for accepting the sample reduction.

ESD tests shall be performed on at least two untested samples of each part number and these samples are not allowed to be used for any other EMC tests.

Test Facility

The test facility to be used for testing shall be defined in the EMC test plan or MoC. Approval of the test facility is at the discretion of the Volvo Cars EMC team. Proof of accreditation and scope of accreditation shall be provided upon request.

For a test facility to be accepted by Volvo Cars it shall fulfill the following requirements:

- Proof of accreditation to ISO 17025 and to the International Standards referenced in the test report by an ILAC MRA signatory body. Accreditation is only required within the scope of the standards and the applicable tests.
- Only ISO 9000 accreditation is required for the methods RE1, CE1 and ISO 16750-4 Climatic loads; however, proof of accreditation is not required. For the RE2 method, CISPR25 accreditation shall be used.
- Name, telephone number and email of the person responsible for maintaining the accreditation in the organization.

Volvo Cars reserves the right to arrange for follow-up correlation tests and/or on-site visits to evaluate the test methods presented herein. A laboratory which refuses such follow-up activities, or for which significant discrepancies are found is subject to having all of its reports disqualified.

EMC test plan requirements

The EMC test plan shall be issued by the supplier in accordance with the supplier's ISO 9000 documentation procedure. The template for the EMC test plan can be obtained from the Volvo Cars EMC department upon request.

The EMC test plan shall be approved by the Volvo Car EMC team before start of test.

This plan shall include the following general items:

- Selected test facility
- Selected surrogates and their main configurations
- The orientation(s) of the DUT for radiated emission and immunity tests
- DUT grounding and power supply feed
- Operating voltage range
- Selected operating voltage for each test with stated rationale
- The DUT I/O selected for inclusion in the test with defined Pass/Fail criteria for each I/O
- How the monitoring of the DUT I/O and response is to be made
- Selected operating modes for each subtest

Test report requirements

General requirements

The test report shall be released by the test facility according to the requirements in ISO 17025.

The test report shall include the following general items:

- The EMC test plan tracking number
- DUT identification (e.g. Volvo component part number and serial number, or other unique identifier)
- Date of tests
- Test preconditions (such as temperature, humidity etc)
- Modifications made on test object, if relevant
- DUT description
- Summary of test results and their relation to operating modes
- Used test equipment
- Photographs of the test setups
- The bonding resistance towards GRP for AN(s) and enclosures

For all individual reported tests, the following shall be included:

- DUT operating modes
- ID of test object
- Photographs and description of the test setup

Additional emission report requirements

For each type of measurement, the following shall be included:

- Measurement resolution bandwidth (RBW)
- Limit lines, with indication of Detection scheme (i.e. Peak, Quasi Peak, Average)
- Measurement dwell time or sweep rate
- A notification if FFT measurement mode is used
- Plots of the test setup ambient data
- Pass/fail statement for the requirement

DUT emissions measured in the frequency domain shall be plotted over each frequency band. The plots shall be clearly annotated with the following information:

- DUT operating mode
- DUT identification
- Limit lines
- Antenna polarization/position when relevant
- DUT orientation
- Used instrument settings or deviations from the general settings
- Margin to limit for the highest values for at least 6 frequencies in tabular form and their corresponding frequencies

Additional immunity report requirements

For each type of test, the following shall be included:

- Upon request, the generated monitoring data used to define the immunity performance criteria as specified in EMC test plan
- Upon request, plots of amplifier power vs. field strength shall be available, but do not need to be included in the test report.

Frequency domain immunity tests:

Applied test level shall be plotted over each frequency band. The plots shall be clearly annotated with the following information:

- DUT operating mode
- DUT identification
- Type of test
- Required test level
- Antenna polarization/position and/or exposure point when relevant
- DUT orientation
- Used instrument settings or deviations from listed general settings - including dwell time, modulation settings
- Used acceptance criteria related to test level
- Pass/fail statement
- In case of deviation: the threshold level

- In case of deviation: a detailed description of the observed phenomena in a tabularized summary

Time domain immunity tests:

Immunity test results in the time domain (ESD, transients and fluctuations) shall be presented being clearly annotated with the following information:

- DUT operating mode
- DUT identification
- Type of test and point of injection (pin, surface point etc. with clear identification)
- Test levels and polarity
- Used instrument settings or deviations from listed general settings – including pulse cycle time, output impedance etc.
- Number of test pulses applied
- Time interval between pulses
- Resulting acceptance criteria related to test level
- Pass/fail statement
- A tabularized summary for DUT immunity performance shall be provided for each test.
- For conducted transients, graphs showing examples of applied pulses shall be included in the test report.

Test environment

Auxiliary Equipment (AE)

Auxiliary Equipment (AE) are as defined in ISO 11452-1.

Load Simulator

The load simulator is the specific Auxiliary Equipment (AE) that is placed inside the test volume and is not a part of the DUT. The Load Simulator is constructed to simulate the vehicle environment as seen by the DUT in its installation. The Load Simulator is a device that contains all external electrical interfaces (sensors, loads, etc.) normally seen by the DUT. The Load Simulator may also serve as an interface to the support and monitoring AE required during testing. It shall be powered by its own dedicated EMC compliant power source.

All Electrical interfaces shall by default be fitted with decoupling capacitors, typically 10 nF. These capacitors shall be connected to the GRP, preferably via load simulator metallic enclosure.

Data bus links to AE shall be realized with a fiber optic link in the Load Simulator. The electrical interface towards the DUT shall follow the relevant Volvo Cars specification for each data bus interface. Note that the DUT side of the optical isolator need to be electrically connected to the GRP.

Care shall be taken to avoid interference between the DUT and the Load Simulator. DUT vehicle power supply is not allowed to be routed through the load simulator. To avoid interference, it is sometimes necessary to fully enclose and shield the Load Simulator. Such shield shall be grounded to the GRP plate-to-plate.

Note: Sometimes the term "Load Box" is used instead - it shall be taken as a synonym for Load Simulator.

Artificial Networks (AN)

Artificial Network design and performance characteristics shall conform to CISPR 25:2021, or ISO 7637-2:2011 where applicable.

The DUT GND, or power return wire, shall not be connected to an AN unless the vehicle installation uses more than 4 meter of GND wire. If no AN is used, the power return wire shall be connected directly to the ground reference plane (GRP) at the AN location used for the power supply wire.

Interconnections

The electrical interconnections between the DUT and Load Simulator shall be facilitated using a standard test harness. The length of this harness shall be 1700 mm +300/-0 mm unless otherwise stated. The cables used in the test harness shall be representative and of the same wiring type as those installed in the vehicle.

The use of shielded cables is not allowed unless specifically called out in the drawings and documented in the EMC test plan and report. Selected tests may require shorter power/power return wiring between the DUT and measurement system.

Bonding of DUT, Load Simulator and Artificial Network to Reference Ground Plane (GRP)

The Load Simulator and Artificial Networks shall be directly bonded to the GRP used in the test setup. Bonding shall be facilitated via screws directly into the GRP. The bond impedance shall be verified to be less than 2.5 mΩ. Use of conductive tapes or bonding straps are not allowed.

The DUT shall be grounded in a manner representative of the installation in the vehicle. The DUT grounding configuration shall be documented in the EMC test plan.

- If the DUT's housing is isolated from the vehicle's chassis, the DUT shall be placed on an insulated support 50 mm above the GRP.

- If the DUT is installed with a direct ground connection to the vehicle's sheet metal, the DUT shall be mounted and connected to the GRP in a manner representative of the vehicle installation. This configuration shall be documented on the drawings and in the product engineering specification.

- If the DUT can be installed both connected and isolated, then both setups shall be tested.

The Bonding resistance shall be documented in the EMC test report.

Environmental Test Conditions

The following climatic test conditions shall be used:

Temperature	23 +/- 5.0 degrees C
Humidity (general)	20 to 80% relative humidity (RH)
Humidity (ESD tests)	20 to 60% relative humidity (RH)

REQ-104557 v5 EMC - Emission requirements introduction

Attribute: EMC
Requirement Classification: Hard
Change classification: Editorial
Design Target : True
Is Generic : No

Purpose:

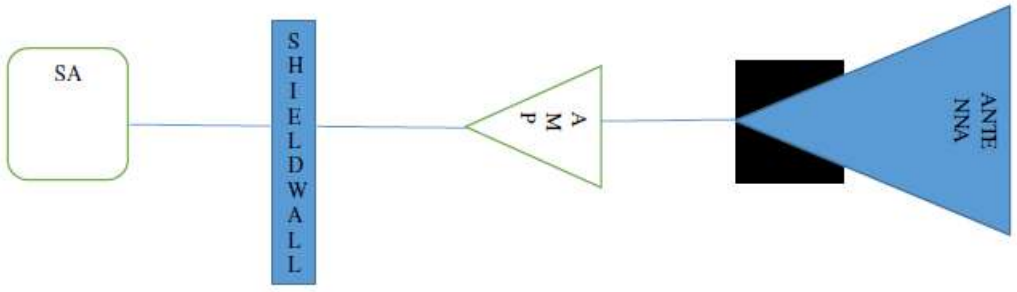
The purpose with this requirement is to specify certain required preconditions as well as providing clarification on certain technical details.

General

The limits in these requirements are defined with a set of boundary conditions that are available to system designers internally within Volvo as Design Guidelines. The use of Spread Spectrum clocks to defeat these requirements is not allowed.

Test setup

Use of multiple measurement antennas at the same time and in the same test setup is not permitted.



The above setup is an example of how to maximize the S/N of the test system. The cable between antenna and low noise amplifier shall be extremely short, preferably not used. A high gain antenna used in the frequency range of 470 MHz - 10.6 GHz is allowed and shall be located in front of the DUT.

Test Procedure

Prior to measurement of DUT radiated emissions, test setup ambient levels (i.e. all equipment energized except DUT) shall be verified to be 6 dB or more below the specified limit. If this requirement is not met, testing shall not proceed until the associated test setup issues are resolved.

Measurements may be performed with a FFT receiver if the results for the test object is equal (less than 3 dB difference) to the results obtained with a scanning receiver / spectrum analyzer. Proof of equality must be included in the test report. The FFT parameters used must be included in the test report.

Detailed measurement data reporting

The test report shall contain the plotted data both in graph and as a tabularized summary for DUT emissions for each frequency band. The table shall include the band frequency boundary, maximum DUT emission level measured for the band, and the associated band limit.

The supplier shall deliver standardized ASCII format files (CSV, ODF, TXT or similar) for all frequency domain emission measurements. The files shall be presented in a human-readable and tabular format. Each file shall contain, at a minimum, the following parameters:

- all measured frequencies,
- corresponding amplitude for each measured frequency,
- detector used,
- resolution bandwidth (RBW),
- sweep/dwell time, and
- the file name shall contain
  - Component name
  - Applicable test case description
  - For conducted measurements: connector ID, pin ID, pin function

The delivery shall be made at the same time as the test report. All data files must conform to the requirements outlined in Volvo Cars Data Reporting Procedures, as specified in NOTE-SPEC-34295713 CAE GENERAL ELECTRICAL DATA REQUIREMENT.

REQ-104572 v5 EMC - TE1 Transient emission requirement

Attribute:	EMC
Requirement Classification:	Intermediate
Change classification:	Editorial
Design Target :	False
Is Generic :	No

Purpose:

The aim with this requirement is to verify that the DUT does not emit fast transient pulses on any power related port that may cause interference to other connected devices in the vehicle.

Applicability:

- Vehicle Power
- Activation Input

Note 1: a component (such as a motor) may comply with the requirement as a system by utilizing a combination with another component (that e.g. can contain a unified protection device). Such system dependencies must be clearly documented to ensure the component is only installed as an approved combination.

Note 2: this requirement assumes that the supply voltage for the vehicle power is nominally set at 12V system voltage. Other nominal voltage supply levels for vehicle power, such as 48VDC, require further contact and agreement with VCC EMC.

This requirement contains four test cases (A through D). The applicability of each test case shall be detailed in the EMC test plan.

Test case A applies to external power toggling – when the power supply to the component is connected or disconnected. This test case applies to all components.

Test case B applies to load stalling – when the component mechanical load is stalled (held in place via external means, e.g. via an end stop or torque limit). This test case applies to components containing or feeding motors, actuators and other kinetic components. It does not apply if it can be demonstrated that stalling cannot occur.

Test case C applies to internal switching – when the operation of internal switches in a component can cause transients. This test case applies to components that contain any power electronics devices (e.g. transistors) used to switch significant loads.

Test case D applies to activation inputs – when a vehicle power network is used as an input to control the operating mode of a component (i.e. as an activation or sleep signal, for example ignition). This test case applies to all components with an activation input.

Requirement:

The prerequisites stated in REQ-104556 Introduction and Applicability and REQ-104557 Emission Requirements Introduction apply to this requirement.

The measured pulses shall comply with the maximum allowed values as below.

Test case A: external power toggling

Test port	**Max peak amplitude [V]**	**Max pulse duration allowed [µs]**
Vehicle power Activation input	+50, -75	100

Test case B: load stalling

Limit as in test case A apply

Test case C: internal toggling

Limit as in test case A apply

Test case D: toggling and load stalling, activation input low

Test port	**Max peak amplitude [V]**	**Max pulse duration allowed [µs]**
Activation input	+15, -15	10

Test setup conditions

The preconditions of ISO 7637-1:2023 shall be used. The measurement shall be made in accordance with ISO 7637-2:2011, fast pulses, with the following specifications:

- Measurement of pulse amplitude (positive and negative) and pulse length shall be made on each separate lead with an oscilloscope. It may be performed simultaneously on all leads.
- The AN given in ISO 7637-2 shall be connected to the power lead under test.
- Each other lead not being measured shall be connected to an AN each. This AN shall be either the one specified in CISPR 25 or ISO 7637-2.
- Make sure a 50 ohm termination is connected to the RF sampling port of each AN.
- The shunt resistor Rs as shown in figure 1b of ISO 7637-2 shall not be installed.
- Ten (10) waveform acquisitions are required for each test case and change of operation mode.
- Test case A shall include at least the following operation mode changes:
    - power ON-to-OFF
    - power OFF-to-ON
    - The ON state shall include all relevant operating modes. These modes shall be defined in the EMC test plan.

- Test case B shall include any stall conditions:
  - Power OFF to ON with STALL
  - Power ON with STALL to OFF
  - The stall should not be held longer than one (1) second. This time restriction is to prevent activation of in-line protection devices (such as Positive-Temperature Coefficient [PTC] resistors) that would interrupt the current to the DUT.
- Test case C shall be tested during power ON with internal mode changes:
  - Measurements shall be made during internal mode changes, such as switching, in the component itself caused by software, triggers or other external input that may cause transients. These mode changes shall be specified in the EMC test plan.
  - Compliance may be shown without testing by simulation and/or circuit analysis, at the discretion of the Volvo Cars EMC department.
- Test case D shall be measured in the same conditions as test case A, B and C (as applicable), but with the activation input held low (inactive):
  - Measurement shall be done on the activation input.
  - This is to ensure that transients are not transmitted to the vehicle power network that is used as the activation input.
- Switchable supply leads shall be high impedance in the off state (e.g. by a switch or disconnect of lead).

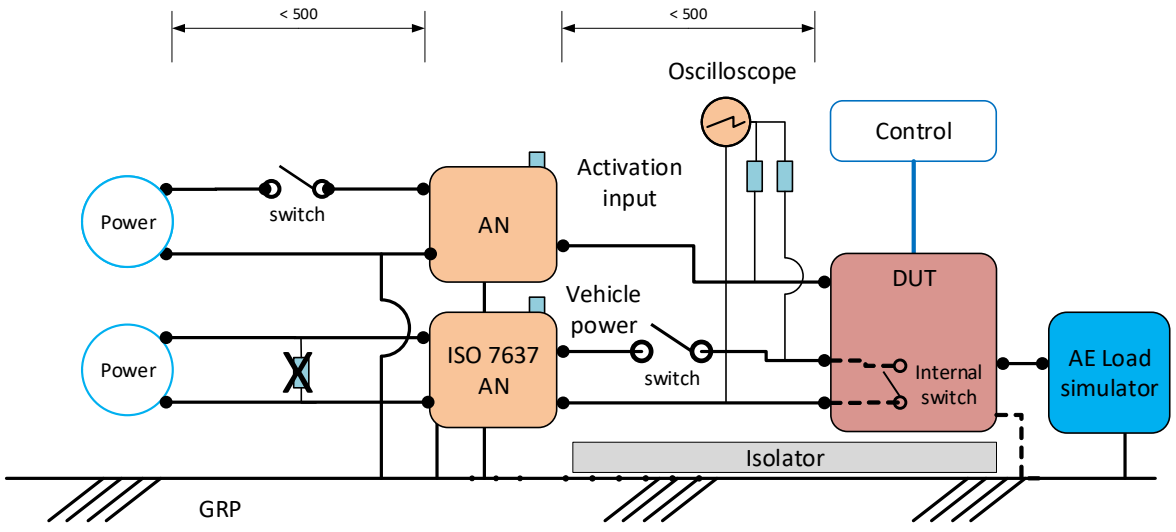


Figure 1 test setup for transient emission

Pulse measurement method:

U_P is defined as the peak transient voltage measured.

U_A is defined as the nominal operating voltage of the component.

U_{Amax} is defined as the maximum operating voltage of the component for which full functionality shall be provided.

U_{Amin} is defined as the minimum operating voltage of the component for which full functionality shall be provided.

The voltage range U_{Amin} to U_{Amax} is denoted as the *nominal operating voltage range* for the purposes of this requirement and is equal to other uses in the EMC requirements (e.g. for the emissions tests).

The voltage range -1V to U_{Amax} is denoted as the *safe operating voltage range* for the purposes of this requirement.

U_A, U_{Amin} and U_{Amax} shall be defined in the EMC test plan.

The pulse amplitude U_P shall be measured as:

- the highest amplitude of the captured waveform, for the positive limit
- the lowest amplitude of the captured waveform, for the negative limit

Both highest and lowest extreme amplitudes shall be measured.

The pulse duration t_d shall be measured as:

- for off-to-on transitions:
    - start point:
      the time at the first crossing outside of the safe operating voltage range of the component, the envelope from -1V to U_{Amax}
    - stop point:
      the time at the last crossing into the nominal operating voltage range of the component, the envelope from U_{Amin} to U_{Amax}
- for on-to-off transitions
    - start point:
      the time at the first crossing outside of the nominal operating voltage window, the envelope from (U_{Amin} to U_{Amax})
    - stop point:
      the time of the last crossing into the safe operating voltage range of the component, the envelope from -1V to U_{Amax}

- for static-on transitions (test case B and C, internal switching and stall)
    - start point:
      the time at the first crossing outside of the nominal operating voltage window , the envelope from (U_{Amin} to U_{Amax})
    - stop point:
      the time at the last crossing into the nominal operating voltage window, the envelope from (U_{Amin} to U_{Amax})
- for static-off transitions (test case D, activation input low)
    - start point:
      the time at the first crossing outside $0.1*U_P$ or $-0.1*U_P$; 10% of the extreme peak voltage in either direction from 0V
    - stop point:
      the time at the last crossing into $0.1*U_P$ or $-0.1*U_P$; 10% of the extreme peak voltage in either direction from 0V

If no over- or undershoot is measured (i.e. the measured voltage stays between the nominal starting and the ending voltage at all times), the DUT is deemed to pass the requirement regardless of the pulse duration.

Test report requirements

The test report shall show a detailed time domain plot with sufficient resolution to show the dynamic response of the measured transient. The time domain plot shall show the following pulse parameters:

- maximum pulse overshoot (U_P),
- minimum pulse undershoot ($-U_P$),
- the pulse duration (t_d), and
- start and stop point values for voltage and time.

An engineering assessment based on that measurement shall be provided in the test report.

Examples of interpretations on how to define the pulse duration t_d are shown in the figures below.

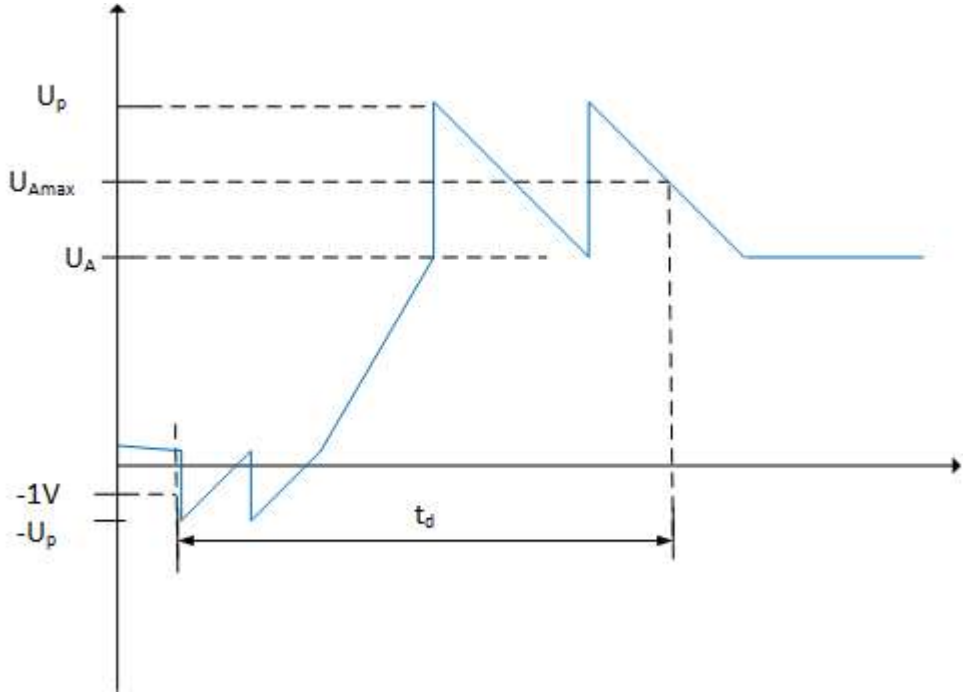


Figure 2 transient pulse measurement example with both under- and overshoot

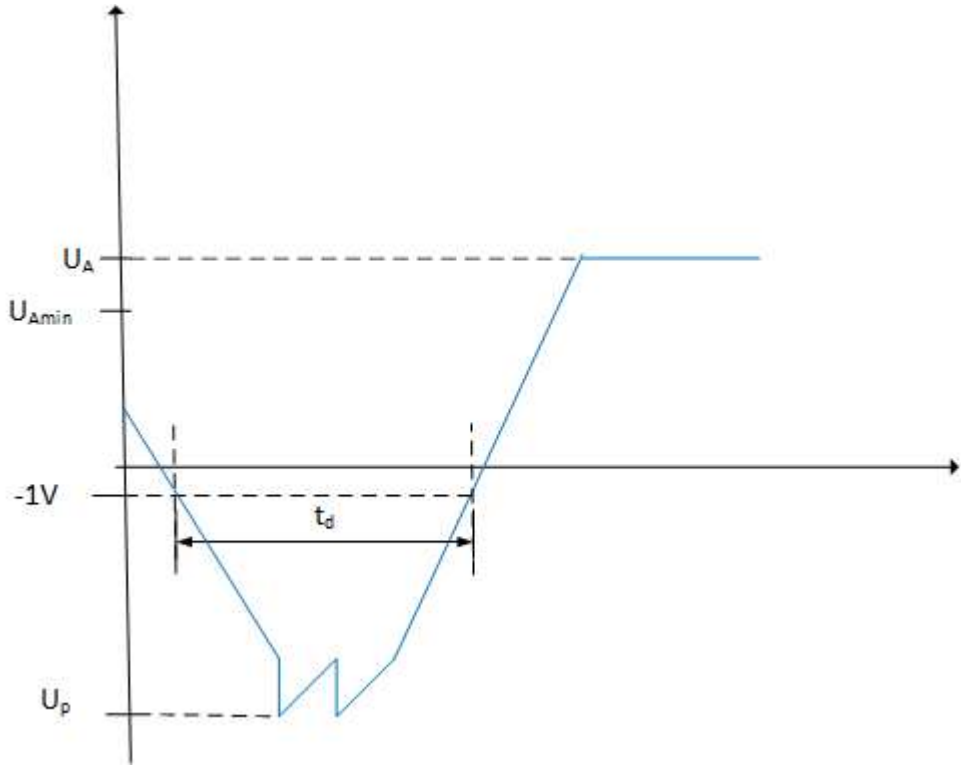


Figure 3 transient pulse measurement example with only undershoot

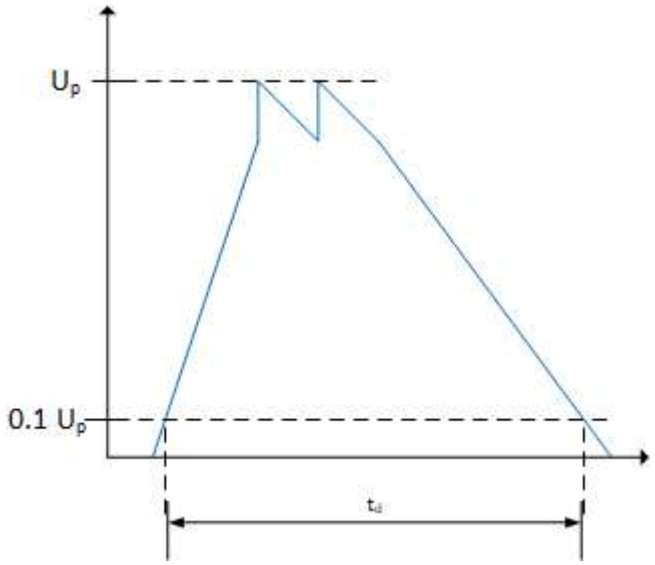


Figure 4 transient pulse measurement example – unpowered port

REQ-104569 v5 EMC - CE1 Conducted current requirement, ripple

Attribute:	EMC
Requirement Classification:	Hard
Change classification:	Critical
Design Target :	False
Is Generic :	No

Applicability

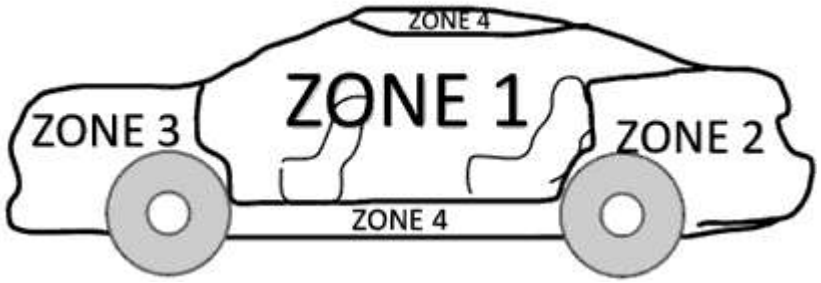
- Vehicle Power
- Load Output

Exclusions

This requirement is not sufficient for component leads that are in very close contact, < 7 cm, with the human body e.g. seat heater and steering wheel heater. These components require a special tailored requirement.

Zone definitions

For this requirement, the vehicle is divided into four different zones., The requirement limit varies depending on which of the zone(s) the cables are routed in. A graphical view of the principal zoning is shown in the figure below. The specific zone definitions are provided in the text below.



Zone 1: The volume inside the passenger compartment or in the doors. The front zone boundary consists of the firewall and the rear zone boundary is limited by a plane 10 cm behind and parallel to the rear surface of the back rest of the rear-most seat row.

Zone 2: The volume inside the trunk behind the rear limiting surface as described in zone 1.

Zone 3: The volume inside the engine bay and potential frunk, in front of the firewall.

Zone 4: The volume
a) under Zone 1 and 2, below the metal floor of the passenger compartment
b) above Zone 1, the roof part outside of the vehicle body, if the roof is metal.

Requirement

The prerequisites stated in REQ-104556 Introduction and applicability and REQ-104557 Emission Requirements Introduction apply to this requirement.

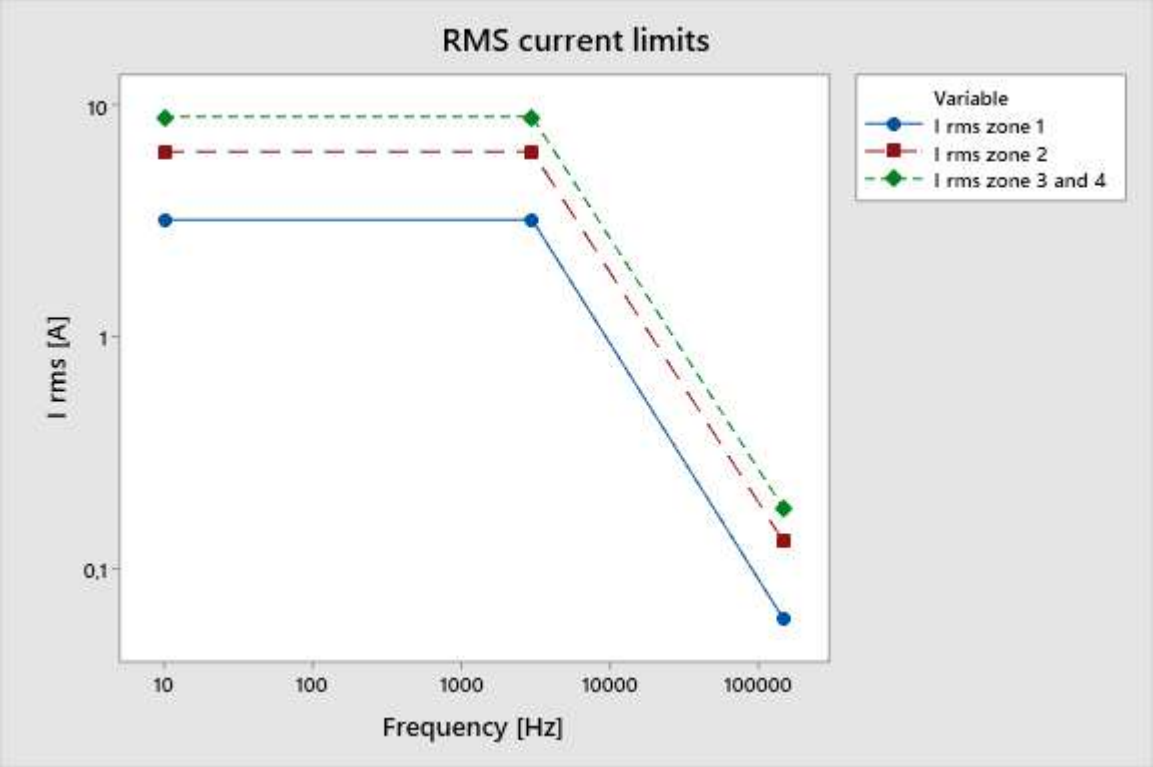
Requirement for single power and return leads, vehicle power (I_L),
and paired bundle of leads, < 0.5 cm power and return separation (I_{CM})

Conducted current emissions on power wiring shall be below the limits given in the table below. If the wires pass through more than one zone, the most stringent Zone requirement applies.

Each single wire current, I_L, shall conform to the values in the table below. For the paired bundle case, only the combined current on both leads, I_{CM}, needs to comply with this requirement.

Frequency	**Zone 1**	**Zone 2**	**Zone 3**	**Zone 4**
[Hz]	**I rms (A)**	**I rms (A)**	**I rms (A)**	**I rms (A)**
10	3,20	6,30	8,9	8,9
3 k	3,20	6,30	8,9	8,9
150 k	0,06	0,13	0,18	0,18

	I peak (A)	**I peak (A)**	**I peak (A)**	**I peak (A)**
Peak amplitude in time domain	4,5	8,9	N/A	N/A



Measurement method

The measurement is performed using the basic setup as in the standard CISPR 25:2021, but using time domain technique with multiple sensors, as defined below. The following modifications apply.

Procedure:

- The DUT is connected to the test setup as shown in the test setup chapter.
- The measurement of RMS current and voltage is made in time domain by simultaneous measurement of line current (IL), CM current (ICM), DM voltage (UDM) and CM voltage (UCM) followed by FFT conversion. The values for all four parameters shall be recorded for each measurement.
- The measurement is made on all leads in the following steps

- line current and voltage on power lead,
- line current and voltage on return lead, if applicable, and
- common mode current and voltage, if applicable.

- An ambient measurement shall be performed, and the level shall be below the limit by a factor of 2 (6 dB).
- The measurement of peak current is made in time domain during at least 1s. The highest value shall be recorded. A built-in oscilloscope measurement function is allowed to be used.

Test setup description

General preconditions

The test setup is made as follows for each type of wiring harness and component.

The DUT shall be placed on the GRP. At the minimum, the GRP shall extend minimum 250 mm underneath the DUT.

The DUT shall be connected to the GRP in the same way as in the specified installation.

The load simulator shall be connected to the GRP in the same way as in the specified installation.

Each AN shall have a 50 ohm termination.

Setup examples are given in the figures below for a set of product types. If the DUT has multiple Vehicle Power inputs, only the measured port needs to have the correct setup. The other port shall have its own dedicated power supply.

Low voltage differential probes are recommended for resolution purposes. The current probe shall be dimensioned also for the intentional DC current.

It is recommended to perform the measurement with an isolated battery mode oscilloscope to evade low frequency stray currents from the surrounding power grid. If the oscilloscope is connected to a laptop PC, this PC should also be in battery mode.

Power supply requirement:

The LV power supply shall have an internal resistance, *R*s < 0,01 d.c. and an internal impedance, *Zs*, equal to *Rs* for frequencies ≤ 400 Hz. The output voltage shall not deviate more than 1 V from zero to maximum load (including inrush current) and shall recover 63 % of its maximum excursion within 100 µs. The superimposed ripple voltage, U_{ripple}, shall not exceed 0,2 V peak-to-peak and shall have a maximum frequency of 400 Hz. It is possible to use either:

- An individual power supply that meets these requirements;
- A combination of a power supply in parallel with an automotive battery. In which case:
  - the power supply current capacity shall be able to supply and maintain the current demanded by the DUT;
  - the power supply shall be able to supply and maintain the required voltage.

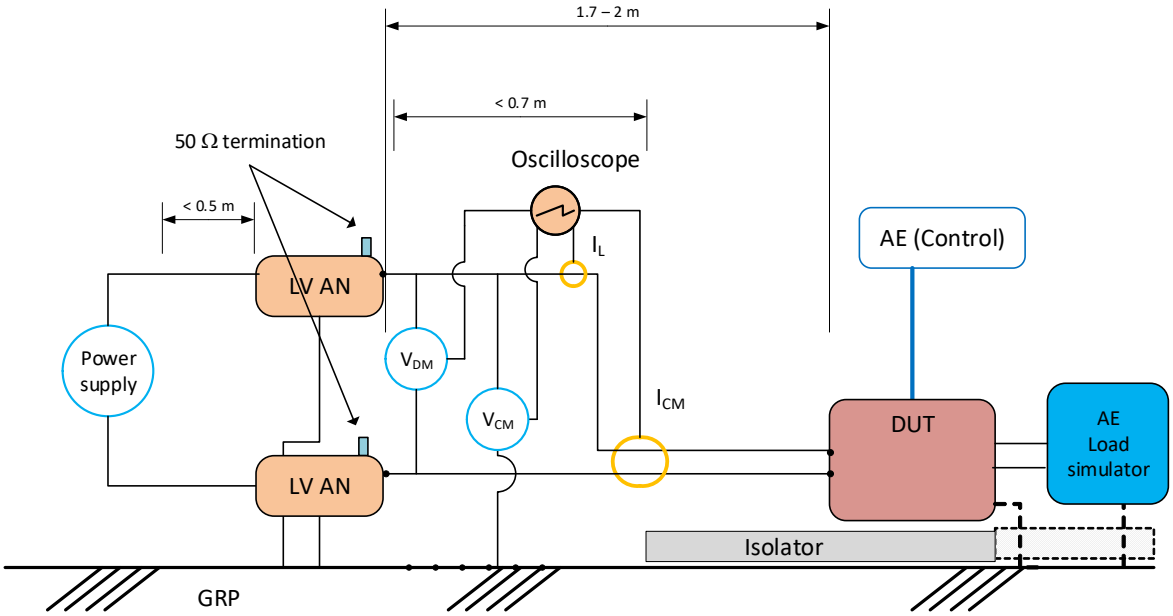


Figure of test setup for Device Under Test (DUT) with Vehicle Power having dedicated return. The AE load simulator may be passive of e.g. a PWM controlled load.

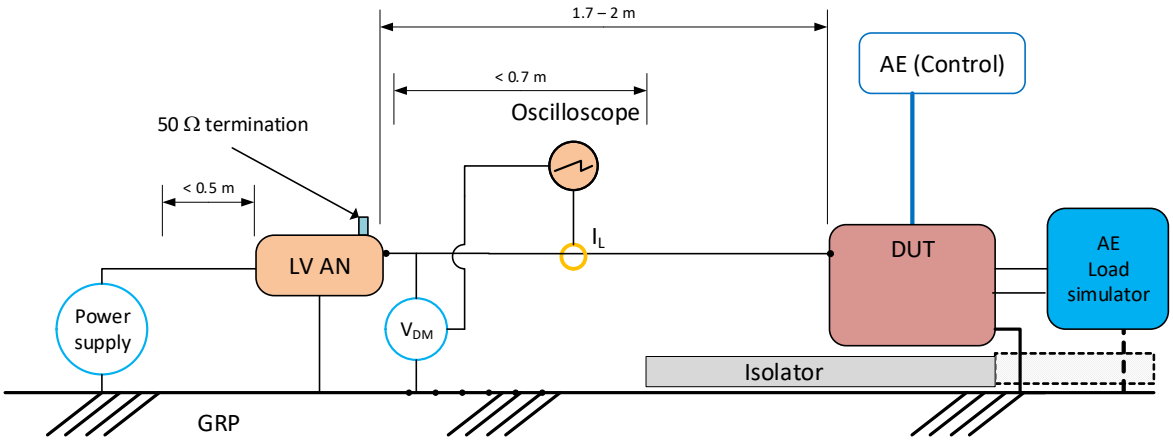


Figure of test setup for Device Under Test (DUT) with Vehicle Power having power return in chassis. Power supply negative lead is connected to the GRP. The Common Mode (CM) measurement is not applicable.

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Template GRS 10.03 Security Class: Proprietary

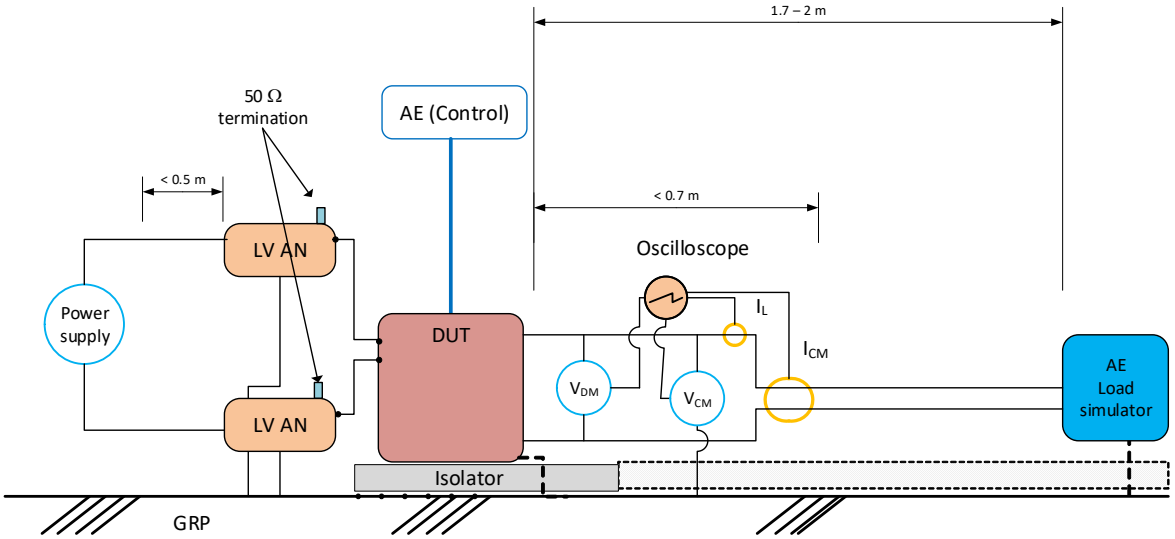


Figure of test setup for Device Under Test (DUT) having a load output with dedicated return. No AN is applied on the test interface (load output). For practical reasons, the ANs may remain on the power supply, since measurement is made on that port with the same basic setup.

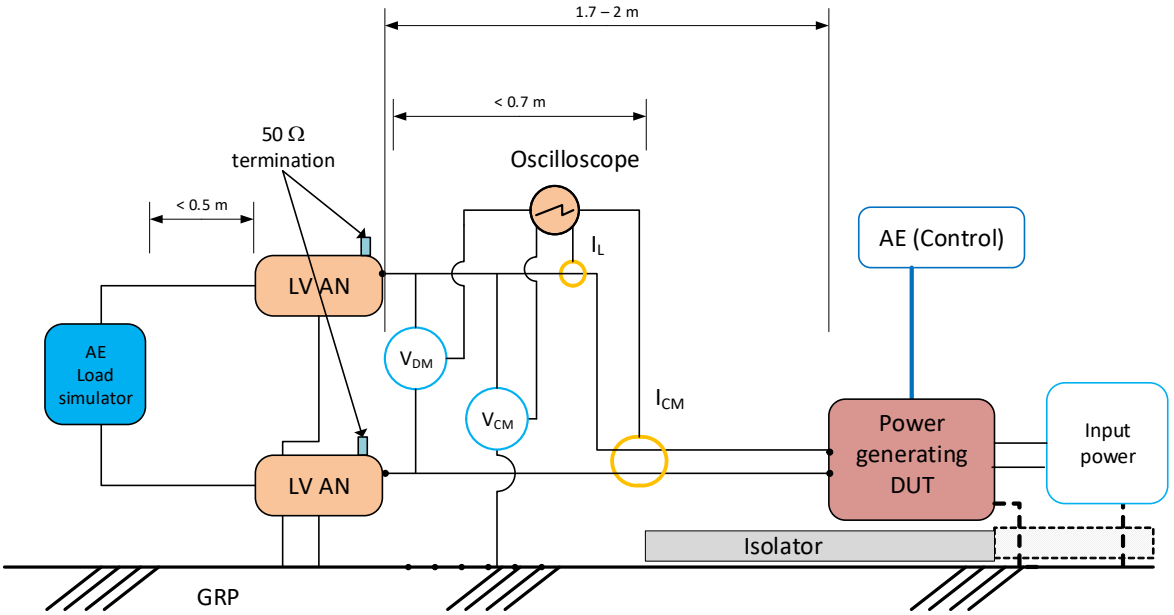


Figure of test setup for Device Under Test (DUT) that is generating power to the vehicle supply system. The AE load is positioned on Vehicle Power AN supply side as a relevant simulation of the load condition.

Measurement system requirements

Parameter	*Specification*
Voltage accuracy	5%
Current accuracy	5%
Instrumentation bandwidth	> 1 MHz
Voltage probe impedance	> 1 MΩ
Oscilloscope y-resolution	≥ 8 bits
Oscilloscope memory depth	≥ 2 MS

Measurement settings for FFT

Aspect	*Specification*
Windowing type	Hanning

Probe coupling	AC
Collection time (FFT window size, the duration of sweep)	1 second ± 20%
Oscilloscope sampling rate	≥ 400 kS/s per channel
Optional filter cut-off frequency	20 MHz (low pass, 2-order type)

Artificial Network (AN)

The purpose of the Artificial Network (AN) is to mimic the system impedance in the actual power system and to create a standardized environment in which tests are to be performed. The used AN shall be as follows.

Power type	*AN specification*
Vehicle power	CISPR 25 AN, 5 µH
Load output	N/A system test impedance used

Test report details

Frequency domain results and ambient shall be provided in graph form. Graphs are preferably presented in log-log scale.

Peak data shall be given as a value in the report.

Evaluation of test results shall be done against all 4 zone limits, with individual compliant / non-compliant statements. Overall test compliance shall be evaluated against the zone(s) defined in the EMC Test Plan.

Data file delivery details

The provided result data files shall contain the amplitude of each measured current and voltage.

REQ-104570 v5 EMC - CE3 Conducted current requirement, current probe

Attribute: EMC
Requirement Classification: Hard
Change classification: Editorial
Design Target : False
Is Generic : No

Purpose:

The aim with this requirement is to limit the RF currents generated by the DUT on its attached leads in order to

- limit off-board RF emission and
- protect the wireless functions (Radio/TV/Phones/Keyless/Connectivity) that Volvo Cars provides to customers, and devices customers use in the vehicle.

Applicability:

- Vehicle Power
- Activation Input
- Load Output
- Signal
- Vehicle AC mains

Requirement:

The prerequisites stated in REQ-104556 Introduction and Applicability and REQ-104557 Emission Requirements Introduction apply to this requirement.

The DUT shall conform to each defined limit in the table below, i.e. at frequencies where more than one detector is specified, all requirements apply simultaneously.

Limits

Frequency Range [MHz]	Limits [dBuA]			
	Peak	Quasi-Peak	Average	CISPR class
0.15 - 1.8	58	NA	38	1
1.8 - 76	NA	18	11	3
76 - 174	NA	3	-4	3
174 - 320	16	NA	-4	3

Test setup conditions

The measurements shall be performed according to CISPR 25:2021, current probe method, with modifications as listed below.

For each DUT connector, the following combinations shall be tested:

- Complete harness attached to the connector (including power and ground)

- Vehicle power supply separately

- Vehicle power return separately

For complex DUTs (i.e. with multiple connectors, several power supplies or returns, many pins etc.) it is suggested that the actual combinations be listed in the EMC test plan.

Measurement shall be performed at two fixed injection probe positions: 50 mm and 750 mm from the DUT.

Measurement dwell/scan times listed in CISPR 25 Tables 1 and 2 shall be increased to capture the maximum level of emission if the DUT operates with intermittent duration.

REQ-104562 v4 EMC - RE1 Magnetic field requirement, close proximity

Attribute:	EMC
Requirement Classification:	Hard
Change classification:	Relief
Design Target :	False
Is Generic :	No

Purpose

The aim with this requirement is to

- limit the personal exposure to magnetic fields generated by the vehicle systems, and

- coexistence for components within the vehicle with respect to magnetic fields.

Applicability

- Enclosure

Exclusions

This requirement is not sufficient for components that are in very close contact, < 7 cm, with the human body e.g. seat heater and steering wheel heater. These components require a special tailored requirement.

Requirement

The requirements in REQ-104556 Introduction and Applicability and REQ-104557 Emission Requirements Introduction apply to this requirement.

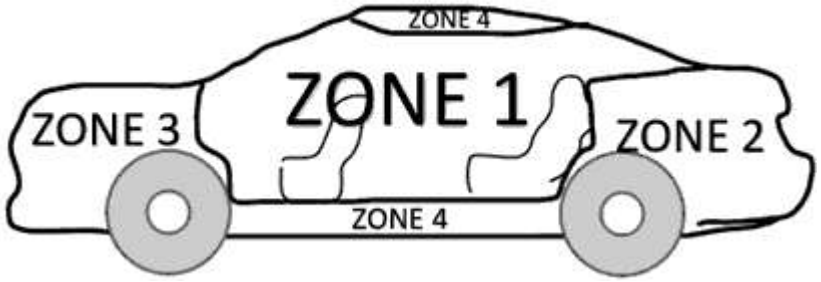
The test method is based on IEC 62311 using measurements as the assessment method and with the requirement levels below.

Evaluation of test results shall be done against all 4 zone limits below, with individual compliant / non-compliant statements.

Overall test compliance shall be evaluated against the zone(s) defined in the EMC Test Plan.

Zone delimitations

For this requirement, the vehicle is divided into four different zones., The requirement limit varies depending on which of the zone(s) the component is mounted in. A graphical view of the principal zoning is shown in the figure below. A more detailed zone boundary definition is provided in the text below.



Zone 1: The volume inside the passenger compartment or in the doors. The front zone boundary consists of the firewall and the rear zone boundary is limited by a plane 10 cm behind and parallel to the rear surface of the back rest of the rear-most seat row.

Zone 2: The volume inside the trunk behind the rear limiting surface as described in zone 1.

Zone 3: The volume inside the engine bay and potential frunk, in front of the firewall.

Zone 4: The volume
a) under Zone 1 and 2, below the metal floor of the passenger compartment
b) above Zone 1, the roof part outside of the vehicle body, if the roof is metal.

Requirement Limits

The requirement is split in two parts. Simultaneous compliance to both parts is mandatory.

Part 1: The weighted time domain magnetic field measurement between 10Hz and 400kHz shall be below the limits given in the table below. The limits are based on 1999/519/EC General Public.

Weighted time domain magnetic field limits:

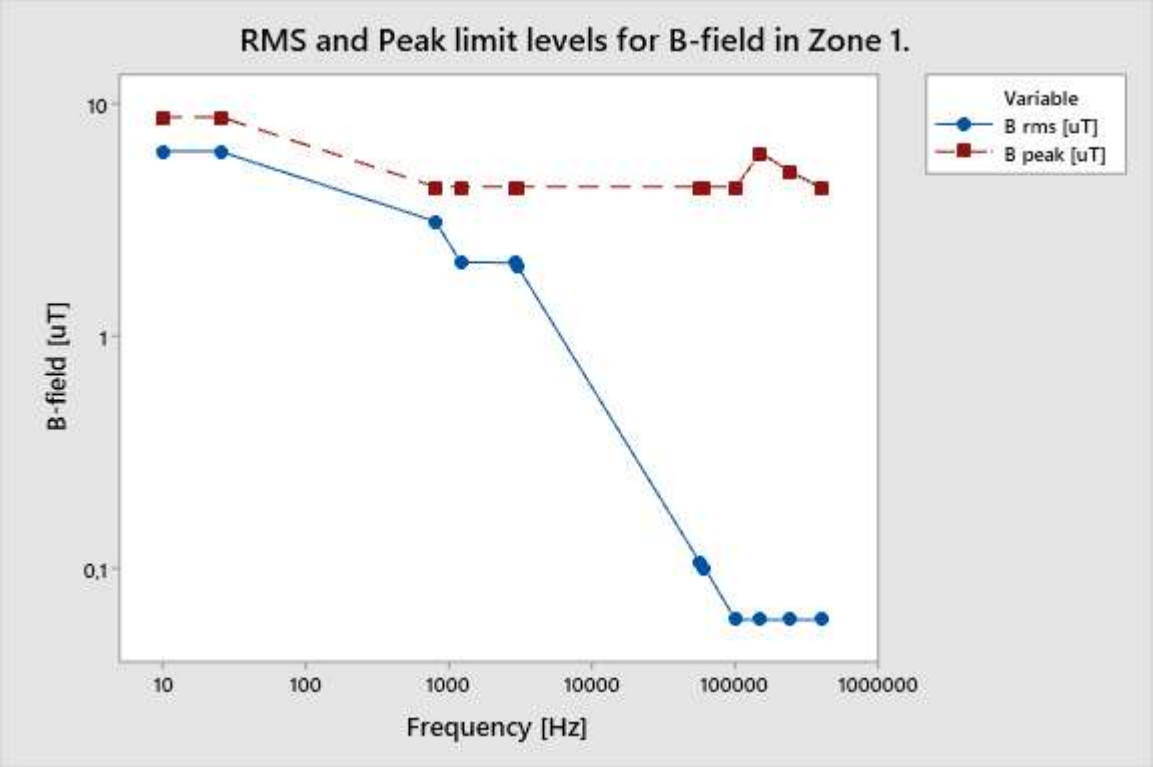
	Zone 1	**Zone 2**	**Zone 3**	**Zone 4**
Limit	0.5 (50%)	1,25 (125%)	2,5 (250%)	0,75 (75%)

Part 2: The frequency domain magnetic field measurement between 10Hz and 400 kHz shall be below the limits given in the table below.

Frequency domain magnetic field limits, 10 Hz – 400 kHz:

	Zone 1		Zone 2		Zone 3		Zone 4	
Frequency [Hz]	**B rms [µT]**	**B peak [µT]**	**B rms [µT]**	**B peak [µT]**	**B rms [µT]**	**B peak [µT]**	**B rms [µT]**	**B peak [µT]**
10	6,25	8,80	15,98	22,49	30,27	42,62	9,38	13,20
25	6,25	8,80	15,98	22,50	30,28	42,63	9,38	13,20
800	3,13	4,40	8,41	11,84	16,55	23,30	4,69	6,60
1 200	2,09	4,40	5,68	12,00	11,32	23,88	3,13	6,60
2 900	2,07	4,40	5,75	12,21	11,60	24,65	3,11	6,60
3 000	2,00	4,40	5,56	12,22	11,22	24,68	3,00	6,60
57 000	0,11	4,40	0,30	12,70	0,63	26,45	0,21	8,80
61 000	0,10	4,40	0,29	12,71	0,60	26,51	0,20	8,80
100 000	0,06	4,40	0,18	12,85	0,37	27,12	0,12	8,80
150 000	0,06	6,15	0,18	18,24	0,38	39,15	0,12	12,30
243 000	0,06	5,10	0,18	15,62	0,41	34,69	0,12	10,20
400 000	0,06	4,35	0,19	14,07	0,46	33,16	0,12	8,70

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Template GRS 10.03 Security Class: Proprietary



Test setup conditions

The measurements shall be performed according to IEC 62311:2019 with basic test set up as in IEC 62233:2008.

All surfaces of the DUT shall be scanned using the weighted time domain magnetic field, according to part 1 above, finding the point with maximum magnetic field in the frequency range 10 Hz to 400 kHz.

In this maximum point the frequency domain measurement according to part 2 above shall also be performed.

The resolution bandwidth (RBW) shall be as in the following table.

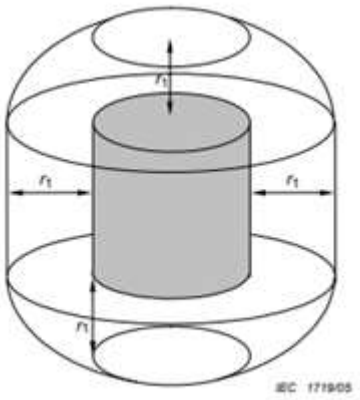
Frequency range	*Frequency resolution*
10 Hz ≤ f < 5 kHz	≤ 1 Hz
5 kHz ≤ f < 50 kHz	≤ 5 Hz
50 kHz ≤ f < 400 kHz	≤ 50 Hz

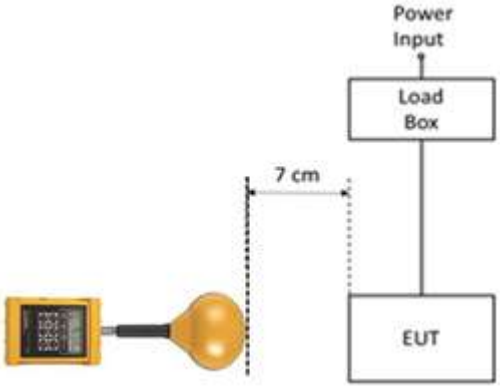
The magnetic field measurement probe shall be isotropic with an outer diameter of no more than 13 cm, and with a probe area of maximum 100 cm2. The probe shall comply with the IEC 61786-1.

Basic test set-up

Basic test set up shall be according to IEC 62233.

The field probe shall be moved around the component at a distance of 7 cm from the surfaces as shown in the figures below.





Test report details
Evaluation of test results shall be done against all 4 zone limits, with individual compliant / non-compliant statements. Overall test compliance shall be evaluated against the zone(s) defined in the EMC Test Plan.

REQ-104563 v3 EMC - RE2 Magnetic field requirement, ALSE

Attribute:	EMC
Requirement Classification:	Hard
Change classification:	Critical
Design Target :	False
Is Generic :	No

Purpose:

The aim with this requirement is to

- limit the magnetic field emission from the DUT to protect off-board radio receivers, and
- coexistence for components within the vehicle with respect to magnetic fields.

Applicability:

- Enclosure

Requirement:

The prerequisites stated in REQ-104556 Introduction and Applicability and REQ-104557 Emission Requirements Introduction apply to this requirement.

Requirement limits

Peak magnetic field emission limits	
Frequency f [MHz]	**Level dB[µA/m]**
0.15 - 4.77	47.36 - 20log10(f)
4.77 - 15.92	74.52 - 60log10(f)
15.92 - 20	26.45 - 20log10(f)
20 - 30	0.43

Test setup conditions

The measurements shall be performed according to CISPR 25:2021, chapter 6.5 ALSE method with modifications as below.

Measurement resolution bandwidth (RBW): 9 kHz

Maximum step length: 5 kHz

Minimum dwell time: 10 ms

Certain sources such as low repetition rate or intermittent signals may require lower scan rates or multiple scans to capture the worst-case emissions.

Antenna: electrically shielded loop antenna as per CISPR 16-1-4:2019, section 4.4.2.

Antenna polarizations: Radial and Transverse. (Vertical orientation is not necessary)

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

Antenna position: The loop antenna lower edge shall be aligned with the GRP height and centered on the power feed cables to the DUT.

The DUT orientation shall be one worst-case orientation in the measurement frequency range of 150 kHz to 30 MHz. The worst-case orientation shall be as defined with analysis in the EMC test plan.

REQ-104564 v3 EMC - RE3 Electric field requirement, ALSE, legal

Attribute: EMC
Requirement Classification: Hard
Change classification: Critical
Design Target : False
Is Generic : No

Purpose:

The aim with this requirement is to limit the electric field emission from the DUT to protect off-board radio receivers.

Applicability:

- Enclosure

Requirement:

The prerequisites stated in REQ-104556 Introduction and Applicability and REQ-104557 Emission Requirements Introduction apply to this requirement.

This test uses the same method as the RE4 test, and it is suggested that they be done in conjunction with each other.

The limits are given in the table below.

The DUT shall conform to each defined requirement – i.e. at frequencies where more than one detector is specified, all requirements apply simultaneously.

Intentional transmitters (e.g. wireless communication) are exempt from the emission requirements in their operating frequency range(s). They are instead covered by band-specific radio regulations, such as type approvals or the Radio Equipment Directive (RED). The intentional emission frequency ranges shall be stated in the EMC test plan. These frequency ranges shall still be measured and documented. The exemption is only valid for the transmit mode of the DUT.

Requirement limits

Frequency f [MHz]	**Limit [dBµV/m]**		
	Peak	**Avg**	**QP**
0.15 to 4.77	98.89 - 20*Log10(f)	N/A	N/A
4.77 to 15.92	126.05 - 60*Log10(f)	N/A	N/A

Frequency f [MHz]	Limit [dBµV/m]		
	Peak	Avg	QP
15.92 to 20	77.98 - 20*Log10(f)	N/A	N/A
20 to 30	51.96	N/A	N/A
30 - 75		52- 25.13*Log10(f/30)	62 - 25.13*Log10(f/30)
75 - 400		42 + 15.13*Log10(f/75)	52 + 15.13*Log10(f/75)
400 - 1000		53	63

Test setup conditions

The measurements shall be performed according to CISPR 25:2021 with modifications as below.

The DUT orientation shall be set in three (3) orthogonal directions. The number of directions may be reduced to one worst case orientation in the measurement frequency range of 150 kHz to 30 MHz. The worst-case orientation shall be as defined with analysis in the EMC test plan.

For components that are physically large, it shall be ensured that the component stays within the receiving antenna's coverage lobe. Multiple antenna positions or other strategies may be necessary to ensure complete coverage. This shall be detailed in the EMC test plan.

Measurement dwell/scan times listed in CISPR 25 Tables 1 and 2 shall be increased if the DUT operates with intermittent duration to capture the maximum level of emissions.

A quick scan using a broadband antenna is allowed in order to identify the worst-case voltage and DUT orientation.

To decrease the test time required, the QP limits may be validated with a Peak detector with the limit unchanged. If the QP limit is exceeded with the Peak detector a retest with the QP detector is required. No reduction in RBW (resolution bandwidth) is allowed.

REQ-104565 v4 EMC - RE4 Electric field requirement, ALSE, coexistence

Attribute: EMC
Requirement Classification: Intermediate
Change classification: Editorial
Design Target : False
Is Generic : No

Purpose:

The aim with this requirement is to

- limit the electric field emission from the DUT to protect on-board radio receivers, and
- ensure coexistence between components in the vehicle.

Applicability:

- Enclosure

Requirement:

The prerequisites stated in REQ-104556 Introduction and Applicability and REQ-104557 Emission Requirements Introduction apply to this requirement.

This test uses the same method as the RE3 test, and it is suggested that they be done in conjunction with each other.

The limits are given in the table below. These limits are based on CISPR 25 class 5 and analysis of coexistence and customer satisfaction in the final vehicle.

The DUT shall conform to each defined requirement i.e. at frequencies where more than one detector is specified, all requirements apply simultaneously.

Intentional transmitters (e.g. wireless communication) are exempt from the emission requirements in their operating frequency range(s). They are instead covered by band-specific radio regulations, such as type approvals or the Radio Equipment Directive (RED). The intentional emission frequency ranges shall be stated in the EMC test plan. These frequency ranges shall still be measured and documented. The exemption is only valid for the transmit mode of the DUT.

Coexistence and customer satisfaction limits

RF Service	Frequency Range [MHz]	RBW [kHz]	Limits [dBuV/m]			CISPR class
			Peak	Quasi-Peak	Average	
RKE	0,1 - 0,2	9/10	65	NA	NA	NA
VHF mobile	68 - 76	100/120	NA	22	15	5
FM	76 - 108	100/120	NA	25	18	5
2 meter	142 - 171	100/120	NA	22	15	5
DAB	174 - 240	100/120	26	NA	16	5
RKE, TPMS	310 - 320	100/120	32	NA	18	5
Tetra	380 - 422	100/120	24	NA	12	NA
RKE, TPMS	425 - 439	100/120	32	NA	18	5
Police	440 - 470	100/120	NA	25	18	5

RF Service	Frequency Range [MHz]	RBW [kHz]	Limits [dBuV/m]			CISPR class
			Peak	Quasi-Peak	Average	
DVBT	470 - 860	100/120	45	NA	35	5
IMT-cellular	717 - 821	100/120	44	NA	24	NA
IMT-cellular	860 - 895	100/120	44	NA	24	5
RKE, TPMS	902 - 928	100/120	32	NA	18	NA
IMT-cellular	925 - 960	100/120	44	NA	24	5
GNSS	1160 - 1300	120	NA	NA	20	NA
IMT-cellular	1427 - 1540	100/120	44	NA	24	NA
GNSS	1552 - 1616	120	NA	NA	20	NA
IMT-cellular	1803 - 1995	100/120	44	NA	24	5
IMT-cellular	1995 - 2025	100/120	44	NA	24	5
IMT-cellular	2110 - 2200	100/120	44	NA	24	5
SDARS / IMT-cellular	2300 - 2400	100/120	34	NA	24	5
Bluetooth WLAN IMT-cellular	2400 - 2690	100/120	44	NA	24	5
IMT-cellular	3300 - 4200	100/120	47	NA	27	NA
IMT-cellular	4400 - 5000	100/120	50	NA	30	NA
WLAN	5000 - 6425	100/120	NA	NA	45	NA
UWB	6000 - 10600	500	80	NA	60	NA
Generic	1000 - 3000	1000	NA	NA	60	NA
Generic	3000 - 6000	1000	NA	NA	64	NA

Test setup conditions

The measurements shall be performed according to CISPR 25:2021 with modifications as below

No RBW reduction is allowed for the GNSS bands. For other bands, average measurements may use a smaller RBW (resolution bandwidth) than stated in this requirement. This shall be documented in the test report together with the selected frequency step size and measurement time.

Measurement dwell/scan times and test method above 6 GHz shall be the same as at 6 GHz.

The DUT orientation shall be set in three (3) orthogonal directions. The number of directions may be reduced to one worst case orientation in the measurement frequency range of 150 kHz to 30 MHz. The worst-case orientation shall be as defined with analysis in the EMC test plan.

For components that are physically large, it shall be ensured that the component stays within the antenna's coverage lobe. Multiple antenna positions or other strategies may be necessary to ensure complete coverage. This shall be detailed in the EMC test plan.

Measurement dwell/scan times listed in CISPR 25 Tables 1 and 2 shall be increased if the DUT operates with intermittent duration to capture the maximum level of emissions.

A quick scan using a broadband antenna is allowed in order to identify the worst-case voltage and DUT orientation.

To decrease the test time required, the QP limits may be validated with a Peak detector. If the QP limit is exceeded with the Peak detector a retest with the QP detector is required.

REQ-104558 v3 EMC - Immunity requirements introduction

Attribute:	EMC
Requirement Classification:	Hard
Change classification:	Critical
Design Target :	True
Is Generic :	No

Purpose:

The purpose with this requirement is to specify certain required preconditions as well as providing clarification on certain technical details.

Definitions

immunity threshold

Maximum level of a given electromagnetic disturbance incident on a particular device, equipment, or system for which it operates at a required degree of functional performance.

Test Setup and Test Procedures

The preconditions given in ISO 11452-1 shall be applied.

- The test harness shall be routed in a straight line.

- Each connector of the DUT shall have a separate cable harness, and the harnesses separated by 50 mm when placed on the test bench. Actual test setup shall be documented in the test plan and report.
- The distance between the test Setup and all other conductive structures (such as the walls of the shielded enclosure) with the exception of the ground plane shall be at least 500 mm.
- Use of multiple test antennas at the same time and in the same test setup is not permitted.
- Immunity testing shall be performed with frequency step sizes no greater than those listed in the table below.
- At each tested frequency all inputs and outputs shall be monitored and the values/status recorded.
- When using modulation. peak conservation shall be used per ISO 11452-1. Modulations used are specified under each test.
- The dwell time shall be a minimum of 2 seconds. Longer dwell times may be necessary if DUT function response times are expected to be longer. This information shall be documented in the EMC test plan and report.
- When using pulse modulations, forward power is required to be measured with either
    - peak envelope power (PEP) sensors or
    - a spectrum analyzer with sufficient RBW in combination with an antenna matched to the test signal frequency.
- Testing shall initially be performed using the most severe requirements at each test frequency. If any DUT performance is outside its specified tolerance, thresholding shall be performed to determine the stress level where full functionality is achieved.
- Thresholding shall be performed as follows:
    - The stress level shall be reduced until all DUT performance is within its specified tolerance.
    - The stress level shall then be increased in small steps until the first DUT deviation is observed.
    - The last level where the DUT has full functional performance shall be reported as the immunity threshold level at this test frequency.

Immunity Test Frequency Steps

Frequency Range [MHz]	**Frequency Step Size [MHz]**
1 Hz - 1 MHz	10 %
1 - 30	0.5

30 - 200	2
200 - 400	5
400 - 1000	10
1000 - 3100	20
3100 - 6000	40
6000 - 18000	100

REQ-104573 v6 EMC - TI1 Transient immunity on Power lines requirement

Attribute: EMC
Requirement Classification: Intermediate
Change classification: Critical
Design Target : False
Is Generic : No

Purpose:

The aim with this requirement is to verify that the DUT withstands

- fast transient pulses due to switching of inductive loads and
- long duration transient pulses on any power related port that may be used for activation.

Applicability:

- Vehicle Power
- Activation Input

Test pulse	Test port	Operating mode
1	Vehicle Power Activation Input	All specified
2a	Vehicle Power	All specified

	Activation Input	
2b	Vehicle Power Activation Input	All specified
2c	Activation Input	Standby – activation input low
3a	Vehicle Power Activation Input	All specified
3b	Vehicle Power Activation Input	All specified

Note 1: this requirement assumes that the supply voltage for the vehicle power is nominally set at 12V system voltage. Other nominal voltage supply levels for vehicle power, such as 48VDC, require further contact and agreement with VCC EMC.

Note 2: These pulses are not applicable for operating voltages above 60 VDC.

Requirement:

The prerequisites stated in REQ-104556 Introduction and Applicability and REQ-104558 Immunity Requirements Introduction apply to this requirement.

Pulses 1, 2a, 2b, 3a and 3b are as defined in ISO 7637-2. They shall be tested with the parameters given in table below.

Pulse 2c is a Volvo specified pulse as described in the test setup conditions.

Transient immunity limits on Power Lines

Test pulse	**Requirement Level U_s[V]**	**Number of pulses or test time**	**Pass/Fail criteria**	**Comment**
1	-100	5000 pulses	Status III	
2a	+50	5000 pulses	Status I	
2b	+10	≥10 pulses	Status II[1)]	
2c[2)]	+50	≥10 pulses	Status IV	
3a	-300	1 h	Status I	Calibrated in open circuit

3b	+200	1 h	Status I	Calibrated in open circuit

1) Function requirement is assessed according to ISO 7637-2 paragraph 4.4.4, i.e. after re-applying the vehicle power
2) Volvo specific pulse – defined in this requirement

Test setup conditions

The preconditions of ISO 7637-1:2023 shall be used. The tests shall be made in accordance with ISO 7637-2:2011 with the following specifications:

- Test shall be made on each separate test port in turn.
- The positive and negative leads under test shall be routed directly to the test generator. For the case when the return current is designed as a chassis return, the connection shall be described in detail in the test plan.
- Leads not under test shall be connected to a separate power supply and AN.
    - This separate AN shall be either the one specified in CISPR 25 or ISO 7637-2. Make sure a 50 ohm termination is connected to the RF sampling port of each AN
- UA shall be defined as the supply voltage for the power lead under test.

Pulse 1, 2b and 2c test:
The DUT shall be monitored during a functional test after the pulse sequence. Note that if DUT functional performance falls outside of its specified tolerance(s) this is deemed to be a failure and shall be reported. No error codes are allowed to be reported including temporary responses.

Pulses 2a, 3a and 3b test:
The DUT shall be tested with continuous monitoring and recording of all inputs and outputs.

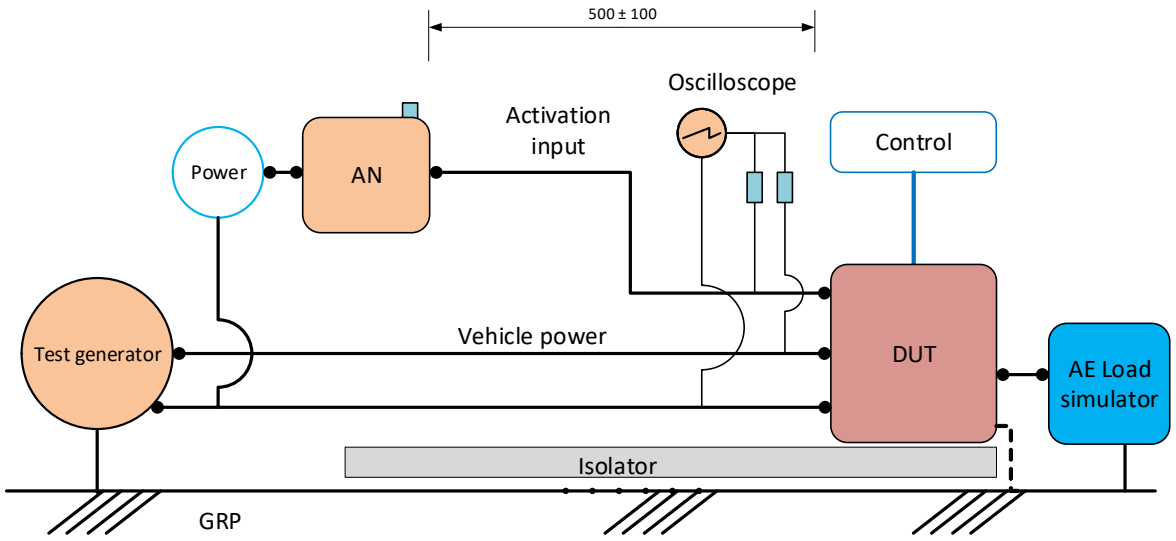


Figure 1 Test setup pulse injection on power input

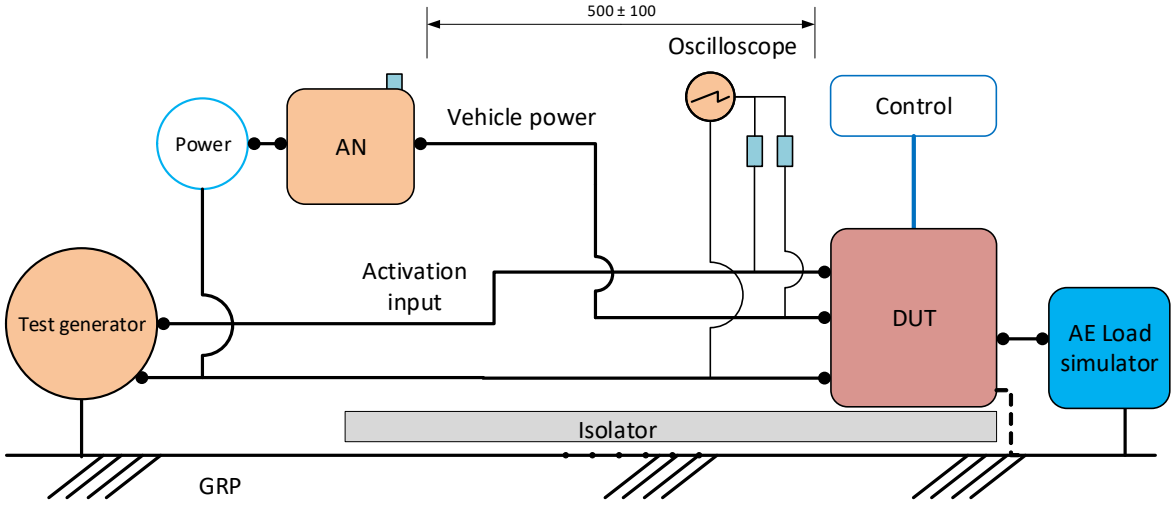


Figure 2 Test setup injection on activation input

Pulse parameter specification for pulse 2c. Time definitions as per ISO 7637-2 are used. The waveshape is allowed to be triangular. The pulse begins and ends at zero volt.

Parameter	Value
Generator output impedance Ri	≤ 0.05 Ω
t_d	100 µs
t_r	< 10 µs
Pulse repetition time t_1	5 s

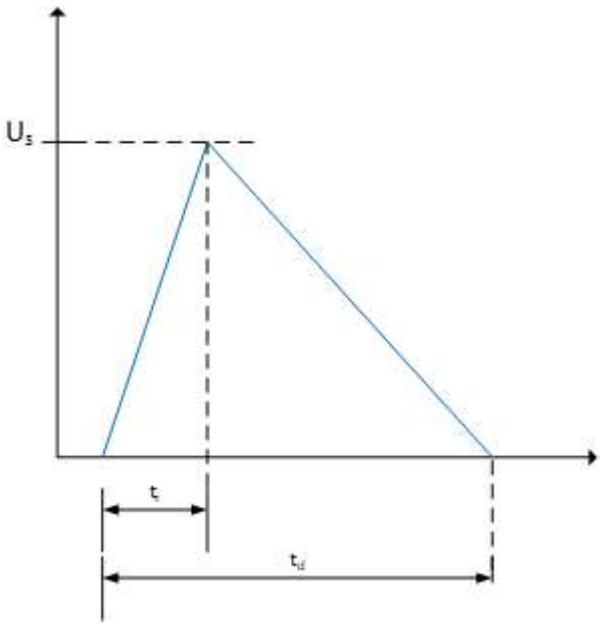


Figure 3 Pulse 2c shape and parameters

REQ-104574 v3 EMC - TI2 Transient immunity on Signal lines requirement

Attribute:	EMC
Requirement Classification:	Intermediate
Change classification:	Editorial
Design Target :	False
Is Generic :	No

Purpose:

The aim with this requirement is to verify that the DUT withstands fast transient pulses on signal leads originating from switching of inductive loads in the vehicle power system.

Applicability:

- Signal

Requirement:

The prerequisites stated in REQ-104556 Introduction and Applicability and REQ-104558 Immunity Requirements Introduction apply to this requirement.

The component shall be immune (i.e. no change of I/O values, software or memory content) to conducted transients coupled to inputs and outputs (I/O), other than battery, ignition or accessory inputs.

Pulses 3a and 3b defined in ISO 7637-3 shall be applied with the parameters given below.

Test pulse	Requirement Level [V]	Minimum test time	Pass/Fail criteria	Comment
3a	-150	1 min	Status I	Amplitude adjusted with 50 ohm load
3b	+100	1 min	Status I	Amplitude adjusted with 50 ohm load

Test setup conditions

The preconditions of ISO 7637-1:2023 shall be used. The tests shall be performed according to ISO 7637-3:2016 with modifications as below.

- The capacitive coupling clamp (CCC) method in chapter 4.5 shall be used
- Use only test pulse 3a and 3b.
- The CCC in ISO 7637-3 shall be replaced by the Coupling Fixture, RSA TS-RI130-Fix from Rohde & Schwarz, or TF 130-150 from Schwarzbeck (or similar device).
- In all other means, the setup descriptions in ISO 7637-3 chapter 4.5.4 and figure 2 apply.
- Apply the specified pulses in the requirement and perform thresholding, if needed

The Coupling Fixture is illustrated below. The fixture consists of a wire support mounted on an aluminum plate.

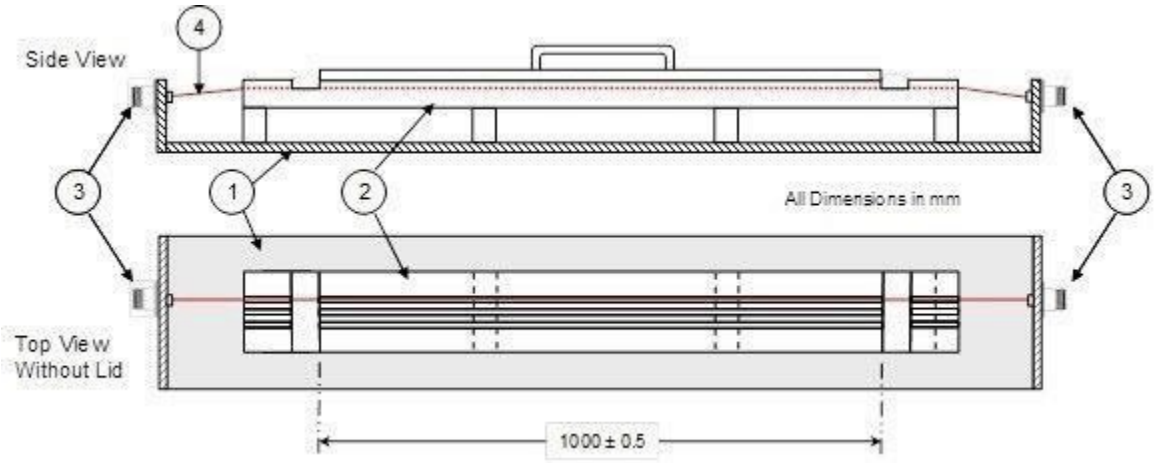


Figure of test fixture (Top View)

1. Aluminum plate

2. Wire support

3. Type N Connector, one connected to the transient generator and one to a 50 ohm termination

4. Source wire

Default DUT Wire Location for single wire with shared return

The fixture contains a single copper wire ("source wire") that is connected to the signal source that generates the disturbances. The DUT is tested by placing individual wires in the same slot as the source wire directly on top of it (Slot A). This is illustrated below.

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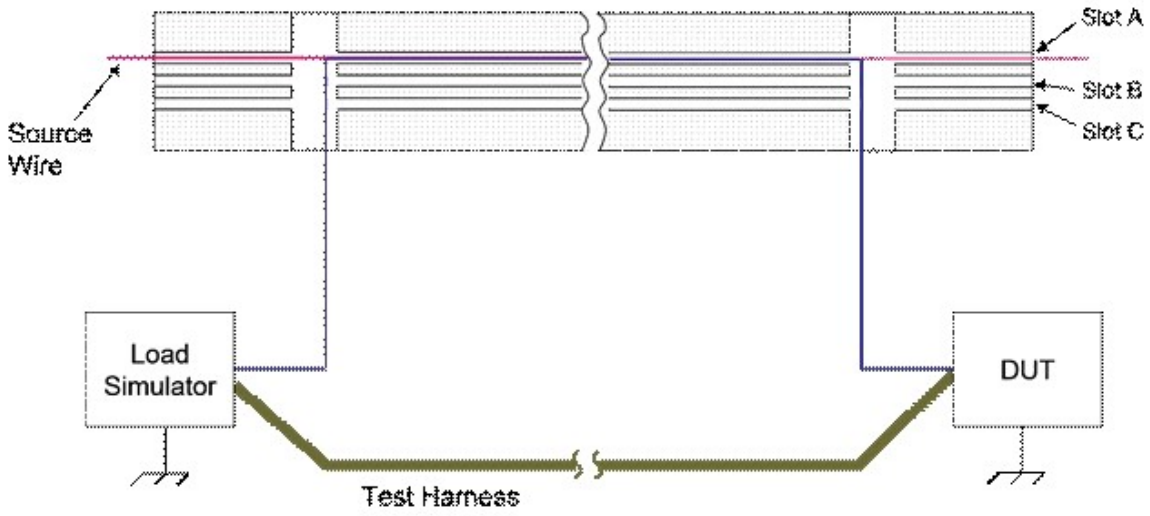


Figure of default DUT Wire Location for single wire with shared return

DUT with Dedicated Return Wire

This configuration applies to I/Os that have a dedicated signal return back to the DUT and do not share the signal return with any other I/O.

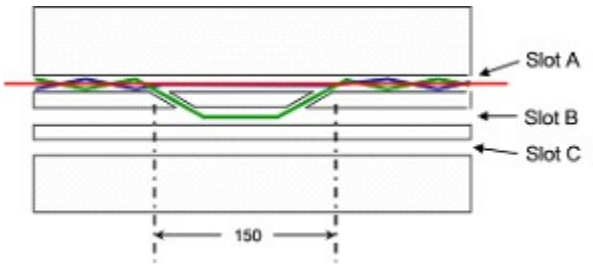
Each wire connected to this I/O shall be placed in separate slots (Slots A and B) located in the test fixture. Dedicated signal returns shall always be located in Slot B unless specified in the EMC test plan. Each slot is 6 mm wide with a wall thickness of 6 mm.

Configuration for a Twisted Wire Pair

This configuration applies to I/Os that use a twisted pair.

The twisted wire pair shall be placed in Slot A as illustrated below.

The wires shall be untwisted for 150 mm. The untwisted part of the wire pair is placed such that one wire sits in slot A and the other in slot B. This is facilitated via the section located in the center of the test fixture.
Note: the inclusion of this untwisted section simulates the device connector and in-line connector.



Configuration for Twisted Wire Pair with dedicated inline connector type

This configuration applies to I/Os that use a dedicated mandatory inline connector type (i.e. certain Ethernet buses). This inline connector only carries the bus in question and no other I/O.

The inline connector may be placed in slot B without untwisting the wires. This must be documented in the EMC test plan.

Configuration for shielded wires

This configuration applies to I/Os that use shielded wire(s).
This is the default configuration for all shielded wires. Note that there are unique setup options below for specific cases.

The wires shall be unshielded for 150 mm. This is facilitated via the section located in the center of the test fixture. Each wire shall be placed in Slot A in turn. The shield extension shall be placed in Slot B.

Configuration for shielded twisted wire pairs

This configuration applies to I/Os that use shielded twisted wire pairs.

The wires shall be unshielded and untwisted for 150 mm. This is facilitated via the section located in the center of the test fixture. Each wire shall be placed in Slot A in turn. The other wire from that pair and the shield extension shall be placed in Slot B.

Configuration for shielded wires with dedicated and shielded inline connectors

This configuration applies to I/Os that use shielded wires with dedicated and shielded inline connectors.
The entire cable shall be tested with an inline connector located in slot B.

Note: a shielded wire configuration can be either a shielded multicore wire or a coaxial cable (i.e. single wire inside).

REQ-104571 v4 EMC - CI3 Conducted current requirement, BCI

Attribute:	EMC
Requirement Classification:	Hard
Change classification:	Critical
Design Target :	False
Is Generic :	No

Purpose:

The aim with this requirement is to verify the DUT immunity to induced RF currents from off-board as well as on-board sources.

Applicability:

- All harnesses

Requirement:

The prerequisites stated in REQ-104556 Introduction and Applicability and REQ-104558 Immunity Requirements Introduction apply to this requirement.

Test levels

Band	Frequency Range [MHz]	Test level [dBuA]	Modulation
1	0.1 - 1	90 - 70	CW, AM 80%
2	1 - 15	70 - 106	CW, AM 80%
3	15 - 30	106	CW, AM 80%
4	30 - 400	106 - 96	CW, AM 80%

Pass/Fail criterion: FPSC = I.

Test setup conditions

Verification of component performance shall be in accordance with the BCI, substitution method, per ISO 11452-4:2020 with the following additions and deviations.

- Each connector on the DUT shall be tested individually with the injection probe placed around the harness associated with the connector.
- Two separate types of BCI measurements are required per connector harness on the DUT:
    1. All wires in the applicable connector harness bundle excluding any power return/s – see Figure 1.
    2. All power return/s tested separately and individually from the applicable connector harness bundle – see Figure 2.
- Note that all power return wires shall be tested separately as if they were located in a dedicated connector. Preparation of the test harness shall be made to facilitate this separation of the return wire/s from the connector harness bundle. All dedicated power returns shall be defined in the EMC test plan.
- The I/O:s included in the injection probe for each test shall be documented in the EMC test report.
- For complex DUTs (i.e. with multiple connectors, several power supplies or returns, many pins etc.) it is suggested that the combinations to be tested should be listed in the EMC test plan.

- An alternative test method must be used for components without connectors. Test method, correlation values and rationale shall be documented in the test plan and report.
- BCI testing shall be performed at two fixed injection probe positions: 150 mm and 450 mm from the DUT.
- The injection probe shall be isolated from the ground plane.
- For enhanced reproducibility, it is suggested that efforts are taken to ensure that the harness is centralized within the injection probe.

Test Setup

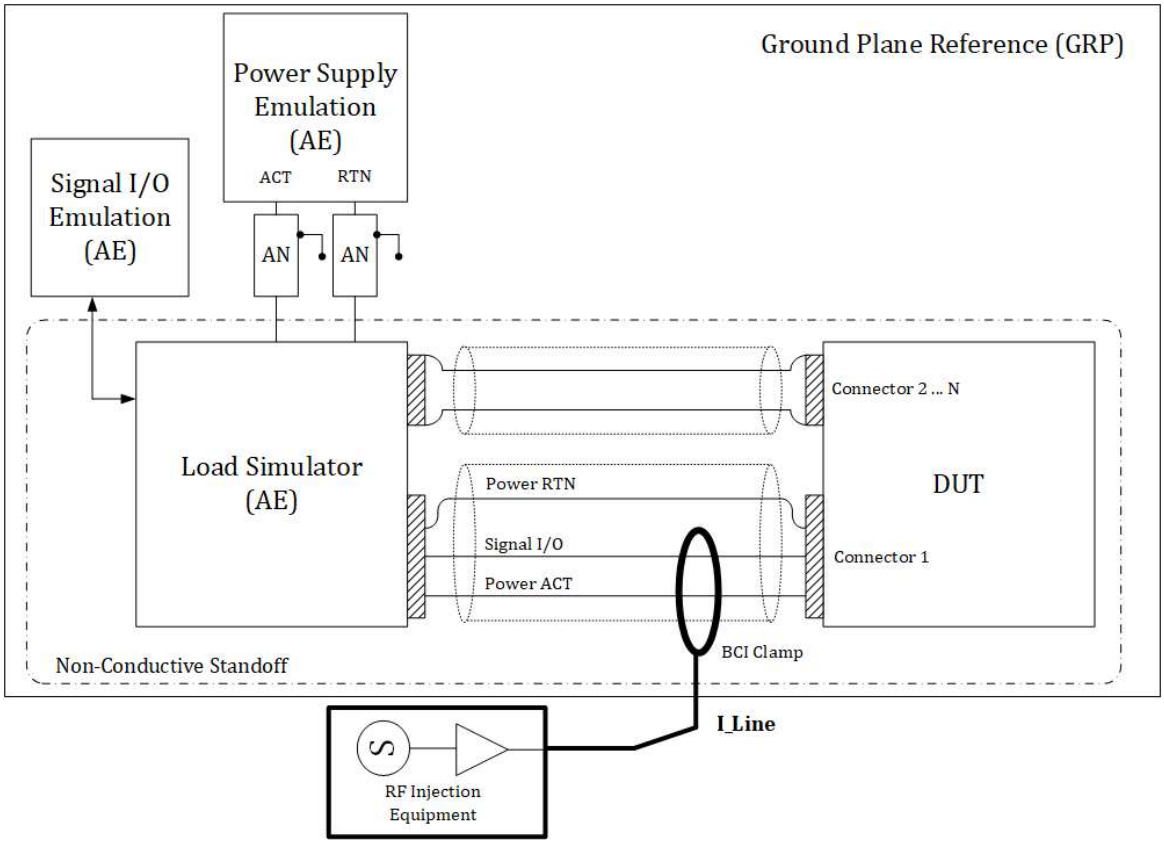


Figure 1: General Test Setup, BCI test on all wires excluding power return/s.

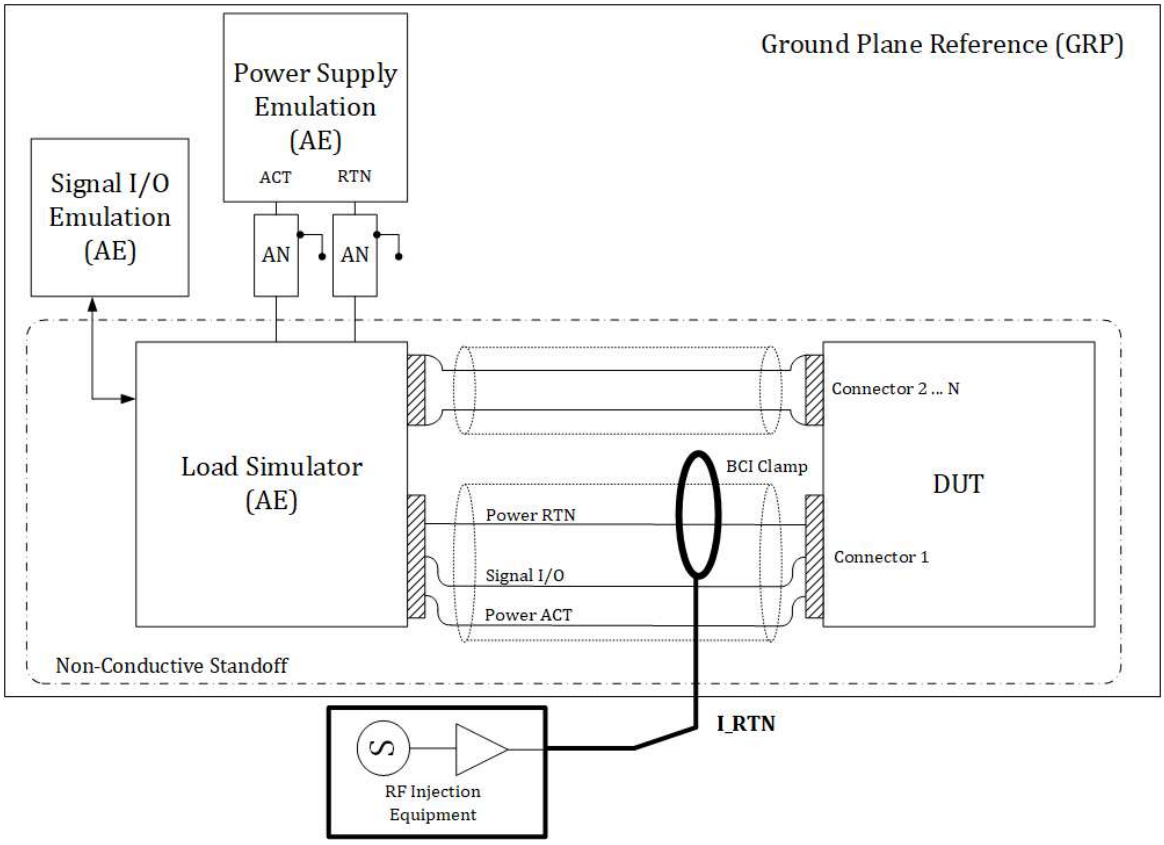


Figure 2 General Test Setup, BCI test on separate Power return/s only

REQ-367801 v2 EMC - CI7 Conducted current requirement, fallback mechanisms

Attribute:	EMC
Requirement Classification:	Hard
Change classification:	Critical
Design Target :	False
Is Generic :	No

Purpose:

The aim with this requirement is to verify the DUT immunity to induced RF currents from off-board as well as on-board sources.

Note: this requirement fulfills the purpose of the former “Safe Stop” test levels.

Applicability:

All harnesses to DUT with hardware related to fallback mechanisms

The following fallback mechanics are included in the scope

- system and components within the scope of Autonomous Drive (AD) fallback mechanisms
- system and components within the scope of by-wire systems responsible for maneuvering the vehicle, e.g. steer-by-wire and brake-by-wire

Note: by-wire systems are considered as a method of system control using electrical signals to transfer force without a mechanical linkage and are related to the safe maneuvering of the vehicle.

Requirement:

The prerequisites stated in REQ-104556 Introduction and Applicability and REQ-104558 Immunity Requirements Introduction apply to this requirement.

Test levels

Band	Frequency Range [MHz]	Test level [dBuA]	Modulation
1	0.1 - 1	90 - 76	CW, AM 80%
2	1 - 15	76 - 112	CW, AM 80%
3	15 - 30	112	CW, AM 80%
4	30 - 400	112 - 102	CW, AM 80%

Pass/Fail criterion:

- FPSC I or, if applicable
- The DUT shall maintain its fallback mechanism

Agreement on the acceptable performance of the fallback mechanism shall be specified by the responsible Volvo Cars function owner in the EMC test plan

Test setup conditions

Verification of component performance shall be in accordance with the BCI, substitution method, per ISO 11452-4:2020 with the following additions and deviations.

- Each connector on the DUT shall be tested individually with the injection probe placed around the harness associated with the connector.
- Two separate types of BCI measurements are required per connector harness on the DUT:
    1. All wires in the applicable connector harness bundle excluding any power return/s – see Figure 1.
    2. All power return/s tested separately and individually from the applicable connector harness bundle – see Figure 2.

- Note that all power return wires shall be tested separately as if they were located in a dedicated connector. Preparation of the test harness shall be made to facilitate this separation of the return wire/s from the connector harness bundle. All dedicated power returns shall be defined in the EMC test plan.
- The I/O:s included in the injection probe for each test shall be documented in the EMC test report.
- For complex DUTs (i.e. with multiple connectors, several power supplies or returns, many pins etc.) it is suggested that the combinations to be tested should be listed in the EMC test plan.
- BCI testing shall be performed at two fixed injection probe positions: 150 mm and 450 mm from the DUT.
- The injection probe shall be isolated from the ground plane.
- For enhanced reproducibility, it is suggested that efforts are taken to ensure that the harness is centralized within the injection probe.

Test Setup

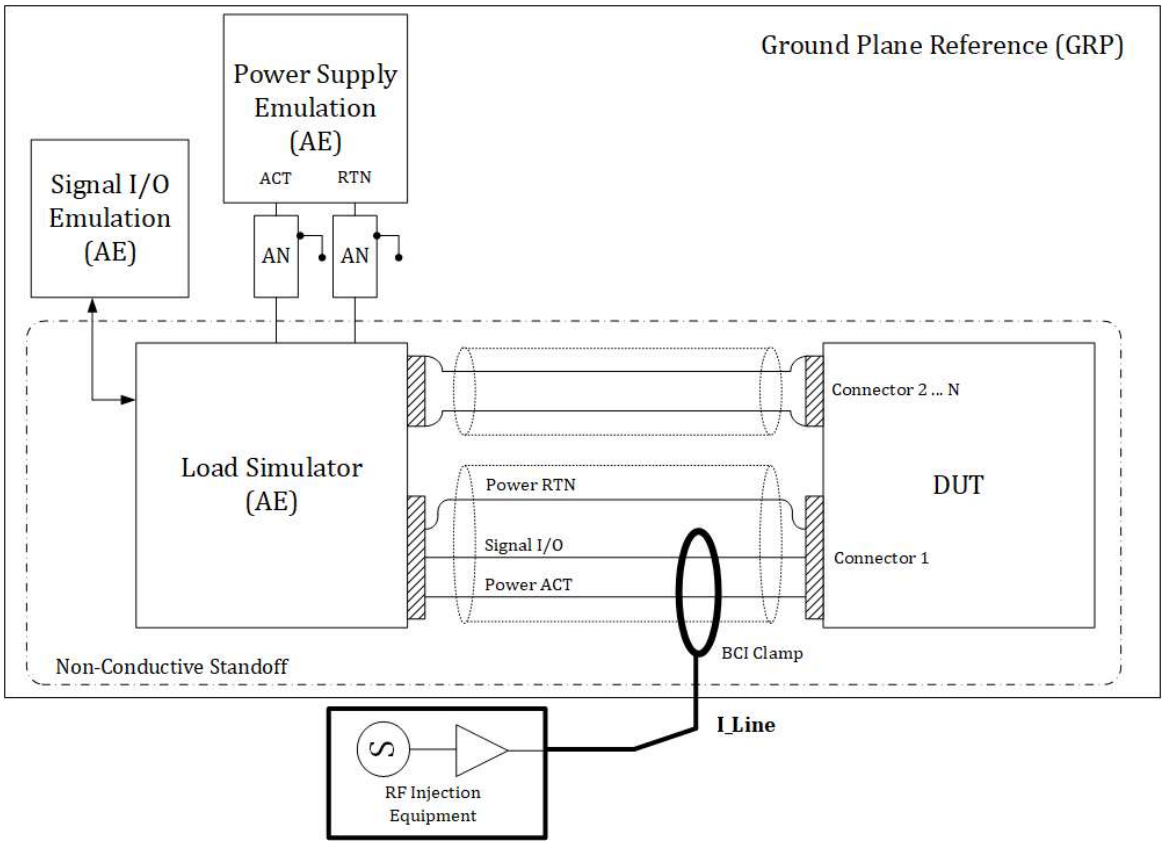


Figure 1: General Test Setup, BCI test on all wires excluding power return/s.

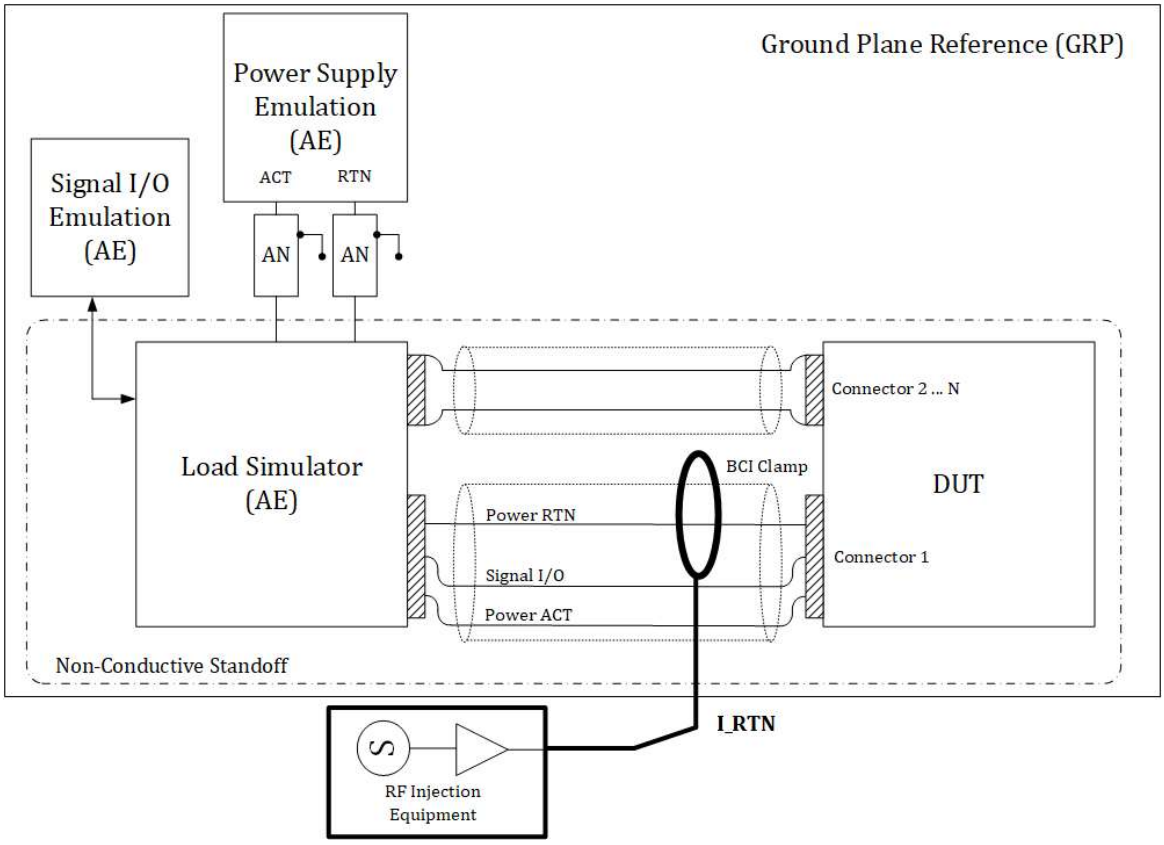


Figure 2 General Test Setup, BCI test on separate Power return/s only

REQ-104566 v3 EMC - RI1 Magnetic field immunity requirement

Attribute:	EMC
Requirement Classification:	Intermediate
Change classification:	Editorial
Design Target :	False
Is Generic :	No

Purpose:

The aim with this test is to verify the DUT immunity to low frequency magnetic fields originating both internal as well as external to the vehicle.

The aim with this requirement is to

- verify the DUT immunity to low frequency magnetic fields, and
- ensure coexistence for components within the vehicle with respect to magnetic fields.

Applicability:

- Enclosure

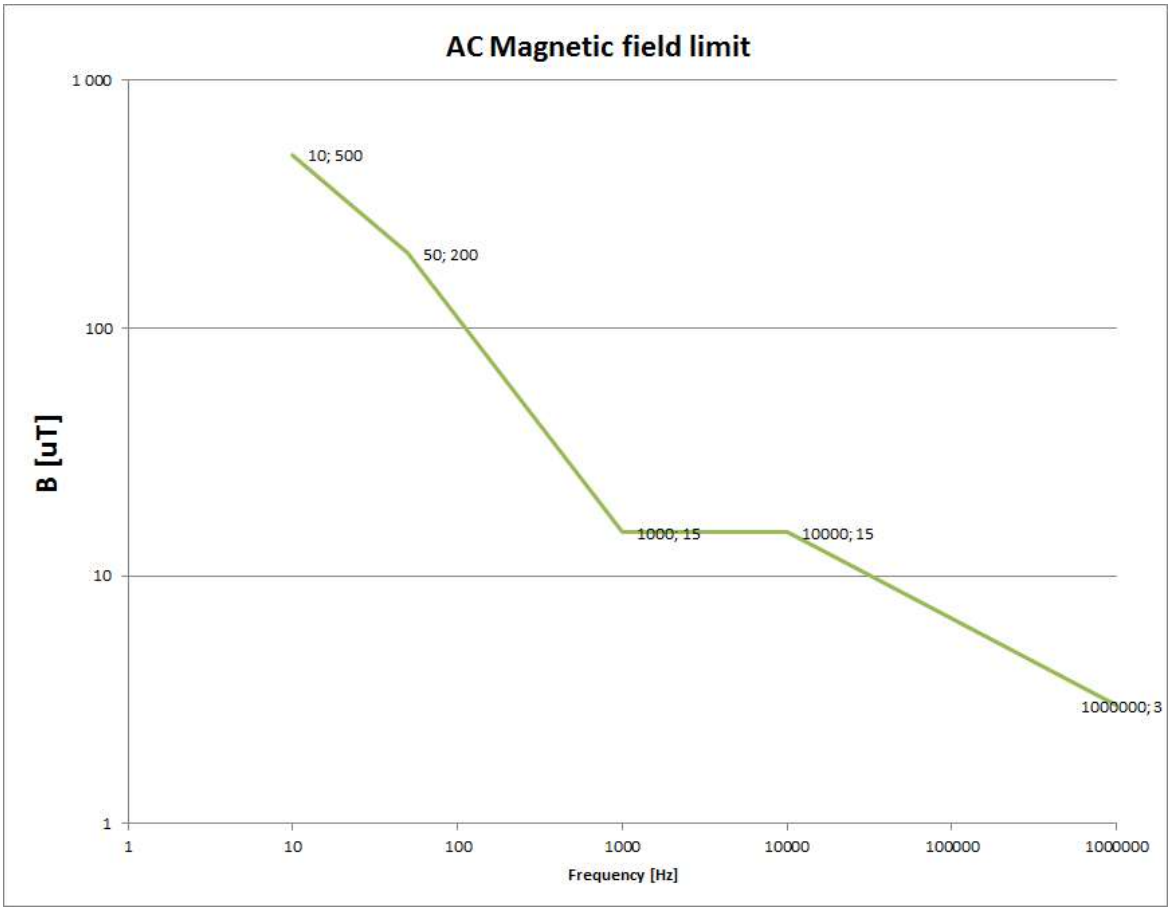
Requirement:

The prerequisites stated in REQ-104556 Introduction and Applicability and REQ-104558 Immunity Requirements Introduction apply to this requirement.

The DUT shall withstand **3 mT at DC** and the AC magnetic field given below.

Magnetic field test levels

Frequency [Hz]	**Test level B [µT]**	**Modulation**
DC	3000	-
10	500	CW
50	200	CW
1000	15	CW
10000	15	CW
1 MHz	3	CW



Graph of AC magnetic field test levels

Pass/Fail criterion: FPSC = I.

Test setup conditions

The measurements shall be performed according to ISO 11452-8:2015 with modifications as below.

Both Radiating Loop and Helmholtz coil (or a combination of the two) are acceptable procedures.

The DUT shall be exposed in accordance with chapter 7.4 of ISO 11452-8. Please note that this is not consistent with chapter 8.3.1.3 of the same standard.

REQ-104567 v4 EMC - RI3 Electromagnetic field requirement, ALSE

Attribute:	EMC
Requirement Classification:	Hard
Change classification:	Critical

Design Target : False
Is Generic : No

Purpose:

The aim with this test is to verify the DUT immunity to RF electromagnetic fields originating both internal as well as external to the vehicle.

Applicability:

- Enclosure

Requirement:

The prerequisites stated in REQ-104556 Introduction and Applicability and REQ-104558 Immunity Requirements Introduction apply to this requirement.

Test levels

Band	Frequency Range [MHz]	Test level [V/m]	Modulation
	200 - 400	100	CW, AM
	380 - 800	100	CW, PM1, PM3
	380 - 6000	70	CW, PM3
L	1200 - 1400	600	Radar
S	2700 - 3100	600	

Modulations

Modulation	Explanation
CW	Continuous wave
AM	Amplitude modulation, 1 kHz sinewave 80%
PM1	Pulse modulation. PRR = 18 Hz, PD = 28 ms
PM3	Pulse modulation, 1 kHz 50% duty cycle
Radar	Gated Pulse modulation. PRR = 300 Hz, PD = 3 µs, gated by a pulse PRR = 1 Hz, PD = 200 ms

Pass/Fail criterion: FPSC = I.

Test setup conditions

The test shall be performed according to ISO 11452-2:2019 with modifications as below

- Field characterization shall be performed at the highest field strengths given in the requirement. Field characterization at lower field strengths with subsequent power scaling for higher field strengths is not permitted.
- The test shall be performed using both horizontal and vertical antenna polarization. As per ISO 11452-2, only vertical polarization is required below 400 MHz.
- The DUT shall be tested in the most susceptible orientation; this may be demonstrated by testing in a minimum of three (3) orthogonal orientations.
- DUT:s smaller than 100 mm in its largest dimension may be tested in one orientation only. The orientation chosen shall be the most susceptible orientation. This shall be detailed in the EMC test plan.
- For components that are physically large, it shall be ensured that the component stays within the antenna's coverage lobe. Multiple antenna positions or other strategies may be necessary to ensure complete coverage. This shall be detailed in the EMC test plan.
- The lowest frequency tested shall be 200 MHz or a quarter of the DUT resonant frequency, whichever is lowest.
- The test distance in the Radar bands (band 7-8) may be reduced to (not closer than) 60 cm provided that the DUT remains in the far field and remains covered by the antenna lobe.
- Components not mounted near a ground plane in complete vehicle can be tested using a low permittivity table (plastic or similar) instead of the regular CISPR 25 setup with a ground plane. This increases the field strength at the DUT for a given amplifier power, but reduces the shielding the ground plane provides.
  Note: such modification shall be documented in the EMC test plan.

REQ-104568 v3 EMC - RI4 Portable transmitters requirement

Attribute:	EMC
Requirement Classification:	Intermediate
Change classification:	Critical
Design Target :	False
Is Generic :	No

Purpose:

The aim with this test is to verify the DUT immunity to RF electromagnetic fields originating from close proximity portable transmitters located in the vehicle.

Applicability:

- Enclosure

Requirement:

The prerequisites stated in REQ-104556 Introduction and Applicability and REQ-104558 Immunity Requirements Introduction apply to this requirement.

Test levels

Service Description	Frequency band [MHz]	Net power [W]	Modulation type
2m	142 - 176	10 W	CW, AM
1.4m	220 - 225	10 W	CW, AM
TETRA / 70 cm	370 - 486	10	CW, PM1
IMT-cellular	660 - 798	6	CW, PM4
IMT-cellular / TETRA	806 - 940	10	CW, PM1, PM4
23 cm	1200 - 1400	2	CW
IMT-cellular	1427 - 1520	2	CW, PM4
IMT-cellular-	1620 - 1915	2	CW, PM4
IMT-cellular	1915 - 2025	1	CW, PM4
IMT-cellular / WLAN	2300 - 2690	1	CW, PM4
IMT-cellular	3300 - 4200	0.5	CW, PM4
5G NR1	4400 - 5000	0.5	CW, PM4
IMT-cellular	5150 - 5925	0.5	CW, PM4

Modulations

Modulation	Explanation
CW	Continuous wave

AM	Amplitude modulation, 1 kHz sinewave 80%
PM1	Pulse modulation. PRR = 18 Hz, PD = 28 ms
PM4	Pulse modulation. PRR = 100 Hz, PD = 5 ms

Pass/Fail criterion: FPSC = I.

Test setup conditions

The test shall be performed according to ISO 11452-9:2021 with modifications as below.

- Requirements are given in Net power at the input port of the antenna.
- This test procedure makes use of a small broadband antenna positioned above the DUT and its wiring harness to simulate electromagnetic fields generated by hand portable transmitters operating in close proximity. The result of near field immunity tests is strongly influenced by the antenna type used. For this reason, only the following antennas and elements shall be used for this test:
    - Schwarzbeck antenna SBA9113 with elements 420NJ
    - Schwarzbeck antenna SBA9119 with elements 422NJ
    - Folded dipole antenna as given in ISO 11452-9:2021, chapter annex C5
- The separation between the test antenna and the DUT surfaces and harnesses shall be either 5 mm or 50 mm depending on expected proximity to intentional storage locations and product type as detailed in the table below.
- The test method 1 with cell partitioning of the DUT (ISO 11452-9, chapter 8.3.2.1) shall be used. The test antenna is positioned in step sizes specified in the table below to ensure all DUT surfaces and harnesses are thoroughly exposed. Each identified exposure location should have a total of four antenna positions: Midpoint, Midpoint rotated 90 degrees, Wing, and Wing rotated 90 degrees as given in the standard.
- The test antenna shall be mounted above the DUT and parallel to the ground plane. The DUT shall be positioned to ensure that the surface under test is facing the antenna. The DUT shall be rotated to facilitate testing of all surfaces.
- Antenna positions shall be detailed in the EMC test plan.
- Shielded enclosures only require test points at all mechanical discontinuities in the enclosure itself (e.g. seams, screw fixations, connectors and feedthroughs), and all non-conductive surface areas (e.g. screens/displays, switches). Proof of the material composition of the enclosure and its conductive properties shall be provided in the EMC test plan.

Separation Distances and Antenna Positioning

DUT Surface or Harness description	Antenna Distance from DUT	Antenna Positioning Steps
DUT surfaces and first 300mm of their harnesses (measured from DUT connector) which are likely to be packaged between 50 to 200 mm of **intentional** and/or **unintentional** locations where a hand portable transmitter may be located.	50 mm	100 mm
DUT surfaces and first 300mm of their harnesses (measured from DUT connector) which are likely to be packaged less than 50 mm from **intentional** storage locations.	5 mm	50 mm
Keys and similar devices which may come in direct contact with hand portable transmitters.	5 mm	50 mm

REQ-367805 v3 EMC - RI7 Electromagnetic field requirement, fallback mechanisms

Attribute: EMC
Requirement Classification: Hard
Change classification: Critical
Design Target : False
Is Generic : No

Purpose:

The aim with this test is to verify the DUT immunity to RF electromagnetic fields originating both internal as well as external to the vehicle.

Note: this requirement fulfills the purpose of the former “Safe Stop” test levels.

Applicability:

Enclosure to DUT with hardware related to fallback mechanisms

The following fallback mechanics are included in the scope

- system and components within the scope of Autonomous Drive (AD) fallback mechanisms
- system and components within the scope of by-wire systems responsible for maneuvering the vehicle, e.g. steer-by-wire and brake-by-wire

Note: by-wire systems are considered as a method of system control using electrical signals to transfer force without a mechanical linkage and are related to the safe maneuvering of the vehicle.

Requirement:

The prerequisites stated in REQ-104556 Introduction and Applicability and REQ-104558 Immunity Requirements Introduction apply to this requirement.

Test levels

Band	Frequency Range [MHz]	Test level [V/m]	Modulation
	200 - 400	200	CW, AM
	380 - 800	200	CW, PM1, PM3
	800 - 6000	140	CW, PM3
L	1200 - 1400	1200	Radar
S	2700 - 3100	1200	
X	8500 - 10500	600	
Ku	15700 - 17700	300	

Modulations

Modulation	Explanation
CW	Continuous wave
AM	Amplitude modulation, 1 kHz sinewave 80%
PM1	Pulse modulation. PRR = 18 Hz, PD = 28 ms
PM3	Pulse modulation, 1 kHz 50% duty cycle
Radar	Gated Pulse modulation. PRR = 300 Hz, PD = 3 µs, gated by a pulse PRR = 1 Hz, PD = 200 ms

Pass/Fail criterion:

- FPSC I or, if applicable
- The DUT shall maintain its fallback mechanism

Agreement on the acceptable performance of the fallback mechanism shall be specified by the responsible Volvo Cars function owner in the EMC test plan.

Plots of amplifier power vs. field strength shall be available upon request, but do not need to be included in the test report.

Test setup conditions

The test shall be performed according to ISO 11452-2:2019 with modifications as below

- Field characterization shall be performed at the highest field strengths given in the requirement. Field characterization at lower field strengths with subsequent power scaling for higher field strengths is not permitted.
- The test shall be performed using both horizontal and vertical antenna polarization. As per ISO 11452-2, only vertical polarization is required below 400 MHz.
- The DUT shall be tested in the most susceptible orientation; this may be demonstrated by testing in a minimum of three (3) orthogonal orientations.
- For components that are physically large, it shall be ensured that the component stays within the antenna's coverage lobe. Multiple antenna positions or other strategies may be necessary to ensure complete coverage. This shall be detailed in the EMC test plan.
- The test distance in the Radar bands (band 7-10) may be reduced to (not closer than) 60 cm provided that the DUT remains in the far field and remains covered by the antenna lobe.
- Components not mounted near a ground plane in complete vehicle can be tested using a low permittivity table (plastic or similar) instead of the regular CISPR 25 setup wooden table with ground plane. This increases the field strength at the DUT for a given amplifier power but reduces the shielding the ground plane provides.
  Note: such modification shall be documented in the EMC test plan.

REQ-104561 v3 EMC - ESD requirements introduction

Attribute:	EMC
Requirement Classification:	Hard
Change classification:	Editorial
Design Target :	True
Is Generic :	No

Purpose:

The purpose with this requirement is to specify certain required preconditions as well as providing clarification on certain technical details.

General

The component shall be immune to overstress due to Electrostatic Discharge (ESD). The requirements cover manufacturing (Rh < 10 % during wintertime), service, handling, material logistics and customer use of the vehicle.

The requirements cover components that are directly accessible and also those that are not directly accessible. The requirement levels are tailored based on location and accessibility.

Test Procedures

The following test sequence shall be used:

1. Verify and document full functionality of all test samples.
2. Perform all ESD tests.
3. Subject the samples to ISO 16750-4 5.3.2, "Rapid change of temperature with specified transition duration", 200 cycles with a soak time of at least 1h.
4. Verify and document full functionality of all test samples. Test is pass if no deviations are detected.

The parameters for the ISO-16750-4, Rapid change of temperature test, have been selected to align with other environmental tests for Volvo Cars. Colocation of units during the test is accepted and encouraged. Tmin and Tmax shall be as specified for environmental testing.

REQ-104575 v3 EMC - ESD1 Handling tests requirement

Attribute:	EMC
Requirement Classification:	Intermediate
Change classification:	Editorial
Design Target :	False
Is Generic :	No

Purpose:

The purpose with this requirement is to verify that the DUT can be installed in the vehicle in the manufacturing plant and handled in service without ESD damage.

Applicability:

- Enclosure
- Connector pins

Requirements

The prerequisites stated in REQ-104556 Introduction and Applicability and REQ-104561 ESD Requirements Introduction apply to this requirement.

Unless otherwise stated the definitions and procedures in ISO 10605 shall be used.

Discharge Sequence	Type of Discharge	Test Voltage Level	Pass/Fail Criteria	Minimum Number of Discharges at each polarity

H1	Contact discharge C = 150 pF, R = 2 kΩ	± 4 kV	Status IV	3
H2	Contact discharge C = 150 pF, R = 2 kΩ	± 6 kV	Status IV	3
H3	Air discharge C = 150 pF, R = 2 kΩ	± 8 kV	Status IV	3

Sequences H1 to H3 shall be tested with a PASS result to be allowed into production.

Test setup conditions

The measurements shall be performed according to ISO 10605:2023 with modifications as below.

The DUT shall be placed unpowered directly on a dissipative mat.

Apply contact and air discharges according to the sequence above on all connector pins, exposed shafts, buttons, switches, and surfaces (including along all air gaps that exist between buttons, faceplates, etc.) that are a result of the design of the product.

Both contact and air discharges shall be applied on all discharge points, regardless of conductivity.

When applying discharges to the DUT connector pins, all DUT power return terminals shall be connected to the ground plane via a grounding strap or wire with a maximum length of 200 mm. If there are multiple power return terminals which are not internally connected within the DUT, the logic return ground shall be connected to the ground plane and the remaining power return terminals shall be subjected to ESD pulses similar to all other I/O pins.

If the connector pins are recessed, an extension contact (< 25 mm) shall be installed to facilitate testing of the individual pins.

For devices that do not have a ground terminal (e.g. switches with internal LED’s that are low-side sensed and/or latched by a controller), attach the low-side output (that would normally be connected to a controller I/O) to the ground plane.

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

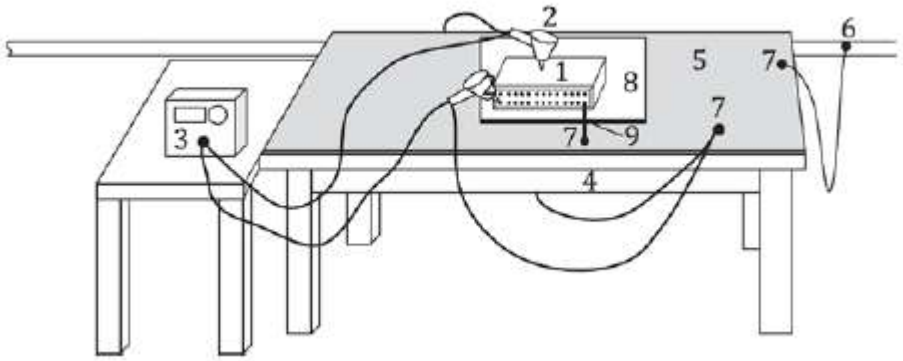


Figure of example test setup (ISO 10605, chapter 9.3.2)

Key to figure

1	DUT	6	Test facility Protective Earth Connection
2	ESD generator	7	Ground point on GP
3	ESD generator main unit	8	Dissipative Mat
4	non-conductive table	9	Ground Wire, no longer than 200 mm. Only used during application of ESD to connector pins
5	Ground Plane (GP)		

Report details

All discharge points shall be specified in the EMC test plan and report.

Tables showing detailed results shall be included in the test report.

REQ-104576 v3 EMC - ESD2 Handling tests (conditional) requirement

Attribute: EMC
Requirement Classification: Intermediate
Change classification: Editorial
Design Target : False
Is Generic : No

Purpose:

The purpose of this requirement is to highlight components that require specific ESD-sensitive attention during vehicle assembly and service.

Applicability:

- Enclosure
- Connector pins

Requirements

Compliance to the test criteria in this requirement is not mandatory. This includes the decision to exclude testing against this requirement.

Exclusion from testing or non-compliance to the test criteria in this requirement results in mandatory notation of the component as ESD sensitive in the specific documentation.

The prerequisites stated in REQ-104556 Introduction and Applicability and REQ-104561 ESD Requirements Introduction apply to this requirement.

Unless otherwise stated the definitions and procedures in ISO 10605 shall be used.

Discharge Sequence	Type of Discharge	Test Voltage Level	Pass/Fail Criteria	Minimum Number of Discharges at each polarity
H4	Contact discharge C = 150 pF, R = 2 kΩ	± 8 kV	Status IV	3
H5	Air discharge C = 150 pF, R = 2 kΩ	± 15 kV	Status IV	3

Test setup conditions

The test shall be performed according to ISO 10605:2023 with modifications as below.

The DUT shall be placed unpowered directly on a dissipative mat.

Apply contact and air discharges according to the sequence above on all connector pins, exposed shafts, buttons, switches, and surfaces (including along all air gaps that exist between buttons, faceplates, etc.) that are a result of the design of the product.

Both contact and air discharges shall be applied on all discharge points, regardless of conductivity.

When applying discharges to the DUT connector pins, all DUT power return terminals shall be connected to the ground plane via a grounding strap or wire with a maximum length of 200 mm. If there are multiple power return terminals which are not internally connected within the DUT, the logic return ground shall be connected to the ground plane and the remaining power return terminals shall be subjected to ESD pulses similar to all other I/O pins.

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

If the connector pins are recessed, an extension contact (< 25 mm) shall be installed to facilitate testing of the individual pins.

For devices that do not have a ground terminal (e.g. switches with internal LED's that are low-side sensed and/or latched by a controller), attach the low-side output (that would normally be connected to a controller I/O) to the ground plane.

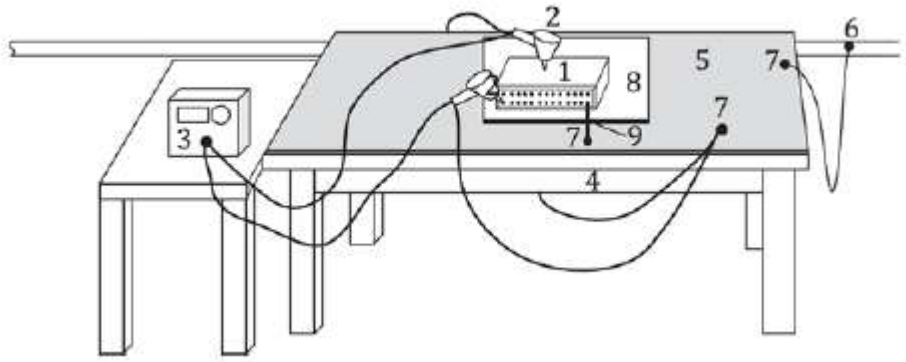


Figure of example test setup (ISO 10605, chapter 9.3.2)

Key to figure

1	DUT	6	Test facility Protective Earth Connection
2	ESD generator	7	Ground point on GP
3	ESD generator main unit	8	Dissipative Mat
4	non-conductive table	9	Ground Wire, no longer than 200 mm. Only used during application of ESD to connector pins
5	Ground Plane (GP)		

Documentation Requirement

Failure to pass test sequence H4 and/or H5 shall result in the following actions:

The supplier shall inform the Volvo Cars Component Responsible that the test has not passed, and that the following needs to be done:

- ESD sensitive warning (ESD label LB9080 / LB9081), or a similar text, shall be added to the component's drawing (see sample label below)
  NOTE: this label shall not be placed on the physical component



- NOTE-TREG-33583158 shall be connected in KDP to the component's Part Folder

The drawing can be updated by either the supplier or the Component Responsible. The TR can only be attached by the Volvo Cars Component Responsible.

REQ-104577 v5 EMC - ESD3 Powered tests, direct discharges requirement

Attribute:	EMC
Requirement Classification:	Hard
Change classification:	Editorial
Design Target :	False
Is Generic :	No

Purpose:

The purpose with this requirement is to verify that the DUT maintains functionality during ESD events in the vehicle installation. This part addresses direct ESD events.

Applicability:

- Enclosure

- Remote I/O pins:
  Remote I/O or communication bus circuits that are connected to components that may be accessible by the operator (e.g. switches, sensors, all LIN nodes, LEDs, USB connectors)

- Diagnostic circuit pins:
  DUT communications bus circuits pins accessible via diagnostic connectors

Requirement:

The prerequisites stated in REQ-104556 Introduction and Applicability and REQ-104561 ESD Requirements Introduction apply to this requirement.

For each of the required discharge voltages, the specified number of positive and negative polarity discharges shall be applied at each of the discharge points.

Test steps:

A Perform sequence P1 through P3 to each shaft, button, switch and surface of the DUT including air gaps that exist between buttons, faceplates, connectors, etc. that are a result of the design of the product.

B. If the DUT has surfaces located in the passenger compartment or trunk (including "frunk", front trunk) that may be touched, repeat step A with discharge sequence P4.

C. Perform sequence P1 through P4 for Remote I/O, using the Remote I/O setup detailed below. Apply the discharges to the end of the stub wire.

D. Perform sequence P1 through P3 for DUT communications bus circuits accessible via diagnostic connectors. Apply the discharges directly to the connector pins.

E. Perform sequence P4 and P5 to DUT surfaces that are:

- located in the passenger compartment and directly accessible from outside the vehicle (e.g. stalk switches, steering wheel, seats, window switches, trunk switches, frunk, antenna patterns)
- directly accessible from the outside of the vehicle (e.g. keyless entry keypad, lights, handles, locks, trailer connector, ultrasonic sensors)
- of special safety concern (e.g. hazard switch, parking brake actuator, e-call button).

Discharge Sequence	Type of Discharge	Test Voltage Level	Pass/Fail Criteria	Minimum Number of Discharges at each polarity
P1	Contact discharge C = 330 pF, R = 330Ω	± 4 kV	Status I	5
P2	Contact discharge C = 330 pF, R = 330Ω	± 6 kV	Status I	5
P3	Contact discharge C = 330 pF, R = 330Ω	± 8 kV	Status I	5
P4	Air discharge C = 150 pF, R = 330Ω	± 15 kV	Status I	5
P5	Air discharge C = 150 pF, R = 330Ω	± 25 kV	Status I	5

Test setup conditions

The measurements shall be performed according to ISO 10605:2023 with modifications as below.

Both contact and air discharges shall be performed for all selected discharge points, regardless of conductivity.

- The DUT and its attached test harness shall be placed on a clean, dielectric support (Epsilon R less than or equal to 1.4) that is 50mm thick. The insulator is placed directly on the ground plane.
- If the DUT can be mounted directly connected to the vehicle chassis, it shall be tested both placed on the dielectric support and placed directly on the ground plane.
- The Load Simulator shall be connected directly to the ground plane.
- Selection of discharge points is to be defined by analysis and documented in the test plan and report. Sufficient discharge points shall be defined to adequately cover the DUT and give reliable proof of immunity to ESD.
- Remote I/Os are tested according to the setup amendment as defined in the ESD Remote I/O section.
- For pins that are connected to diagnostic connectors, the following applies
    - Apply the remote I/O test.
    - Apply discharges directly to these pins. A short (<25 mm) extension wire may be used to facilitate this.

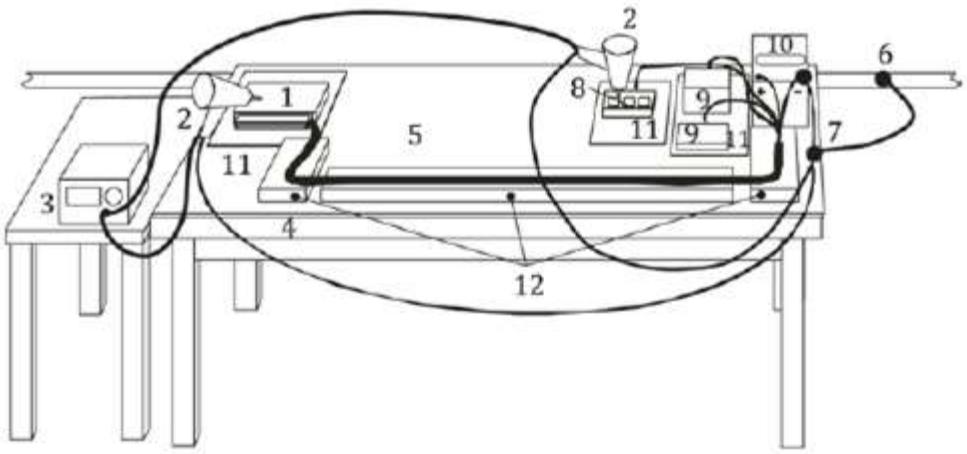


Figure on example of test setup using ground plane (Figure 4 in ISO 10605:2023)

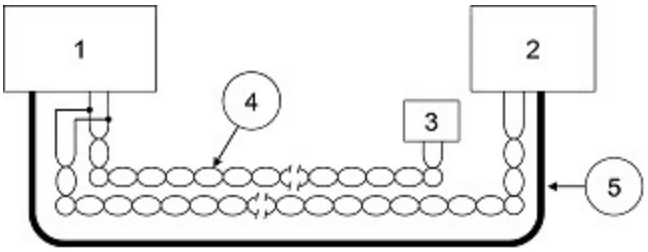
Key to figure

1	DUT	7	GP connection
2	ESD generator	8	Remote I/O discharge connection (interface object to be removed)
3	ESD generator main unit	9	Load Simulator

4	Non-conductive table	10	Battery
5	Ground plane (GP)	11	Optional insulating block – for non-chassis mounted DUT
6	Test facility protective earth connection	12	Insulating blocks

ESD Remote I/O

If the DUT has remote I/O or communication bus circuits that are connected to components that may be accessible by the operator (e.g. switches, sensors, all LIN nodes, LEDs, USB connectors) the associated circuit wires shall be split out of the harness at the DUT connector. A representative stub wire, no longer than 1700 mm, shall be added and discharges shall be applied at the end of this wire. This is shown in the setup picture below.



Key to figure

1	DUT
2	Load Simulator
3	Remote I/O discharge location
4	Remote I/O Wire (referred to as "stub wire" above). Twisted pair shown but this also applies to single wire I/O (e.g. switches and LIN).
5	Other DUT wires (not tested)

Report details

The test plan shall contain the following:

- All defined discharge points
- Applicable test steps
- Remote I/Os

The test report shall contain the following:

- All used discharge points
- Table showing detailed results

The test shall be performed with monitoring and recording of all inputs and outputs. The recordings shall be available upon request.

REQ-104578 v4 EMC - ESD4 Powered tests, indirect discharges requirement

Attribute:	EMC
Requirement Classification:	Hard
Change classification:	Critical
Design Target :	False
Is Generic :	No

Purpose:

The purpose with this requirement is to verify that the DUT maintains functionality during ESD events in the vehicle installation. This part addresses indirect ESD event.

Applicability:

- Enclosure
- All harnesses

Requirement:

The prerequisites stated in REQ-104556 Introduction and Applicability and REQ-104561 ESD Requirements Introduction apply to this requirement.

For each of the required discharge voltages, the specified number of positive and negative polarity discharges shall be applied at each of the discharge points.

Test steps:

F. Perform sequence P1 to P4 using the Indirect discharge setup for all DUTs

G. Perform sequence P5 using the indirect discharge setup on DUTs that are directly accessible from the outside the vehicle:

- Located in the passenger compartment and directly accessible from outside the vehicle (e.g. stalk switches, steering wheel, seats, window switches, trunk switches, frunk, antenna patterns).
- Directly accessible from the outside of the vehicle (e.g. keyless entry keypad, lights, handles, locks, trailer connector, ultrasonic sensors)
- Located in the passenger compartment and of special safety concern (e.g. hazard switch, parking brake actuator, e-call button)

Discharge Sequence	Type of Discharge	Test Voltage Level	Pass/Fail Criteria	Minimum Number of Discharges at each polarity
P1	Contact discharge C = 330 pF, R = 330Ω	± 4 kV	Status I	5
P2	Contact discharge C = 330 pF, R = 330Ω	± 6 kV	Status I	5
P3	Contact discharge C = 330 pF, R = 330Ω	± 8 kV	Status I	5
P4	Air discharge C = 150 pF, R = 330Ω	± 15 kV	Status I	5
P5	Air discharge C = 150 pF, R = 330Ω	± 25 kV	Status I	5

The test shall be performed with monitoring and recording of all inputs and outputs. If any DUT I/O is outside its specified tolerance as stated in the DPR/TR, this is to be deemed as a failure and shall be reported.

Test setup conditions

The measurements shall be performed according to ISO 10605:2023 with modifications as below.

Both contact and air discharges shall be performed for all selected indirect discharge points.

The following setups for indirect discharge shall be used

- The DUT and its harness shall be placed on the field coupling plane as given in ISO 10605, chapter 8.4.2.2. See picture of example setup below.

- In addition, external lights shall use an aluminum foil covering only the lens (the clear or colored part where the light is supposed to exit) as a coupling plane. The residual charge on the foil shall be bled-off between the ESD pulses. This may be accomplished by e.g. connecting the foil to the GP via a 1 Mohm resistor.
  Note: this test replaces the direct ESD test on the lens.

- Optionally, for large DUTs, a VCP (Vertical Coupling Plane) as specified in IEC 61000-4-2 may be used as an additional setup

- The Load Simulator shall be connected directly to the ground plane.

- Each harness shall be tested separately and placed on the field coupling plane. The harnesses not being tested shall be placed on the GRP.

- The ground plane shall be attached to the negative terminal of the power supply and to the test facility ground.

- If the DUT has a conductive enclosure, which is not directly connected to the vehicle chassis, its enclosure shall be placed on top of a dissipative mat or a thin insulator.

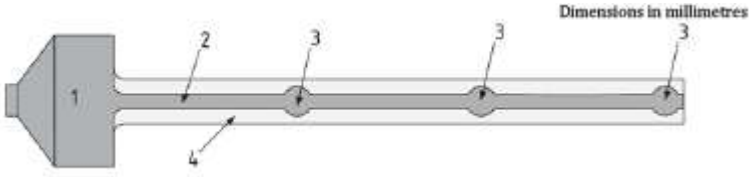
Discharge shall be applied to

- Each discharge island

- The edge of the field coupling plane

- The edge of the aluminum foil on the external light (when applicable)

- The mid-point edge of the VCP (if used)



Field coupling plane as given in ISO 10605:2023, annex F

Key to figure

1	Field coupling plane
2	Field coupling strip
3	Discharge island

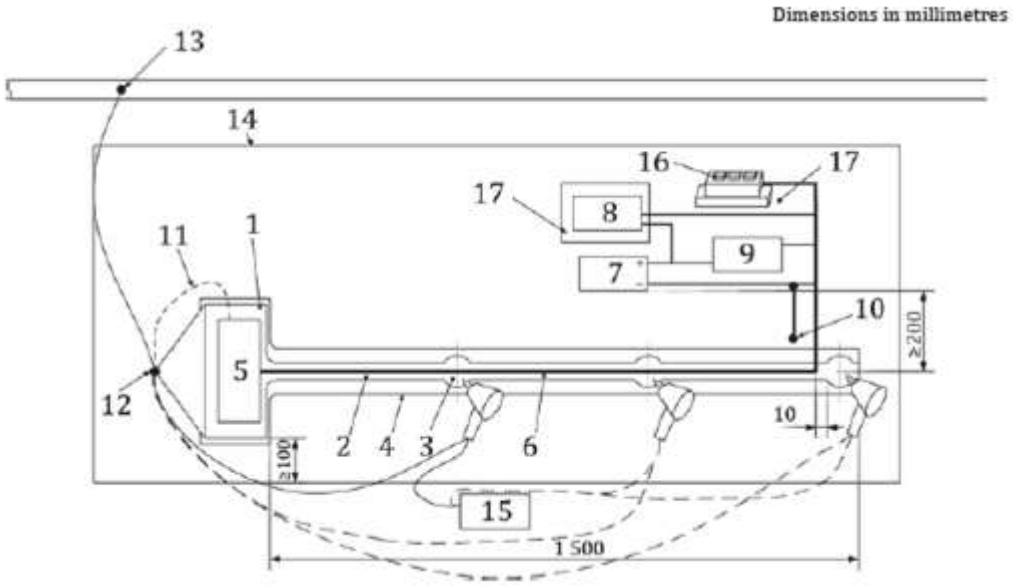


Figure on example of test setup using field coupling plane (Figure 7 in ISO 10605:2023)

Key to figure

1	Field coupling plane	10	Ground reference point
2	Field coupling strip	11	DUT optional grounding to GP (representative to its installation in vehicle)
3	Discharge island	12	Coupling fixture ground reference point
4	DUT wiring harness(es) isolation block	13	Facility protective earth connection
5	DUT	14	Ground reference plane (GRP)
6	DUT wiring harness(es) Ground plane	15	ESD generator main unit
7	Battery	16	Remote I/O discharge connection (interface object to be removed)
8	Load Simulator	17	Insulating block
9	Artificial Network (AN) as specified in the test plan		

Report details

All discharge points shall be documented in the EMC test plan and report. The test steps applicable to the component shall be detailed in the EMC test plan.

The test shall be performed with monitoring and recording of all inputs and outputs. The recordings shall be available upon request.

Tables showing detailed results shall be included in the test report.

4.1.4.9 Environment

REQ-417649 v1 EU Critical Raw Materials Act (CRMA) – Reporting Requirements for Permanent Magnets

Suppliers shall provide the necessary data to Volvo Cars to ensure full compliance with the EU Critical Raw Materials Act (Regulation (EU) 2024/1252). Suppliers shall be prepared to clearly report the presence of any permanent magnets in supplied components, including magnet type, weight, composition, recycled content, and safe removal instructions. Permanent magnets may include but not limited to: Neodymium-Iron-Boron (NdFeB), Samarium-Cobalt (SmCo), Aluminium-Nickel-Cobalt (AlNiCo), and Ferrite.

REQ-199200 v3 Chemically recycled material certification need

Attribute:	Environment
Requirement Classification:	Intermediate
Change classification:	Editorial
Design Target :	True
Is Generic :	No

For chemically recycled material an LCA shall be required from the supplier according to Volvo Cars guideline on carbon footprint calculation of components and materials. The carbon footprint should be lower than the carbon footprint for prime material.

Prime Material:

- Fossil: Not applicable
- Bio-attributed: ISCC plus with traceability & massbalance
- Bio-based: ISCC plus with traceability

Chemically Recycled Material: ISCC plus with massbalance

Physically Recycled Material:ISCC plus with massbalance

Mechanically Recycled Material: Not applicable

Note: Requirement Not applicable for Wood, Palm oil, Cotton, Wool and Rubber

4.1.4.10 Manufacturing

Aiming and light picture features should be agreed between Volvo and supplier.

REQ-3952 v3 730 MFG EXTRA LIGHT: NO ADJUSTMENT

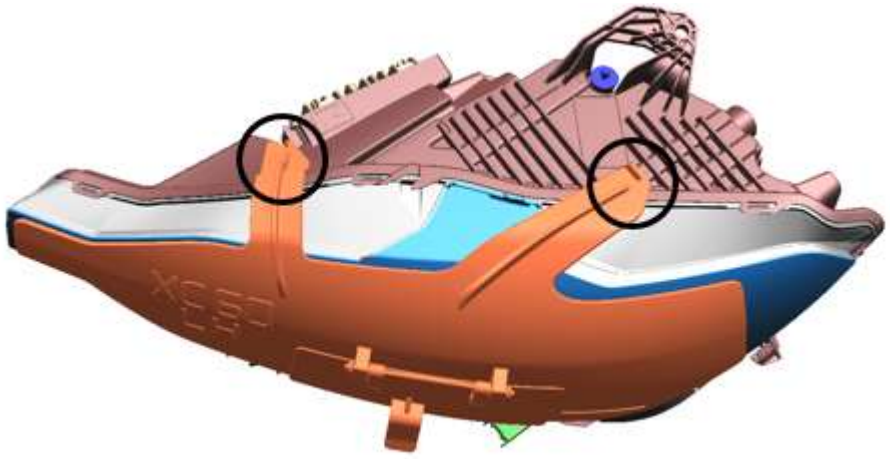
Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
TCreqID: REQ-025972/1
TCrNumber: 13.1.2.7.2.3

Title: EXTRA LIGHT, NO ADJUSTMENT
Purpose: Minimize investments.
Requirement: No other light than headlamp must need light adjustment.
Verification method: Engineering check shall be performed by the responsible manufacturing engineer. The check is done virtual (drawings/3D-model and TR) and physical.

REQ-6206 v3 730 MFG MASKING OF HEADLAMP IN DARKROOM PROCESS

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
Is Generic : No

Title: MASKING OF HEADLAMP IN DARKROOM PROCESS
Purpose: Quality assurance.
Requirement: The headlamp must have features that enables positioning of mask in X,Y,Z direction. Mask is used to block out interfering light during darkroom process. Suitable features is to be agreed by responsible ME engineer, see example below.
Verification method: Engineering check shall be performed by the responsible manufacturing engineer. The check is done virtual (drawings/3D models or TR) or physical.



REQ-7267 v3 730 MFG HEADLAMP ADJUSTING EQUIPMENT

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
Is Generic : No

Title: HEADLAMP ADJUSTING EQUIPMENT
Purpose: Minimize investments.
Requirement: It must be possible to read and adjust the light picture with the aid of standard adjustment equipment available from VCC approved equipment suppliers.
Verification method: Engineering check shall be performed by the responsible manufacturing engineer. The check is done virtual (drawings/3D-model and TR).

REQ-7268 v3 730 MFG LIGHT PICTURE CONTROL IN DARKROOM

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
Is Generic : No

Title: LIGHT PICTURE CONTROL IN DARKROOM
Purpose: Minimize investments.

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

Requirement: It must be possible to check the light picture visually in the darkroom with automatic measuring equipment at a distance of 10 meters.
Verification method: Engineering check shall be performed by the responsible manufacturing engineer. The check is done virtual (drawings/3D-model and TR).

REQ-7269 v3 730 MFG TESTING OF DETACHED HEADLAMP

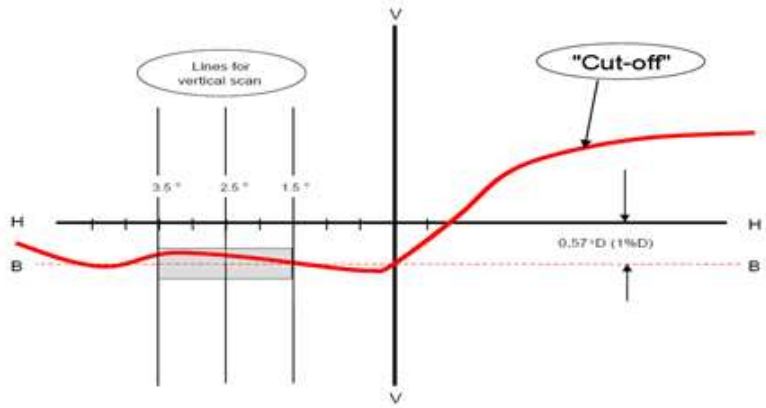
Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
Is Generic : No

Title: TESTING OF DETACHED HEADLAMP
Purpose: To facilitate design of light adjustment equipment.
Requirement: It must be possible to light up and operate the headlamp when detached from the car, for example at a light adjustment equipment supplier.
Verification method: Engineering check shall be performed by the responsible manufacturing engineer. The check is done virtual (drawings/3D-model and TR) and physical.

REQ-23766 v6 730 MFG HEADLAMP LIGHT PICTURE CUT-OFF QUALITY

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
Is Generic : No

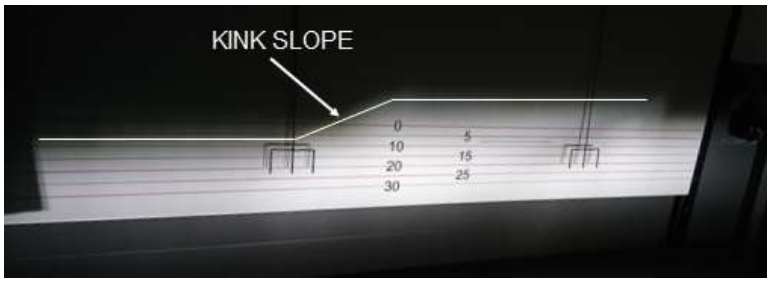
Title: HEADLAMP LIGHT PICTURE CUT-OFF QUALITY
Purpose: Quality assurance and variability reduction
Requirement: Line created by maximum gradient (cut-off) shall be be singular. The flat part where vertical scan is performed shall also be horizontal from 1,5° to 3,5° from Vertical zero (VOL shown in picture), with no larger vertical deviations than ±1cm/10m.
Headlight Aiming measurement point is at 2,5° (43,7cm/10m).
Verification method: Engineering check shall be performed by the responsible manufacturing engineer. The check is done virtual (drawings/3D models or TR) or physical.



REQ-23768 v4 730 MFG HEADLAMP ADJUSTMENT FEATURE IN LIGHT PICTURE

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
Is Generic : No

Title: MFG HEADLAMP ADJUSTMENT FEATURE IN LIGHT PICTURE
Purpose: Quality assurance and variability reduction.
Requirement: If no kink slope exists in light picture, a feature easily measurable with current equipment must be created. E.g. detectable single hot spot.
Verification method: Engineering check shall be performed by the responsible manufacturing engineer. The check is done virtual (drawings/3D models or TR) or physical.



REQ-23769 v3 730 MFG HEADLAMP REFERENCE RUN

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
Is Generic : No

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

Title: MFG HEADLAMP REFERENCE RUN
Purpose: Quality assurance and variability reduction.
Requirement: Headlamp must always perform full reference run in both Y and Z when headlight is activated during light adjustment in plant.
Verification method: Engineering check shall be performed by the responsible manufacturing engineer. The check is done virtual (drawings/3D models or TR) or physical

REQ-98263 v2 730 MFG HEADLAMP KINK SLOPE ANGLE

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
Is Generic : No

MFG Headlamp Kink slope angle
Purpose: Quality assurance, minimizing investment need and manhour efficiency.
Requirement: For headlamps where the kink slope is a measured feature during light adjustment in plant, the kink slope angle shall not be below 15°. The kink slope angle shall also never deviate more than ±4° from nominal value stated in drawing.
Verification method: Engineering check shall be performed by R&D and accepted by Mfg responsible. The check is done virtual or physical.

REQ-139428 v2 730 MFG AUXILIARY LAMPS PLUG & PLAY

Attribute:
Requirement Classification:
Change classification:
Design Target :
Is Generic : No

Title: MFG AUXILIARY LAMPS PLUG & PLAY
Purpose: Quality assurance, minimizing investment need and manhour efficiency.
Requirement: Any auxiliary lamps powered by HCM or similar, must be “plug & play”, as in not requiring any flashing/programming (for example LED binning) to function correctly.
Verification method: Engineering check shall be performed by R&D and accepted by Mfg responsible. The check is done virtual or physical.

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

4.1.4.10.1 ME Common Final Assembly

4.1.4.10.1.1 System

REQ-3938 v3 MFG no function tests of delivery units allowed

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
TCreqID: REQ-017481/3
TCrNumber: 13.1.2.2.2.3

Title : MFG NO FUNCTION TESTS OF DELIVERY UNITS ALLOWED

Purpose:
To minimize investment and man-hour in the Assembly shop.

Requirement:
Function tests of delivery units are not allowed in the Assembly Shop .

Verification method:
Engineering check shall be performed by the responsible manufacturing engineer.
The check is done virtual (e.g., drawings/3D-model and TR) or physical.

Revision history from TCr

Revision	Date	Description of change	Responsible
1		First issue	Jonas Sörensen
2	20150709	Verification method clarified	Joakim Pernstal
3	20161031	Title changed	Joakim Pernstål

REQ-3939 v5 MFG restrictions for process equipment

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
TCreqID: REQ-017479/6
TCrNumber: 13.1.2.2.2.2
Verification Method: Inspection

Title:

MFG RESTRICTIONS FOR PROCESS EQUIPMENT

Purpose:
Reuse of process equipment to minimize cost.

Requirement:
In design and mechanical integration work, the restrictions for process equipment, for example, lifting tools, fixtures, transport racks, and nut runners shall be taken into consideration. The interfaces between process equipment and parts shall be common for all variants within an architecture.
Mfg restriction models for some of these equipment's can be found in the VSS Node under Vehicle Support Structure\Manufacturing, or can be provided by responsible manufacturing engineer.

Verification method:
Engineering check shall be performed by the responsible manufacturing engineer. The check is done virtual (drawings/3D-model and TR).

4.1.4.10.1.2 Assembly Restrictions

REQ-3908 v5 MFG No added refinement on parts in Final Assembly

Attribute:	Manufacturing
Requirement Classification:	
Change classification:	
Design Target :	
TCreqID:	REQ-017506/2
TCrNumber:	13.1.2.2.6.2

Title: MFG NO ADDED REFINEMENT ON PARTS IN FINAL ASSEMBLY

Purpose: To secure quality, avoid disturbances and minimize man-hour in the Final Assembly process.

Requirement: The following process steps are not allowed in Final assembly:
· Drilling, machining or welding.
· Applying corrosion protection.
· Applying lubricants
· Applying primer

Verification method: Engineering check shall be performed by the responsible manufacturing engineer. The check is done virtual (e.g., C-notes, drawings/3D-model and TR). If applying lubricants is not possible to avoid, the substances must be confirmed ok by manufacturing

engineer to secure no secondary contamination and feasibility to apply. To be documented in drawing and C-note.

REQ-3909 v2 MFG restriction assembly direction for rigid part

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
TCreqID: REQ-017485/2
TCrNumber: 13.1.2.2.6.1

Title: MFG RESTRICTION ASSEMBLY DIRECTION FOR RIGID PART
Purpose:
To avoid process disturbance.
Requirement:
For rigid parts all attachments and guiding pins shall be applied in the same direction and normal to the attachment surface (e.g., sheet metal).
Verification method:
Engineering check shall be performed by the responsible manufacturing engineer.
The check is done virtual (e.g., drawings/3D-model and TR) or physical.

Revision history from TCr

Revision	Date	Description of change	Responsible
1	20110101	First issues	Jonas Sörensson
2	20150709	The text in this req. has been revised to better clarify the meaning of the req. Verification method clarified.	Joakim Pernstal

4.1.4.10.1.3 Component

REQ-3915 v2 MFG No adding of glue on parts in the Final Assembly Shop

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
TCreqID: REQ-052229/2
TCrNumber: 13.1.2.2.7.5

Title:
MFG No adding of glue on parts in the Final Assembly Shop

Purpose:
To avoid glue in the final assembly process.

Requirement:
Adding glue for assembling parts is not allowed in the Assembly shop. If it is not possible to avoid glue it must be documented on C-note, and if needed, marked areas on drawing.

The parts listed below is allowed to be glued in Final assembly due to strategic decisions.

Parts:
- Glass (Wind-screen, Rear-screen and fixed Q-glass).
- Roof panels (Panoramic roof, Lidar- and Antenna-module).
- Components on Headliner.
- HV-battery (incl. Pre-Assemblies) in GPA ->

Verification method:
Engineering check shall be performed by the responsible manufacturing engineer. The check is done virtual (e.g., C-notes, drawings/3D-model and TR) or physical.

REQ-3916 v2 MFG No contamination on delivered parts in the Assembly Shop

Attribute:	Manufacturing
Requirement Classification:	
Change classification:	
Design Target :	
TCreqID:	REQ-027748/4
TCrNumber:	13.1.2.2.7.1

Title:
MFG No contamination on delivered parts in the Assembly Shop

Purpose:
To avoid contamination in the assembly process.

Requirement:
Parts delivered shall be free from contamination (e.g., grease, oil, dirt, excessive dust from the component, and glue) in the Assembly Shop. If it is not possible to avoid contaminations, areas with contaminations must be marked on drawing.

Verification method:
Engineering check shall be performed by the responsible manufacturing engineer. The check is done virtual (e.g., drawings/3D-model and TR) or physical.

Revision history from TCr

Revision	Date	Description of change	R esponsible
1	20110101	First issue.	Jonas Sörensson
2	20141106	The text has been revised to clarify that any contamination needs to specified in C-notes	Joakim Pernstål
3	20150323	The text has been revised to clarify that this req concerns contamination on delivered parts.	Joakim Pernstål
4	20150709	Assembly Shop used in req. text Verification method clarified	Joakim Pernstal

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4.1.4.10.1.4 Part and Component Assembly

REQ-3925 v7 MFG Error proofed assembly

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
TCreqID: REQ-017486/4
TCrNumber: 13.1.2.2.3.4

Title: MFG Error proofed assembly

Purpose: To minimize man-hour cost and secure quality in the assembly process

Requirement: Parts shall be designed to be guided to correct position first time with an error proofed solution (e.g., geometry fixtures or geometrical adjustments of parts are not allowed.
The parts listed below is allowed to be adjusted after they have been assembled to mating part(s).
The adjustment method, of the parts listed below, shall not exceed 50 seconds for these parts and must be agreed with responsible manufacturing engineer.

Verification method: Engineering check shall be performed by the responsible manufacturing engineer.
The check is done virtual (e.g., drawings/3D-model and TR) or physical.

Table with parts allowed to be adjusted:

Part
Strikers for side doors, tailgate, trunk lid and hood
Trunk lid/Tailgate (incl. hinges & bump stop)

Side doors (incl. hinges)
Hood (incl. hinges & bump stop)
Front bumper
Rear lamp
Rear window body Y-dir (sedan)
GOR
Fender
Tailgate spoiler

REQ-3932 v2 MFG guiding principle

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
TCreqID: REQ-017483/4
TCrNumber: 13.1.2.2.3.2

Title: MFG GUIDING PRINCIPLE

Purpose:
To secure quality and to avoid process disturbance .
Requirement:
Guiding features in product design used for positioning must guide the components before the fixations enter the holes.
Verification method:
Engineering check shall be performed by the responsible manufacturing engineer.
The check is done virtual (e.g., drawings/3D-model and TR) or physical.

REQ-3934 v2 MFG third hand solution

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
TCreqID: REQ-017482/3
TCrNumber: 13.1.2.2.3.1

Title: MFG THIRD HAND SOLUTION

Purpose:
To facilitate and secure the product and assembly process.

Requirement:
All components that require a third hand solution must have this feature integrated by design. Third hand solution is a feature that makes the part stay in position until it is fixated with the fastener.

Verification method:
Engineering check sh all be performed by the responsible manufacturing engineer.
The check is done virtual (drawings/3D-model and TR) or physical.

REQ-3935 v4 MFG tolerance calculation

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
TCreqID: REQ-017492/3
TCrNumber: 13.1.2.2.3.7

Title: MFG TOLERANCE CALCULATION

Purpose:
To secure assembly tolerances and quality in the assembly process.

Requirement:
Calculations of the chain of tolerances between components (including cables), e.g., fixing/attachment holes and holes for guiding devices, presented to responsible manufacturing engineer on request.

Verification method:
Engineering check shall be performed by the responsible manufacturing engineer.
The check is done virtual (e.g., drawings/3D-model and TR) or physical .

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REQ-5085 v3 MFG Assembly feedback

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
Is Generic : No

Title: MFG Assembly feedback

Purpose:

To ensure quality

Requirement:
The product design (e.g., cover, panel, clips, and connectors) shall provide distinct visual, tactile or audible feedback to the operator.

Verification method:
Engineering check shall be performed by the responsible manufacturing engineer. The check is done virtual (e.g., drawings/3D-model and TR) or physical

REQ-64209 v2 MFG 100% geometrical verification/documentation

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
Is Generic : No

Purpose: To secure that suppliers perform 100 percent measurement and verification of geometrical requirements on components delivered, and provide requisite documentation of the results.

Requirement: The supplier shall conduct 100% measurement and verification of geometrical requirements on components in accordance with up to 20 control points (CPT) given on drawing. The measured data for each individual component delivered shall be documented and sent to Volvo Cars in accordance with Dimensional Control Plan (DCP).

Verification method: The responsible manufacturing engineer and GAE shall check that the supplier fulfills the demands on 100% verification and documentation of the geometrical requirements on the component.

4.1.4.10.1.5 Electrical Assembly

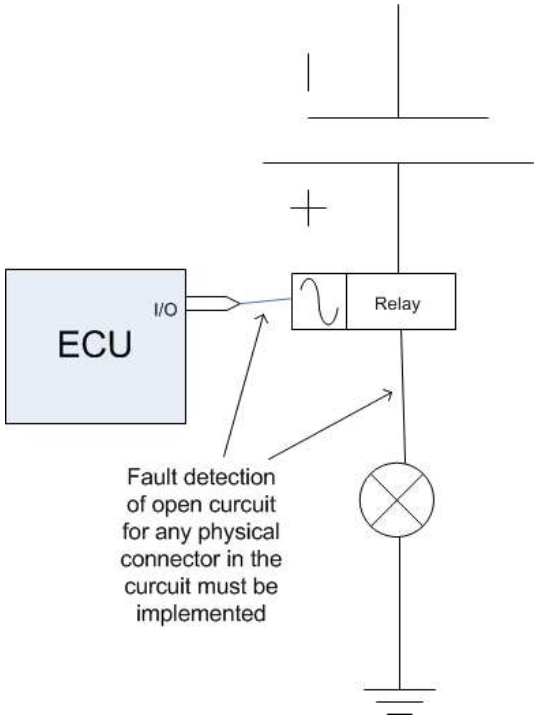
REQ-3920 v3 MFG- fault detection for not connected electrical component

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
TCreqID: REQ-017633/3
TCrNumber: 13.1.2.2.4.4

Purpose: To secure that all electrical components in the car are connected.
Requirement: Vehicle diagnostics shall be able to detect not connected components in all

external electrical circuits in the vehicle (e.g., sensors, actuators, lights, cables and connectors). The test criteria for detection shall be Usage Mode Available or Convenience and the test run shall not exceed 10s.

Notes:
It is not necessary to have a unique detection of open circuit for each physical connector in an electrical circuit, but if ANY of these connectors is not connected this shall be detected, see example below.



Verification method: The check is done virtually and physically .Check technical specifications for functions/systems. Demonstration, secure no faults in car (Zero fault), disconnect any connector, and check if there are any faults detected, it shall be at least one fault.

Revision history from TCr

Revision	Date	Description of change	Responsible
1		First issue	Jan Witt
2	20140213	Owner of requirement changed.	Joakim Pernstal
3	20151009	Req. text changed, clarifying that only electrical connectors are included.	Joakim Pernstal

REQ-3922 v2 MFG no tools for connecting el. connectors

Attribute: Manufacturing
Requirement Classification:

Change classification:
Design Target :
TCreqID: REQ-017497/2
TCrNumber: 13.1.2.2.4.3

Title: MFG NO TOOLS FOR CONNECTING EL. CONNECTORS
Purpose: To minimize man-hour and secure quality in the assembly process.
Requirement: All electrical connectors must be possible to connect without any tools, except ring terminals.
Verification method: Engineering check shall be performed by the responsible manufacturing engineer. The check is done virtual (e.g., drawings/3D-model and TR) or physical.

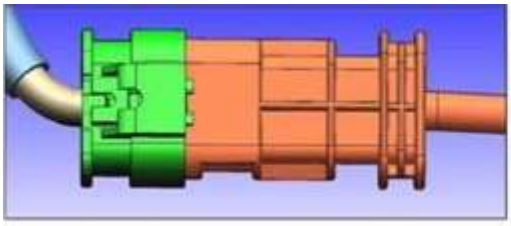
Revision history from TCr

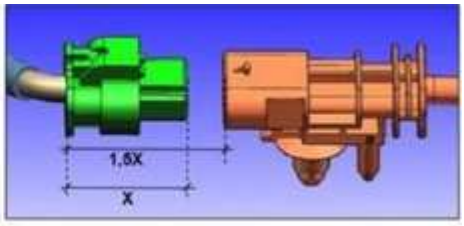
Revision	Date	Description of change	Responsible
1	20110101	First issues	Jonas Sörensson
2	20150709	The text in this req. has been revised in order to clarify that the req. is valid for conne cting as well as for disconnecting electrical connectors . Verification method clarified.	Joakim Pernstal

REQ-3923 v3 MFG space for connecting connectors

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
TCreqID: REQ-017498/2
TCrNumber: 13.1.2.2.4.2

Title: MFG SPACE FOR CONNECTING CONNECTORS
Purpose: To minimize man-hour and secure ergonomic's and quality in the assembly process .
Requirement: The space for connecting an electrical connector shall be 1,5 times the connector's length, but not less then 50mm in the connection direction, see picture below.
Verification method: Engineering check shall be performed by the responsible manufacturing engineer. The check is done virtual (drawings/3D-model and TR) or physical.





REQ-3921 v5 MFG harness connection to component

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
TCreqID: REQ-017496/3
TCrNumber: 13.1.2.2.4.1

Title: MFG CONNECTION TO COMPONENT
Purpose: Due to ergonomic and quality perspective
Requirement: All components must be designed to enable connection of the component after it is in its final position
Verification Method: Engineering check shall be performed by the responsible manufacturing engineer. The check is done virtual (drawings/3D-model and TR) or physical

Revision history from TCr

Revision	Date	Description of change	Responsible
1	20110101	First issues	Jonas Sörensson
2,3	20150709	The text in this req. has been revised in order to clarify that the req. is valid for assemblies on the car as well as for pre-assy on modules. Verification method clarified.	Joakim Pernstal

REQ-82044 v2 MFG el harness fixing method

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
Is Generic : No

Title: MFG EL. HARNESS FIXING METHOD
Purpose: To quality assure assembly method

Requirement: Cable harness fixation points shall be integrated in the harness and have a well-defined final position in x,y,z-direction. (E.g. a color marking or depression for edge clips)
Verification method: Engineering check shall be performed by R&D and accepted by Mfg responsible. The check is done virtual or physical.

REQ-86202 v1 MFG mating force electrical connector

Attribute: Manufacturing
Requirement Classification:
Change classification:
Design Target :
Is Generic : No

Title: MFG mating force electrical connectors
Purpose: To enable an ergonomic risk assessment
Requirement: An electrical connector shall have a specified mating force, stated on the cover page of the connector's drawing. For connectors integrated in a component, the mating force shall also be documented on the component's 2D-drawing. The assembly force shall be tested according to test method USCAR2 rev. 7.5.4.2.3A.
Verification method: Engineering check shall be performed by the responsible manufacturing engineer. The check is done virtual (drawings).

4.1.4.11 Mechanical Theft Protection

REQ-31281 v3 Thatcham Insurance Classification

Thatcham Insurance Classification
The car shall meet 12E.
Allowed front damage; bumper cover, bumper beam, compatibility beam, crash can one side, headlight, GOR and the hood.
Allowed rear damage; bumper cover, bumper beam.

4.1.4.12 Passive Safety

REQ-31280 v3 GDV (Allianz) Insurance Classificaion

GDV (Allianz) Insurance Classification
The car shall meet VK 20.
Allowed front damage; bumper cover, bumper beam, compatibility beam, crash can one side, headlight, GOR and the hood.
Allowed rear damage; bumper cover, bumper beam.

4.1.4.13 Perceived Quality

REQ-31259 v4 Dividing lines on lens

Background
Dividing lines on lenses are coming from tool splits or slides in the tools. The dividing lines are unwanted from an appearance perspective as they create unintended visible lines in the lenses. They are also unwanted from a maintainance perspective as sharp edges could harm the hands during car washing.

Any dividing lines in the lens must be handled in the Approved Design Quality process (ADQ). This means that supplier and Volvo Cars must have an agreement on the appearance of the dividing lines before FDJ.

Scope
All lamps.

Requirement
Dividing lines from tool splits or slides on visible surfaces of the lens shall be avoided when possible. If not possible, the dividing lines shall be done in such a way that they do not interfere with the daily maintenance of the car. E.g. not sticking out on surfaces that can be touched by hand. This can be accomplished by an over moulding of the lens or similar techniques. The chosen technique should be included in the quote.

Verification
To be verified by supplier and/or VCC.

Verification method
Virtual simulations and physical assessment at VP, TT, PP build. Subjective visual evaluation performed by Perceived Quality, VCC.

4.1.4.13.1 PQ Illumination- Appearance Execution Requirements 728B

REQ-10743 v6 PQ ILL ARCH Designed light behavior per component

Attribute:	Perceived Quality
Requirement Classification:	Intermediate
Change classification:	
Design Target :	True
Is Generic :	Yes

PURPOSE
This requirement shall secure the possibility to design specific light behaviours in order to give our vehicles a personality through light.

DEFINITION
The number of different behaviours need to be agreed between UX design and implementing ART.

UX Design will provide input on behaviour profile.

REQUIREMENT
Light control system shall support specific profiles for light behaviour. Parameters to control are:

- Ramp type
- Ramp time

- Light intensity (PWM%)
- Light color (when applicable)

VERIFICATION

To be verified by responsible SA/GDL and agreed with PQ.

REQ-13768 v5 PQ ILL ARCH Rampable lights resolution

Attribute:	Perceived Quality
Requirement Classification:	Intermediate
Change classification:	
Design Target :	True
Is Generic :	Yes

PURPOSE

This reuirement is published in order to make sure we can create uniform and flicker free dynamics in the use case scenarios.

REQUIREMENT

- All rampable lights/channels shall have a ramping PWM frequenzy high enough to create transitions with no visible flicker.
- Frequenzy <120 Hz is not allowed.

RECOMMENDATION

- Recommended target is 1250 Hz.

VERIFICATION

Verified by responsible SA before PC
Verified by responsible SA before FDJ

REQ-307918 v2 PQ ILL SYS Signature Lit Surface Intensity Homogeneity 1.2

Attribute:	Perceived Quality
Requirement Classification:	Intermediate
Change classification:	Editorial
Design Target :	True

PURPOSE

This requirement is provided to secure premium appearance of a lit surface.

DEFINITION

Intensity homogeneity is defined as even distribution of light over a lit surface according to design intent. Any pattern of highlights or shadows shown in design intent is not a deviation to the homogeneity requirement.

Scope

Requirement covers DRL/front and Rear signature light.

1- Prerequisites for evaluating the homogeneity

1-1- Luminance image of the lit surface (s) in 1:1 scale, as a measurement or simulation format, should be provided to VCC, in agreed format.

1-2- Project dependent views (point and direction) and corresponding tolerances should be provided from VCC.

1-3- Project dependent design intent luminaire contour and corresponding section to analysis should be provided from VCC.

1-4- Project dependant definition of neighboring areas to be compared should be provided from VCC.



Figure 1: Example of a Design Intent Lit Area (DILA) for H0V0

2- REQUIREMENT

Homogeneity of lit surface is determined by following four criteria:

i. Contour sharpness / border / visibility signature luminance

ii. Average luminance ratios between separate parts

iii. Luminance variation towards average value, within individual parts

iv. Gradient in luminance along predefined section(s), within individual parts

i: Contour sharpness / border / visibility signature luminance

Gradient in luminance that is aligned perpendicular to the signature is acceptable, as long as it is continuous along the light profile and located at the signature edge.



Figure 2: illustration of accaptable luminance gradiant apperance

ii: Average luminance ratios between separate parts

Provided specifications from design intent (luminaire contour as border of lit area) defines separate parts (see 1-3). A lamp component can include multiple parts, areas/parts considered to be neighboring are also defined (see 1-4). Harmony between separate parts is secured when average luminance of each parts complies following rules.

Balance between neighboring parts $70\% \leq {}^{L_{average\ DILA\ n}}/_{L_{average\ DILA\ n+1}} \leq 140\%$

Holistic balance $50\% \leq {}^{L_{average\ DILA\ n}}/_{L_{over\ all\ average}} \leq 200\%$

1, 2, 3, 4, …., n refers to naming of separate parts.

$L_{average\ DILA\ n}$ is average luminance value over part number n in Cd/m^2. Luminance values are extracted over predefined sections.

iii: Luminance variation towards average value, within individual parts

Luminance values along the section (see 1-3) should not exceed ± 35% of the average value over the section.

iv: Gradient in luminance along predefined section(s), within individual parts

"Box over section" method is used to verify homogeneity (see verification section). The difference between average luminance of adjacent boxes (e.g. box 1 to box 2) must be:

$$-12.5\% \leq L_n/L_{n+1} \leq +9.5\%$$ Average value of box 1 is L_1 in Cd/m^2

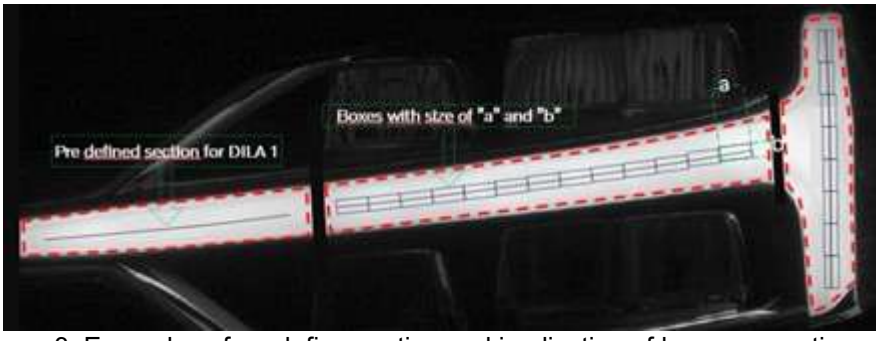


Figure 3: Examples of predefine section and implication of box over section method.

RECOMMENDATION
Considering criteria iv, avoid having cluster of 3 or more bright or dark boxes since it will be perceived inhomogeneous. Recommendation is delta between average value of adjacent clusters should be ± 20%.

Verification method and test case

- Following angles to be assessed if not stated otherwise in prerequisite document: H0V0, H0V5, H0V10, H0V25, H0V-5, H45V0, H45V10, H45V25, H90V0, H90V10

Criteria iv - "Box over section" method

In this method boxes, with size of ”a” and “b” in mm, are drawn along the section and the average luminance values within these boxes are to be compared, see figure 3 and 4. Note that boxes do not overlap, so each pixel is counted only once and the bigger side of the box follows section orientation.

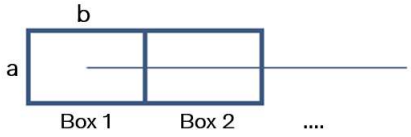


Figure 4: Box over section method; a and b define the size of tolerance of the averaging area.

H0V-5 a:2mm b:8mm	H0V0 a:2mm b:8mm	H0V5 a:2mm b:8mm	H0V10 a:2mm b:8mm	H0V25 a:2mm b:8mm
	H45V0 a:2mm b:8mm		H45V10 a:2mm b:15mm	H45V25 a:2mm b:15mm
	H90V0 a:2mm b:20mm		H90V10 a:2mm b:20mm	

- Visual assessment by PQ Illumination always overrides measured data.
- To be verified virtually and physically by supplier and VCC.

REQ-44769 v11 PQ ILL SYS Light leakage

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification: Editorial
Design Target : True
Is Generic : Yes

Purpose
This requirement is published in order to secure that all light installations are light tight and avoid visual defects such as mixtures of light colors and characteristics.

Scope
All light installations/systems in the vehicle, if not contradicting design input, including switches, symbols, interior lights and exterior lights.

Requirement
All light components/systems shall be designed light tight and no unintended light output is allowed.
- No unintended light leakage on any surface or through any gap are allowed when light component/system is assembled in vehicle.

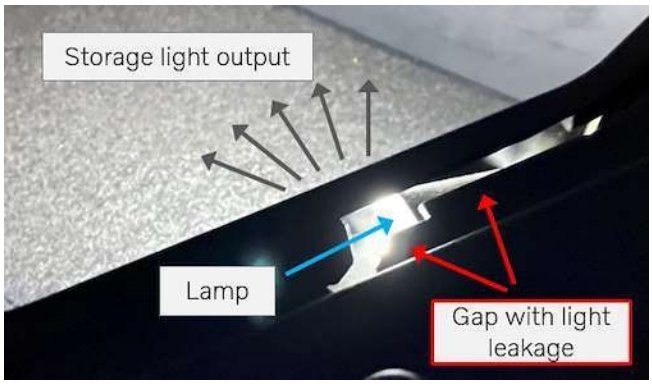


Figure1: Example of light leakage in assembly

- Light from two separate functions acting together may not visually disrupt each other shape or light color.



Figure2: Example of OK/NOK light disruption

Verification
To be verified by responsible SA/GDL and PQ. Virtually at V0, V1, V2, FDJ and physically in VP, TT, PP.
SPEOS components need to be provided to PQ for virtual verification.

Verification made from the relevant CFoVs (see REQ-231676).

REQ-20706 v10 PQ ILL SYS Glare & visual comfort

Attribute:	Perceived Quality
Requirement Classification:	Intermediate
Change classification:	Editorial
Design Target :	True
Is Generic :	Yes
Requirement Type:	Structural

PURPOSE
To secure visual comfort and reduce glare for the customer.

SCOPE
Requirement is valid for all interior light and applicable exterior lights

For exterior lights (front/rear) with legal demands, requirement is valid for use case approaching vehicle <5 meter and loading trunk/frunk.

For exterior side positioned lights (door handles), requirement is valid for use case approaching vehicle <5 meter and entering/exiting front and rear door.

REQUIREMENT
Light sources shall be designed and positioned to minimize glare to a persons eye, direct or indirect via chrome parts or other reflective surfaces.
No effects of light shall be experienced in a way that causes discomfort or dysfunctional glare to user or observer of the

vehicle.

VERIFICATION
Required viewpoints for verification are PQ Illumination customer field of view (CFoVs). Requirements are not only restricted to CFoVs and may be valid in any other relevant viewing angles.

To be verified by responsible SA and PQ.

Reference
PQ CFoV is found in TeamCenter according to REQ-231676 in SystemWeaver

REQ-20713 v6 PQ ILL SYS Intensity homogenity on distributed light

Attribute:	Perceived Quality
Requirement Classification:	Intermediate
Change classification:	Editorial
Design Target :	True
Is Generic :	No
Requirement Type:	Structural

PURPOSE
This requirement is published in order to secure a premium appearance of distributed light, emitted from a lamp system and illuminating a target area, with respect to light intensity.

REQUIREMENT
*Light distribution shall follow design intent when applicable.

*Light distribution shall not have unintended hotspots, darkspots, light streaks, sharp lines, gradients or shadows within the distributed area.

*Light shall be distributed only to the intended area.

*Light distribution shall be even and on target according to relevant separate intensity requirements per component.

VERIFICATION
Visual assessment of PQ Illumination always overrides measured data.

To be verified by responsible SA/GDL and PQ. Virtually at V0, V1, V2, FDJ and physically in VP, TT, PP.

REQ-20714 v4 PQ ILL SYS Color homogenity on distributed light

Attribute:	Perceived Quality
Requirement Classification:	Intermediate
Change classification:	Editorial
Design Target :	True

Is Generic : No

Information.
This requirement is published in order to secure a premium appearance of distributed light, emitted from a lamp system and illuminating a target area.

Requirement.
No unintentional artefacts such as rainbow effects or other color shifts caused by optic design is allowed.

Chromatic aberration is to be kept to a minimum when unavoidable.

Color matching of dual white, RGB, RGBY, RGBW LED chips are to show no color deviations in the light at target area.

Verification.
To be verified virtually using SPEOS simulations on component level by responsible SA/GDL before FDJ. To be verified by PQ, virtually on complete vehicle by PQ in FDJ and physically in VP, TT, PP.

REQ-6621 v7 PQ ILL SYS Color Rendering capabilities of light

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification: Editorial
Design Target : True
Is Generic : Yes
Requirement Type: Structural

PURPOSE
The PQ Illumination requirements on Color rendering capabilities are published in order to secure that we get a genuine perception of colors and that they are perceived natural.

SCOPE
All lights (light source including optic system) with the purpose to illuminate (not lit surfaces) with capability to emit white light must perform according to requirement. Values to be measured on the outer lens. LED sourcing must consider the color shift of the optical system.

REQUIREMENT
Interior lights: CRI ≥90.
Exterior functional light (puddle light, license plate light, EVI charge indication): CRI ≥80.
Exterior driving lights (front light, front fog, reverse light, illuminated emblem): CRI ≥65.

All sourcing of LED BINS shall be verified by PQ Illumination.

RECOMMENDATION
Exterior functional light (puddle light, license plate light, EVI charge indication): CRI ≥90.
Exterior driving lights (front light, front fog, reverse light, illuminated emblem): CRI ≥70.

VERIFICATION
Visual assessment by PQ Illumination always overrides measured data.

To be verified by responsible SA/GDL and PQ.

REQ-39923 v10 PQ ILL SYS Exterior white light target

Attribute:	Perceived Quality
Requirement Classification:	Intermediate
Change classification:	Editorial
Design Target :	True
Is Generic :	No
Requirement Type:	Structural

Purpose.
To harmonize white light CCT on the exterior of the car.

Information.

Tolerance box for individual component also acts as requirement for white light color homogeneity on visible lit surface for exterior lights. Tolerance of color homogeneity include deviations measured in Kelvin for CCT and Δuv for green/magenta color shifts and also deviations in form of rainbow effects and/or chromatic aberration.

Target and tolerance applies to the complete lamp system and is to be measured on the outer lens element.

Subjective evaluation by Perceived Quality Illumination (PQ) may overrule measurement data, meaning component not meeting technical tolerance may still be OK if visual appearance is subjectively OK. Also, component within tolerance may be NOK if visual appearance is subjectively judged as NOK.

Tolerance is based on SDCM (Standard Deviation Color Matching) also known as MacAdam ellipses, reference CIE 1931 chromaticity diagram.

Scope.
This requirement covers:
- Target coordinates (x, y) for exterior white light for Volvo and Polestar brand.
- Outer tolerance box for exterior white light for Volvo and Polestar fleet.
- Tolerance for one pair of lamps with the same function per vehicle, visible from the same CFoV, e.g. front position lights, side puddle lights, license plate lights, reverse lights.
- Tolerance for individual components per vehicle, e.g. Front position light, puddle light, reverse light, EVI White light, charge cable etc.

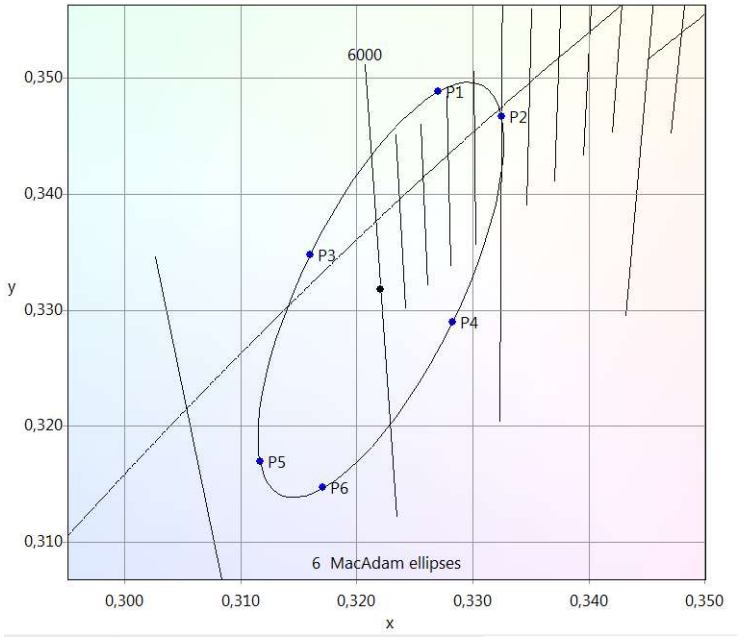
Requirement:

*No deviations in white light color on lit surface is allowed outside the given tolerance, per component. Valid for components with surfaces visible from normal CFoV.

*Target for exterior white light is **CCT 6000K Δuv=0.**

- X: 0,322082 Y: 0,331752

*Outer tolerance box per fleet for all exterior white light, based on 6 SDCM.



	X	Y
P1	0,327	0,3488
P2	0,3325	0,3467
P3	0,3160	0,3348
P4	0,3283	0,329
P5	0,3117	0,317
P6	0,3171	0,3147

*Tolerance per pair of components visible from same CFoV.

Components	**Example of pair**	
	A	**B**
Front position light	Left	Right
Front fog light	Left	Right
Side puddle light	Front	Rear
License plate light	Left	Right
Reverse light	Left	Right

- Any measurement point on the lit surface of component A of a pair must be within 4 SDCM of any point on the lit surface of component B in the pair, and vice versa.

*Tolerance box for individual functions in one component.

- Any two measurement points on the lit surface within the same component must be within 2 SDCM.

Verification.

To be verified by supplier and/or VCC. Virtually using simulation and physically in VP, TT, PP build.

Verification method.

1. Subjective visual evaluation performed by lighting expert at Perceived Quality Illumination VCC.

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

2. Measurment by spectrometer for distributed light. Position and distance for measuring to be agreed per component.

3. Measurment by luminance camera for lit surfaces. Position of measuring points to be agreed per component.

REQ-44824 v12 PQ ILL SYS Exterior colored light target 1.1

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification: Editorial
Design Target : True
Is Generic : No

PURPOSE
This requirement is published in order to harmonize exterior colored light

DEFINITION

All the red or yellow color in exterior illuminated components of complete vehicle should perceived the same.

SCOPE

Covers all exterior illuminated components with colored light on Volvo and Polestar branded vehicles such as rear lamp, front lamp and side turn indicator.

REQUIREMENT

Bellow color target and tolerance for red and yellow color is specified. Note;

- Target and tolerance apply to the complete lamp system and are to be measured on the outer most lens element.

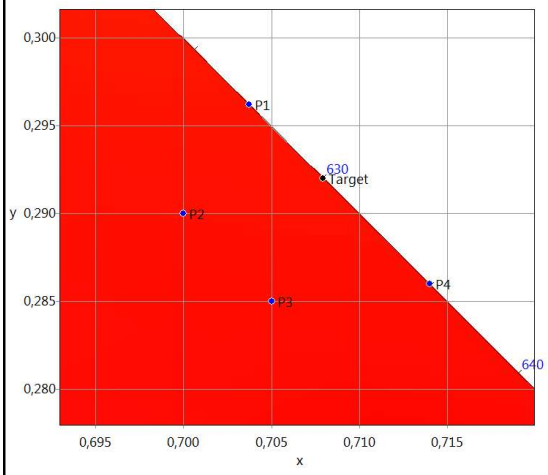
- Tolerance for color target also acts as requirement for light color homogeneity on lit surface for exterior lights.

- Tolerance is per fleet and per vehicle.

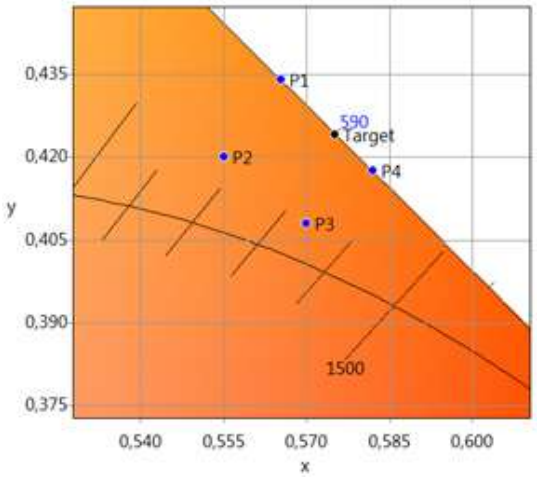
- Design intent may override nominal values in this requirement though the tolerance values are always valid.

<table>
<tr><th></th><th>Red</th><th>Yellow / Amber</th></tr>
<tr><td>Nominal target</td><td>630 nm</td><td>590 nm</td></tr>
<tr><td>Tolerance per vehicle</td><td>+ 3 nm / - 5 nm *</td><td>+/- 1,5 nm</td></tr>
<tr><td>Tolerance per fleet</td><td>
<table>
<tr><th></th><th>X</th><th>Y</th></tr>
<tr><td>Target</td><td>0,7079</td><td>0,292</td></tr>
</table>
</td><td>
<table>
<tr><th></th><th>X</th><th>Y</th></tr>
<tr><td>Target</td><td>0,5751</td><td>0,4242</td></tr>
</table>
</td></tr>
</table>

P1	0,7037	0,2962
P2	0,70	0,29
P3	0,705	0,285
P4	0,714	0,286



P1	0,5653	0,434
P2	0,555	0,42
P3	0,57	0,408
P4	0,582	0,4175



* Stop light and CHMSL to be harmonized within +/- 3 nm

Verification.

To be verified by supplier and/or VCC. Virtually using simulation and physically in VP, TT, PP build.

Verification method.

1. Subjective visual evaluation performed by lighting expert at Perceived Quality Illumination VCC.
2. Measurement by spectrometer for distributed light. Position and distance for measuring to be agreed per component.
3. Measurement by luminance camera for lit surfaces. Position of measuring points to be agreed per component.

REQ-17289 v6 PQ ILL SYS Sequential light resolution

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification:
Design Target : True

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

Is Generic : Yes
Requirement Type: Structural

Purpose
This requirement is published in order to secure smooth sequential dynamic behaviour.

Definition
Dynamic activation and deactivation of illuminated components with consideration of their geometrical shape, strengthen our brand and trim-level.

Scope
Primarily signature lights, emblem and turn indicator function but it varies based on UX design intend.

Requirement
The electronic architecture of system shall support smooth sequential dynamic behaviour:
- Segment length in 1:1 scale below 30 mm
- Control segments individually

Recommendation
Segment length in 1:1 scale to be ~20 mm.

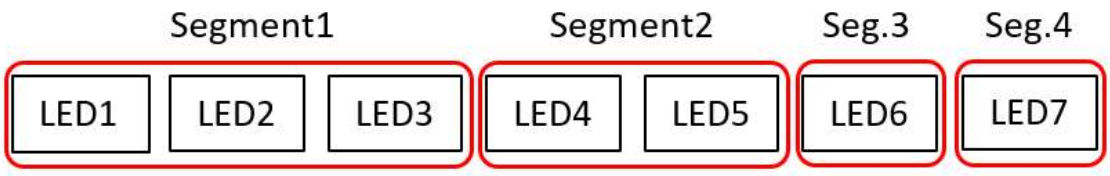
Verification
To be verified visually by responsible SA/GDL and PQ. Virtually at V0, V1, V2, FDJ and physically in VP, TT, PP.

REQ-318947 v2 PQ ILL Syncronized LED ramping tolerance

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification: Editorial
Design Target : True

Purpose

This requirement is published to avoid visual delay during ramping of LED segments within a lamp.



Segmentation example.

Scope

All lamps, or functions within a lamp, with multiple LED segments/channels controlled individually.

Requirement

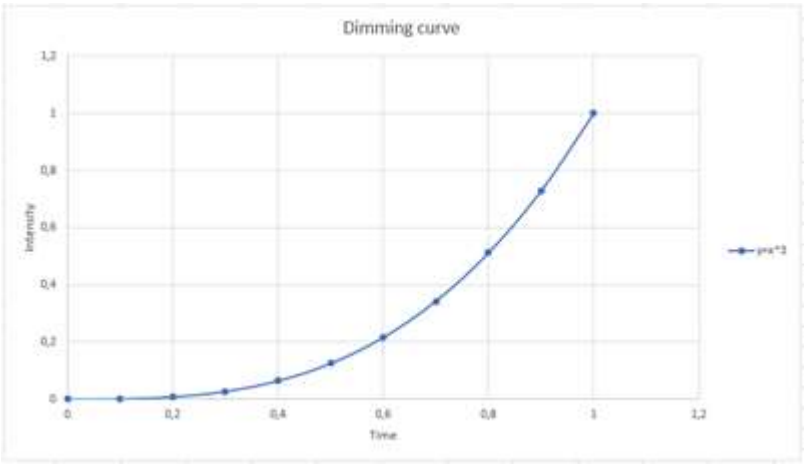
LED segment hardware must be designed to achieve simultaneous activation/deactivation of LED light output during ramp up/down respectively.

Tolerance: all involved LED segments shall activate/deactivate light output in <30ms.

Example dimming curve

One example of dimming curve used by VCC:

Transition from 0% to x% intensity in 800ms following a y=x^3 curve.



REQ-395366 v3 PQ ILL SYS Volvo Word Mark lit appearance

Attribute:	Perceived Quality
Requirement Classification:	Intermediate
Change classification:	New
Design Target :	True

Purpose

This requirement is published to secure premium execution of illuminated Volvo Spread Word Mark, in accordance to Volvo Cars Visual Brand Standards.

Scope

Requirement is applicable to illuminated Volvo Spread Word Mark and unlit Volvo Spread Word Mark with an illuminated background.

Examples:





REQUIREMENT

Lit surface shall be even and show no defects.

Illuminated text:

Criteria 1. Within each letter: max intensity/min intensity <1,5

Criteria 2. Brightest letter average/darkest letter average <2

Criteria 3. Each consecutive letter average 0,7 < L n/L n+1 <1,4

Illuminated background (including areas within "O" letters):

Criteria 1. Intensity of any point in the illuminated background may vary +/- 40% from total average.

Criteria 2. Over any 10 mm section: brightest point/darkest point <1,8.

VERIFICATION
Requirement to be verified in viewing angles agreed per component. This and detailed analysis method(s) are to be shared in prerequisite document delivered by Perceived Quality Illumination team (and updated if the design is changed).

- To be verified subjectively by responsible SA/GDL and PQ. Virtually at V0, V1, V2, FDJ and physically in VP, TT, PP. Evaluation shall be conducted in darkness and daylight.

- Objective analysis to be based on SPEOS simulation in virtual phase (by supplier) and physical parts using luminance camera (by both supplier and PQ).

If no prerequisite document is delivered the following is applied:

Logo Criteria 1: a circular probe of ∅ 0,4 mm shall be used for min/max readings.
SML Criteria 1: a circular probe of ∅ 1 mm shall be used for min/max readings.
SML Criteria 2: Line drawn across any area subjectively assessed as high contrast. To mitigate visible optics, parallel and perpendicular averaging of 1 mm can be applied to the line.

Verification angles:

All angles below to be checked for subjective appearance.

Angles in **bold** text below to be objectively analysed.

H-45 V45 up	H-20 V45 up	**V45 up**	H20 V45 up	H45 V45 up
H-45 V20 up	H-20 V20 up	**V20 up**	H20 V20 up	**H45 V20 up**
H-45 V0	H-20 V0	**Normal to lit surface**	H20 V0	H45 V0

REQ-425645 v2 PQ ILL Illuminated SML homogeneity

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification: New
Design Target : True

PURPOSE
To secure even and premium appearance of Side Marker Lamp (SML) in lit condition.

SCOPE
Requirement is valid for Side Marker Lamp (SML) without text/logo in the design.

The requirement is valid in lit condition. Requirement is valid if not in conflict with design intent.

REQUIREMENT

Homogeneity of lit surface is determined by following three criteria:

Criteria 1: The full surface area of the designed light function shall be illuminated. If a light guide is used with visible prisms they should be evenly spaced with a maximum distance of 2 mm. Recommended spacing <1 mm.

Criteria 2: Luminance variation within designed lit area:
Min/max range of any point: 60% ≤ Average Intensity ≤ 140%

Criteria 3: Over any 10 mm section: brightest point/darkest point <1,8.

VERIFICATION
Requirement to be verified in viewing angles agreed per component. This and detailed analysis method(s) are to be shared in prerequisite document delivered by Perceived Quality Illumination team (and updated if the design is changed).

- To be verified subjectively by responsible SA/GDL and PQ. Virtually at V0, V1, V2, FDJ and physically in VP, TT, PP. Evaluation shall be conducted in darkness and daylight.

- Objective analysis of criteria 2 and 3 to be based on SPEOS simulation in virtual phase (by supplier) and physical parts using luminance camera (by both supplier and PQ).

If no prerequisite document is delivered the following is applied:

Criteria 1: Subjective evaluation.
Criteria 2: Circular probe of ∅ 1 mm shall be used for min/max readings.
Criteria 3: Cross sections drawn in areas subjectively assessed as high contrast. If visible optics, 1 mm averaging can be applied to smoothen optics.

Verification angles:

All angles below to be checked for subjective appearance.

Angles in **bold** text below to be objectively analysed.

H-45 V45 up	H-20 V45 up	**V45 up**	H20 V45 up	H45 V45 up
H-45 V20 up	H-20 V20 up	**V20 up**	H20 V20 up	**H45 V20 up**
H-45 V0	H-20 V0	**Normal to lit surface**	H20 V0	H45 V0

REQ-297392 v2 PQI Clean surface guideline

PURPOSE
This requirement is published to achieve a lit surface that is free from flaws.

DEFINITION
Illuminated surfaces shall be clean and free from injection points, split lines, fasteners, clips and other objects that can cause defects such as hotspots, shadows or optical effects.

The requirement is valid if not contradicting design input. The requirement is valid, seen from the relevant CFoVs (see UC-3306).

DESIGN GUIDELINE
Not allowed to have injection points, split lines, fasteners, clips and other objects on the lit surface that can cause bad optical appearance.

A potential bad optical appaerance shall be minimized and reduced as much as possible.

VERIFICATION
Visual assessment of PQ Illumination always overrides measured data.

To be verified by responsible SA/GDL and PQ. Virtually at V0, V1, V2, FDJ and physically in VP, TT, PP.

4.1.4.13.2 PQ Geometry - Appearance Execution Requirements 728B

REQ-6227 v8 PQ SF Substrate Finish Plastics

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification:
Design Target : True
Is Generic : Yes

PERCEIVED QUALITY SURFACE FINISH - SUBSTRATE FINISH PLASTICS *(generic)*

Requirement
Requirement according to VCS 5068,849 (Surface requirements - Plastic substrates).

Additional explanation regarding surface classes
For each component there must exist a drawing which states the surface classification of the component.
The classification of surfaces is specific to each vehicle. Surface class models can be found in TCe on each vehicle family in the program node under the following path:

/VEHICLE SUPPORT STRUCTURE/ATTRIBUTE/PERCEIVED QUALITY/PAINT AND SURFACE FINISH/

Engineering assessment method:
Assessment according to VCS 5068,849 (Surface requirements - Plastic substrates).
Assessment is carried out by VCC Surface Finish Group.

REQ-6205 v14 PQ PF Paint Finish - Component Requirement

Attribute:	Perceived Quality
Requirement Classification:	Intermediate
Change classification:	
Design Target :	True
Is Generic :	Yes

PERCEIVED QUALITY PAINT & FINISH - PAINT FINISH
Component Requirement

Requirement:
Approved results regarding paint finish according to TR 31826779 Paint Finish Requirement body coloured surfaces – Car Complete.

Requirements surface class I – III: ≥ grade 7 (satisfied customers)
Requirements surface class IV: ≥ grade 6 (critical customers complain)
Requirements surface class V: no requirements

Engineering assessment method:
Assessment according to TR 31826779 and corresponding standards included in TR31826779.
For assessment and measurement of paint texture "orange peel", if it is not obvious, it must be stated on drawings whether a surface should be regarded as horizontal or vertical, for example inclined surfaces.

Verification:

- For exterior parts the requirements are fulfilled when the component has been verified and approved by VCC Colour and Coatings exterior parts according to the Appearance Approval Process. The results are documented in the Appearance Approval Report.
- Visual assessment of the paint surface texture on the component is performed according to the standard inculded in TR31826779.
- Paint surface texture measuring of components is performed according to the standard (see VCS 1026,52749).

REQ-6299 v12 PQ PF Paint Systems for Painting Classes A, B and C - Component Requirement

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification:
Design Target : True
Is Generic : Yes

PERCEIVED QUALITY PAINT & FINISH - PAINT SYSTEMS FOR PAITNING CLASSES A, B AND C
Component Requirement

Requirements:
Requirement according to VCS 5751,6 Paint systems for painting classes A, B, and C.
Corrosion requirements are not valid. They are supplied by the Corrosion attribute.

Test methods:
Test methods according to VCS 5751,6 Paint systems for painting classes A, B, and C.

Verification

- The requirements are fulfilled when the component has been verified and approved by VCC Coating systems. The results are documented in the VCC official report system.
- Depending on type of component (eg. substrate), some test methods are not valid and can be excluded from the verification plan.

References

- VCS 5751,6 Paint systems for painting classes A, B and C

REQ-11056 v16 PQ APPEARANCE EXECUTION - 01 SCREWS

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

PERCEIVED QUALITY G&A APPEARANCE EXECUTION - 01 SCREWS

Purpose
To secure a premium execution of all areas that can be perceived by customers.

Defininitions, see:
REQ-228993 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS
REQ-228921 PQ APPEARANCE EXECUTION REQUIREMENT ZONES

Requirement



Refers to screws & bolts and other fastening elements with similar appearance.

Visibility Requirement:

Number of visible screws allowed.

INTERIOR	EXTERIOR	DLO	ENGINE BAY	UNDERBODY
None	None	Minimize	Allowed	Minimize

Execution Requirements & Guidelines : (R=Requirement, G=Guideline)

Valid for all visible screws, allowed areas included.

Virtual Verification:

- R: If placed in an exposed area, color shall be black and the surface matte, alternatively appearance shall be set to match the adjacent surfaces. If placed in a dark area, color shall be undamaged black and the surface matte.
- G: No visible washers preferred.
- R: Visible screw thread (shanks) not allowed.
- R: Hole shall be completely covered by screw head or washer.
- G: If head is visible, socket screws (hex, allen, torx) are preferred to Phillips or slot screws.
- G: If not placed in a depression, placement shall secure that element does not visually interfere with surrounding features. Min distance of 2-3 mm recommended.
- G: Head shall have centered and symmetric nominal position in relation to surrounding shapes.

Physical Verification:

- R: Entire screw/bolt head shall be in contact with target surface. Washers shall be entirely in contact with target surface.
- R: No scratches on screw heads allowed

REQ-11061 v13 PQ APPEARANCE EXECUTION - 04 ENGINEERING CLIPS & CLAMPS

Attribute: Perceived Quality

Requirement Classification: Intermediate

Change classification:

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

Design Target :
Is Generic : Yes

PERCEIVED QUALITY G&A APPEARANCE EXECUTION - 04 ENGINEERING CLIPS & CLAMPS

Purpose
To secure a premium execution of all areas that can be perceived by customers.

Defininitions, see:
REQ-228993 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS
REQ-228921 PQ APPEARANCE EXECUTION REQUIREMENT ZONES

Requirement



Refers to clips, clamps & pins in plastic or metal with purely functional appearance.

Visibility Requirement:
Requirement level for amount of visible engineering clips and clamps allowed.

INTERIOR	EXTERIOR	DLO	ENGINE BAY	UNDERBODY
None	None	None	Minimize	None

Execution Requirements & Guidelines : (R=Requirement, G=Guideline)
Valid for all visible engineering clips & clamps, Allowed areas included.

Virtual Verification:

R: If placed in a dark area, color shall be black and the surface matte.

G: Appearance shall be as smooth and even as possible.

REQ-11062 v15 PQ APPEARANCE EXECUTION - 05 CABLES & CONNECTORS

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

PERCEIVED QUALITY G&A APPEARANCE EXECUTION - 05 CABLES & CONNECTORS

Purpose
To secure a premium execution of all areas that can be perceived by customers.

Defininitions, see:
REQ-228993 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS
REQ-228921 PQ APPEARANCE EXECUTION REQUIREMENT ZONES

Requirement



Refers to electrical cables & wires as well as harness connectors.

Visibility Requirement:
Requirement level for amount of visible cables & connectors.

INTERIOR	EXTERIOR	DLO	ENGINE BAY	UNDERBODY
None	None	None	Minimize	Minimize

Execution Requirements & Guidelines : (R=Requirement, G=Guideline)
Valid for all visible cables & connectors, Allowed areas included.

Virtual Verification:

R: Cables and cable insulation shall be black and have a matte surface. Alt. metallic woven covers accepted if they follow appearance of adjacent surfaces.

R: Connectors shall be black and have a matte surface.

Physical Verification:

R: No visible inner cables between cable insulation and connectors.

G: Cables shall follow a precise route and be perceived as tightly attached.

Exception 1 - Provided that visibility requirement cannot be fulfilled: Cables for high voltage buses which are not located within enclosures shall be identified by having an outer covering with the colour orange . Exception shall be approved due to R100 legal requirement.

Exception 2 - Provided that visibility requirement cannot be fulfilled: For connection of accessories, battery chargers or equivalent, where colour coding is judged necessary due to substantial risk of customer misuse or mislead, exceptions shall be approved.

REQ-11070 v13 PQ APPEARANCE EXECUTION - 13 ADHESIVE DECALS

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification:

Design Target :
Is Generic : Yes

PERCEIVED QUALITY G&A APPEARANCE EXECUTION - 13 ADHESIVE DECALS

Purpose
To secure a premium execution of all areas that can be perceived by customers.

Definitions, see:
REQ-228993 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS
REQ-228921 PQ APPEARANCE EXECUTION REQUIREMENT ZONES

Requirement



Refers to adhesive decals.

Visibility Requirement:
Requirement level for amount of visible adhesive decals.

INTERIOR	EXTERIOR	DLO	ENGINE BAY	UNDERBODY
None	None	Minimize	Allowed	Minimize

Adhesive decals are accepted if they are needed to fulfil legal requirements. When printed information is necessary for the customer, printed or embossed text is preferred.

Execution Requirements & Guidelines : (R=Requirement, G=Guideline)
Valid for all visible adhesive decals, Allowed areas included.

Virtual Verification:

- R: In exposed areas, decal should have same color as adjacent surface. In this case, color should be coordinated. Alternatively color shall differ significantly but be matched from a harmony perspective.
- R: In dark areas, color shall be black. Contrast between text and decal shall be minimized.
- G: Orientation and shape shall follow adjacent shapes and design elements.
- G: Size of decal should be minimized.
- G: Min distance to adjacent edges and surfaces of 10 mm.

Physical Verification:

- R: Decals shall be in contact to target surface

REQ-11073 v14 PQ APPEARANCE EXECUTION - 16 TEXT & PRINTS

Attribute: Perceived Quality

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

PERCEIVED QUALITY G&A APPEARANCE EXECUTION - 16 TEXTS & PRINTS

Purpose
To secure a premium execution of all areas that can be perceived by customers.

Defininitions, see:
REQ-228993 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS
REQ-228921 PQ APPEARANCE EXECUTION REQUIREMENT ZONES

Requirement



Valid for printed or moulded text that does not to provide information to customer or is not needed to fulfil legal demands.

Visibility Requirement:
Requirement level for amount of visible text & prints.

INTERIOR	EXTERIOR	DLO	ENGINE BAY	UNDERBODY
None	None	None	Allowed	Minimize

Execution Requirements & Guidelines : (R=Requirement, G=Guideline)
Valid for all visible text & prints, Allowed areas included.

Virtual Verification:

- G: Strive for sober color and avoid high contrast between text and surface (printed text).
- G: Orientation and shape shall follow adjacent shapes and design elements.

REQ-11077 v12 PQ APPEARANCE EXECUTION - 20 CROSS-SECTION SURFACES

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

PERCEIVED QUALITY G&A APPEARANCE EXECUTION - 20 CROSS-SECTION SURFACES

Purpose
To secure a premium execution of all areas that can be perceived by customers.

Defininitions, see:
REQ-228993 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS
REQ-228921 PQ APPEARANCE EXECUTION REQUIREMENT ZONES

Requirement



Refers to when cuts through components results in a cross-section surface that has a different appearance than the intended a-surface appearance, e.g. multi-layer headlining or dashboard skins.

Visibility Requirement:
Requirement level for amount of visible cross sections surfaces.

INTERIOR	EXTERIOR	DLO	ENGINE BAY	UNDERBODY
None	None	None	None	None

Execution Requirements & Guidelines : (R=Requirement, G=Guideline)
Valid for all visible cross-section surfaces, Allowed areas included.

Virtual Verification:

G: Bend cut away from prioritized Customer Field of View.

Physical Verification:

R: No visible fringes allowed.

REQ-11078 v14 PQ APPEARANCE EXECUTION - 21 STRUCTURE & FEATURES

Attribute:	Perceived Quality
Requirement Classification:	Intermediate
Change classification:	
Design Target :	
Is Generic :	Yes

PERCEIVED QUALITY G&A APPEARANCE EXECUTION -21 STRUCTURE & FEATURES

Purpose
To secure a premium execution of all areas that can be perceived by customers.

Defininitions, see:
REQ-228993 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS
REQ-228921 PQ APPEARANCE EXECUTION REQUIREMENT ZONES

Requirement



Engineered features on components such as ribs, reinforcements, clips, hooks, towers, hemmings and flanges.

Visibility Requirement:
Requirement level for amount of visible structures & features.

INTERIOR	EXTERIOR	DLO	ENGINE BAY	UNDERBODY
None	None	None	Minimize	Minimize

Execution Requirements & Guidelines : (R=Requirement, G=Guideline)
Valid for all visible structures & features, Allowed areas included.

Virtual Verification:

G: Make features as even as possible. Strive to integrate in design intent and achieve a “styled” appearance.

REQ-11080 v13 PQ APPEARANCE EXECUTION - 23 DEPRESSIONS & BULGES

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

PERCEIVED QUALITY G&A APPEARANCE EXECUTION - 23 DEPRESSIONS & BULGES

Purpose
To secure a premium execution of all areas that can be perceived by customers.

Defininitions, see:
REQ-228993 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS
REQ-228921 PQ APPEARANCE EXECUTION REQUIREMENT ZONES

Requirement



Depressions/bulges on metal and plastic components.

Visibility Requirement:

Requirement level for amount of visible depressions & bulges.

INTERIOR	EXTERIOR	DLO	ENGINE BAY	UNDERBODY
None	None	Minimize	No Requirement	No Requirement

Execution Requirements & Guidelines : (R=Requirement, G=Guideline)

Valid for all visible depressions & bulges, Allowed areas included.

Virtual Verification:

- R: Depressions shall not be partially hidden, for instance by plastic trim.
- G: Depth of depression shall be equal for entire area.
- G: Depressions should not extend cross a radius if the radius is placed on a curve seen by the customer. An uneven silhouette is created.
- G: Orientation and shape shall follow adjacent shapes and design elements.
- G: For sheet metal depressions, minimum distance to adjacent elements such as trim should be 10 mm.

REQ-11081 v14 PQ APPEARANCE EXECUTION - 24 PROCESS HOLES

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

PERCEIVED QUALITY G&A APPEARANCE EXECUTION - 24 PROCESS HOLES

Purpose

To secure a premium execution of all areas that can be perceived by customers.

Defininitions, see:
REQ-228993 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS
REQ-228921 PQ APPEARANCE EXECUTION REQUIREMENT ZONES

Requirement

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary



Discrete uncovered holes on component.

Visibility Requirement:
Requirement level for amount of visible process holes.

INTERIOR	EXTERIOR	DLO	ENGINE BAY	UNDERBODY
None	None	Minimize	No Requirement	No Requirement

Execution Requirements & Guidelines : (R=Requirement, G=Guideline)

Valid for all visible process holes, Allowed areas included.

Virtual Verification:

R: Minimize interference with adjacent shapes and features.

REQ-11082 v13 PQ APPEARANCE EXECUTION - 25 RAW METALLIC SURFACES

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

PERCEIVED QUALITY G&A APPEARANCE EXECUTION - 25 RAW METALLIC SURFACES

Purpose
To secure a premium execution of all areas that can be perceived by customers.

Defininitions, see:
REQ-228993 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS
REQ-228921 PQ APPEARANCE EXECUTION REQUIREMENT ZONES

Requirement

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary



Metallic surfaces without surface treatment.

Visibility Requirement:
Requirement level for amount of visible raw metallic surfaces.

INTERIOR	EXTERIOR	DLO	ENGINE BAY	UNDERBODY
None	None	None	Allowed	Allowed

Execution Requirements & Guidelines : (R=Requirement, G=Guideline)
No execution requirements.

REQ-11086 v11 PQ APPEARANCE EXECUTION - 29 SEALING EXECUTION

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

PERCEIVED QUALITY G&A APPEARANCE EXECUTION - 29 SEALING EXECUTION

Purpose
To secure a premium execution of all areas that can be perceived by customers.

Defininitions, see:
REQ-228993 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS
REQ-228921 PQ APPEARANCE EXECUTION REQUIREMENT ZONES

Requirement



Rubber sealing profiles & end moulding.

Visibility Requirement:
Requirement level for amount of visible rubber sealings & mouldings.

INTERIOR	EXTERIOR	DLO	ENGINE BAY	UNDERBODY
Minimize	Allowed	Allowed	Allowed	Allowed

In some split-lines, visible sealings are preferred to extensive see-through.

Execution Requirements & Guidelines : (R=Requirement, G=Guideline)

Valid for all visible rubber sealings & mouldings, Allowed areas included.

Virtual Verification:

- R: Minimize the width of visible sealings and the total area of sealings visible on the vehicle.
- R: Minimize the size of end mouldings.
- R: End moulding shall not appear as “bulky” and shape shall harmonize with design intent.
- R: When visible inside a split-line, sealing shall cover entire split without visible endings.
- G: For sealings in DLO DOOR splice shall be placed where it is minimally exposed to customer.
- G: For sealings in DLO REAR and ENGINE BAY splices shall nominally be positioned in Y0.
- G: Avoid lining up splice with features or splits between other components if there is a risk for positioning variation.

Physical Verification:

- R: Sealing lips shall be in contact to target surface (optically verified).
- G: Splice shall be smooth and free from prominent lines/edges, waviness or other optical distortions.
- G: For splices, components shall have equal, non-deformed cross section on both sides of joint with flush relations.

REQ-11089 v16 PQ APPEARANCE EXECUTION - 32 ADHESIVES

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

PERCEIVED QUALITY G&A APPEARANCE EXECUTION - 32 ADHESIVES

Purpose
To secure a premium execution of all areas that can be perceived by customers.

Definitions, see:
REQ-228993 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS
REQ-228921 PQ APPEARANCE EXECUTION REQUIREMENT ZONES

Requirement



Adhesives such as PUR etc.

Visibility Requirement:

Requirement level for amount of visible adhesives.

INTERIOR	EXTERIOR	DLO	ENGINE BAY	UNDERBODY
None	Minimize	Minimize	Minimize	Minimize

Execution Requirements & Guidelines : (R=Requirement, G=Guideline)

Valid for all visible adhesives, Allowed areas included.

R: Exposed areas: No execution requirement. No visible glue allowed.

Virtual Verification:

R: Dark areas: Adhesive shall have dark appearance.

Physical Verification:

R: Dark areas: No reflections or disturbances due to uneven application.

REQ-11091 v13 PQ APPEARANCE EXECUTION - 34 TOOL PARTING LINES

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

PERCEIVED QUALITY G&A APPEARANCE EXECUTION - 34 TOOL PARTING-LINES

Purpose

To secure a premium execution of all areas that can be perceived by customers.

Defininitions, see:
REQ-228993 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS
REQ-228921 PQ APPEARANCE EXECUTION REQUIREMENT ZONES

Requirement



Tool parting lines.

Visibility Requirement:

Requirement level for amount of visible tool parting lines.

INTERIOR	EXTERIOR	DLO	ENGINE BAY	UNDERBODY
Minimize	Minimize	Minimize	Allowed	No Requirement

For dark areas: Tool parting lines are allowed if placed deep within dark area.

Execution Requirements & Guidelines : (R=Requirement, G=Guideline)

Valid for all visible tool parting lines, Allowed areas included.

Virtual Verification:

R: No visible ingates.

Physical Verification:

LEVEL 1: (Areas clearly visible from Customer Field of View)

R: Maximum edge/flash height on plastic parts is 0.2mm. Acceptable flash/edge height parallelism along an edge is 0.1mm.

R: Maximum edge/flash height on chrome part is 0mm.

LEVEL 2: (Not visible from Customer Field of View but visible when closer inspecting the vehicle)

R: Maximum edge/flash height on plastic parts is 0.5mm. Acceptable flash/edge height parallelism along an edge is 0.2mm.

Contact Attribute Leader PQ if there are uncertainties regarding the level classification.

REQ-11092 v13 PQ APPEARANCE EXECUTION - 35 EJECTOR MARKS

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

PERCEIVED QUALITY G&A APPEARANCE EXECUTION - 35 EJECTOR MARKS

Purpose

To secure a premium execution of all areas that can be perceived by customers.

Definitions, see:
REQ-228993 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS
REQ-228921 PQ APPEARANCE EXECUTION REQUIREMENT ZONES

Requirement



Ejector marks created by tool ejector pins.

Visibility Requirement:
Requirement level for amount of visible ejector marks.

INTERIOR	EXTERIOR	DLO	ENGINE BAY	UNDERBODY
None	None	None	None	None

Execution Requirements & Guidelines : (R=Requirement, G=Guideline)
No execution requirements.

REQ-11095 v12 PQ APPEARANCE EXECUTION - 38 HOLES

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

PERCEIVED QUALITY G&A APPEARANCE EXECUTION - 38 HOLES

Purpose
To secure a premium execution of all areas that can be perceived by customers.

Definitions, see:
REQ-228993 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS
REQ-228921 PQ APPEARANCE EXECUTION REQUIREMENT ZONES

Requirement

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary



Obviously unintended holes between components where product is not enclosed and does not look finalized.
Failure to achieve enclosed execution of design surfaces.

Requirement: (R=Requirement, G=Guideline)
Virtual Verification:
R: No visible holes allowed.

REQ-11096 v13 PQ APPEARANCE EXECUTION- 39 CAVITIES

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

PERCEIVED QUALITY G&A APPEARANCE EXECUTION - 39 CAVITIES

Purpose
To secure a premium execution of all areas that can be perceived by customers.

Defininitions, see:
REQ-228993 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS
REQ-228921 PQ APPEARANCE EXECUTION REQUIREMENT ZONES

Requirement



Cavities in-between primary surfaces or edges that result in hollows but do not necessarily imply a hole between components.

Requirement: (R=Requirement, G=Guideline)
Virtual Verification:
R: Minimize size and amount of cavities in-between surfaces and edges.

In some critical areas, cavity requirement is supported by radii requirement in PQ GEOMETRY REQUIREMENT DOCUMENT.

REQ-11097 v13 PQ APPEARANCE EXECUTION - 40 CUTOUTS

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

PERCEIVED QUALITY G&A APPEARANCE EXECUTION - 40 CUTOUTS

Purpose
To secure a premium execution of all areas that can be perceived by customers.

Defininitions, see:
REQ-228993 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS
REQ-228921 PQ APPEARANCE EXECUTION REQUIREMENT ZONES

Requirement



Cutouts in an edge that create disruptions and distort the intended design.

Requirement: (R=Requirement, G=Guideline)
Virtual Verification:
R: No visible cutouts.

REQ-11098 v13 PQ APPEARANCE EXECUTION - 41 SEE-THROUGH

Attribute: Perceived Quality
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

PERCEIVED QUALITY G&A APPEARANCE EXECUTION - 41 SEE-THROUGH

Purpose
To secure a premium execution of all areas that can be perceived by customers.

Defininitions, see:
REQ-228993 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS
REQ-228921 PQ APPEARANCE EXECUTION REQUIREMENT ZONES

Requirement



Unsightly elements visible through split-lines or openings.

Requirement: (R=Requirement, G=Guideline)

Virtual/Physical Verification:

R: See-through, when distorting elements are visible in split-lines or openings, is not allowed.

R: Complete see-through, *When you can see straight through components out through the other side,* is not allowed.

REQ-286725 v2 PQ APPEARANCE EXECUTION - 44 BLANK SHAPES & PLACEHOLDERS

Attribute:	Perceived Quality
Requirement Classification:	Intermediate
Change classification:	New
Design Target :	
Is Generic :	Yes

Purpose

To secure a premium execution of all areas that can be perceived by customers.

Defininitions, see:
REQ-228993 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS
REQ-228921 PQ APPEARANCE EXECUTION REQUIREMENT ZONES

Requirement



Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

Visibility Requirement:

Requirement level for amount of visible blank shapes.

INTERIOR	EXTERIOR	DLO	ENGINE BAY	UNDERBODY
None	Minimize	Minimize	Allowed	Allowed

For dark areas: Blanks are allowed if placed deep within dark area.

Execution Requirements & Guidelines :

(R=Requirement, G=Guideline)

Valid for all blanks & placeholders, allowed areas included.

Virtual Verification:

R: All placeholders without text are considered blank and will be contested from PQ.

Virtual Verification:

LEVEL 1: (Areas clearly visible from Customer Field of View)

R: No blank shapes allowed without function or design intent.

G: Frame shape should not be sharp, radius is needed around stamp line.

REQ-228993 v3 PQ APPEARANCE EXECUTION VISIBILITY REQUIREMENT LEVELS

DEFINITION OF VISIBLE

For Interior, Exterior, DLO and Engine Bay:

A visible component is any component that is not permanently occluded by other components assuming any possible customer eye position or use case.

For Underbody:

A visible component is any component visible 8m from car above a height of 1118 mm from CURB 2.

A component visible in an exposed area is clearly visible to customer and highly illuminated.

A component visible in a dark area is seen through a hole, split or mesh and is not highly illuminated.

Execution requirements can differ between dark and exposed areas.

To support the evaluation of issue severity based on visibility the Customer Field of View models are released by PQ starting DSM0 and can be found under the following TCE path:

VEHICLE SUPPORT STRUCTURE/ ATTRIBUTE/PERCEIVED QUALITY/GEOMETRY AND APPEARANCE QUALITY/APPEARANCE QUALITY

VISIBILITY REQUIREMENT LEVELS

None: Project target to reach zero occurrence. All identified deviations from visibility requirement to be reported to AL PQ. Execution Requirement valid if there are deviations.

Minimize: Project target to minimize occurrence. All identified deviations from visibility requirements to be reported to AL PQ. Execution Requirement valid if there are deviations. Support long term goal to reach zero occurrence.

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

Allowed: Visible elements allowed in project. Project target to fulfil execution requirement. All Identified deviations from execution requirements to be reported to AL PQ.
No Requirement: No visibility Requirement. No execution Requirement.

4.1.4.14 Performance

REQ-459250 v1 Headlamp performance

General

Applicable on both Low and High beam and all different technologies

Scope

Valid for vehicles with fuel level indication shown to driver

Requirement

All Low beam & High beam headlamp versions shall uniformly illuminate the road and shoulder areas in front of the vehicle without any discontinuities within the field of vision.

The illumination must fulfill minimum values stated below:

a) The amount of light available

Function	Variant	ECE/ROW [lm]	SAE [lm]
Low Beam	**One Spec**	1000	1000
High Beam	**One Spec**	2000	2000

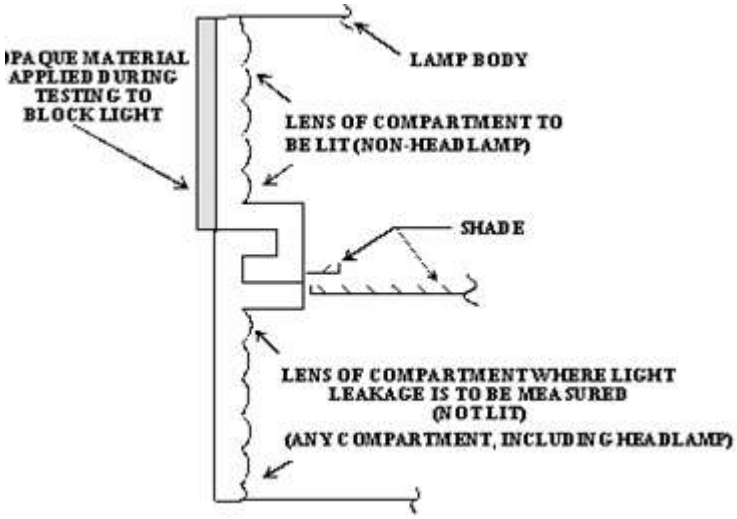
b) Maximum Luminous Intensity (Emax)

Function	Variant	ECE/ROW [lx]	SAE [lx]
Low Beam	**One Spec**	63	63
High Beam	**One Spec**	160	120 (@HV)

DVM:
a) The amount of light available; Minimum Luminous Flux; Φ @13,2V
b) Maximum Luminous Intensity; Minimum Emax; lx @13,2V

REQ-30268 v4 Light leakage between functions

Light leakage from a non-headlamp function to any adjacent compartment of a multi-compartment lamp cannot exceed 15 candela. This requirement shall not apply to the combination of functions having the same colour or the same function. If the colour of the lighting function is created by the light source or a fully enclosed colour filter (e.g. optics plate) then this requirement does not apply. NOTE: Fully enclosed colour filter means every light ray is only observable as the filtered colour.



Type Of Lamp	Measuring Distance
Headlamp Fog Lamp	10 m
Tail Lamp Parking Lamp Clearence Lamp Stop Lamp Turn-signal Lamp Side-marker Lamp Back-up Lamp	3 m
Reflex Reflector	30.48 m

REQ-198209 v1 Digital aiming resolution

Purpose:

In order to do a accurate aiming the levelling motor steps and headlamp frame geometry shall be sufficient to allow a good resolution of the aiming performance.

Requirement:

When digital aiming is performed in vertical direction the resolution of the movement of the aiming beam pattern shall be <= 1.7 mm on a 10 meter screen.

When digital aiming is performed in horizontal direction the resolution of the movement of the aiming beam pattern shall be <= 3.3 mm on a 10 meter screen.

REQ-59723 v6 Forward visibility

Requirement:

For option lamp the meters in TC4-45 assessment have to be at minimum according to the table.

LB	
Zone A	115
Zone B	125
Zone C	63
D left	13,25
D right	13,25
E left	10
E right	10
flux	2000
glare	Target CNCAP

HB	
H range 1	280
H range 2	75
H range 3	60
H range 4	75
H range 5	202
H E left	7,5
H E right	7,5
H flux	4000

*It is allowed to deviate from Zone D=13,25 provided that (Zone Dleft+Zone Dright)>26,5
*It is allowed to deviate from LB Zone E=10 provided that (Zone Eleft+Zone Eright)>20.
*It is allowed to deviate from HB Zone E=7,5 provided that (Zone Eleft+Zone Eright)>15

Supplier shall also evaluate beam patterns according to GTB HSPR (Headlamp Safety Performance Rating) and deliver the corresponding ies files to Volvo. No specific target level is decided presently. The collected data will be used for establishing future target levels for other projects. GTB HSPR is an extension of TC4-45 with ADB evaluation.

REQ-34646 v2 Headlamp beam pattern evaluation

Requirements:
- The low beam shall uniformly illuminate the road and shoulder areas in front of the vehicle without any discontinuities within the field of vision.
- The high beam shall uniformly illuminate the far zone and harmonize with the near zone (low beam) illumination.
- The illumination performance of every function must equal or exceed the program target (project specific)
- No stray light is allowed outside of the uniform beam patterns (jury evaluation)
- The rating must be at least 8 (good)

Validation:

These graphics illustrate the rating system and zones for performance evaluation criteria of high beam headlamp beam pattern.

These graphics illustrate criteria of Low Beam & High Beam and how these criteria are used to effectively evaluate a headlamp beam pattern.

Rating Index	1	2	3	4	5	6	7	8	9	10
Evaluation of Attribute Performance	Not Acceptable		Poor		Borderline	Acceptable	Fair	Good	Very Good	Excellent
Improvements Desired by:	All Customer			Average Customer		Critical Customer		Trained Observer		Not Perceptible

Low Beam Criteria:



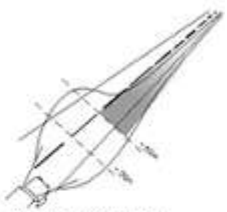
1) left side range



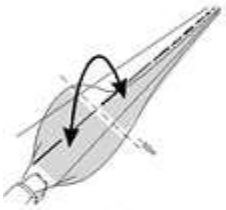
2) left side illumination



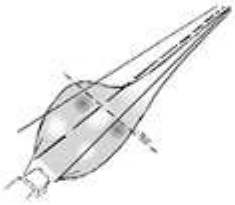
3) right side illumination



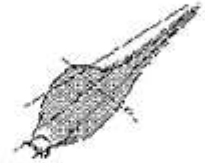
4) seeing distance



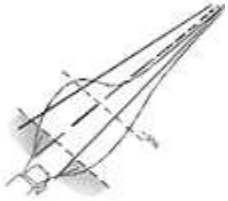
5) near and far zone harmonization



6) homogeneity/ uniformity



7) light volume

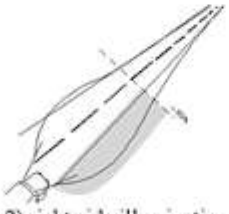


8) near side illumination

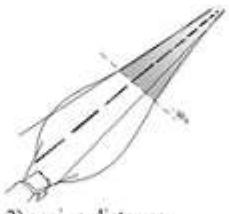
High Beam Criteria:



1) left side illumination



2) right side illumination



3) seeing distance



4) near and far zone harmonization



5) homogeneity/ uniformity



6) light volume

REQ-53598 v2 Maximum stray light

Content GRS 10.03 Security Class: Confidential
Template GRS 10.03 Security Class: Proprietary

Purpose:
Purpose of this requirement is to avoid visible light spots on the walls of a tunnel or on objects like trees or houses on the side of the road.

Requirement:
The light intensity should not exceed 125 cd in area between 10 degrees up and 90 degrees up. Applies to all possible light beams, including all swivelling and levelling positions.

Validation:
Validation done by simulations and night drives according to project schedule.
Simulation should be done in 180 degrees left/right and 90 degrees up and down. Simulation results checked before freezing night drive status and before FDJ.

REQ-60034 v2 Light picture homogeneity

Requirement:

Homogeneity will be subjectively assessed and need to be approved by VCC Technical Experts during night drives before tool order.

Ground illumination illustrated with 75%, 50% and 25% isolux lines shall be closed ellipses without any additional spot. A spot means another closed contour within 75%, 50% or 25% plot.

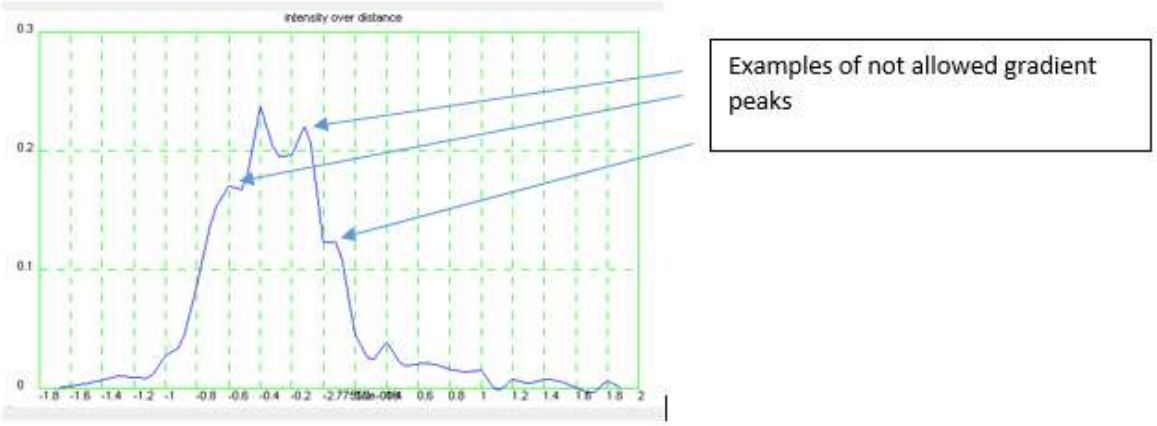
REQ-61051 v3 Beam pattern horizontal cut off

Information:
The beam pattern must be designed so it can be visually checked at a screen 10m in front of the car. The visual check must be able to determine the cut off position with +/-1cm accuracy on a screen 10m in front of the car. To achieve this the cut off must be sufficiently sharp and only one cut off shall be visible.

Requirement:

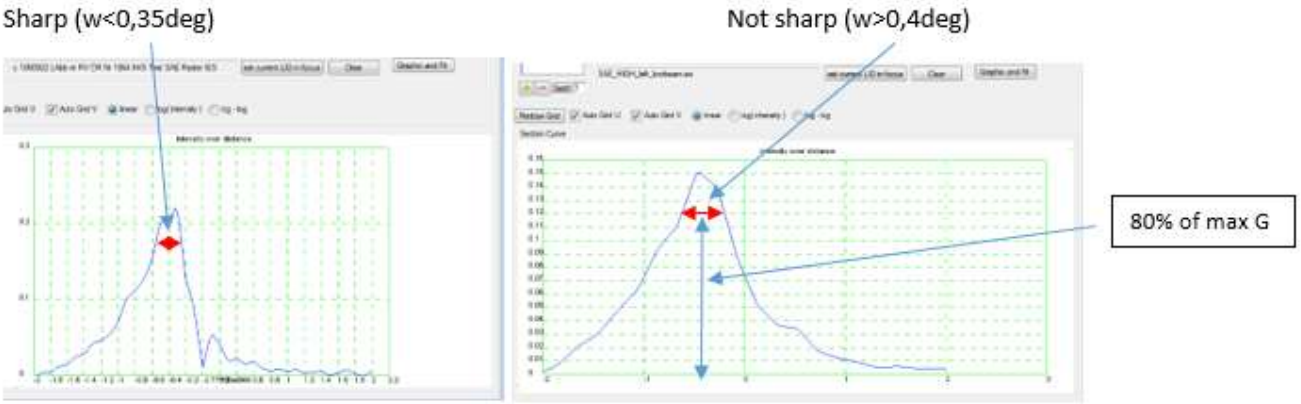
Maximum gradient
The maximum gradient G shall be G>0,20
G = logE(a)-logE(a + 0.1), where ‘‘G’’ is the gradient, ‘‘E’’ is illumination and ‘‘a’’ is vertical angular position.

Gradient curve
No secondary peaks over G=0,1 are allowed.
A peak is defined as a location on the gradient curve where the derivate is 0 and a lower gradient value is present on at least one of the sides of the 0 derivative point.



Sharpness

The width w of the curve at 80% of maximum shall not be more than 0,4deg (for example when max gradient is 0,2, the width of the curve shall not be more than 0,4deg at G=0,16)
See examples:



Fulfilment of this requirement needs to be monitored during running production.

REQ-61054 v3 Relation between different beams

Requirement

Modules inside a headlamp have to be very well aligned to eachother in order to have a good performance. The relative position of different modules can differ max +- 0,1 degrees both horizontally and vertically from the supplier stated design intent nominal.

Fulfilment of this requirement needs to be monitored during running production and after thermal and vibration testing according to REQ-61056.

REQ-61057 v4 Cut off position stability after reference run

Requirement:
Repeated reference runs shall not cause variation in cut off position. The variation between cut off position on a 10 m screen must stay within ± 5 mm during 20 reference runs. (with lamp at a stable temperature).

Verification:
Verification to be performed on both component and complete vehicle level.

REQ-61106 v5 Cut off position stability after digital aiming

Purpose

To ensure the positional stability of the cut-off line after repeated digital aiming operations, thereby guaranteeing consistent lighting performance and compliance with regulatory requirements.

Scope

All exterior front lamp assemblies equipped with digital aiming functionality.

Requirement

Repeated digital aiming operations shall not cause variation in the cut-off position. The cut-off position, measured at 10 m wall, shall remain within ±5 mm of its initial position throughout 20 consecutive digital aiming operations. All measurements shall be performed with the lamp stabilized at its nominal operating temperature.

Supplementary criteria for digital horizontal aiming:

a) After each digital aiming operation, the motor shall be de-energized, as it is during normal vehicle operation.

b) The holding force provided by the motor and its installation, when de-energized, shall be sufficient to prevent any movement of the aiming position under conditions representative of vehicle driving (e.g., vibration, shock, temperature), in accordance with project-specific environmental requirements.

REQ-61107 v2 Headlamp aimability

Requirement:
Volvo expect lamp supplier to take part in 2 work shops with the supplier of light aiming (Durr) and quality control (LET) stations in the factory, to optimise headlamp aiming. Delivery of measured headlamps for these work shops shall be included in the quotation. The headlamp supplier shall design the beam pattern considering aimability and present aiming guidelines. Measurement points at supplier beam pattern EOL control shall exist in order to secure that delivered lamps can be aimed with accuracy and repeatability and fulfil IIHS rating targets. The measured data shall be stored for quality follow up purposes.

REQ-33144 v2 Photometry requirements for Signalling functions, front

The intention with the requirement is to be sure that all signalling lamps are well within legal limits also during running production.

Requirement:

The light intensity of every measuring point and, where appropriate, for every group, should be at the least M times the minimum value and at the most N times the maximum value, which is applicable to the lamp according the applicable regulation. For ECE type approval values apply.

FMVSS/CMVSS-market:

	M	N
The group values	1.4	0.9
The point values for function where the group values are stated	1.2	0.9
The point values for functions without group values for all signalling functions	1.4	0.9
The point, line and zone values (if applicable) for front fog lamp and cornering lamp	1.4	0.9

ECE-market:

	M	N
All signalling functions	1.2	1.0
The point, line and zone values (if applicable) for front fog lamp and cornering lamp	1.2	1.0

M= Coefficient for minimum values

N= Coefficient for maximum values

Reflex reflector calculations shall show that Volvo demand is fulfilled. The area must be stated on the drawing.

For initial samples all functions must be designed to conform to the above mentioned VCC-required minimum/maximum values.

In serial production VCC accepts values less/higher than in the table provided legal values are fulfilled.

Alternatively the supplier can show an existing product similar to the new product and prove that the existing product in running production meets legal limits with 6Sigma performance. The supplier must also at production start show that the new product also meets legal requirement with 6-Sigma performance. If 6- Sigma is not reached, the supplier must measure all values on the new product in running production at his own expense.

Reflex reflectors

The CIL value at every measuring point should be at least M times the minimum value, which is prescribed, for the reflector in the relevant regulations.

FMVSS/CMVSS market	M = 1.4
ECE/EEC market	M = 1.2

All reflex reflectors must be designed to conform to the above mentioned Volvo-required minimum values.

The above mentioned Volvo-required minimum values are valid for initial samples.

In serial production Volvo accepts values less than in the table provided legal values are fulfilled.

M = coefficient for minimum values

N = coefficient for maximum values

REQ-61056 v3 Cut off stability after tests

To be evaluated after:
Long term heat ageing test, exterior REQ-5307
Short term heat test, exterior REQ-5302
Climate variation REQ-4987
Component vibration testing REQ-30373

Requirement:

The cut-off line position needs to be recorded before and after the test. The difference must be smaller then ±10 mm on a 10m wall both horizontally and vertically.
REQ-61054 Relation between different beams (± 0,1 degrees) needs to be fulfilled before and after the tests.

4.1.4.15 Serviceability

REQ-31275 v3 Mounting and dismounting requirements

For parts that must be dismounted for service (e.g. filament bulbs or complete lamp) there is not allowed to be any neither functional, dimensional changes or visual defects after mounting and dismounting the part 10 times, with influence from ageing and environmental factors.

Sealing function and appearance shall not be affected.

If a cover is screwed into the housing, the housing/cover must withstand a min torque of 3,5 Nm.

If the replacement of a spare part requires a screw to be disassembled/assembled, the torque for this screw must be defined on the drawing.

REQ-97768 v1 Headlight HCM

Attribute:	Serviceability
Requirement Classification:	Intermediate
Change classification:	
Design Target :	
Is Generic :	Yes

1-Requirement:
We shall have the possibility to change the HCM on Headlight.

2-Purpose:
HCM shall be possible to remove and install without any risk of electric shock. Replcement of HCM units shall be possible without making replace.

3-Verification
Conducted by reponsible ART.

REQ-97769 v2 Headlight holder

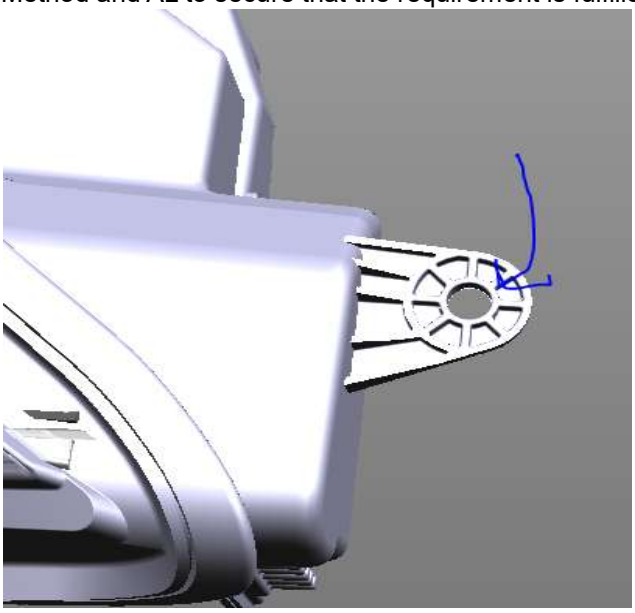
Attribute: Serviceability
Requirement Classification: Intermediate
Change classification:
Design Target :
Is Generic : Yes

1-Requirement:
As the unit price of a lamp is high and as the position of the lamp is vulnerable even for low speed crash, the insurance cost for broken lamps is considerably high. Measure must be taken to reduce the cost of replacing lamps when possible. By introducing a replaceable headlight holder that function as the weakest point in the construction during low speed crash, a lamp could be saved by changing the headlight holder after a minor crash.

Headlight holder/fixations should be designed for possibility to be changed.

2-Purpose:
The purpose of the demand is to lower the insurance cost for replacing lamps.

3-Verification
Method and AL to secure that the requirement is fulfilled.



REQ-31283 v3 Spare parts

For every component, which will be spare part, shall technical documentation exist in form of drawings and information in Volvo PLM system. Confirmed spare parts structure shall be on the change order.

4.1.4.16 Solidity

REQ-310327 v1 Tactile stiffness front lamps

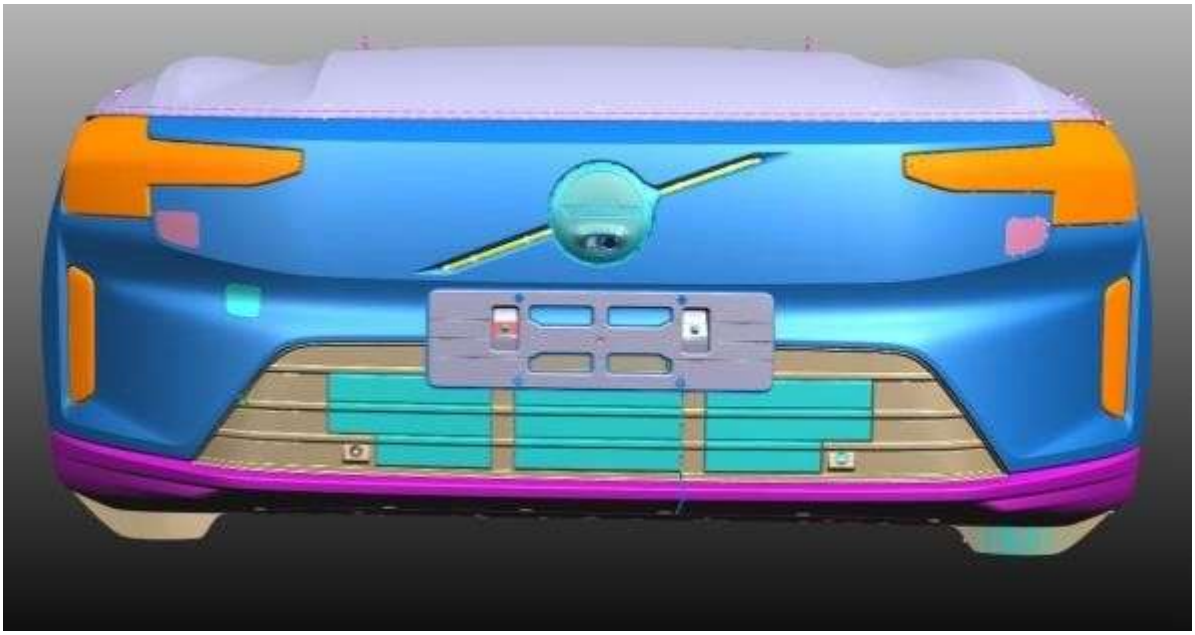
Attribute: Solidity
Requirement Classification: Intermediate
Change classification: New
Design Target :

Background

This requirement is developed together with ART to make sure that we have solid and robust front lights.

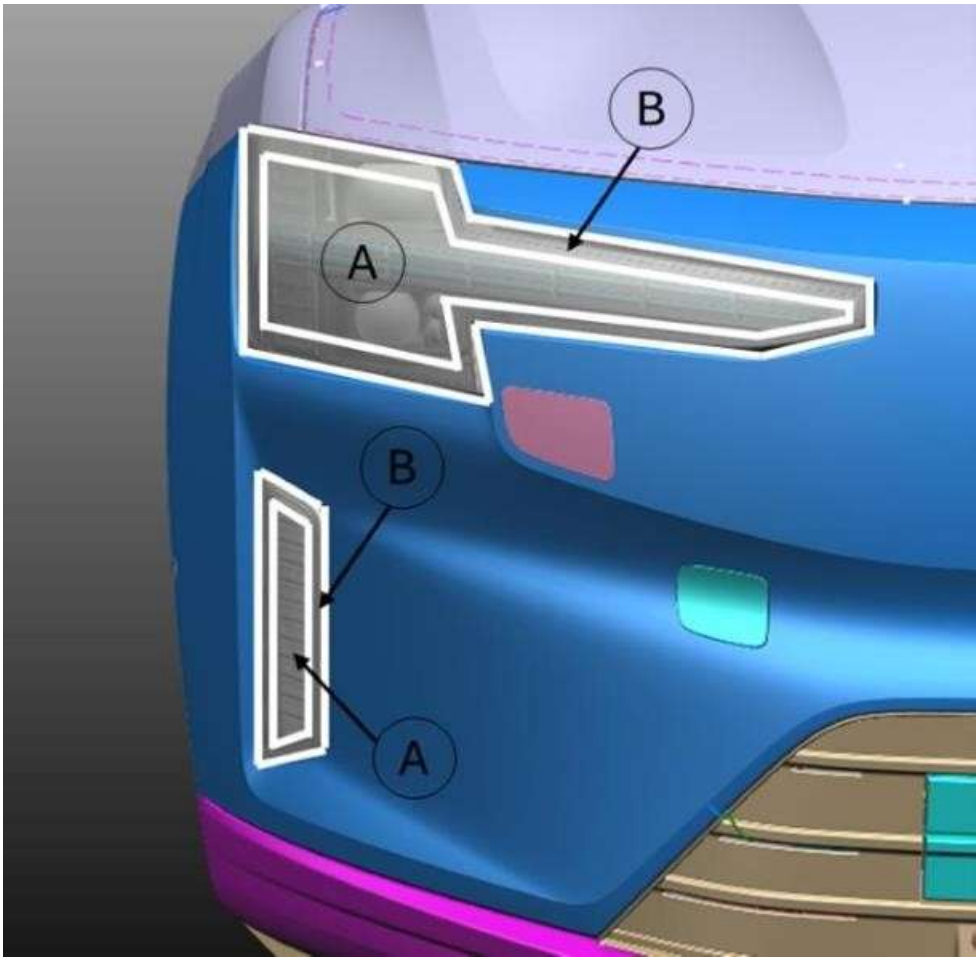
Applicability

This requirement is valid for all cars with front lights, see picture 1.



Picture 1: Front Lights

Front lights zone area, see picture 2.



Picture 2: Front Lights – Zone area on A & B

Requirement target

The force is applied to front lights, defined as normal to the surface with a 40 mm diameter test probe.

Forces and displacements are shown in the table below.

See also REQ-393864 for generic force-displacement curve.

The edge area of the front lamp is defined as the area 40 mm from the outer boundaries of the lamp. This includes (but is not limited to) the split lines between the headlight/bumper, fender/front light and hood/front lamp. The displacement requirement for the split lines is defined as the relative displacement between the parts at the split line (close to the load application point) in the direction of the load application.

Part of vehicle	Zone	Max applied force [N]	Max allowed displacement, direction	Max allowed relative disp. in the split line (in

			normal to surface [mm]	the load application direction) [mm]
Front lights surface	A	150	7,5	NA
Front lights edge	B	150	4	2

Verification

Verification to be done by CAE simulations, test method SOLCAE00005/TM-914

For physical verification use test method SOL00009/ TM-1023/TM-895

REQ-393864 v1 Tactile stiffness requirment generic part

Attribute:
Requirement Classification: Intermediate
Change classification: New
Design Target : False

When the load is applied the component/s must be free from:

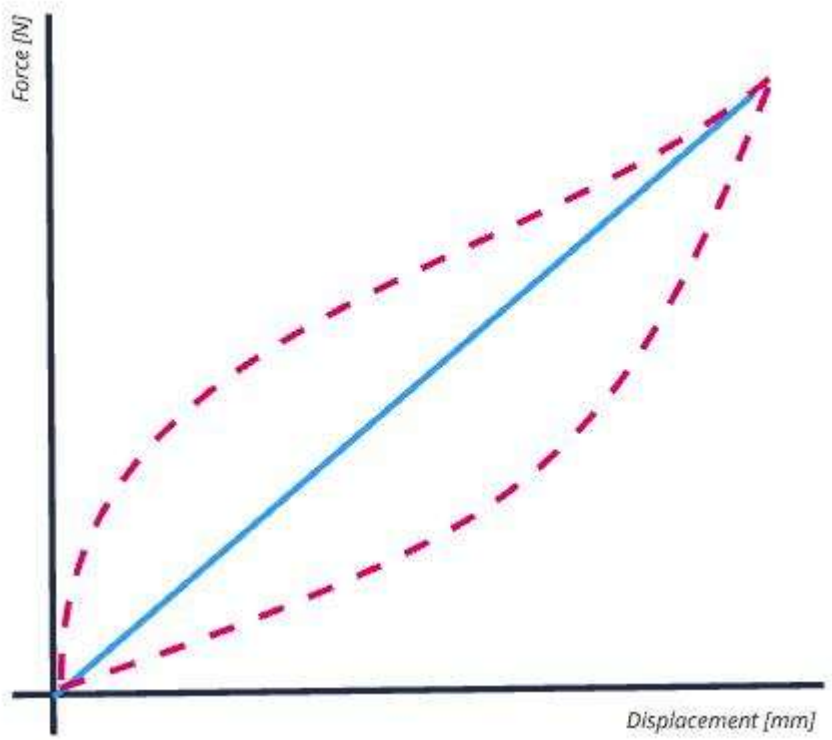
1. Noise (i.e. squeaking, creaking) during load.
2. Visible movements at split lines.

After the load has been applied no remaining deformation is allowed.

The test is done when the part is assembled in the vehicle or with equivalent attachment stiffness conditions.

This applies at ambient temperature +23 °C ±2 °C.

Tactile stiffness generic Force Displacement curve

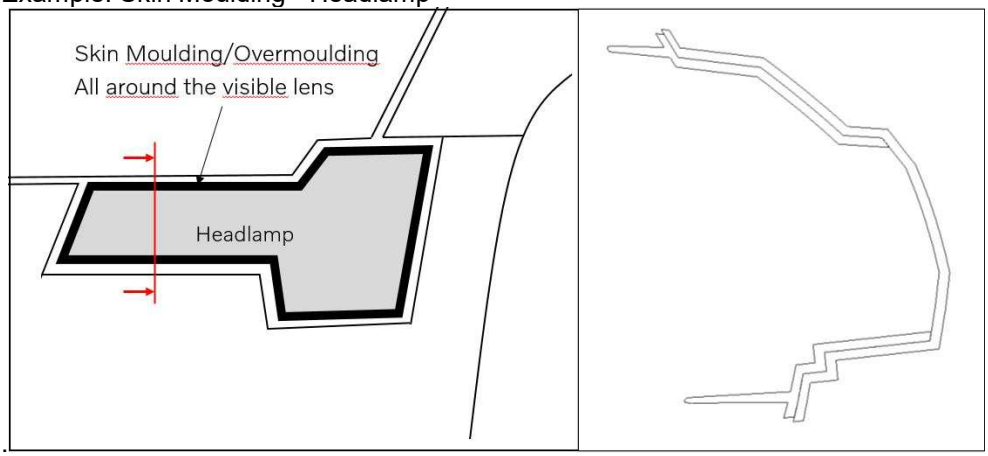


REQ-148687 v1 2k Outer Lens

Overmoulding or Skin moulding requirment for Outer lens

It is important to have skin moulding all around the edge of the visible outer lens. This is applicable for both Headlamp & Bumper lamp. In case of tooling constrains this has to be discussed with Volvo cars prior to the concept freeze.

Example: Skin Moulding - Headlamp



VMR 0682 v3 VMR 0682 SQUEAK AND RATTLE AVOIDANCE

ART ownership:
Attribute: Solidity

VMR 0682 SQUEAK AND RATTLE AVOIDANCE

VMR 0682 Squeak and Rattle avoidance

Definitions:
Squeak - noise created by frictional sliding instability between material pairs
Rattle - noise created by impacting events between two surfaces
Buzz - noise created by vibrating components/surfaces

All component interfaces must meet the existing specified requirements under both static and dynamic vehicle conditions, ambient temperature range +60°C to – 20°C, during the cars life cycle 100 000 km or 5 years and applicable on test tracks stated in
TB 33340123 Solidity Squeak and Rattle Complete Vehicle

Rattle
Designed in interference is acceptable as long as there is no relative movement or if the materials are compatible between the mating parts. If by design an interface between two components is -3 mm to +2 mm, then the potential for rattle issues exists.

Squeak
System, subsystem and component interfaces from minus 3 mm of interference to plus 2 mm of clearance must meet Material compatibility requirements.
Materials can be checked for compatibility by using the Material Compatibility Matrix (see example below). If the material pair in question is not listed in the Material Compatibility Matrix, samples are to be provided to the Squeak and Rattle Team for compatibility testing.

For both Squeak and Rattle
If an interface of two components does not meet these requirements any of the following options exist:

- Increase clearance between interfacing components

- The parts must be restrained with additional or stiffer attachments in areas of interaction to prevent possible contact between two surfaces or increase pre load between the two surfaces to prevent relative movement.

- Isolation with appropriate materials e.g. textile tape, foam, dry coating or lubricant

- Graining of contact surfaces

- Material Change for compatibility.

It's important that the corrective action is released on the drawing or other appropriate document.



Fig. 1 Example of Material Compatibility Matrix (room temperature). Important!
This matrix must only be used as guidance to the combination of materials best suited to the situation.
It does not guarantee a silent component!
Issues, such as form, rigidity, acoustics and fastening method are equally important in designing a silent component.

EDS wiring harnesses:
Use fastening methods to avoid any movement of the cable that could cause Squeak and Rattle, recommended distance of fastening cables is every 100-150mm. When excessive cables are required for assembly it must be insulated. Avoid PVC sheathing for cables in the passenger compartment. Prevent rattling by cables in the head lining by minimizing the length of cable, providing adequate restraint, or by using insulation.
Branching cables need an extra fixation to avoid rattling. Wiring that is in contact with the door panel need some kind of isolation to avoid rattling. Make labels as small as possible to avoid rustle.

When attaching cables to the head lining, tape which does not cause adhesion noise must be used. When using foam on cables it must not squeak against adjacent materials.

Change log
Revision 5: 2016/10/20 Editorial: Link to TB updated with new TB number, updated distance for fastening cables.
Revision 4: 2015/10/01 Editorial: Text updated for clarification and merging of VMR 0446 and 0445.
Revision 3: 2014/06/13 Editorial: Name changed to VMR
Revision 2: 2014/04/16 Editorial: Text updated for clarification.

4.1.4.17 Strength & Endurance

VMR 0167 v5 VMR 0167 EXTERIOR LIGHTING VIBRATION ENDURANCE

ART ownership: Exterior Lighting
Attribute:

VMR 0167 EXTERIOR LIGHTING VIBRATION ENDURANCE

Purpose

This requirement intends to verify structural endurance of exterior lighting to be able to meet endurance requirement on vehicle level.

Variants that target applies to

The requirement applies to all exterior lighting devices in all vehicle variants.

Load cases

The same test object shall be subjected to a sine sweep and to a random PSD spectrum in each direction x, y and z in the vehicle coordinate system.

Target levels

The sine sweep is given in Table 1, and also plotted in Figure 1. The duration of the sine sweep in each direction is given in Table 2. The sweep rate is 0,5 octave/min.

Table 1 Sine sweep

Frequency (Hz)	Amplitude
5 - 10	5 mm

10 - 60	20 m/s^2
60 - 100	10 m/s^2

Table 2 Duration of sine sweep in each direction

x -direction	0,5 h
y -direction	1 h
z -direction	1,5 h

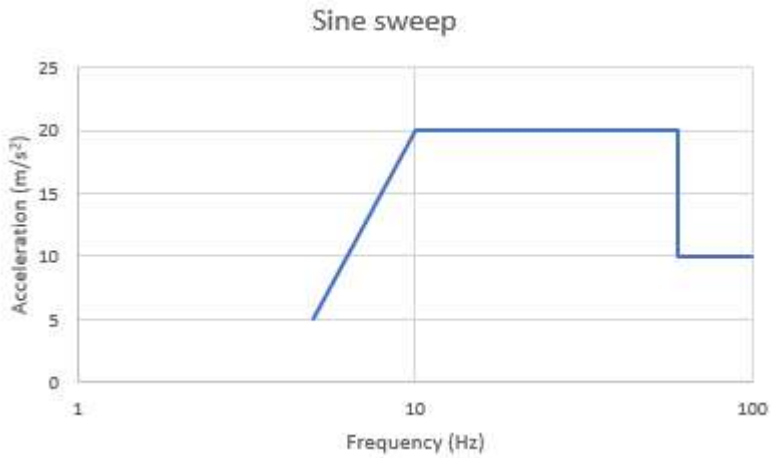


Figure 1 Sine sweep

The PSD spectra are different depending on if the lighting is attached in the front or the rear of the vehicle, and if the vehicle is an XC vehicle or a non XC vehicle. The PSD spectra are given in Table 3, Table 4, Table 5 and Table 6, respectively. They are also plotted in Figure 2, Figure 3, Figure 4 and Figure 5.

Interpolation between points in the PSD tables shall give straight lines in log - log scale.

The duration of the random PSD vibration is 22 h in each direction.

Table 3 PSD spectra for lighting in the front of non XC vehicles

Frequenc y (Hz)	PSD X dir $((m/s^2)^2/Hz)$
7	0,03
9	0,16
13	0,5
17	0,5
25	0,08

Frequenc y (Hz)	PSD Y dir $((m/s^2)^2/Hz)$
7	0,2
8	1
9	2
14	1,7
22	0,2

Frequenc y (Hz)	PSD Z dir $((m/s^2)^2/Hz)$
7	1
12	15
25	0,55
32	2
75	2

30	0,14
80	0,2
200	0,035
300	0,012
1000	0,004

RMS 5,6 m/s^2

28	0,2
34	0,7
130	0,05
200	0,07
300	0,03
1000	0,003

RMS 7,3 m/s^2

100	1
180	0,14
300	0,14
1000	0,014

RMS 16,9 m/s^2

Table 4 PSD spectra for lighting in the front of XC vehicles

Frequenc y (Hz)	PSD X dir ((m/s^2) ^{2}/Hz)
7	0,15
10	1,8
16	1,5
20	0,45
30	0,24
45	0,55
52	0,3
68	0,5
100	0,2
200	0,033
260	0,033
350	0,06
1000	0,006

RMS 8,4 m/s^2

Frequenc y (Hz)	PSD Y dir ((m/s^2) ^{2}/Hz)
7	1,5
8	3,4
11	3,4
18	0,5
24	1,4
40	1,25
100	0,35
115	0,16
190	0,3
250	0,16
280	0,2
350	0,2
1000	0,005

RMS 12,9 m/s^2

Frequenc y (Hz)	PSD Z dir ((m/s^2) ^{2}/Hz)
7	2
12	20
19	2,1
32	1,9
70	2
170	0,12
280	0,4
440	0,06
520	0,12
1000	0,01

RMS 18,1 m/s^2

Table 5 PSD spectra for lighting in the rear of non XC vehicles

Frequenc y (Hz)	PSD X dir ((m/s^2) ^{2}/Hz)
7	0,07
11	0,9
17	1
26	0,1
48	0,13
100	0,014
200	0,005
300	0,002
1000	0,00015

Frequenc y (Hz)	PSD Y dir ((m/s^2) ^{2}/Hz)
7	1
9	5,5
14	10
32	0,4
42	0,4
100	0,012
200	0,004
400	0,0018
650	0,025

Frequenc y (Hz)	PSD Z dir ((m/s^2) ^{2}/Hz)
7	1
12	9
30	0,46
33	0,7
70	0,1
160	0,01
300	0,004
420	0,004
640	0,025

RMS 4,1 m/s²	1000	0,001	1000	0,001
	RMS 10,1 m/s²		RMS 9,1 m/s²	

Table 6 PSD spectra for lighting in rear of XC vehicles

Frequency (Hz)	PSD X dir ((m/s²)²/Hz)
7	0,4
11	5
16	2,4
20	0,7
36	0,3
50	0,16
100	0,02
250	0,005
320	0,008
400	0,005
1000	0,0005
RMS 6,9 m/s²	

Frequency (Hz)	PSD Y dir ((m/s²)²/Hz)
7	3
10	9
14	10
20	4
30	1,5
100	0,04
1000	0,001
RMS 12,0 m/s²	

Frequency (Hz)	PSD Z dir ((m/s²)²/Hz)
7	3,5
9	6
12	6
18	2
24	3,5
50	0,2
100	0,08
1000	0,001
RMS 10,2 m/s²	

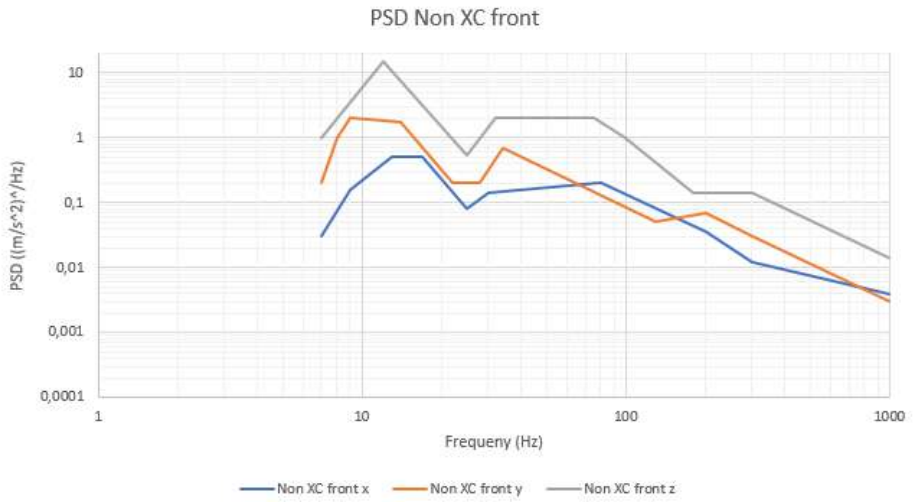


Figure 2 PSD spectra for lighting in front of non XC vehicle

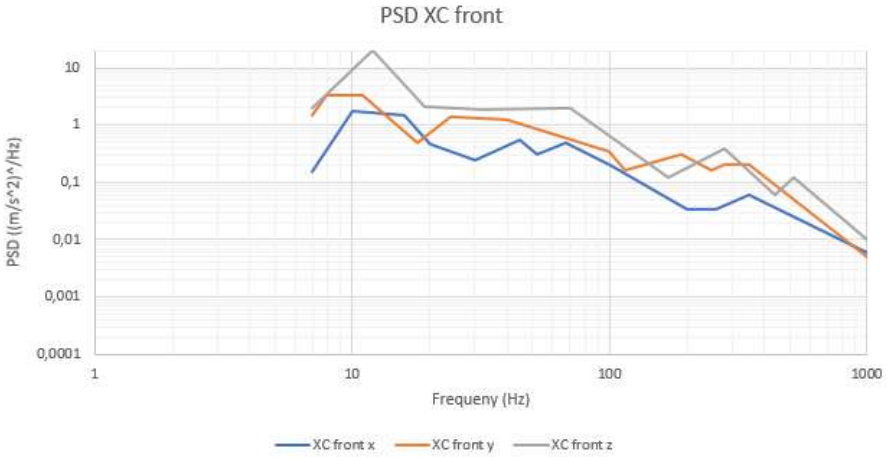


Figure 3 PSD spectra for lighting in front of XC vehicle

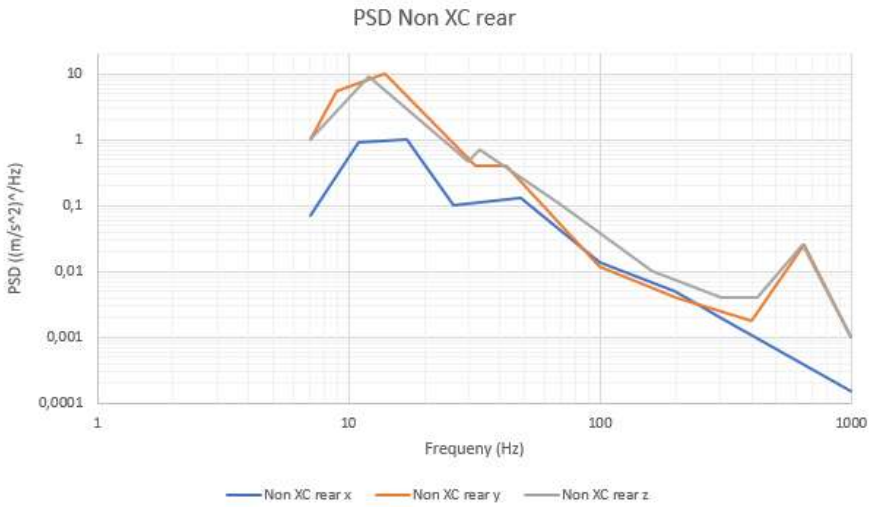


Figure 4 PSD spectra for lighting in rear of non XC vehicle

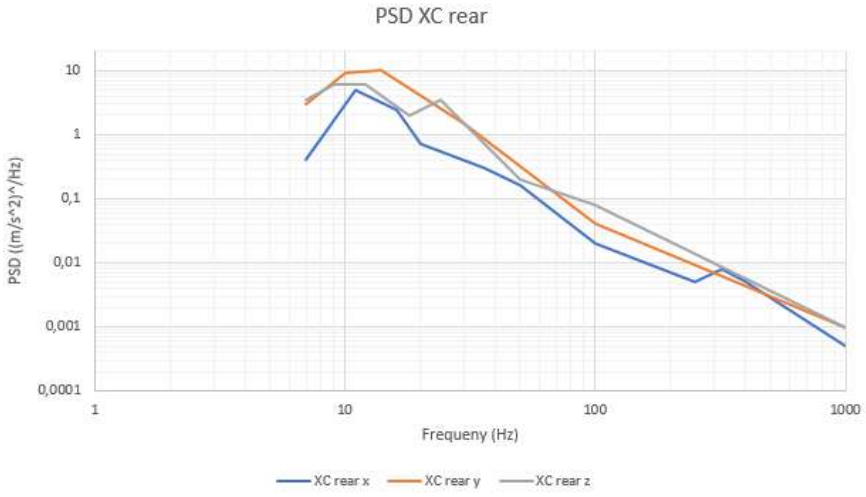


Figure 5 PSD spectra for lighting in rear of XC vehicle

Loading prerequisites

The vibration test shall be performed according to ISO 16750 and the Volvo supplement 31822854, with the exception for the vibration levels and temperature cycles, which shall be according to the target levels and loading prerequisites here.

The sine sweeps shall be performed in room temperature.

The random PSD vibration shall be performed together with the temperature cycle in Table 7, also plotted in Figure 6.

Before and after the vibration test a leakage test shall be performed.

Table 7 Temperature cycle for random PSD vibration test

Time from start (h)	Temperature (°C)
0	20
1	-40
2	-40
3	20
4	50
5	50
6	20
8	20
9	-40
10	-40
11	20
12	50
13	50
14	20
16	20
17	-40
18	-40
19	20
20	50
21	50
22	20

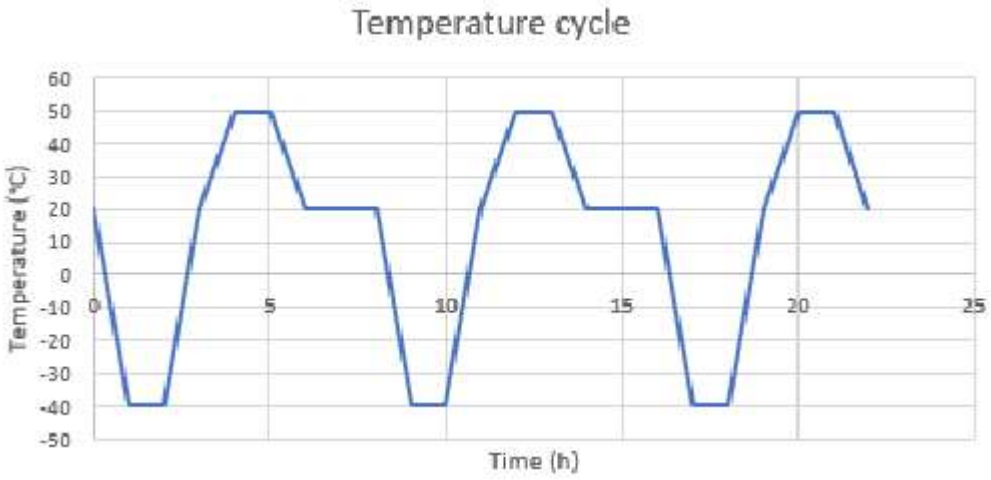


Figure 6 Temperature cycle for random PSD vibration test

Acceptance criteria

For the structural and the plastic parts the acceptance criteria after the test are
No cracks
No deformation
No leakage
After the test and disassembly of the lamp, the interior of the lamp must be free from dust.
The acceptance criteria for the electronic parts are according to ISO16750 and the Volvo supplement, 31822854.

Target background

The requirement is based on acceleration measurements in V541 and V526 on the endurance track on Hällered proving ground.

References

Vibration spectra according to VIB_2022_06.

Change log

Revision	Change	Date	Responsible
3	Editorial: References updated	2014-04-30	
4	?		
5	Editorial: Rewritten for clarity. Text “Exterior lighting” added to name. VMR-0167 now also covering and superseding REQ-30373 Component vibration testing	2022-06-13	Åsa Sällström

VMR 0173 v3 VMR 0173 RESISTANCE TO IMPACT FOR FRONT LIGHTING DEVICES

ART ownership: Exterior Lighting
Attribute:

VMR 0173 RESISTANCE TO IMPACT FOR FRONT LIGHTING DEVICES
Front lighting devices mounted in vehicle environment shall not have coating delamination, cracks or broken parts when subjected to impact testing at 50ºC and -40ºC using a drop weight of 0.5kg with a hemispherical nose radius of 19.05 mm @ 54 HRC hardness . Use one drop for every 150 square cm of lens surface (minimum 1 drop in each section of the lens: color, material, function, optics type). The drop height from point of impact on the hemispherical nose radius to point of impact on the lens is as follows: - upper front lamp (above bumper) 20 cm - lower front lamp (below bumper) 30 cm. The minimum temperature of -40ºC and the maximum temperature of 50ºC shall be used.

Change log
Revision 3: 2014/04/30 Editorial: References updated.

VMR 0175 v3 VMR 0175 NON-HEADLAMP EXTERIOR LIGHTING DEVICE DEFLECTION RESISTANCE

ART ownership: Exterior Lighting
Attribute:

VMR 0175 NON-HEADLAMP EXTERIOR LIGHTING DEVICE DEFLECTION RESISTANCE
When mounted in the vehicle, each exterior lighting device that is not attached to a bumper cover/fascia must withstand a 180N inward force applied normal to the lens over each compartment of the device. The device must not retain more than 0.25 mm of permanent set. NOTE: To ensure that the lighting device feels "robust" to the customer when they press against the lighting device.

Change log
Revision 3: 2014/04/30 Editorial: References updated.

VMR 0176 v3 VMR 0176 HEADLAMP DEFLECTION RESISTANCE

ART ownership: Exterior Lighting
Attribute:

VMR 0176 HEADLAMP DEFLECTION RESISTANCE
The headlamp and its front structure interface must withstand a 220 N inward force applied normal to the lens surface of the device. The device must not retain more than 0.25 mm of permanent set.

Change log

Revision 3: 2014/04/30 Editorial: References updated.

VMR 0177 v3 VMR 0177 EXTERIOR LIGHTING RESONANT FREQUENCY

ART ownership: Exterior Lighting
Attribute:

VMR 0177 EXTERIOR LIGHTING RESONANT FREQUENCY
All exterior lighting devices must have a resonant frequency above 50 Hz and be designed to ensure that they are decoupled from the vehicle and the source.

DVM-00 31-EX

REQ-55330 v3 Resulting forces on headlamp from hood overslam

Requirement:
The headlamp should not crack, lose function or have any loose parts after a hit with energy of 2J in the estimated points of contact with headlamp and hood during a severe overslam.

Contact points to be estimated by supplier based on hood geometry and has to be confirmed by strength and endurance attribute for each project.

Validation:
2 J impact energy with a 1000 g solid steel ball.

REQ-55452 v3 Robustness requirement

Information:
Valid for components under the hood. Possible loading caused by customer usage (pushing, sitting etc), but the requirement is primarily a robustness requirement.

A vertical load is to be applied with test body. Applicable components/areas are those that expose a horizontal surface large enough for the test body to be applied.



Test body. Diameter 150 mm

Requirement:
Must withstand 400 N pushing with the test body while mounted in a rig.

No separation
No cracks visible for customer
Max 0,5 mm total permanent deformation
Styling surfaces: no visible permanent deformation in the normal direction
No permanent change in light adjustment
No loss of function

4.1.4.18 Thermal Efficiency

REQ-85925 v7 Allowed derating due to high temperatures, front lights

General

With increased ambient temperature, the performance in general decreases for LEDs. The luminance thus decreases as well. LEDs emit heat and at some temperature level, the current must be decreased in order to avoid damages of the lamp.

Purpose

The purpose of the demand is to improve the lifetime and avoid thermal damage.

Definition

The requirement is valid for all functions in front lamps.

Requirement

It is allowed to derate the current of LED-s in order to improve the lifetime and to avoid thermal damage.

During development, if needed, Tier1 supplier must show a physical or virtual mock-up (with measurements) with the reduced flux according to derating curve. This to judge the flux derating curve. Judgement shall be done 10 weeks before FDJ.

During DV/PV-testing, Tier1 supplier must show the reduced flux according to derating curve with measurements. Test shall be performed on complete lamps from serial production tools.

It is not allowed to start current derating before +40□C ambient temperature.

The complete flux derating curve needs to be agreed for each function

Temperature interval:

BEV Vehicles:
-40°C to +85°C according to "G" in ISO 16750 Code Allocation REQ-33243 and REQ-58883 Temperature steps: According to ISO 16750-4 §5.2

ICE Vehicles:
-40°C to +105°C according to "K" in ISO 16750 Code Allocation REQ-33243 and REQ-58883 Temperature steps: According to ISO 16750-4 §5.2

Test should be performed with 60 minutes intervals with an temperature increase of +5°C

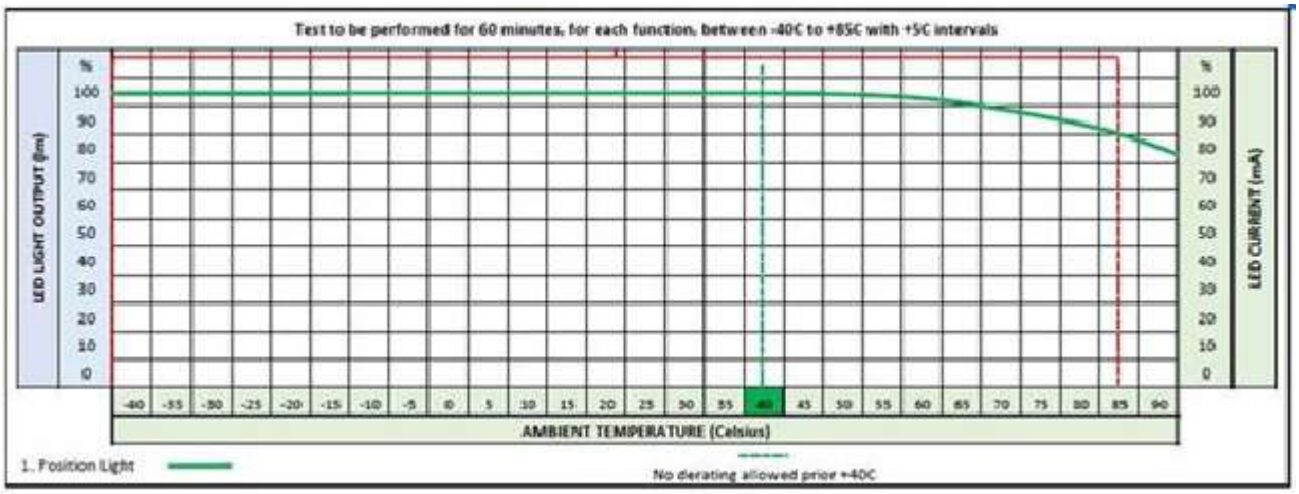
Test sequence :

Function to be ON for full test :

Supplier should present 5 derating curves:
1. DRL
2. Turn Indicator
3. Low beam
4. Low beam + High Beam

5. Low beam + high beam + turn indicator

Example



Supplier should also present ambient and internal temperature (hot spots) during test.

Supplier needs to present thermal calculations and simulation results with explanations.

The derating strategy can't be different for components realizing the same function in order to avoid unequal light intensities in a function.

The definition of the simulation set up and the physical test set up will have to be defined in the TR.

Verification

- The definition of the simulation set up and the physical test set up will have to be defined in the TR.
- Lamp will be tested also with ALL functions ON together at high temperature until 105°C to check that functions are in derating and that no components have been destroyed/burnt.
- Details of the test setup and operating conditions shall be described in the test plan.
- The test report shall include test setup, operating conditions and detailed test results.

Verification method

Physical/virtual test

- To be verified by supplier virtually before FDJ. To be verified by supplier physically in VP, TT, PP.
- Supplier needs to present thermal calculations and simulation results with explanations.
- During development, if needed, Tier1 supplier must show a physical/virtual mock-up with the reduced flux according to derating curve. Mock-up shall be done 10 weeks before FDJ.

REQ-58967 v7 Mission profile for different functions

General
The mission profiles are different for each function. The function, as a whole, should be designed to function the respective time presented in the chart. Specifically for the LEDs, AEC-Q102 applies, but is specified in a separate requirement (AEC - Q102 RV level).

Definition
All exterior lamps within the GPA platform.

Requirement
- Total ignition on lifetime is 20 000 h.
- Different functions need to be designed with the following lifetime:

Function	% on of life-time	Hours = % * life-time
DRL	64%	12 800 h
Low Beam	33%	6 600 h
High Beam	3%	600 h
Front Position	36%	7 200 h
Licence plate	100%	20 000 h
Front fog	1%	200 h
Rear fog	1%	200 h
Front turn signal	6%	1 200 h
Rear turn signal	6%	1 200 h
Reversing lamp	1%	200 h
Cornering lamp	8%	1 600 h
Stop/CHMSL	25%	5 000 h
Rear position light	100%	20 000 h
Courtesy lamp	1000 h / activated max 5 minutes per use occasion	1000 h / activated max 5 minutes per use occasion

Verification

Engineering judgment based on supplier simulations and documentation.

REQ-462547 v1 Headlamp temperature profile for ICE/Hybrid vehicles

General
The design of the lamp must consider the environmental properties. The engine bay emits heat that must be considered. Time of exposure: REQ-30627v3 Calculation of Specific temperature conditions.

Purpose
The purpose of this requirement is to present the temperatures and time the lamp is exposed for in the ICE/Hybrid engine bay and bumper area.

Definition
The requirement is valid for lamps in ICE/Hybrid vehicles.

Requirement
The lamp should withstand temperatures both from a structural and functional perspective in table below.

Temperatures behind headlamp (due to engine heat).	
Temperature [℃]	**Time [h]**
105	200
90	6.600
< 80	13.200
Total time	**20.000**

Verification
To be verified by supplier virtually before FDJ. To be verified by supplier physically in VP, TT, PP.

Verification method
Physical test/CFD
Details of the test setup and operating conditions shall be described in the test plan. The test report shall include test setup, operating conditions and detailed test results.

4.1.4.19 Vehicle Energy Efficiency

REQ-101146 v1 Front Lamp Power Consumption

Requirement
At low temperatures, to compensate for the increase of LED flux (according to LED supplier data sheet), Tier 1 supplier are encouraged to propose a solution to reduce the current to have a stable flux between -40°C and +23°C.

Verification method
The supplier to propose a verification method for above mentioned requirement.

REQ-458884 v1 Exterior Lights Power Consumption 728B

Purpose

To secure that the average energy spent on exterior lighting for a typical customer supports a competitive complete-vehicle energy- or fuel consumption.

Requirement

Target for average power consumption weighted by utility factors defined below:
Below figures includes,

- HCM Efficiency,
- LED ICs,

Per Side	ECE Option Lamp (W)	SAE Option Lamp (W)
Low Beam (Class V)	< 29	< 29

Low Beam (Class C)	< 29	< 29
High Beam (E Class)	< 65	< 65
Cornering	< 7	< 7
Front PL	< 2.5	< 2.8
Front TI	< 30	< 32
DRL Headlamp	< 25	< 28
SML	NA	< 1

For fans, power consumption of the each fan and the usage to be provided by supplier.

Verification method:

Calculation before FDJ
Measurement before PPAP

4.1.4.20 Water Tightness

REQ-129367 v3 Component Condensation Test - Front Lighting

General

Condensation adversely affects both the quality and performance of the lamp, as well as the perceived quality.

Effective condensation management is essential to ensure both the longevity of the product and the fulfillment of quality expectations.

Purpose

The purpose of this requirement is to explain the complete vehicle condensation test REQ-6910 and to provide guidance to suppliers concerning component-level verification.

Scope

Front lamps.

Requirement

Front lighting lamps must comply with the complete vehicle condensation requirement REQ-6910. Due to restrictions on sharing the test procedures referred to, a summary is provided below to aid suppliers in understanding the key aspects. The supplier is responsible for confirming the alignment between the summary provided in this requirement and the latest version of REQ-6910 with the Volvo Cars Engineer. Additionally, the supplier is responsible for developing their own methods for early verification(s) to ensure compliance with the specified requirements.

Summary of Complete Vehicle Condensation Requirement (REQ-6910**)**

Front lighting lamps shall undergo the vehicle condensation test in accordance with the steps outlined below, tailored to the specific type of vehicle on which they are installed. For Battery Electric Vehicle (BEV) cars, where the absence of a heat source in the engine bay affects thermal dynamics, the duration of certain test steps has been optimized and may differ compared to the test of Internal Combustion Engine (ICE) cars.

#	BEV	ICE
0	Start-up preparation: Place the test vehicle in a garage maintained at a temperature between 15°C and 20°C for a minimum duration of 1 hour.	
1	Start the vehicle and ensure that the exterior lights are on, with the headlights set to either Low Beam or DRL mode (each mode to be tested individually). High beam activation and washer fluid usage are prohibited throughout the entire cycle. The lights must remain ON while driving and OFF during parking.	
2	Drive on a country road for **30 minutes** at a speed of 70 km/h under outdoor conditions*****.	Drive on a country road for **1 hour** at a speed of 70 km/h under outdoor conditions*****.
3	Park the vehicle in a garage maintained at a temperature between 15°C and 20°C for a duration of **30 minutes**.	Park the vehicle in a garage maintained at a temperature between 15°C and 20°C for a duration of **1 hour**.
4	Park the vehicle in a climate chamber maintained at -20°C for a duration of 40 minutes. Note if outdoor temperature is colder than -10°C, then park the vehicle under outdoor conditions*****.	
5	Park the vehicle out of the climate chamber under outdoor conditions***** for a duration of **5 minutes**.	Park the vehicle out of the climate chamber under outdoor conditions***** for a duration of **15 minutes**.
6	Conclude with a recovery phase by driving on a country road for **10 minutes** at a speed of 70 km/h under outdoor conditions*****.	Conclude with a recovery phase by driving on a country road for **30 minutes** at a speed of 70 km/h under outdoor conditions*****.
7	Park the vehicle under outdoor conditions***** for a duration of **20 minutes**.	Park the vehicle under outdoor conditions***** for a duration of **30 minutes**.
8	Final inspection at the end of the test	

***Note: Temperature and humidity parameters under outdoor conditions may vary due to naturally changing environmental conditions. Data collected from local weather sources for the designated test site(s) may be considered for early or auxiliary verification methods if needed.**

Verification Method

Simulations prior to FDJ, physical tests at DV and PV.

Component-level Verification -Experimental Guideline

This information serves as a experimental guideline for suppliers, providing a test method developed by Volvo Cars Engineering that closely correlates with the vehicle-level condensation test.

a) Test Set-up

The test setup illustrated below requires dual climate chambers to establish distinct temperature and humidity profiles at the front and rear of the lamp. Additionally, different engine bay profiles are specified for ICE and BEV configurations.

1. Climatic Chamber 1 (Engine bay side)

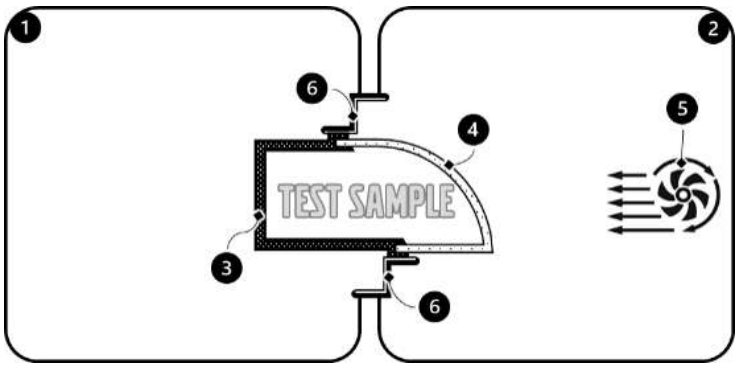
2. Climatic Chamber 2 (Lens side)

3. Housing of the lamp (test sample)

4. Outer lens of the lamp (test sample)

5. Wind Simulator Fan (25km/h ±2.5km/h)

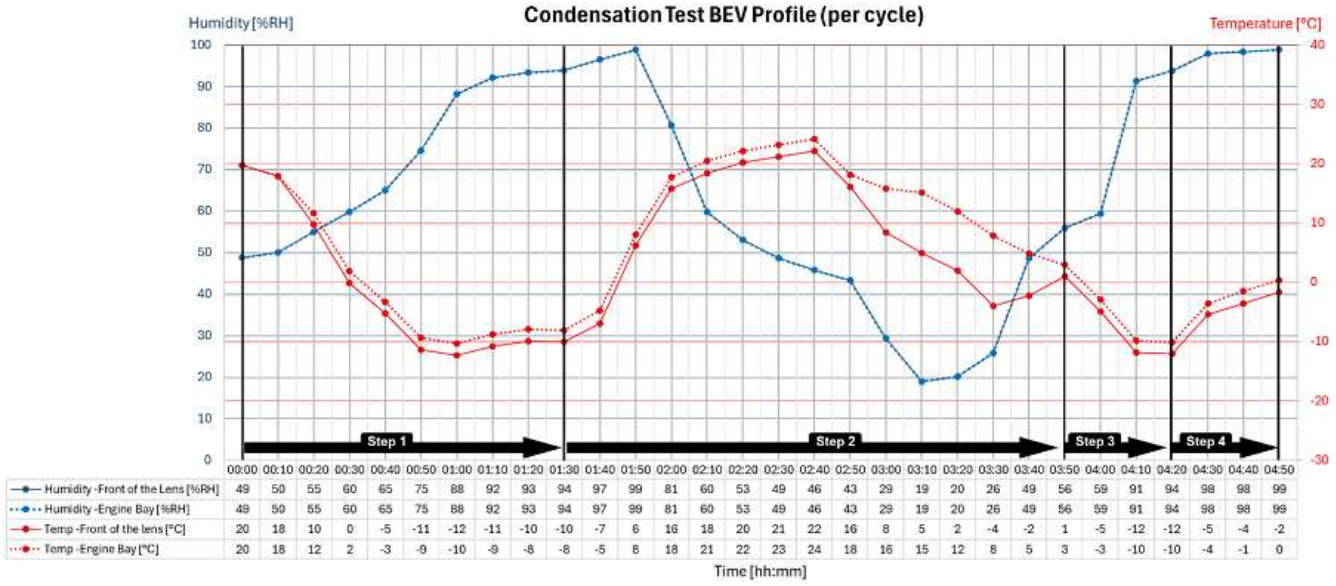
6. Isolator



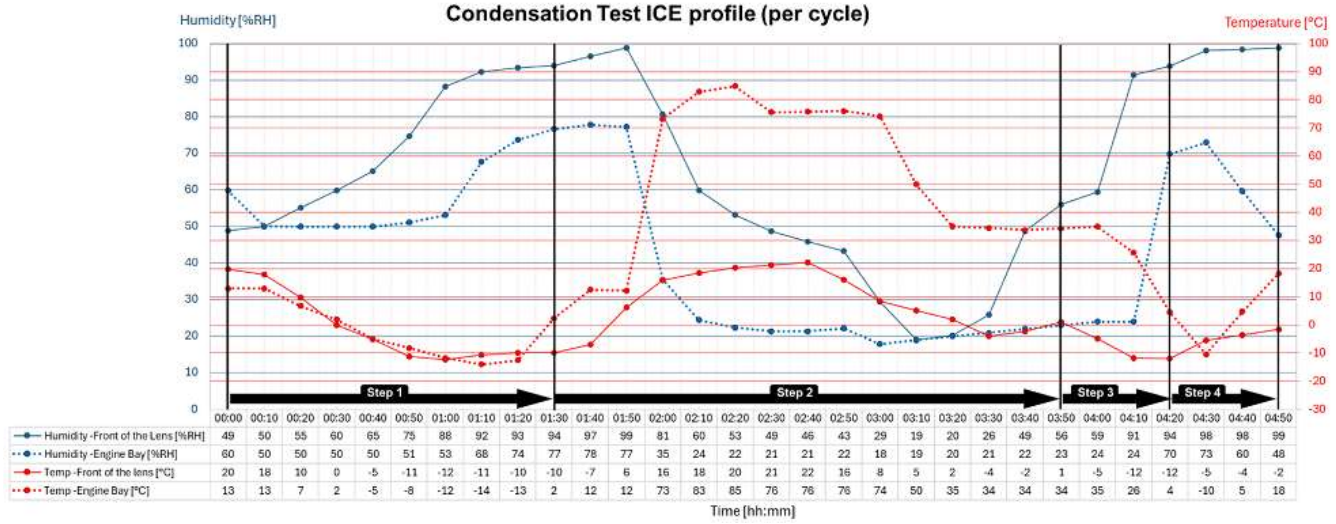
b) Test Cycle

The test cycle time is extended compared to the vehicle test due to the time required for the chambers to reach the specified temperature and humidity levels.

The temperature and relative humidity values are simultaneously and continuously measured from the atmosphere in the climatic chambers during the test cycle. The charts below illustrate the variations in temperature and relative humidity values at 10-minute intervals. Since the charts reflect measured values, certain stages of the test cycle may not be fully regulatable. The supplier is required to adjust the sequencing of their climate chambers to replicate the charts shown below as an output of their test.



Time [hh:mm]	00:00	00:10	00:20	00:30	00:40	00:50	01:00	01:10	01:20	01:30	01:40	01:50	02:00	02:10	02:20	02:30	02:40	02:50	03:00	03:10	03:20	03:30	03:40	03:50	04:00	04:10	04:20	04:30	04:40	04:50
Humidity -Front of the Lens [%RH]	49	50	55	60	65	75	88	92	93	94	97	99	81	60	53	49	46	43	29	19	20	26	49	56	59	91	94	98	98	99
Humidity -Engine Bay [%RH]	49	50	55	60	65	75	88	92	93	94	97	99	81	60	53	49	46	43	29	19	20	26	49	56	59	91	94	98	98	99
Temp -Front of the lens [°C]	20	18	10	0	-5	-11	-12	-11	-10	-10	-7	6	16	18	20	21	22	16	8	5	2	-4	-2	1	-5	-12	-12	-5	-4	-2
Temp -Engine Bay [°C]	20	18	12	2	-3	-9	-10	-9	-8	-8	-5	8	18	21	22	23	24	18	16	15	12	8	5	3	-3	-10	-10	-4	-1	0



Time [hh:mm]	00:00	00:10	00:20	00:30	00:40	00:50	01:00	01:10	01:20	01:30	01:40	01:50	02:00	02:10	02:20	02:30	02:40	02:50	03:00	03:10	03:20	03:30	03:40	03:50	04:00	04:10	04:20	04:30	04:40	04:50
Humidity -Front of the Lens [%RH]	49	50	55	60	65	75	88	92	93	94	97	99	81	60	53	49	46	43	29	19	20	26	49	56	59	91	94	98	98	99
Humidity -Engine Bay [%RH]	60	50	50	50	50	51	53	68	74	77	78	77	35	24	22	21	21	22	18	19	20	21	22	23	24	24	70	73	60	48
Temp -Front of the lens [°C]	20	18	10	0	-5	-11	-12	-11	-10	-10	-7	6	16	18	20	21	22	16	8	5	2	-4	-2	1	-5	-12	-12	-5	-4	-2
Temp -Engine Bay [°C]	13	13	7	2	-5	-8	-12	-14	-13	2	12	12	73	83	85	76	76	76	74	50	35	34	34	34	35	26	4	-10	5	18

Unless otherwise specified, all values in the charts above are subject to general tolerances that ±1°C for temperature values and ±3%RH for relative humidity values.

The test shall be conducted separately for both DRL and Low Beam modes. The wind simulator fan shall be activated concurrently with the light function.

Cycle [#]	Step [#]	DRL activated	Low Beam activated	Wind simulator fan activated	Headlamp internal fan activated (if available)
1	1	**YES**	NO	**YES**	The operating conditions of the fan(s) inside the headlamp may vary based on project requirements and shall be determined by Volvo Cars Engineering with supplier involvement.
	2	NO	NO	NO	
	3	**YES**	NO	**YES**	
	4	NO	NO	NO	
2	1	NO	**YES**	**YES**	
	2	NO	NO	NO	
	3	NO	**YES**	**YES**	
	4	NO	NO	NO	

The final recovery phase is incorporated within the test profiles. No visible condensation shall be present upon completion of the test.

The resulting graphs, illustrating the performed test sequence, shall be included in the test report.

Acceptance Criteria

No visible condensation is allowed after the test

REQ-404612 v2 Internal Airflow for Condensation Prevention

Background

Condensation inside exterior front lamps can lead to reduced visibility, impaired lighting performance, and long-term reliability issues. Traditionally, such problems have been detected late in the development process, resulting in costly redesigns and delays. By addressing airflow management from the earliest project phases, this requirement aims to eliminate condensation risks proactively and ensure robust lamp performance under all conditions.

Purpose

The purpose of this requirement is to proactively prevent potential condensation issues inside the lamp by controlling and optimizing airflow from the earliest phases of the project.

Scope

All exterior front lamp assemblies.

Requirement

The lamp system shall be designed to ensure effective airflow management, preventing condensation on all visible lens surfaces. The design must achieve a minimum airflow velocity of ***0.2 m/s*** across the visible B-surfaces of the outer lens, with no areas prone to air traps, vortex formation, or obstruction. The airflow shall be capable of clearing a ***2-micron*** fog film from all visible lens areas within ***30 minutes***.

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Verification method

Verification shall be performed by reviewing CAD model and simulation results provided by the supplier at each defined project milestone TI3, TI4, FTI, AA1 TI, FDJ. The simulations shall be performed and their results shall be documented using the template specified by Volvo Cars in Project Prerequisites.

Note
Detailed design instructions and best practices for achieving these requirements are provided in the document Best Practices for Lamp Airflow Management, which is available to the supplier upon request. The guidelines serve as advisory recommendations only; adherence to them is at the supplier's discretion. The supplier is solely responsible for meeting the requirements stated in this requirement, regardless of whether the guidelines are followed.

REQ-6911 v11 WATER TIGHTNESS IN EXTERIOR LIGHTING

Attribute:	Water Tightness
Requirement Classification:	Hard
Change classification:	
Design Target :	
Is Generic :	No
TCreqID:	REQ-038383/2
TCrNumber:	2.8.2.8.2

WATER TIGHTNESS IN EXTERIOR LIGHTING

Area where exterior lighting is positioned is divided in a wet zone and a dry zone.
Example on a dry zone > luggage compartment, inside of tailgate.
Example on a wet zone > engine bay, outside of tailgate.

Electrical components in wet zone must follow the component IP classification requirement.

Under no conditions is water leakage into the dry area acceptable.

No water leakage between lens and house on exterior lights is permitted.
No water leakage between rear exterior lighting and tailgate / painted body is permitted.
Fixations and grommets to body must be water tight.

No water should be trapped between the rear lamps and the tailgate that could cause a run off problem when opening/closing the tailgate.

Verification methods:
LEPREF: Water tightness test during parking.
LEPRAIN: Parking in rain with different gradients .
LEPHP: Car wash by hand with high pressure .
LEPHPHOT: Engine bay wash with high pressurized hot water .
LEPAUTO: Car wash in automatic car wash facility.
LEPDRIZZLE: Parking in drizzle rain.
LEPHOSE: Car wash by hand with hose rinsing.

LEPSEAL: Component test for sealings
LEPBOX: Component water test
LEPVIRT: Virtual water tightness verification
LEPIP: Water tightess test according to IP classification
LEPSIM-Tailgate: Preon Lab simulation

For components positioned lower than 450 mm from ground:
LEPWADE
LEPSPLASH

REQ-6910 v9 WATER TIGHTNESS CONDENSATION IN EXTERIOR LIGHTING

Attribute:	Water Tightness
Requirement Classification:	Intermediate
Change classification:	
Design Target :	
Is Generic :	No
TCreqID:	REQ-038382/3
TCrNumber:	2.8.2.8.1

WATER TIGHTNESS CONDENSATION IN EXTERIOR LIGHTING

The area where exterior lighting is positioned is divided in a wet zone and a dry zone. (Passenger compartment / engine bay)
Electrical components in wet zone must follow the component IP classification requirement.
(Printed) Circuit board must be clear coated to withstand moisture and water droplets.

The vehicle shall be capable of driving in all customer-environmental conditions and all customer-handling conditions without impairing exterior light device integrity and performance.

If condensation occurs on inside of lens, it must disappear within 30 minutes
After clearing there shall be no visible staining.

Verification methods:
LEPCONS: Water condensation in exterior lighting device, summer conditions
LEPCONW: Water condensation in exterior lighting device, winter conditions
LEPVIRT: Virtual water tightness verification
LEPBOX: Water tightness component test
LEPCONCOMP: Water cond. in ext. lighting device comp. test
LEPCONBEV: Condensation in exterior lighting device all year

4.1.4.21 Weight

REQ-458881 v1 Maximum headlamp weight

Requirement

Maximum headlamp weight: 5 500 g

Validation

Calculation in CAD at V0, V1, FTI and FDJ

Weight measurement at PV and DV.

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5 MARKING

Applicable Requirements on text, symbols and colour-marking according to Volvo Cars standards.

All parts that are technically possible to mark shall be marked in accordance with VCS 5051,17. Reduced marking is allowed but must contain one of the Volvo, SPACMA or Polestar logotypes if technically possible and available space exists.

Exceptions are vehicle glass, tubes, hoses, profiles, etc., which should be marked in accordance with VCS 5052,219 and 5052,319.

Any supplier marking is prohibited and shall not be placed on our parts, see section **Supplier marking** below.

5.1 Unique external parts

If this part is unique Polestar part, it requires an external standard, please indicate by marking X in the box.

☐ *This part is a unique Polestar part and shall be marked according to PS205051,17*

If the box has been marked, section **Default marking** shall be disregarded.

5.2 Default marking

The marking information in designation 9, VCS 5051,17, marking method MET 1, is the preferred marking.



5.3 VCS 5051,17 Text marking on parts

Our marking standard VCS 5051,17 includes different marking ingredients/content (trademarks and markings without trademarks, reduced marking, etc.). In addition, there are several marking methods. Therefore, the DPR must be specific about these items.

The marking requirement in this DPR shall be expressed as a code. If the DPR covers several parts or systems, a marking code must be given for each part covered. Fill out the table below according to section 2 in VCS 5051,17.

Part number	Part name	Marking method	Basic marking	Text height
80068750	Headlamp LED LH ECE ROW	1.1	9 - HJK	5.2
80068751	Headlamp LED RH ECE ROW	1.1	9 - HJK	5.2
80068752	Headlamp LED LH ECE RHD	1.1	9 - HJK	5.2
80068753	Headlamp LED RH ECE RHD	1.1	9 - HJK	5.2
80068756	Headlamp LED LH SAE	1.1	9 - HJK	5.2
80068757	Headlamp LED RH SAE	1.1	9 - HJK	5.2
80068799	Bumper Bracket LH	1.1	9 - HJK	5.2

80068800	Bumper Bracket RH	1.1	9 - HJK	5.2

* If the box is marked in section **Unique external parts**, the external marking code shall be referred to.

5.4 VCS 5051,4 Parts marking with bar codes and 2-D symbology's

Marking with bar codes and 2-D symbology's (Datamatrix/DMC) is normally only required on parts subject to traceability requirements, see VCS 5032,3.

If a bar codes or 2-D marking requirement exists in this DPR, it shall be expressed as a code. Fill out the table below according to section 2 in VCS 5051,4.

* Only applicable to 2D markings

5.5 VCS 5052,219 Linear text marking of parts

Can be used on tubes, hoses, profiles, etc., as an alternative to the use of VCS 5051,17.

5.6 VCS 5750,159 Safety decals

Warning and information symbols as well as warning and information text must always be presented on a safety decal in accordance with VCS 5750,159.



5.7 Supplier marking

The general rule is that a manufacturer's/supplier's trademark/logotype and part number, or any other information, shall not be placed on Volvo-branded parts. Exceptions can be according to the Brand exemption process, see section 2.1 in VCS 5051,17. All primary documents such as drawings, TREGs, etc., shall be checked for markings and are rejected if supplier information without valid approval is found.

6 OTHER INFORMATION

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7 DOCUMENTATION, TYPES OF DOCUMENT

A Primary document is a product-defining document.

An Auxiliary document, is a non-product-defining document such as: DPR, packaging model, etc.

See VCS 5021,11, for a full description of standards for documents. Document types are defined in VCS 5021,61.

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