

AEC-Q200: A Proposal for Assessing New Requirements for Electric Vehicle Mission Profiles (MP)

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Agenda

- Scope
- Service life requirements for passives
- Proposal
- Model Updates HTOL
- Discussion

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Mission Profile Definition

What is a Mission Profile?

- A Mission Profile is a simplified representation of all relevant static load conditions and dynamic load profiles that a population of electrical, mechanical, electronic and electro-mechanical components is exposed to during its entire life cycle.
- The Component Capability describes the use conditions that a population of electrical, mechanical, electronic and electro-mechanical components can be exposed to during their entire life cycle without compromising their dependability for the defined purpose. [1]
 - Large variety of Mission Profiles in the Market
 - Huge effort is spent at both Tier-1s and Tier-2s figuring out if a component is suitable for a given use case
 - **Standardising** mission profiles within the industry is a **difficult task**

Reference [1]: U. Abelein, M. Hommel, R. Rongen, F. Schröder, A. Webber „AEC and Extended Mission Profiles” 22nd Annual Automotive Electronics Reliability Workshop, Detroit April 24th, 2024

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Service life Requirements from OEM and Tier-1 derived from LV 124

Service Life Requirements according to OEM standards e.g. VW80000, BMWGS95024-3-1, MBN 10306 [2]

	Combustion Engine	Electric Vehicle
Mode	Driving / Off-Grid-Parking	Driving / Charging + Conditioning / On- / Off-Grid-Parking
Total POH	8,000h (300,000km/15years)	8,000h (300,000km/15years) + approx. 123,400h or as defined in the individual performance specification specifically for each component

Service Life Requirements according to Tier-1 company standards

	Combustion Engine	Electric Vehicle
Mode	Driving / Off-Grid-Parking	Driving / Charging + Conditioning / On- / Off-Grid-Parking
Total POH	8,000h (300,000km/15years) + upon request approx. 120,000h as defined in the individual specification for the pertaining component	Up to 131,000h power on hours (POH) derived from [3]

Reference [2]: BMW GS 95024-3-1:2024-12, Mercedes-Benz MBN 10306:2020-06, Volkswagen VW 80000:2022-12

Reference [3]: A. Webber, F. Schroeder "Applying the ZVEI Robustness Validation process to automotive mission profiles", 3rd European Automotive Electronics Council Reliability Workshop Toulouse: Oct. 4th, 2023

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AEC-Q200 HTOL as an accelerated lifetime simulation

- Thermal/thermomechanical models as Arrhenius/Coffin-Manson for describing irreversible degradation of material properties by thermal, electrical, or chemical stresses
- Triggering temperature and voltage driven failure mechanisms by high temperature operating life test (HTOL) [4]

Stress Qualifications for HTOL acc. AEC-Q200 rev. E	Additional requirements to MIL-STD-202 Method 108
Tantalum and Niobium Capacitors	$t = 1,000\text{h} / U_{\text{op}} = 2/3 U_{\text{rated}} / T_{\text{max}} \leq 150^{\circ}\text{C}$
Ceramic Capacitors	$t = 1,000\text{h} / U_{\text{op}} = U_{\text{rated}} / T_{\text{max}} = T_{\text{rated}}$
Aluminum Electrolytic Capacitors	$t = 1,000\text{h} / U_{\text{op}} = U_{\text{rated}} / T_{\text{max}} \leq T_{\text{op,rated}}$
Film Capacitors	$t = 1,000\text{h} / U_{\text{op}} = 1.25 U_{\text{rated}} / T_{\text{max}} \leq 85^{\circ}\text{C}$ or $t = 1,000\text{h} / U_{\text{op}} = U_{\text{rated}} / T_{\text{max}} > 85^{\circ}\text{C}$
Inductors/Transformers	$t = 1,000\text{h} / T_{\text{max}} \leq 125^{\circ}\text{C}$
NTC, PTC	$t = 1,000\text{h} / T_{\text{max}} \leq 150^{\circ}\text{C} / 0.1 \times P_{\text{rated}}$
Varistors	$t = 1,000\text{h} / U_{\text{op}} = 0.85 U_{\text{rated}} / T_{\text{max}} \leq 150^{\circ}\text{C}$
...	

Reference [4]: AEC-Q200 rev E: 2023-03-20

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Examples to evaluate the qualified robustness for a typical MP from OEM, Tier-1 I

In the absence of a commonly aligned universally applicable MP to evaluate the robustness of a passive component we focussed on the recently published MP from VW/AUDI [5]

MP OEM VW/AUDI, presented at AEC RW 2025, Bordeaux

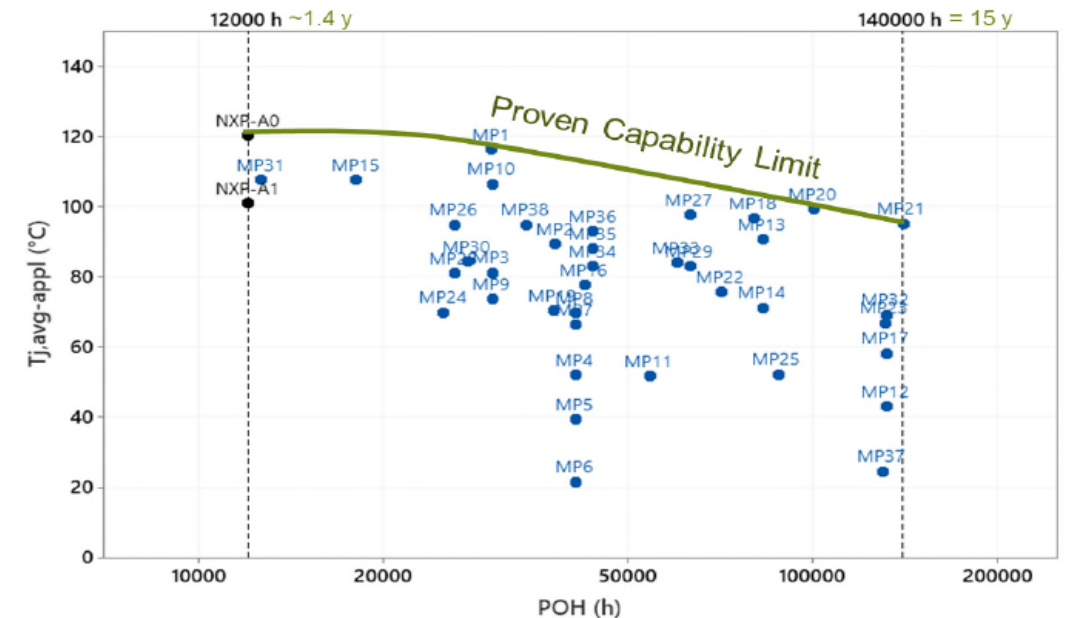
MP Actives, Tier-1 NXP, presented at AEC RW 2024, Detroit

Which lifetime do we need?
Some practical examples:



ECU	Active Times														Sum active Time ECU [h]		
	Drive (KI 15 on)				Charging				Conditioning				bidl - Charging			Parking (inkl. ON Grid)	
	Time [h]	Ambient Temperature ECU		Time [h]	Ambient Temperature ECU		Time [h]	Ambient Temperature ECU		Time [h]	Ambient Temperature ECU		Time [h]	Ambient Temperature ECU			
ECU 1	8500	-40	70	13350	-40	60	3800	-40	60	28500	10	55	0	-40	85	54150	
ECU 2	8500	-40	85	18980	-40	80	365	-40	85	0	10	55	9542	-40	85	37387	
ECU 3	8500	-40	75	12000	-40	75	3200	-40	75	0	1800	-40	75	-40	75	25500	
ECU 4	8000	-40	85				6200	-40	85	0	800	-40	85	-40	85	15000	
ECU 5	8000	-40	85				6200	-40	85	0	800	-40	85	-40	85	15000	
ECU 6	8000	-40	85				6200	-40	85	0	800	-40	85	-40	85	15000	
ECU 7	8000	-40	80				6200	-40	80	0	800	-40	80	-40	80	15000	
ECU 8	8000	-40	80				6800	-40	80	0	500	-40	80	-40	80	15300	
ECU 9	8000	-40	70	30000	-40	65										38000	
ECU 10	8000	-40	80	12000	10	75	8000	-40	75	28500	10	75	74900	-40	75	131400	
ECU 11	8000	-40	90	13350	-40	90	3800	-40	90	28500	-40	90	0	0	0	53650	
ECU 12	8000			30000												38000	
ECU 13	8000			6200												14200	
ECU 14	8000			13333			2800									24133	
ECU 15	8000						6200						39500			53700	
ECU 16	8000						6200						8300			22500	
ECU 17	8000			24800			6200									39000	
ECU 18	8000	-40	130 (60% - 140°C)	13350	-40	75										21350	

With an active time of 55,000 h, 95% of all use cases will be covered. ✓



Reference [5]: Dr. S. Simon, K. Schmidt-Grethe, "Extended Lifetime Evaluation – An OEM Point of View", 4th European Automotive Electronics Council Reliability Workshop Bordeaux, Oct. 9th, 2025

Reference [1]: U. Abelein, M. Hommel, R. Rongen, F. Schröder, A. Webber „AEC and Extended Mission Profiles” 22nd Annual Automotive Electronics Reliability Workshop, Detroit April 24th, 2024

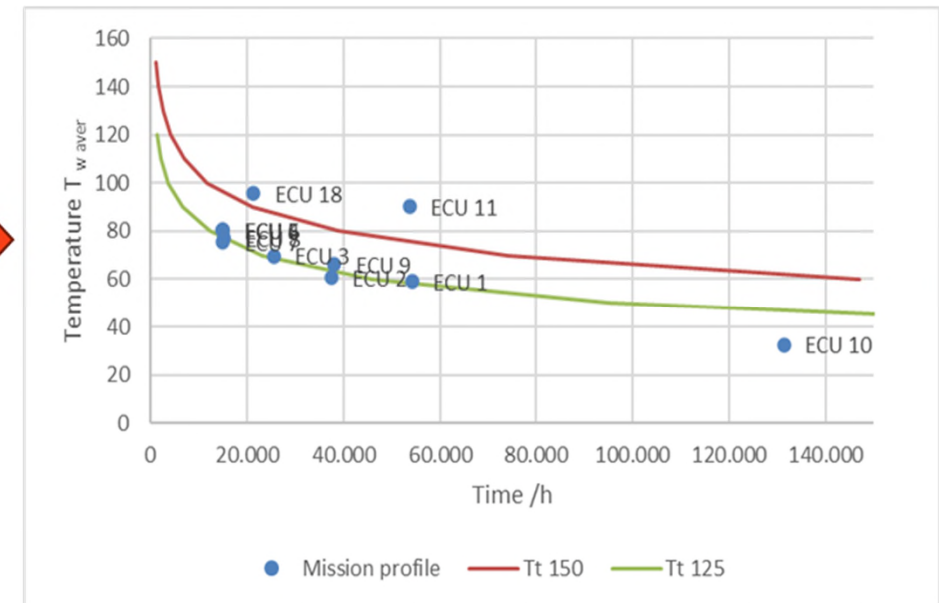
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Example to evaluate qualified robustness for a typical MP II

Applying a Transfer Operator to this MP similar to reference [6] to assess the qualified robustness for **SMD MLV, NTC, Inductors/Transformers (Components)**:

Result: For the majority of ECUs, the qualified robustness of the Components lies within or below the range of the isotherms at 150°C (SMD MLV, NTC) and 125°C (inductors) respectively.

ECU	Active Times														Sum active Time ECU [h]				
	Drive (KI 15 on)				Charging				Conditioning				bidi - Charging			Parking (inkl. ON Grid)			
	Time [h]	Ambient Temperature ECU		Time [h]	Ambient Temperature ECU		Time [h]	Ambient Temperature ECU		Time [h]	Ambient Temperature ECU		Time [h]	Ambient Temperature ECU					
		Tmin in °C	Tmax in °C		Tmin in °C	Tmax in °C		Tmin in °C	Tmax in °C		Tmin in °C	Tmax in °C		Tmin in °C		Tmax in °C			
ECU 1	8500	-40	70	13350	-40	60	3800	-40	60	28500	10	55	0	-40	85	54150	✓		
ECU 2	8500	-40	85	18980	-40	80	365	-40	85	0			9542	-40	85	37387	✓		
ECU 3	8500	-40	75	12000	-40	75	3200	-40	75	0			1800	-40	75	25500	✓		
ECU 4	8000	-40	85				6200	-40	85				800	-40	85	15000	✓		
ECU 5	8000	-40	85				6200	-40	85				800	-40	85	15000	✓		
ECU 6	8000	-40	85				6200	-40	85				800	-40	85	15000	✓		
ECU 7	8000	-40	80				6200	-40	80				800	-40	80	15000	✓		
ECU 8	8000	-40	80				6800	-40	80				500	-40	80	15300	✓		
ECU 9	8000	-40	70	30000	-40	65										38000	✓		
ECU 10	8000	-40	80	12000	10	75	8000	-40	75	28500	10	75	74900	-40	75	131400	✗		
ECU 11	8000	-40	90	13350	-40	90	3800	-40	90	28500	-40	90	0	0	0	53650	✓		
ECU 12	8000			30000												38000	✓		
ECU 13	8000			6200												14200	✓		
ECU 14	8000			13333			2800									24133	✓		
ECU 15	8000						6200						39500			53700	✓		
ECU 16	8000						6200						8300			22500	✓		
ECU 17	8000			24800			6200									39000	✓		
ECU 18	8000	-40	130(600s - 140°C)	13350	-40	75										21350	✓		



Reference [6]: VDE ITG MN 5.7 – White Paper on Extended Mission Profiles, in preparation, unpublished yet

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Example to evaluate the qualified robustness for a typical MP II

Applying a set of Transfer Operators to this MP to assess the qualified robustness for

SMD MLV, NTC, Inductors/Transformers:

- Assuming Arrhenius law with $E_a = 0.673\text{eV}$.
- At E_a , the focus is on the solder joint at the circuit board level as the most sensitive point. E_a according to the use of standard SAC solder in accordance with [7].
- Adding up the times t_i for each mode, effective exposure time $t = \sum t_i$ e.g. ECU 1: $t = 54,150\text{h}$
- Temperature ranges T_i replaced by the weighted average $T_{w\text{ aver}} = \sum \frac{t_i \times T_{i\text{ max}}}{\sum t_i}$

Reference [7]: AEC - Q005 - REV-A:2010-06-01

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Is the Qualification robust to comply mission profiles?

Opportunities:

- A qualification of passives according to the stress tests provided in the AEC-Q200 may cover lifetime requirements for cars with combustion engine as well as for electric vehicles.

Challenges:

- A common understanding to apply a generic MP and a generic set of transfer operators, activation energy E_a , or Coffin-Manson exponent m etc., effective duration time t , weighted average temperature $T_{w\ average}$ etc. is inevitable.

Constraints:

- HTOL does not define the operating times during operation in the field nor considers the operating conditions in the respective application
- Any MP assessment by the supplier shall be deemed solely as an additional tool for the user to estimate the robustness of a passive by fulfilling the qualification tests according to HTOL
- Any such statements by the supplier do not constitute a warranty for the service life of a passive component and have no influence on the warranty periods as agreed upon between supplier and the user
- Mounting of a passive into an individual application may lead to different chemical, thermal and mechanical conditions. These effects and impacts on the passive and on its assembly and joining technology are under the sole responsibility and must be taken into account by the user for each case individually.

AEC-Q200: Assessing New Requirements for Electric Vehicle Mission Profiles Discussion

Lists

- Opportunities
- Challenges
- Road Blocks
- Strengths