European Plastic Energy Storage Systems Association

EuPC Sector Group

Position Paper of the European Plastic Energy Storage Systems Association, ensuring robust validation of Plug-in hybrid electric vehicles (PHEV) and Range Extender Electric Vehicle (REEV) plastic fuel tanks through a modified, time-efficient version of the alternative test scenario

Executive Summary

Plug-in Hybrid Electric Vehicles and Range Extender Electric Vehicle (PHEVs and REEV) will continue to play a critical role in enabling vehicle manufacturers to achieve fleet-average CO_2 emission targets across global markets. Due to their operation with sealed fuel tanks during electric-drive phases—controlled through a Fuel Tank Isolation Valve (FTIV)— fuel tanks experience increased internal pressure loads compared to conventional internal combustion engine (ICE) vehicles.

High-density polyethylene (HDPE) plastic fuel tanks have been established in the market since the 1970s. For more than a decade, millions of vehicles globally have been equipped with plastic fuel tanks enhanced by mature structural reinforcement solutions. These systems have demonstrated excellent long-term robustness, including creep resistance and resistance to pressure-temperature cycling.

The German OEMs have introduced a common, extensive dual-path validation concept involving two test sequences of different test durations, with a duration between 190 and 332 days of testing.

Based on more than ten years of global field experience across non-German OEMs and multiple proven tank designs, the European Plastic Energy Storage Systems Association considers a modified single application of the alternative test sequence as sufficient to ensure safety, durability, and regulatory compliance.

This position paper substantiates why the time-efficient, modified version of the alternative test sequence provides adequate, scientifically grounded, field-validated assurance of tank performance—while avoiding unnecessary complexity, redundancy, and excessive development timelines.

1. Background: The Role of Plastic Fuel Tanks in PHEV Architecture

1.1 Increased Tank Pressures Due to FTIV Operation

Vehicles routinely operate with the pressurized fuel tank sealed during electric driving phases and during parking. This temporarily prevents venting to the carbon canister and leads to:

- higher peak internal pressure,
- combined mechanical load from fuel vapor expansion,
- cyclic thermal-mechanical creep effects.

1.2 Established Suitability of HDPE Fuel Tanks

HDPE fuel tanks have been used for over **50 years** in ICE vehicles and **over 10 years** in PHEVs, and the members of PlasEnSys have delivered over 5 million tanks. Modern pressurized tanks utilize proven solutions such as:

- internal tie-rod systems,
- external stiffening structures,
- multi-layer barrier technology ensuring no emission increase,
- optimized geometry design for pressure distribution.

Hundreds of millions of fleet-operating days confirm the long-term stability of these systems.

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2. Existing International OEM Practices Demonstrate Adequacy of Shorter Test Procedure

Many non-German OEMs—representing a large share of global PHEV volume—apply **shorter pressure-temperature cycling tests** that differ significantly from the duration and complexity of the German proposal.

The real-world durability delivered by these tanks includes:

- large global temperature ranges,
- long-term exposure in hot climate markets,
- repeated high-pressure events caused by electric operating modes,
- robust aging behavior of HDPE multilayer structures.

No systemic field failures have been observed over a decade, despite millions of PHEV vehicles in operation.

Thus, the empirical evidence strongly supports the sufficiency of a **streamlined validation approach**.

Refer to Annex I for detailed values.

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3. Technical Review of the German Test Procedures

The German concept comprises:

- a **standard test procedure** with multiple extensive load collectives,
- an **alternative test procedure** including a shortened pressure vacuum

Both require performing the entire load spectrum **twice**, resulting in test campaigns of **190–332 days**.

The association acknowledges the technical rigor but emphasizes:

- significant redundancy between load collectives,
- extremely long test durations with limited added engineering insight,
- misalignment with global best practices.

The alternative test procedure with sustained pressure loading addresses the critical load case most relevant for pressurized tanks: **creep behavior under elevated temperature and sustained overpressure**. This is the dominant failure mode of interest—even more than short-term cycling at extreme temperature points.

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4. Why a Single, Modified Alternative Test Sequence Is Fully Sufficient

4.1 Creep and High-Pressure Endurance Are the Governing Failure Mechanisms

Creep deformation under sustained load is the most critical long-term stressor for HDPE. As defined further, our proposal directly evaluates:

- plastic deformation potential,
- time-dependent strain behavior,

- structural response at the worst-case load combination (max pressure at + 50°C).

This is the most meaningful predictor of tank stability during operation.

4.2 Focus on Other Load Collectives

The remaining tests include:

- cold-temperature pressure cycles,
- alternating pressure pulses,
- high-temperature pulse cycles.

Technically thorough, they do provide substantial additional insight.

4.3 Field Data Confirms Robustness Without Excessive Testing

More than a decade of field performance across numerous OEMs demonstrates:

- no safety-critical failures linked to insufficient pressure validation,
- no abnormal permeation increases,
- long-term stability of tie-rod and stiffening systems,
- effective durability at global climatic extremes.

This empirical evidence outweighs theoretical concerns.

4.4 Engineering Efficiency and Practicality

A single, alternative test sequence

- reduces total test duration,
- aligns with global OEM practice,
- allows faster development cycles for new tank variants,
- avoids unnecessary testing costs without reducing safety.

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5. Recommended Modified Alternative Test Procedure

The association recommends the following validation approach as **fully sufficient** for plastic pressurized fuel tanks:

Step	New Test Sequence	Duration
Pre-Test	Determination of $P_{max,UT}$ in the 6-day cycle, Fill 100%	6 days
Test Preparation	3Dscan of new part: Fill 0% & Fill 100%	
Pre Conditioning	Fill 100%, soak at 40°C, 2 weeks	14 days
Initial filling	Fill 90% medium @ RT	
Initial measurement	Measurement at 90% medium	
A: Pressure cycling	5000 cycles @ -30C with -150 hPa / +20 hPa, 54 sec cycle	4 days
B: Pressure cycling	5000 cycles @ +50C with -150 hPa / 340 hPa, 96 sec cycle	6 days
C': Sustained Overpressure	1500 hours @ +50C with 2 intermediate measurements: 500h, 1000h with 360 hPa	62,5 days
D: Overstress	100 cycles same 30…70°C at 40% fill with 200 hPa / 360 hPa, 120 min cycle	8,3 days
E: Secondary tests	Depends on OEM requirements	
Final test	3Dscan of test part: Fill 0% & Fill 90%	Total: 100,5 days

Refer to Annex II for more details.

5.2 Acceptance Criteria

- no leakage
- no crack initiation
- No unallowed deformation

- stable creep rate without an accelerating deformation step
- unchanged weld integrity

This modified alternative test procedure test is the most appropriate safety-relevant load case and reflects real operational stresses.

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6. Regulatory and Industry Benefits

Adopting this streamlined approach will:

6.1 Maintain Safety and Environmental Protection

All key durability and emission requirements remain fully fulfilled.

6.2 Strengthen Harmonization Across Europe

A unified, proportionate test method avoids fragmentation within the EU automotive supply chain.

6.3 Reduce Development Time and Unnecessary Cost

More efficient testing supports:

- faster innovation cycles,
- improved competitiveness of European suppliers,
- reduced prototype consumption.

6.4 Sustain Market Availability of Efficient PHEV and REEVs Solutions

Supporting the continued viability of pressurized tanks helps OEMs:

- bridge the transition to full electrification,
- meet CO_2 fleet targets,
- offer consumers diverse mobility choices.

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7. Conclusion

Based on:

- more than a decade of proven global field experience,
- the technical understanding of HDPE tank behavior under pressure,
- the governing role of high-temperature creep load cases,

- and the redundancy contained in the extended German test concept,

The European Plastic Energy Storage Systems Association **(PlasEnSys) concludes that a single, modified application of the alternative test sequence provides complete and sufficient validation for pressurized plastic fuel tanks.**

This scientifically justified, industry-aligned approach upholds safety, ensures environmental compliance, and supports the competitiveness of the European automotive supply chain—without imposing unnecessary testing burdens that do not improve real-world robustness.

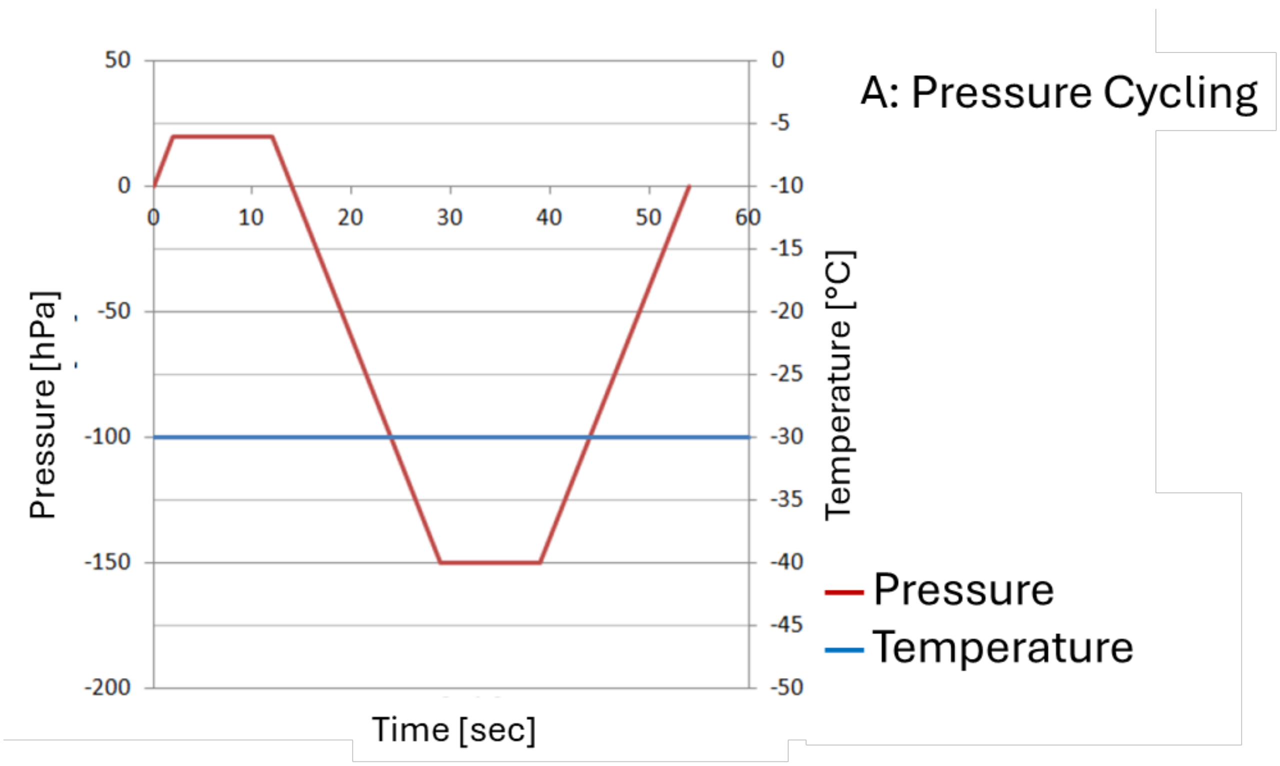
Annex I

OEM	Test description	Max tank pressure (mbar)	Min Tank pressure (mbar)	Max Temperature (°C)	Duration (h)
German OEM Procedure	Tests chained: PV cycling, constant pressure , thermal cycling	370-400 OEM specific	-150	70	7970
OEM1	Pressure vacuum cycle	350	-150	50	750
OEM2	Pressure vacuum cycle	350	-150	50	750
OEM3	Pressure vacuum cycle with several pressure steps	400	-150	80	135
OEM4	Pressure vacuum cycle	350	-150	80	625
OEM5	Constant pressure test	350	350	60	600
OEM6	Creep resistance test with several pressure steps	480	250	60	2270
OEM7	Pressure vacuum cycle with several pressure steps	420	-150	60	200
OEM8	Pressure vacuum cycle with several pressure and temperature steps	350	-150	60	370
OEM9	Pressure vacuum cycle with several pressure steps	350	0	project specific	80
OEM10	Pressure vacuum cycle with several pressure steps	350	-150	70	550
OEM11	Pressure vacuum cycle	400	-150	50	1723
OEM12	Pressure vacuum cycle	420	-100	60	144
ÒEM13	Pressure vacuum cycle	350	-250	60	1656
OEM14	Pressure vacuum cycle	480	-150	23	672
OEM15	Pressure vacuum cycle, China OEM	400	-150	50	1704
OEM16	Pressure vacuum cycle, China OEM	350	-150	60	300
OEM17	Pressure vacuum cycle, China OEM	350	-150	60	672

Annex II

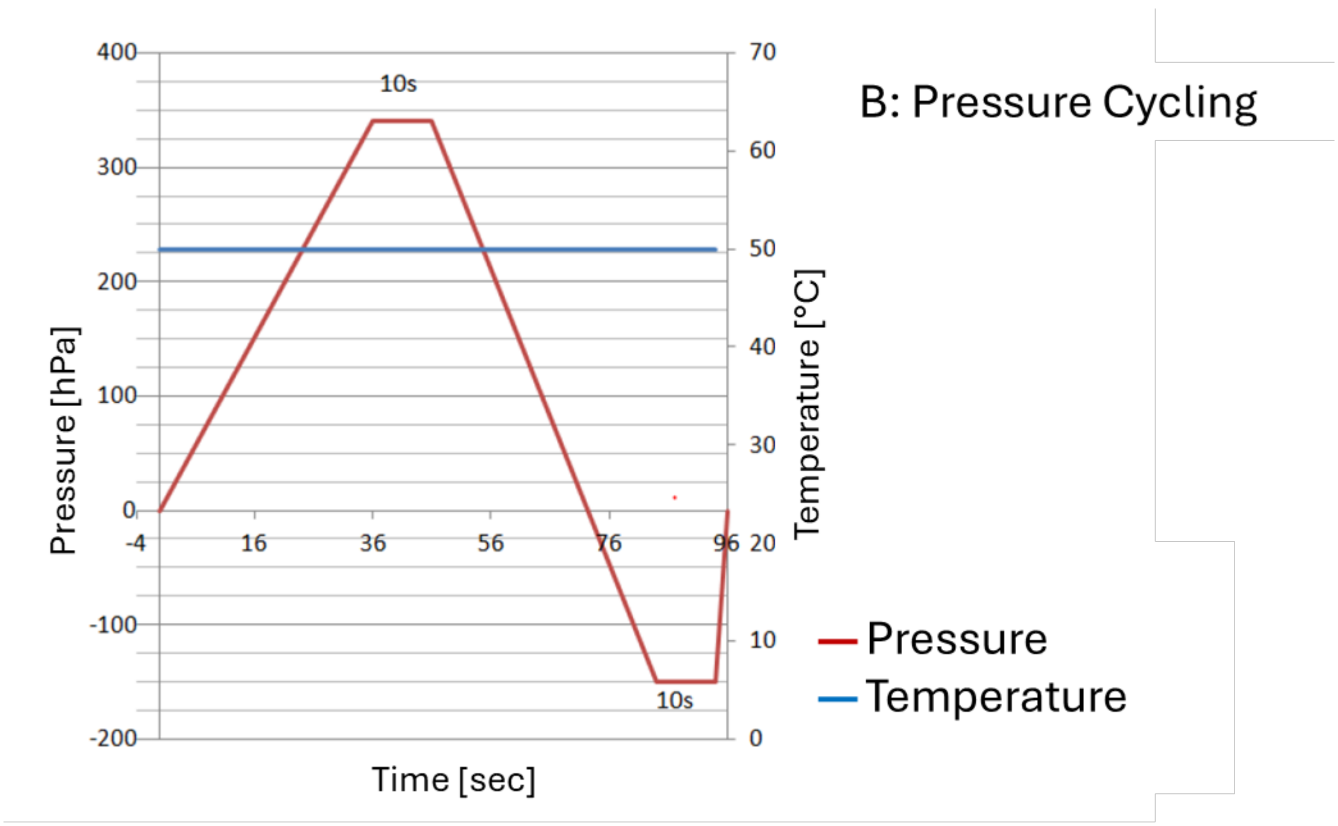
Sceem A: Pressure Cycling

Pressure [hPa]	Change Duration [sec]	Holding time [sec]	Ambient temperature [°C]	Number of Cycles
0 to 20	2 ± 2		-30	5000
20	-	10 ± 2		
20 to $p_{min,OT}$ (-150)	17 ± 2			
$p_{min,OT}$ (-150)	-	10 ± 2		
$p_{min,OT}$ (-150) to 0 0	15 ± 2			



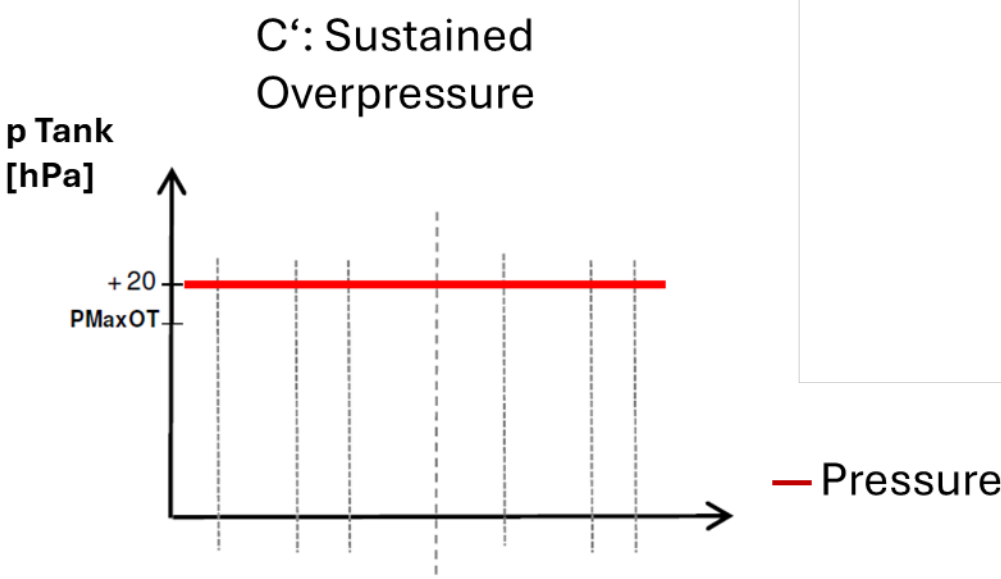
Sceem B: Pressure Cycling

Pressure [hPa]	Change Duration [sec]	Holding time [sec]	Ambient temperature [°C]	Number of Cycles
0 to $p_{max,OT}$ (340)	36 ± 2		50	5000
$p_{max,OT}$ (340)	-	10 ± 2		
$p_{max,OT}$ (340) to $p_{min,OT}$ (-150)	38 ± 2			
$p_{min,OT}$ (-150)	-	10 ± 2		
$p_{min,OT}$ (-150) to 0 0	2 ± 2			



Sceem C': Sustained Overpressure

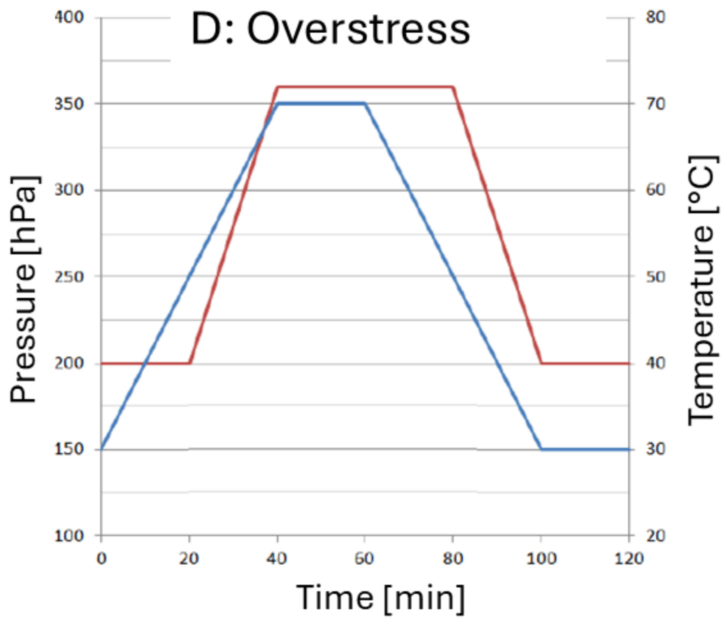
Pressure [hPa]	Holding time [sec]	Ambient temperature [°C]
$p_{max,OT}$ = 340 + 20 hPa = 360	5.400.000	50



Sceem D: Overstress

Pressure [hPa]	Change Duration [min]	Holding time [min]	Number of Cycles
200	-	20 ± 1	1
200 to $p_{max,OT}$ +20 (360)	20 ± 2		
$p_{max,OT}$ + 20 (360)	-	40 ± 1	100
$p_{max,OT}$ +20 (360) to 200	20 ± 2	-	
200	-	20 ± 1	

Ambient temperature [°C]	Change Duration [min]	Holding time [min]	Number of Cycles
30 to 70	40 ± 4-		
70	-	20 ± 1	100
70 to 30	40 ± 4		
30	-	20 ± 1	



About PlasEnSys

PlasEnSys, the European Energy Storage Systems Association, is a sector group of EuPC that stands as a leading association dedicated to representing the interests of the plastic energy storage system industry within the automotive and transport sector. With over 20 years of experience, PlasEnSys fosters collaboration, knowledge sharing, and innovation, adapting to the ever-evolving regulatory and industrial landscapes.

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