

**APPROACH FOR ADDING  
PERFORMANCE-BASED STRESS RUPTURE VERIFICATION  
TO GTR#13 IN PHASE 2**

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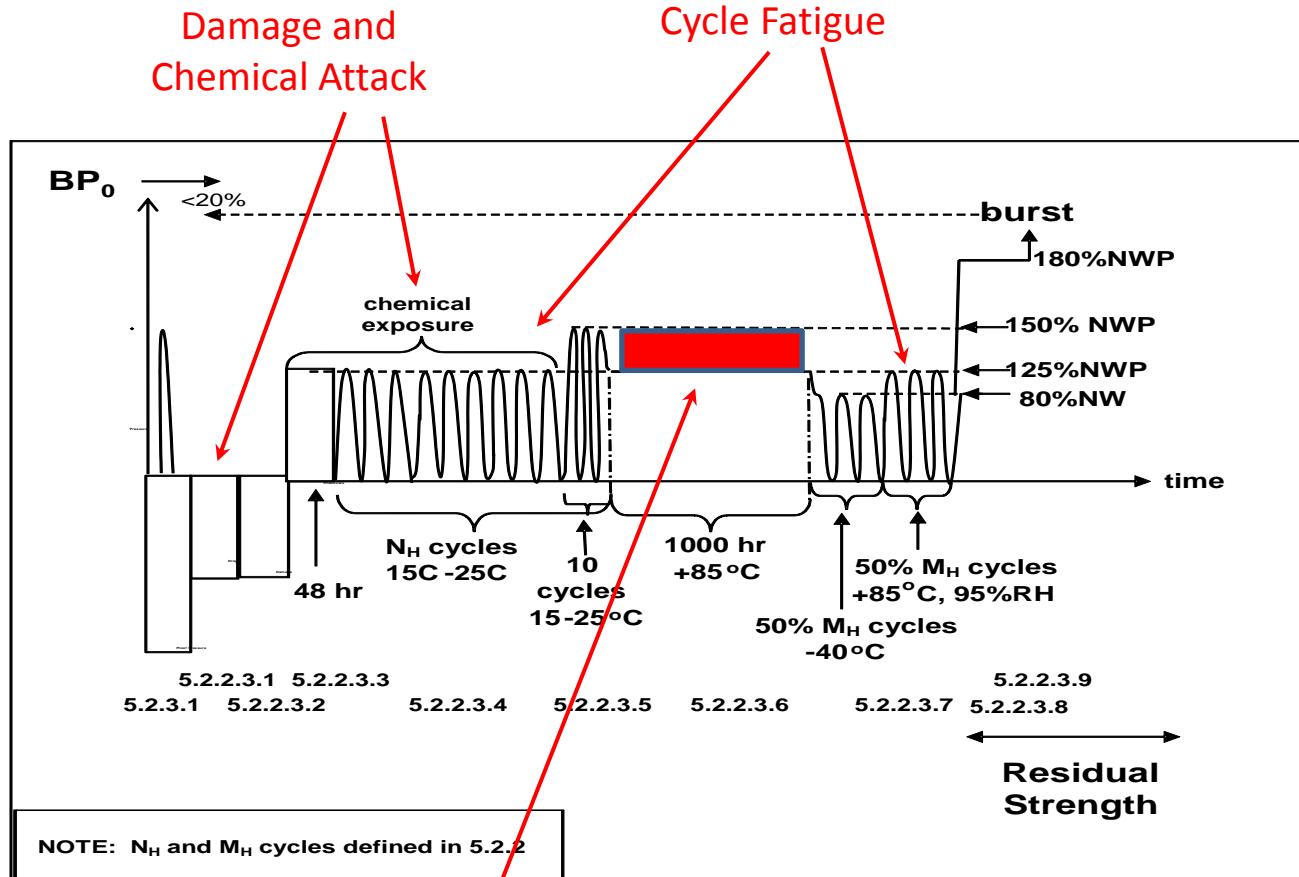
# INTRODUCTION

- At the June meeting of the hydrogen vehicle GTR #13, a performance-based approach to evaluate stress rupture of Type 3 and 4 composite over-wrap pressure vessels (COPVs) was presented based on the recent revision to SAE J2579.
- The purpose of this presentation is to follow up on comments and questions raised during the review at the June meeting.

# Durability (Hydraulic) Test Protocol

## Proposed Change to High Temperature Static Pressure Test for Extreme Parking Durability

**Combines stress rupture with other life-limiting effects.**



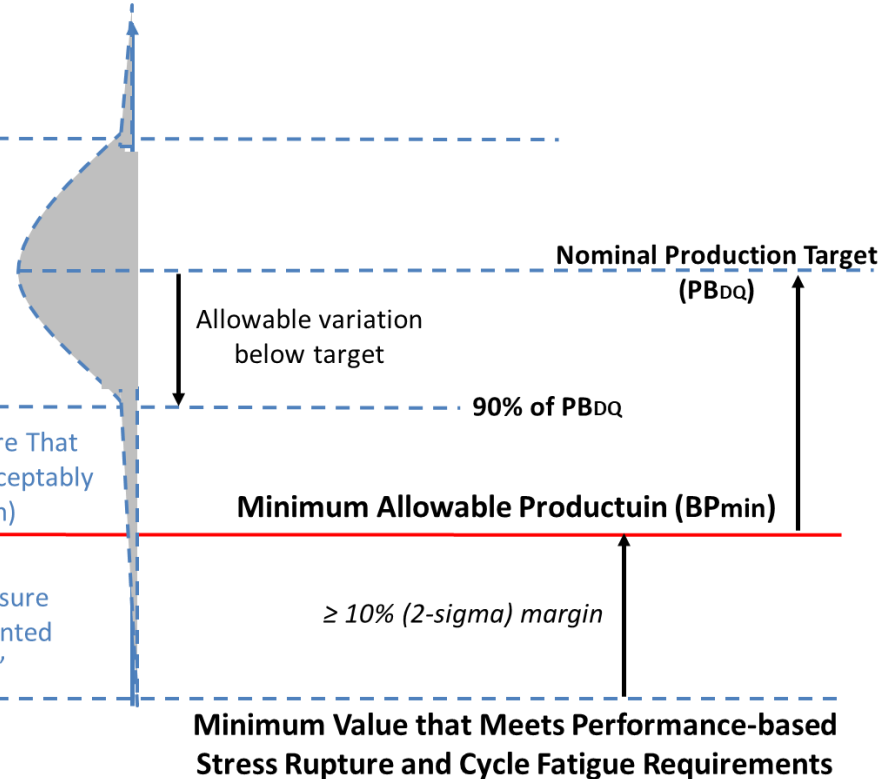
**Increases pressure of the hold from 1.25xNWP to 1.5xNWP and decreases time of hold decreased by approximately 1 month (from 1000 to 105 hours).**

# RELATIONSHIP BETWEEN MINIMUM STRESS RUPTURE WITHSTAND REQUIREMENT AND PRODUCTION TARGETS

**Production Targeted So That  
Occurrence of a Container with  
Minimum Stress Rupture  
Withstand is Highly Unlikely**



Typical Production  
Span for a Fiber Lot



Margin Needed to Ensure That  
Probability of Burst is Acceptably  
Low (<1 in a million)

Margin Needed to Ensure  
Detectability of Unwanted  
"Production Drift"

Nominal Production Target  
(PB<sub>DQ</sub>)

Allowable variation  
below target

90% of PB<sub>DQ</sub>

Minimum Allowable Productuin (BP<sub>min</sub>)

≥ 10% (2-sigma) margin

Minimum Value that Meets Performance-based  
Stress Rupture and Cycle Fatigue Requirements

**Stress Rupture Withstand  
Requirement To Meet  
Minimum Requirements of  
Road Service**



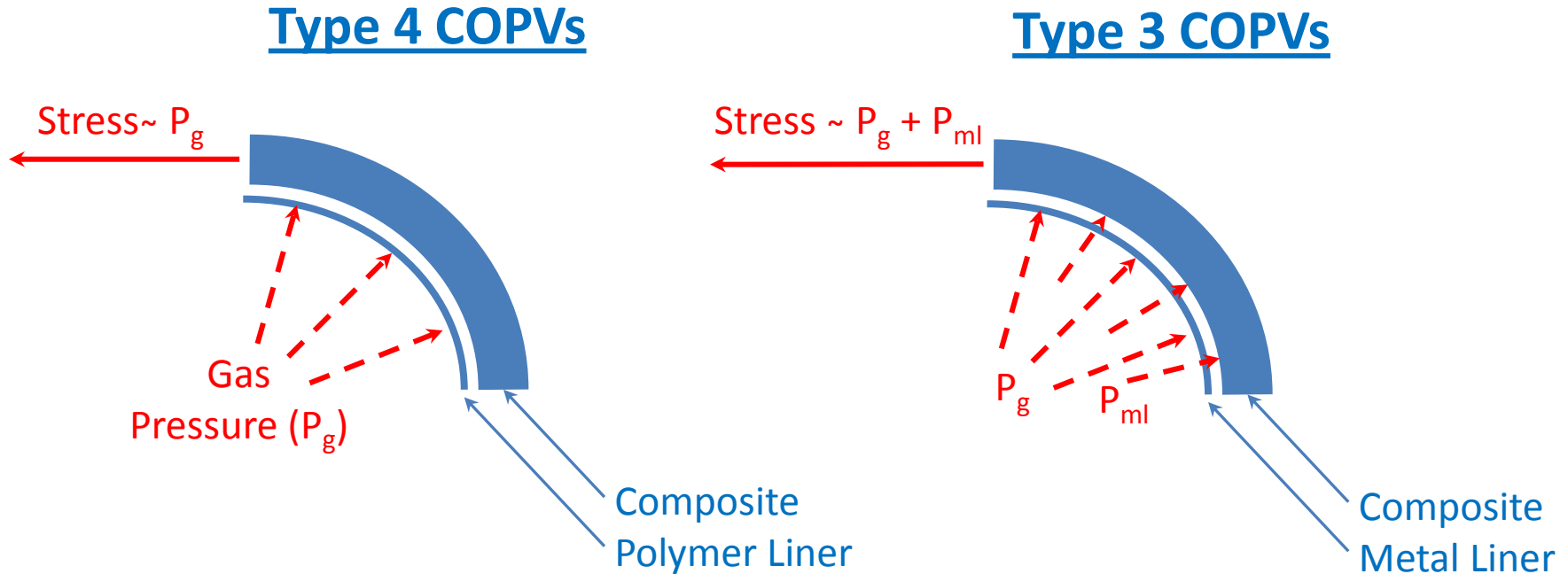
# KEY QUESTIONS

## FROM THE JUNE GTR MEETING TO BE

### ADDRESSED

- 1) Does (or can) the liner of a Type 3 COPV place a load on the composite over-wrap? If so, how much additional stress?
- 2) Can the performance-based test used with Type 3 COPVs?

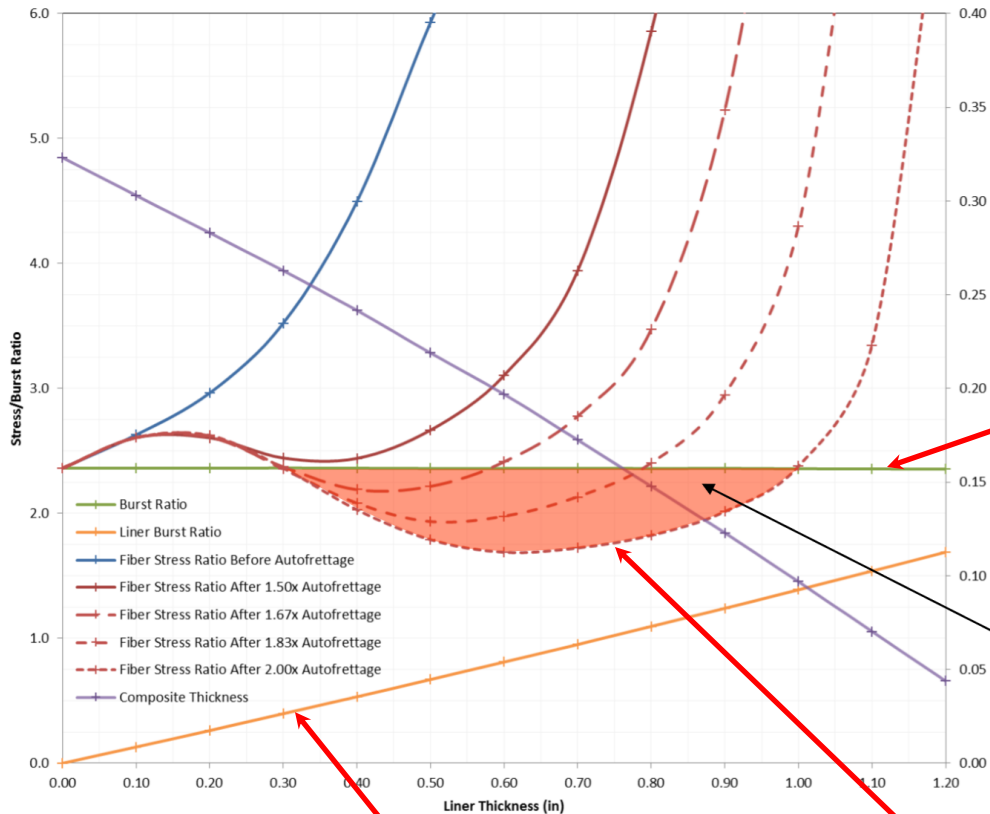
# DIFFERENCE BETWEEN TYPE 3 AND 4 COPVs FOR STRESS RUPTURE TESTING



- “Thick” metal liners of a Type 3 vessels can place additional pressure ( $P_{ml}$ ) on the composite over-wrap at elevated autofrettage pressure.
- To retain the possible added stress of an autofrettaged liner,  $P_g$  should not exceed  $1.5 \times \text{NWP}$  during stress rupture testing.

# EXAMPLE OF FEA PREDICTIONS FOR TYPE 3 COPV

Provided by Dr. Norman Newhouse (Hexagon Lincoln) to TC58/SC3/WG24



Carbon Fiber / Aluminum Liner  
2.36 Cylinder Burst Ratio

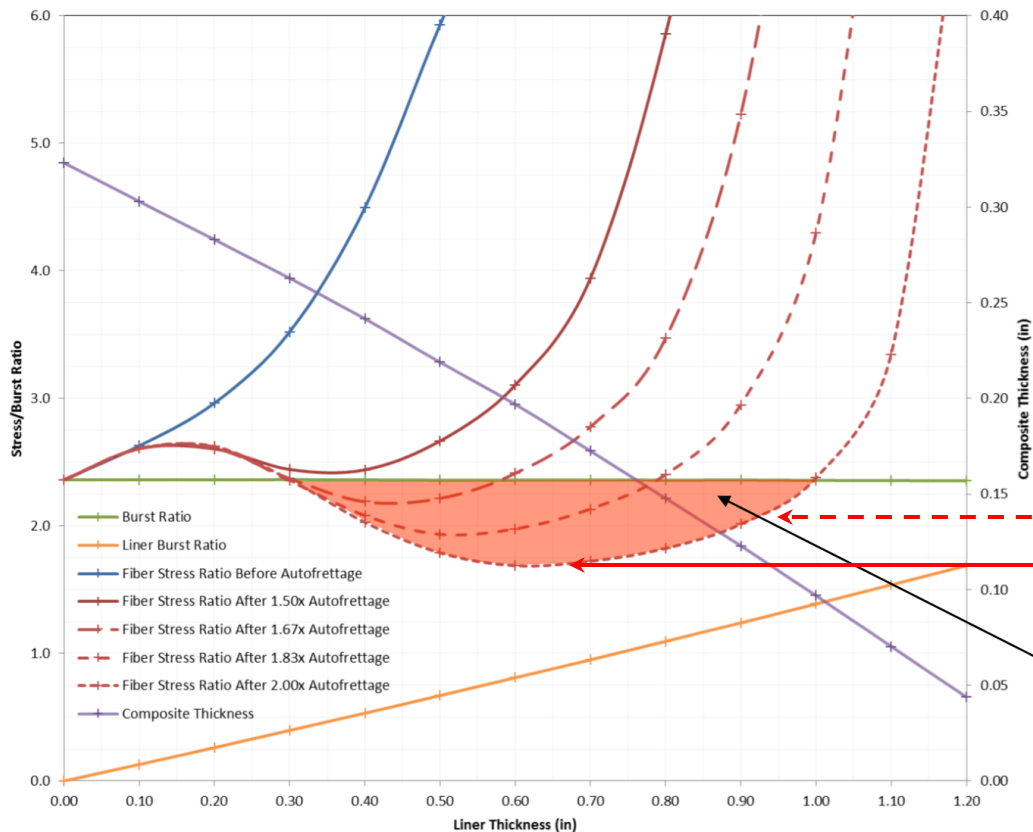
**Burst ratio is held constant for calculations**

Designs operating in the shaded area will have fiber stress ratios lower than the cylinder burst ratio

**Type 3 liner increased**

**Shaded region is where stresses in composite are higher than indicated by burst ratio.**

# CONCLUSIONS BASED ON FEA PREDICTIONS OF TYPE 3



Carbon Fiber / Aluminum Liner  
2.36 Cylinder Burst Ratio

**Detectability of stress ratio for carbon fiber COPVs**

***TBD for 85C test condition  
<1.67 at room temperature***

Designs operating in the shaded area will have fiber stress ratios lower than the cylinder burst ratio

***CONCLUSION: Analysis at 85C IS required to judge effectiveness of the proposed stress rupture withstand test in detecting problems.***



# SUMMARY AND CONCLUSIONS

- The proposed stress rupture withstand test evaluates minimum acceptability for vehicular duty.
- FEAs of Type 3 carbon and glass COPVs at 1.5xNWP and 85C are required to understand stresses in composite over-wrap at the proposed test conditions for stress rupture withstand and thereby establish the effectiveness of the proposed test.
- Verification by test of the stress rupture withstand methodology is also recommended.