

Hydrogen Fueling for Transit Roundtable

6th International Fuel Cell Bus Workshop



June 5, 2009



H2 Bus Fueling Testing Project



▶ CaFCP Bus Team request

- Fast increase of miles driven (>250k miles)
- Typical transit operations – 6-10 min diesel bus fueling
- No existing guidelines for HD hydrogen vehicle fueling

▶ Increasing number of HD FCV programs

▶ Necessity for transit agencies in extreme climates

- ▶ Facilitate fast fueling for heavy-duty hydrogen vehicles that are not using bus-to-station temperature and pressure communication
- ▶ Heavy-duty vehicles (>10kg) using 350 bar (5000psi) hydrogen gas
- ▶ Performance and safety limits of gaseous hydrogen fast fueling

Fueling Testing

▶ Participants

- SunLine Transit, ISE Corporation
- Feedback/input UTC Power and AC Transit

▶ Location

- Thousand Palms – extreme climate (desert)

▶ Goals

- Assess fueling rate FCBs
- Create benchmark for controlled lab testing by testing at high temperature
- Input to SAE J2601 HD H2 vehicle fueling section



- ▶ Establish baseline showing normal fills of hydrogen storage system (8 Type III SCI tanks)

- ▶ Perform 4-tank fills by shutting valves 4 tanks
 - Increases fill rate of remaining tanks if fill rate at nozzle/receptacle is similar
 - At higher ambient temperature

- ▶ Thermocouples/probes in all tanks, several inches from fill port (measuring T gas, not liner)

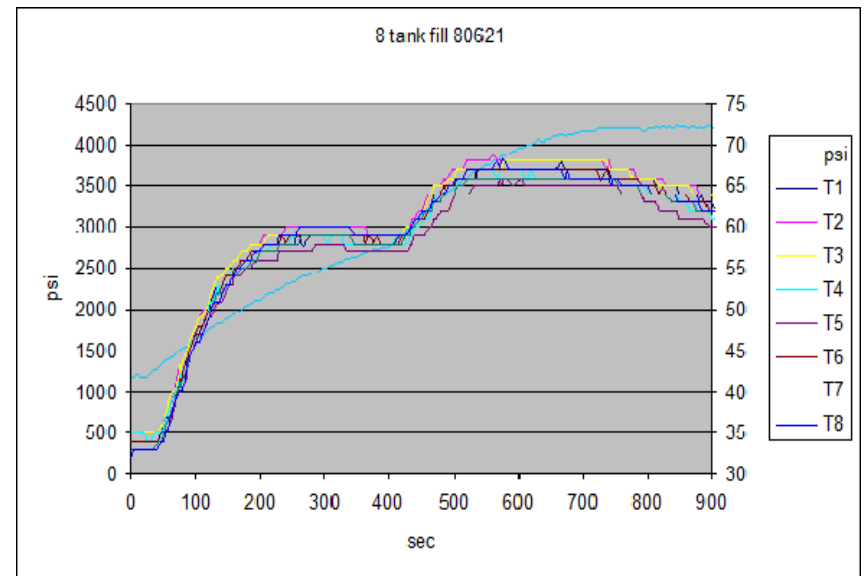
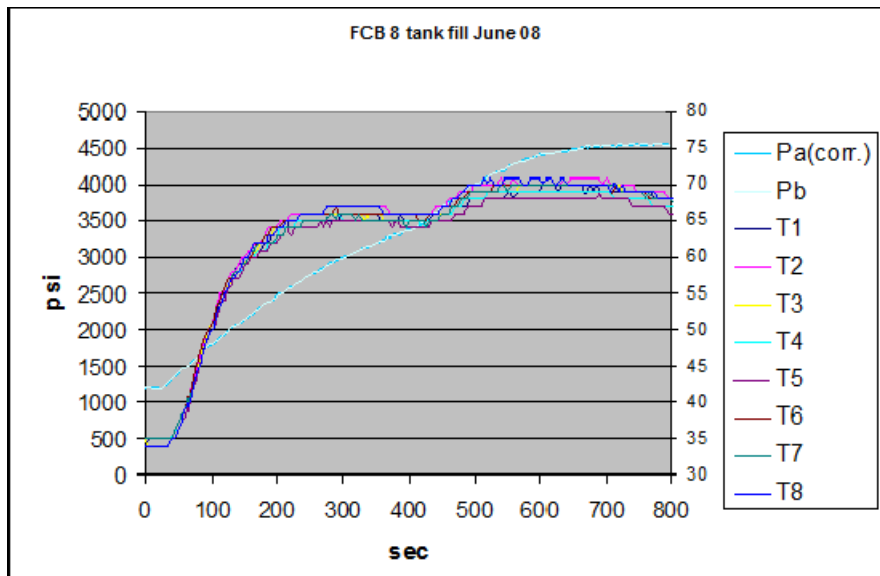
Factors ΔT Fast Fill

- ▶ Supply gas conditions
- ▶ Initial $P + T$ in tanks prior to fill
- ▶ Construction details vehicle cylinder
- ▶ Vehicle cylinder P_{\max} and T_{\max}
- ▶ Rate of fill



Test Results

▶ System fill – 8 tanks

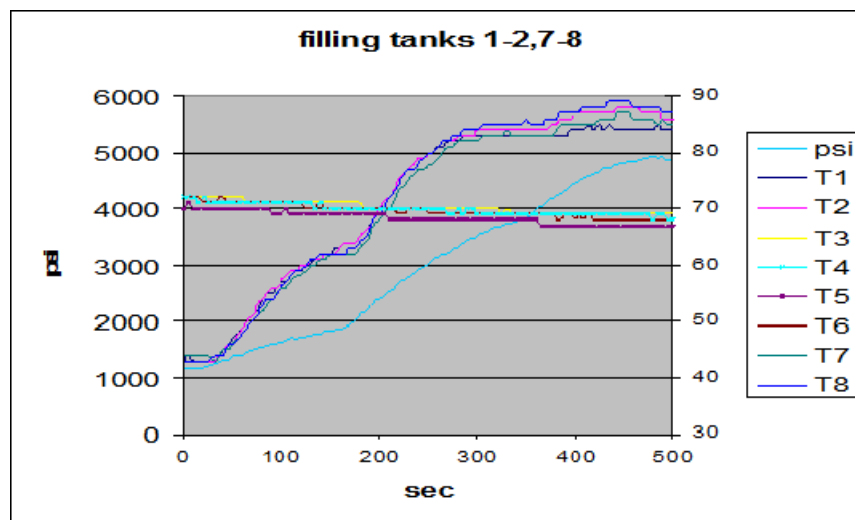
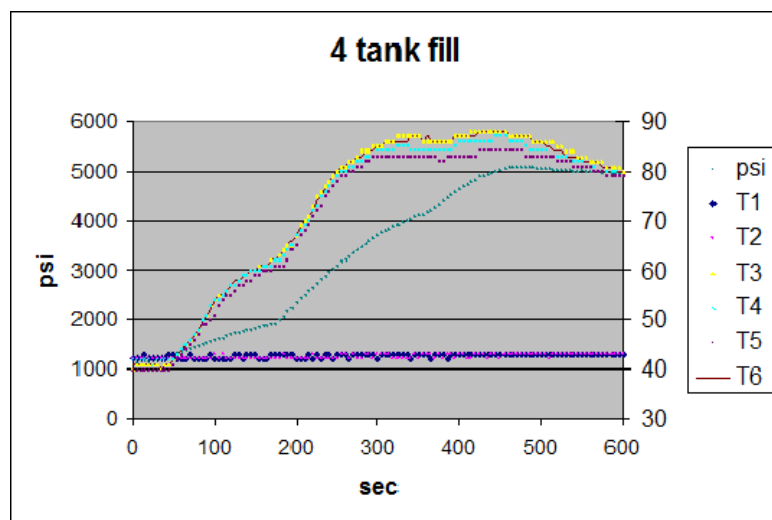


Test #	1	2
Pressure rise	1300 – 4600 psi	1200 – 4200 psi
Temperature rise	35°C	32°C

Test Results (2)

▶ Fill – 4 tanks

- First fill of 4 tanks, second fill of other 4 tanks in system, closing off first 4 and opening other 4 tanks



Test #	1	2
Pressure rise	1200 – 5000 psi	1200 – 5000 psi
Peak temperature	>85°C	86°C

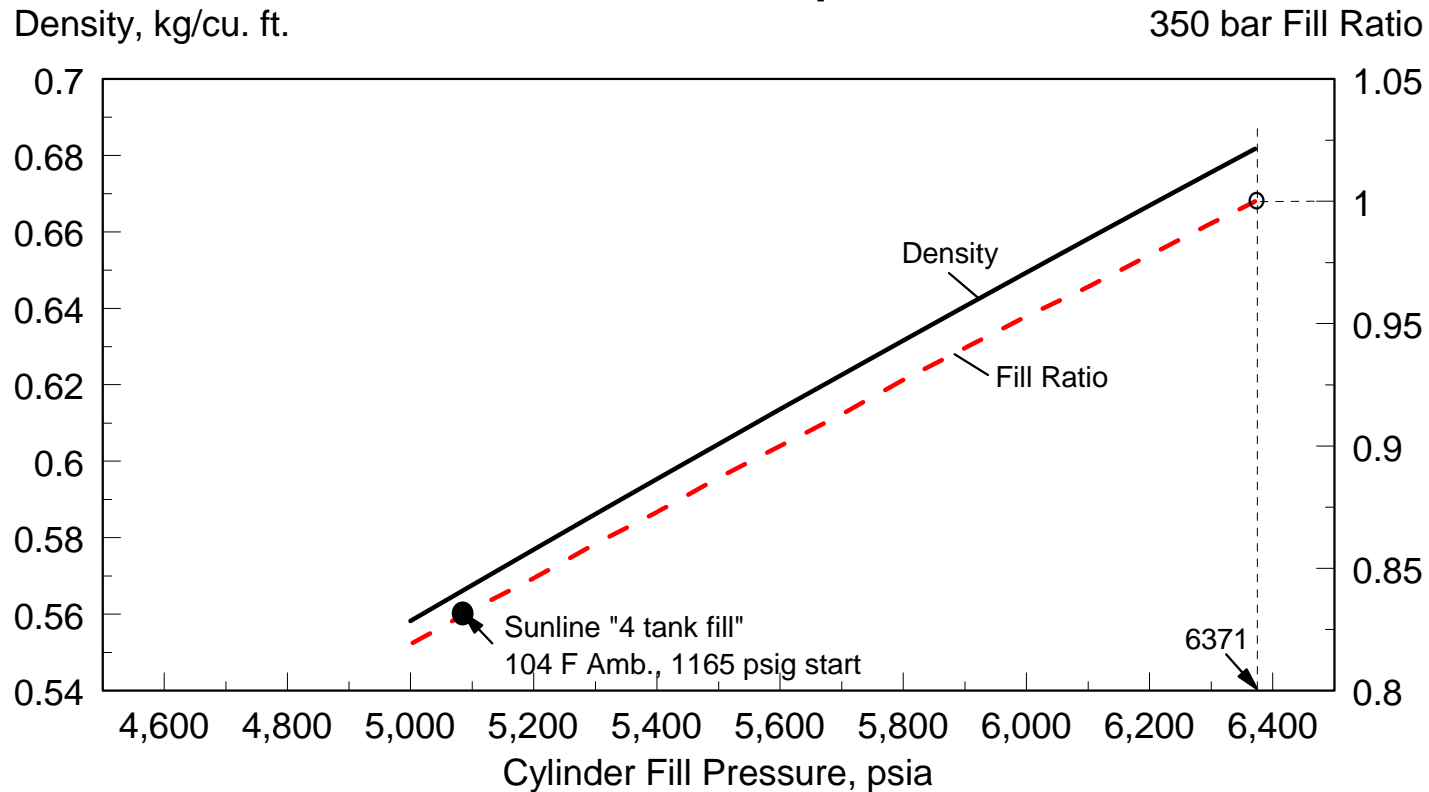
Evaluation Results GTI



- ▶ Ambient temperature at 104°F (41°C) is a limiting factor preventing a complete fill
- ▶ Fill terminated at 5100 psi in order to avoid internal gas temperature to exceed 185F
- ▶ Temperature probes in each of the tanks closely followed each other

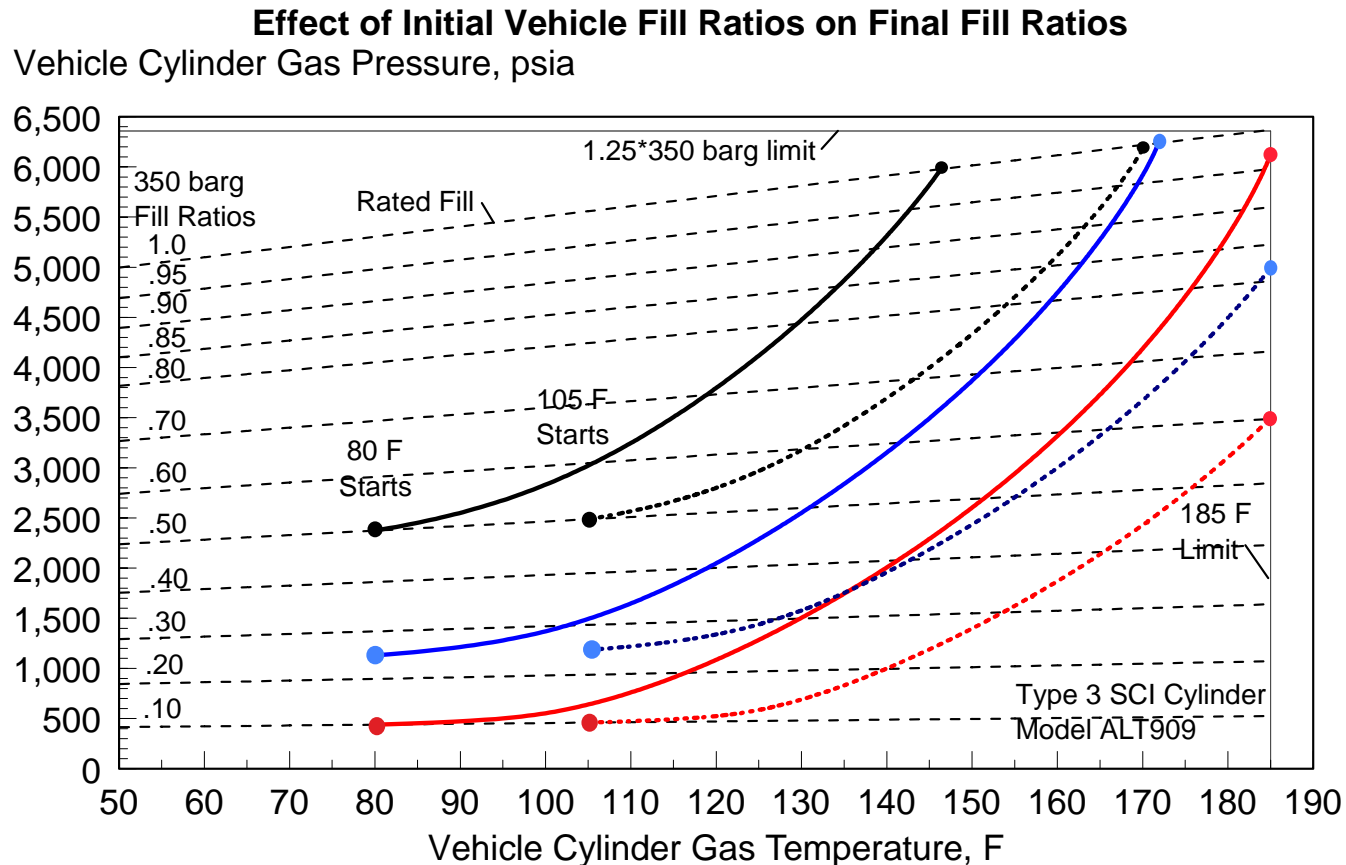
Evaluation Results GTI (2)

Cylinder H₂ Density and 350 bar Fill Ratio For 185 F H₂ Temperature

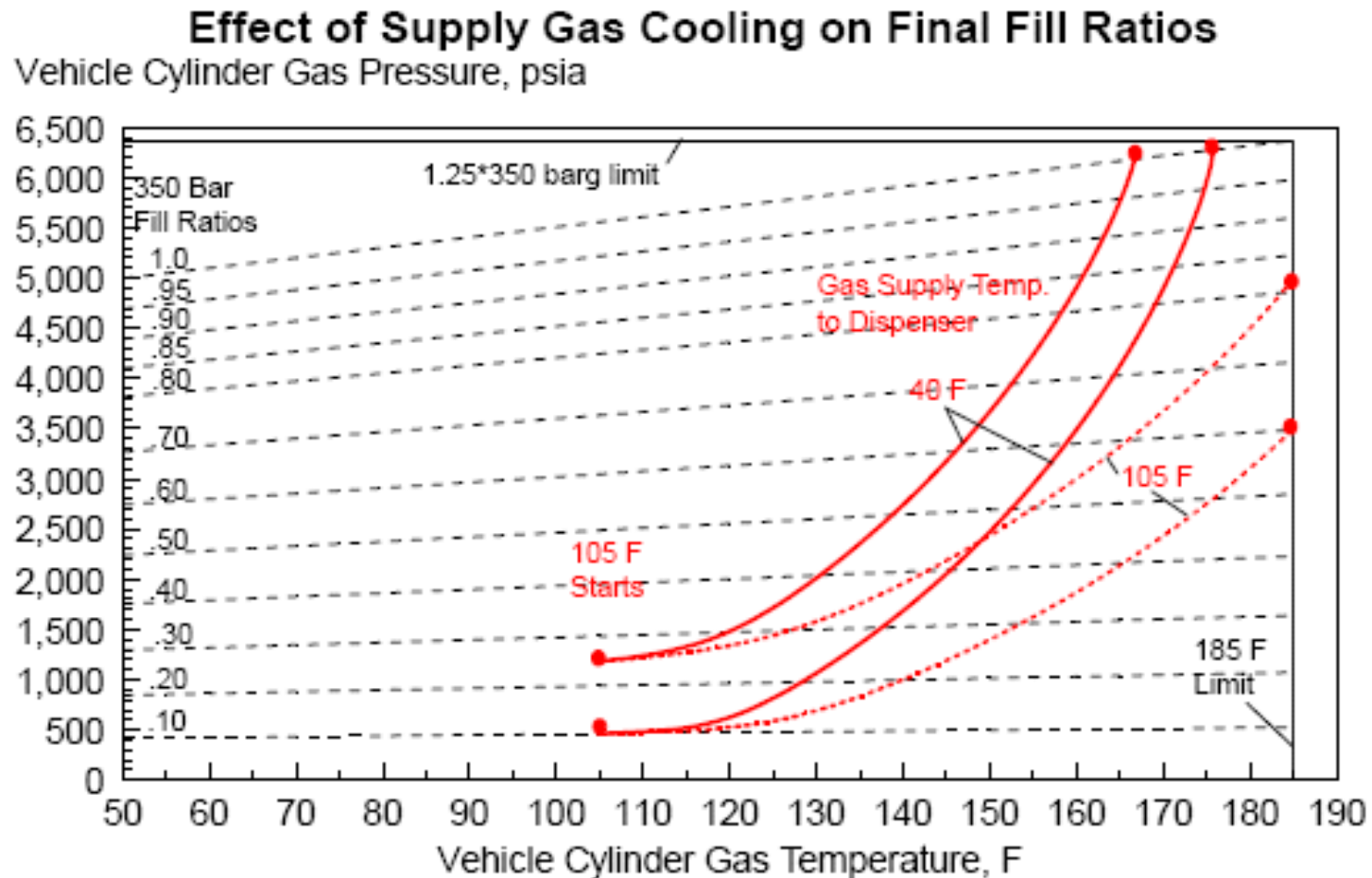


Evaluation Results GTI (3)

- ▶ Impact of gas supply T on on-board storage vessel T
 - Starting fill process at 50%, 25%, and 10% initial fill ratio



Evaluation Results GTI (4)



CFCPx3.pre

Conclusions

- ▶ T ground storage + vehicle tank fill ratio at $t=0$ significantly impact ability to achieve “full fill” within limits T
- ▶ Slowing rate of fill minor benefit
- ▶ Potential benefits in moderate pre-cooling
- ▶ T gas in tank during fill not necessarily uniform
- ▶ Analytical results need confirmation through empirical testing

Next steps

- ▶ Secure funding
- ▶ Execute controlled lab testing
- ▶ Verify results at transit agency
- ▶ Publicize and share results

Questions?



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Roundtable Discussion

- ▶ Hydrogen station reliability and recoverability
- ▶ Challenges of providing H2 to transit
- ▶ How to standardize transit H2 operations?
- ▶ Streamlining transit H2 fueling procedures
- ▶ Key needs and gaps
- ▶ Who else to involve?
- ▶ Option of volume procurement?