Controlling Puff Loss Emissions August 18, 2021

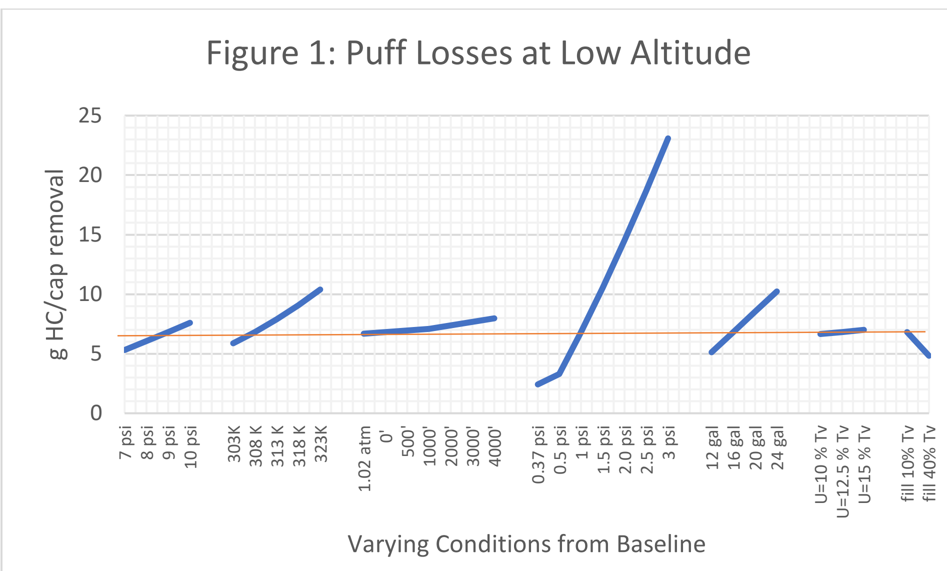
I had the opportunity to participate in the virtual workshop on August 11. I was most interested in ascertaining how CARB staff had responded to the inputs received on the Puff Loss presentation from the May public workshop. Unfortunately, there was no detail on this item in the August 11 workshop materials. Thus, I am providing more formal technical input based on the material presented at the May workshop.

Background:

CARB staff presentations indicate that the proposed regulation will use a design-based approach rather than a SHED-based emissions performance test and emission standard. Under this design-based approach the requirement would be that the canister must have excess capacity (relative to that required for ORVR) to capture emissions vented to the canister before the cap is removed. As I understand it, the certifying manufacturer must calculate the refueling and puff loss loads (in grams) using the equation and related guidance presented CARB staff presented in the May workshop materials, and the canister capacity in grams must be equal to or greater than that sum.

Sensitivity of Puff Loss Emissions to Various Parameters

Presented below is a figure which shows the sensitivity of puff loss emission rates to changes in various parameters. For this chart, the baseline values are: RVP 7 psi; tank temp 308°K; elevation 0'; tank pressure 1 psi; tank vol 16 gal; tank void volume 12.5%; tank fill 10%. Note here that the 0.37 psi is equal to the 10" $H_2O$/2.5 kPa criterion in the running loss test for puff loss venting to the canister. Also note that emissions are most sensitive to tank pressure and tank volume, and effects are additive.




Observations/Suggestions:

1. <u>$P_{tvs}$</u>: Of all the parameters influencing puff loss mass, $P_{tvs}$ is the most significant. $P_{tvs}$ is very sensitive to fuel system design. Instead of using a prescribed $P_{tvs}$ value, CARB should require that the $P_{tvs}$ be measured during the running loss drive and that the peak value be used in the calculation.

2. $\underline{V_{tvs}}$: Puff loss emissions are a function of the total void volume ($V_{tvs}$) in the fuel system. The value for $V_{tvs}$ should include the fraction of the tank capacity not filled with fuel (90%) + the volume of the tank design ullage + the fill pipe volume + the external/internal vent line volume.

3. Vapor molecular weight: The 5.3 g/gal vapor density value on page 4 of the May presentation (for 7 psi RVP fuel at 105°F) seems appropriate. However, the nomograph is based on a non-ethanol gasoline. Since the molecular weight of ethanol vapor is less than that of gasoline vapor, 7 RVP E10 fuel vapor would be less dense.

4. Applicability: Since the 1995 model year, CARB regulations (1976(c) Title 13 of the CCR at Part III. section C.1.2.3) have included a requirement that puff loss emissions be routed to the canister if the pressure on the running loss drive exceeds 10" $H_2O$ (2.5 kPa). The puff loss control requirement should apply not only to NIRCOS, but also to any vehicle which has a tank pressure meeting or exceeding this threshold. Based on the equation used to generate the figure above, I would also add that the mass of puff loss emissions at 10" $H_2O$ are still quite substantial – 2.5 grams. For an ORVR-equipped with a 16-gallon tank, this value is more than the total displacement emissions measured in the refueling emissions test. Stage II EVR has no impact on puff losses.

5. Control system performance: The design-based approach provides no assurance of emission control. As written, there is no means by which to determine if puff loss emissions are vented to the canister or to the atmosphere. Excess canister capacity is necessary, but it alone is not sufficient to assure control. This is the problem with the 1995 regulatory provision, and it is not resolved by adding a design requirement. At a minimum a SHED based back-up test is needed.

6. Gameability: In the current evaporative and refueling emission regulations fuel tank capacity is prescribed by the manufacturer: (nominal fuel tank capacity means the volume of the fuel tank(s), specified by the manufacturer to the nearest tenth of a U.S. gallon, which may be filled with fuel from the fuel tank filler inlet.) There is no specific method prescribed in the regulations, even though one exists in SAE (see SAE J396b). The problem here is that a manufacturer could demonstrate compliance using the design-based approach equation simply by making a change in the tank capacity reported in the certification application but not really changing the tank design or canister capacity.

7. Purge: System performance depends not only on canister capacity, but also purge. The approach presented at the May workshop did not address how the manufacturer would demonstrate that the canister would be prepared for puff losses for the next refueling event.

8. Separate puff loss control systems: Provisions are needed to direct how to assess capacity and purge for designs which use a separate control technology for puff losses (e.g., canister).

9. Test Procedure and Emission Standard: The CARB regulations identified in point 3 above call for the manufacturer to demonstrate that puff loss emissions are vented to the canister if the tank pressure exceeds 10" $H_2O$ during the running loss drive. Regulations covering how to demonstrate compliance with this requirement have never been implemented. I recognize that CARB does not want to increase manufacturer testing burden, but none of the issues/concerns raised above exist with a SHED based procedure. Some manufacturers may prefer a performance standard and EPA may need one under the CAA. There is likely little harm in providing a test procedure and emission standard as an option and a technical back-up for the design-based approach. While a procedure incorporated in to the ORVR test would be preferable, it would create a burden since the ORVR requirements are not changing in LEV IV. Conversely, the running loss requirements are changing, and the procedure in Figure 2 (below) would serve to demonstrate canister capacity and purge.

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Figure 2: Puff Loss Test Procedure and Emission Standard

Start

Within 5-minutes of completing running loss emission test drive, move the vehicle into the SHED for the 105°F hot soak test as is currently prescribed, including operation of SHED mixing fans. At this point the tank would have about a 35% fill.

Use a SHED that is configured for ORVR, (i.e., with glove boxes to access fuel inlet).

Immediately close SHED door

Zero and span FID

Identify the background HC concentration in the SHED air and record this value if not already done.

Activate on-vehicle fuel door release as necessary based on vehicle design.

Open fuel door and remove fuel cap through the glove box access.

Wait 30-60 seconds.

Immediately thereafter replace fuel cap and close fuel door.
(Repeat preceding 4 steps for dual tank vehicles)

Continue the 105°F hot soak test and 72-hour diurnal test.

Measurement

Within 60 seconds of closing the fuel door measure the puff loss HC concentration in the SHED and record the value. This will be the value for t=0 HC concentration for the hot soak test.

At the end of the 1- hour hot soak, adjust the HC concentration in the SHED by subtracting the measured puff loss HC concentration (t=0 for hot soak) from measured total HC concentration after completion hot soak.

Use this "adjusted" SHED concentration for the hot soak calculation.

Calculation of puff loss mass

Convert the puff HC concentration to grams HC using techniques now prescribed for diurnal.

Emission standard:

A "zero" puff loss standard is technically feasible. I would suggest an emission standard structure like LEV III with no averaging.

| Vehicle Class* | Nominal Tank Volume (gallons) | Tank vapor volume: (10% fill and 12.5% of tank volume for tank vapor dome, fill pipe, and external vent line) (gallons) | ** Puff loss emission /tank (grams) [7 RVP tank temp = 318°K, ΔP = 3 psi) | Puff loss emission standard/tank/test based on ~98% reduction (milligrams)*** |
|---|---|---|---|---|
| LDV/LDT1 | 16 | 16.4 | 23.9/18.1 | 250 |
| LDT2 | 22 | 22.55 | 32.8/24.9 | 350 |
| LDT3,4/MDPV | 28 | 28.7 | 41.8/31.6 | 450 |

*Special provisions may be needed for dual tank vehicles with tanks of greatly different volumes.
** Values to the right of the / are for a 35% fill which is about the tank fuel level entering the hot soak test.
*** By comparison, the calculated puff loss value for 0.37 psi (10"$H_2O$) is 2.5 grams for the 16-gallon tank.