DELTA: A Multiple-day Cold Soak Emissions Calculator for MOVES

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Background: Why are we updating cold soak?

- MOVES2010b only uses average three day diurnal certification testing results to compute cold soak emissions.
- MOVES2010b does not separate the effect of properly functioning vehicles and leaking vehicles in cold soak.
- Cold soak emissions at 4+ days are significantly greater than those at three days.
- Cold soak emissions are a dynamic system that cannot be modeled using a simple equation.

What is DELTA?

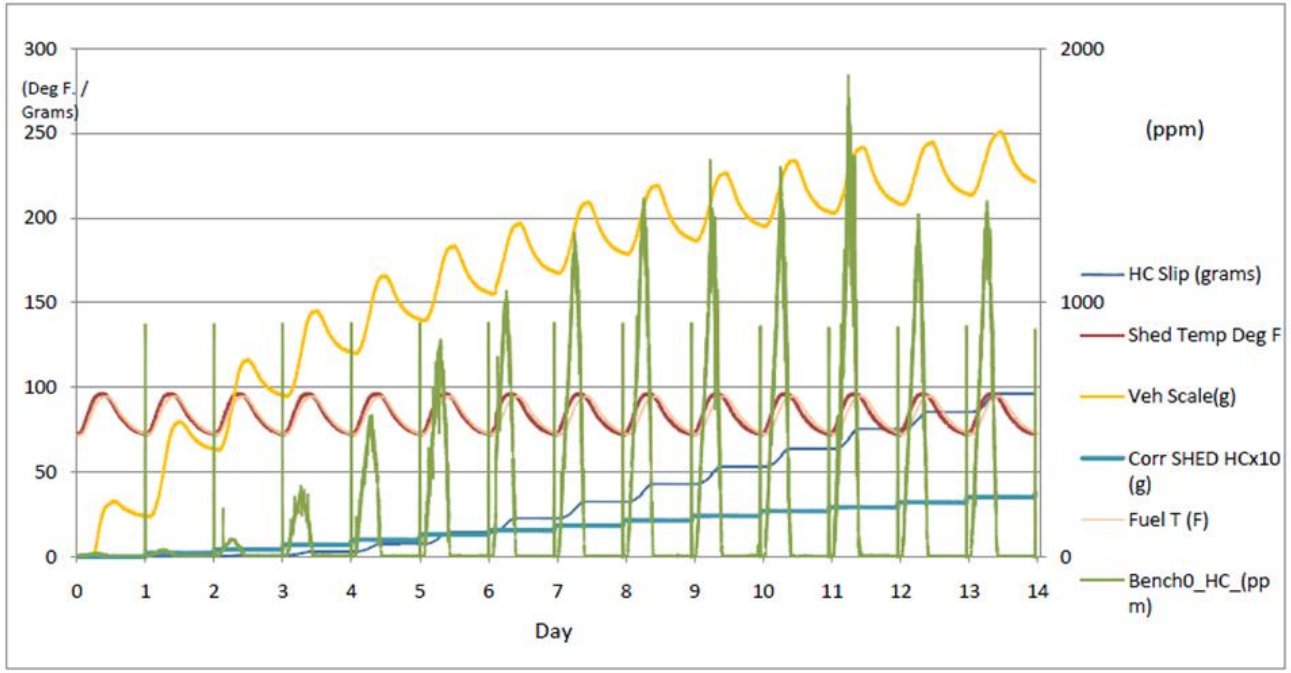
D iurnal
E missions
L eaving
T o
A tmosphere

- **A model developed by EPA to:**
  - Calculate tank vapor generation for various tank sizes, diurnal temperature changes, and fuel properties
  - Predict tank vapor venting for arbitrary diurnal temperature and fuel property combinations for a single or fixed group of vehicles
  - Integrate high evap leak rates and profiles into vapor venting predictions
- **The response to new cold soak testing from both E-77 and 14-day cold soak testing**
- **Building into MOVES2013 code**

Definition of cold soak terms

- Tank vapor generated (TVG): hydrocarbons evaporated from fuel contained in a tank as temperature rises through a diurnal cycle. f(RVP, EtOH, headspace, altitude, ΔT)
- Tank vapor vented (TVV): hydrocarbons not captured by carbon contained in the tank canister released to the atmosphere. f(canister capacity, TVG)
- Backpurge: hydrocarbons cleared from the carbon contained in the canister as clean air is drawn into the tank during the cooling phase of a diurnal. f(amt. hydrocarbons in canister)
- Canister capacity: the total amount of hydrocarbons a tank canister can hold without venting. f(canister size, carbon quality)

14 Day “Real world” cold soak

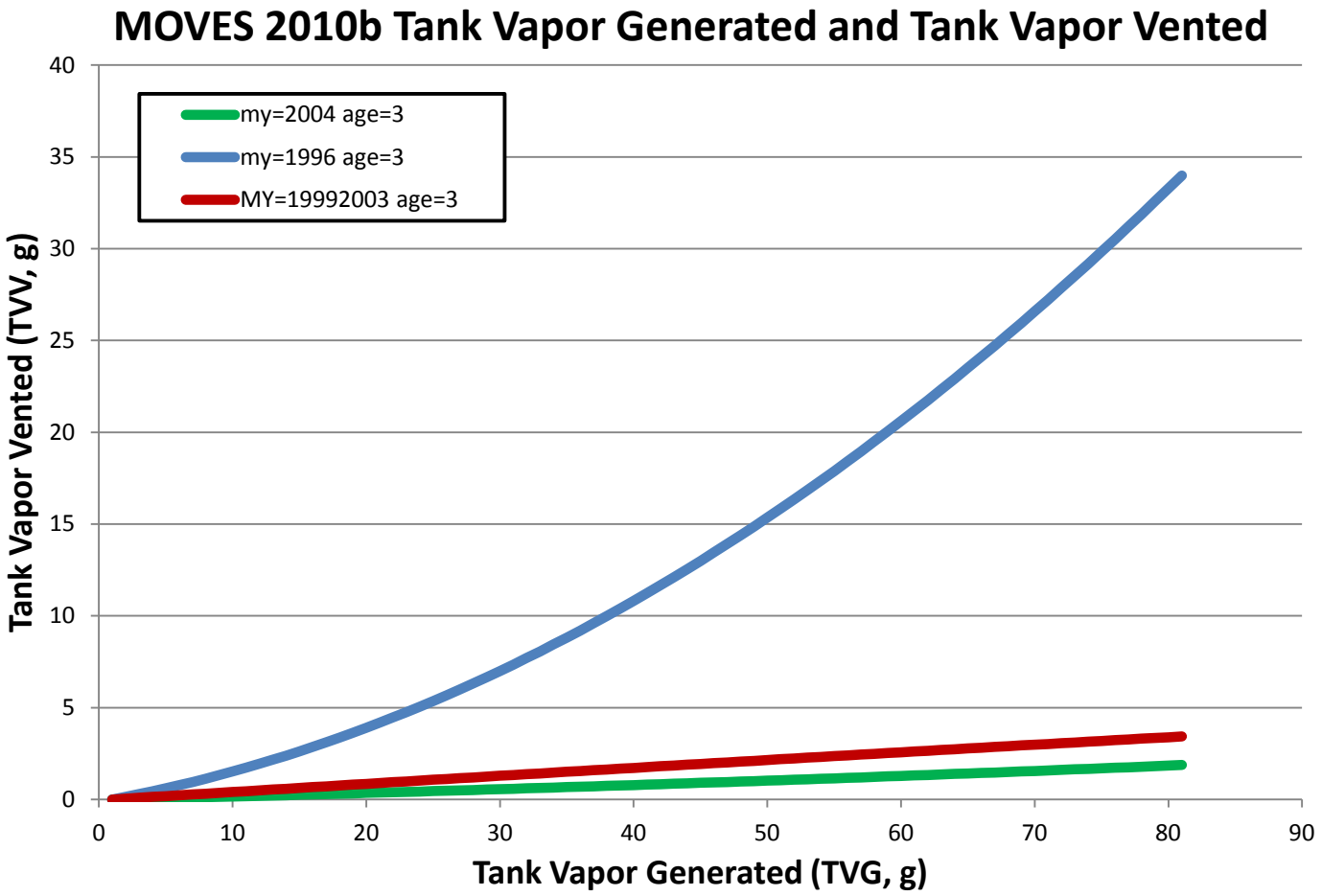


Test 4317- Canister was purged before test.

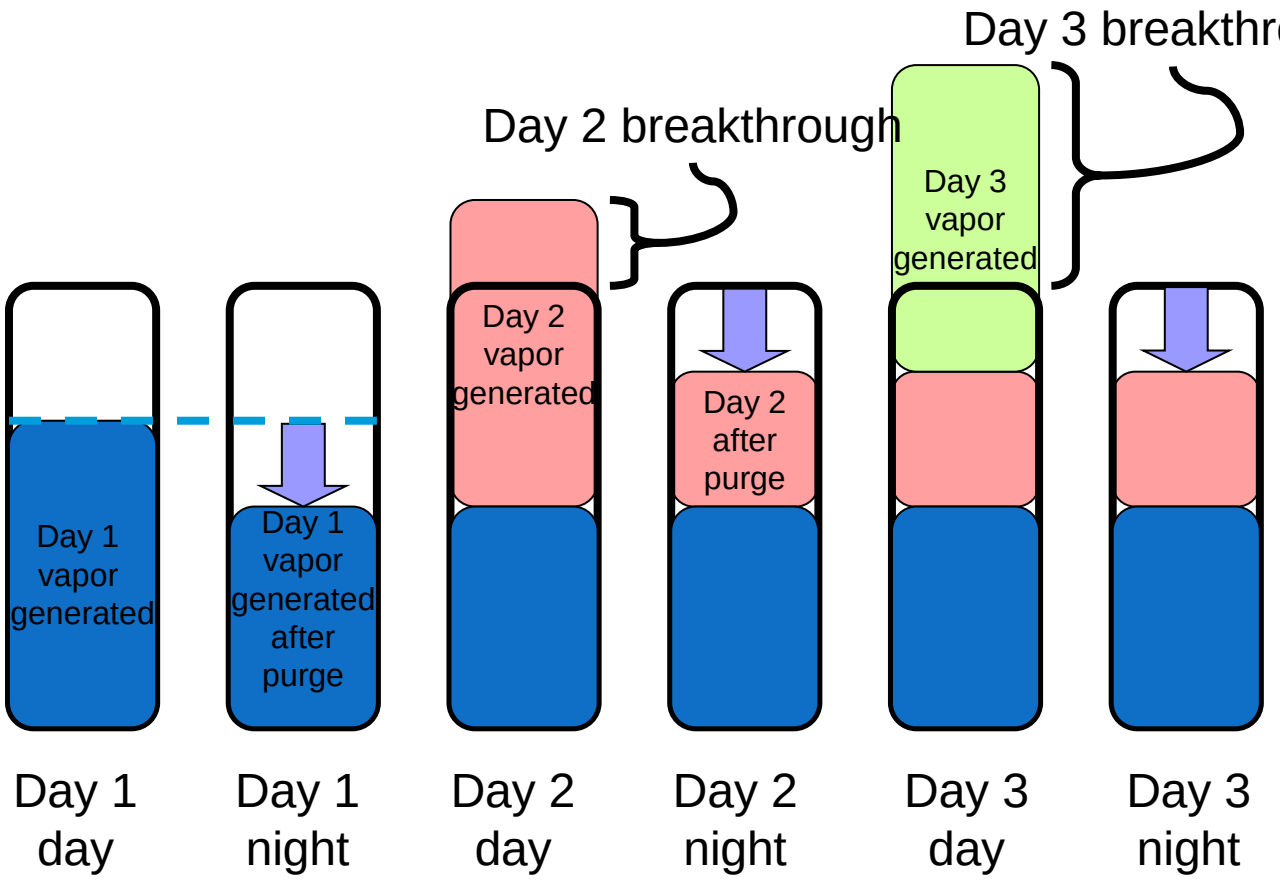
Daily Mass Gains/Losses

Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	Total (g)
SHED HC (g)	0.212	0.212	0.302	0.278	0.31	0.245	0.277	0.311	0.276	0.266	0.243	0.278	0.312	0.289	3.811
HC Slip (g)	0.076	0.197	0.566	2.101	4.540	6.870	8.160	9.845	10.579	10.211	10.535	11.810	9.918	10.891	96.299
Veh Scale (g)	23.9	39.6	31.9	25.3	19.8	15.4	12.7	11	8	8.4	7.8	5.2	5.2	7.1	221.300

MOVES 2010b Cold soak equations

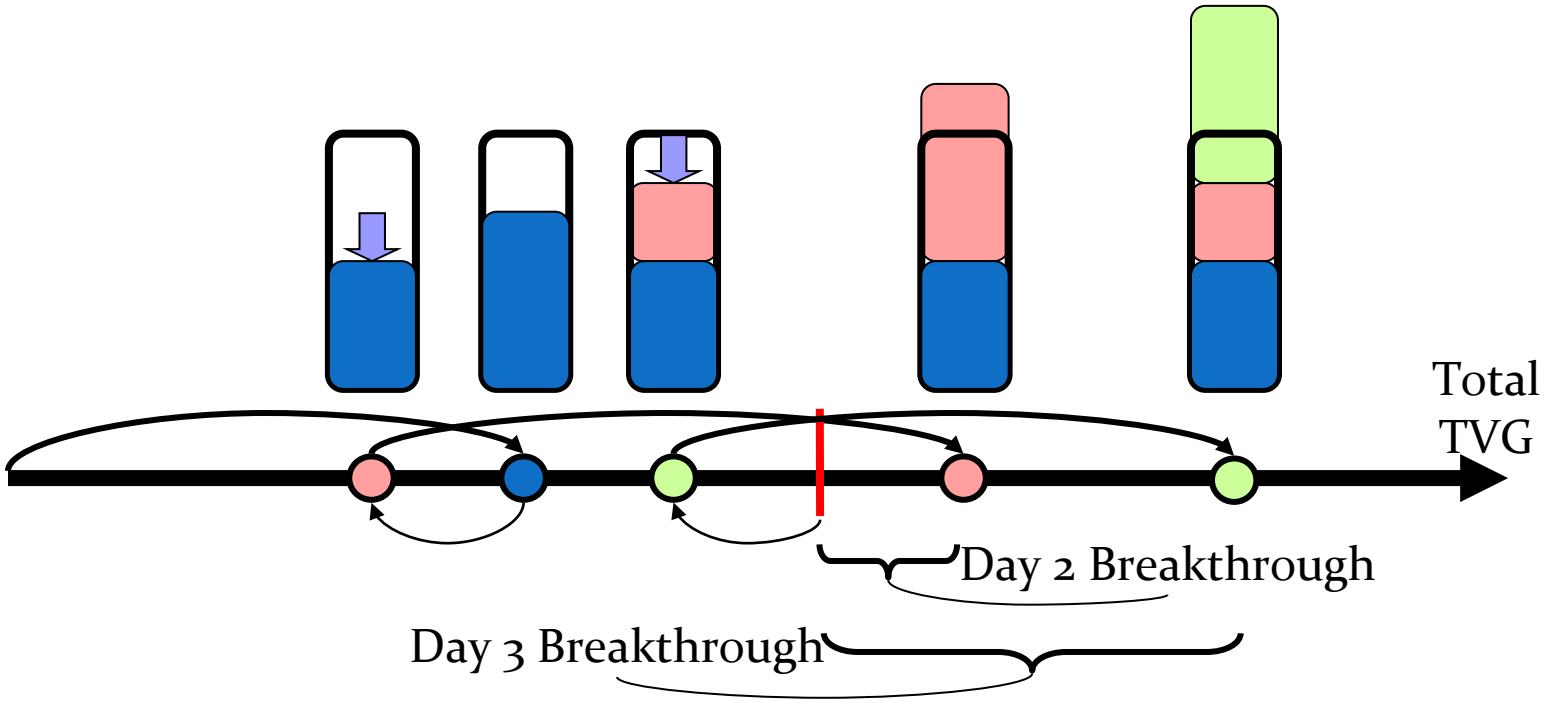


DELTA Methodology: Multiple day canister loading



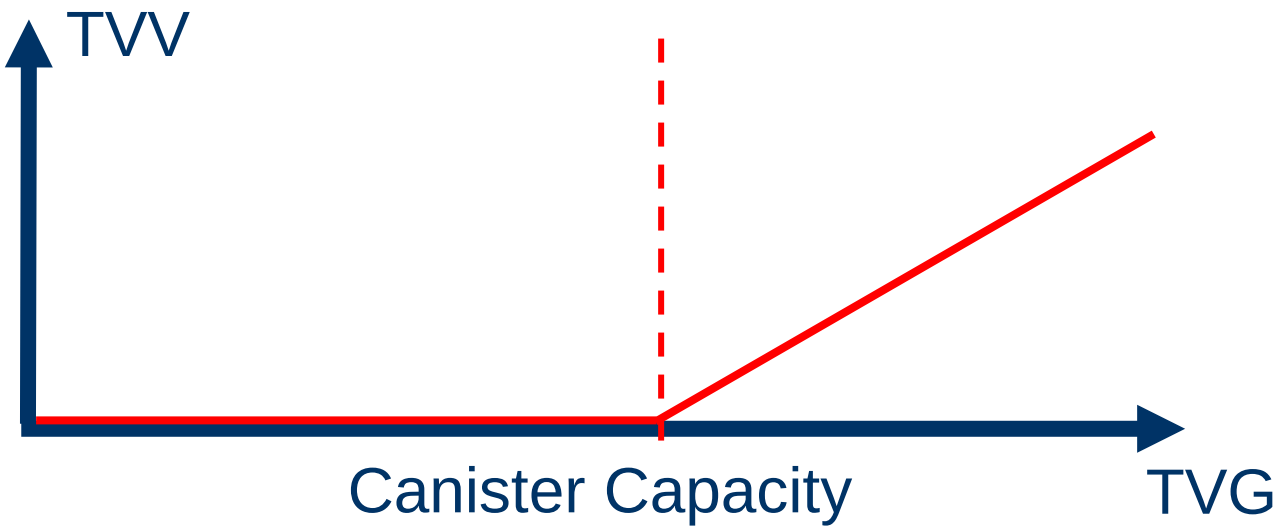
Day 4+ Same as Day 3 – The canister has reached its maximum capacity

DELTA Methodology: Another way of looking at TVG



- TVG remains the same for every day the vehicle is soaking.
- Backpurge can be thought of as negative vapor generation; it is creating additional canister capacity during the cooling phase of the diurnal.
- After the canister is full, backpurge begins at the canister capacity, any additional vapor generated has been lost to the environment.

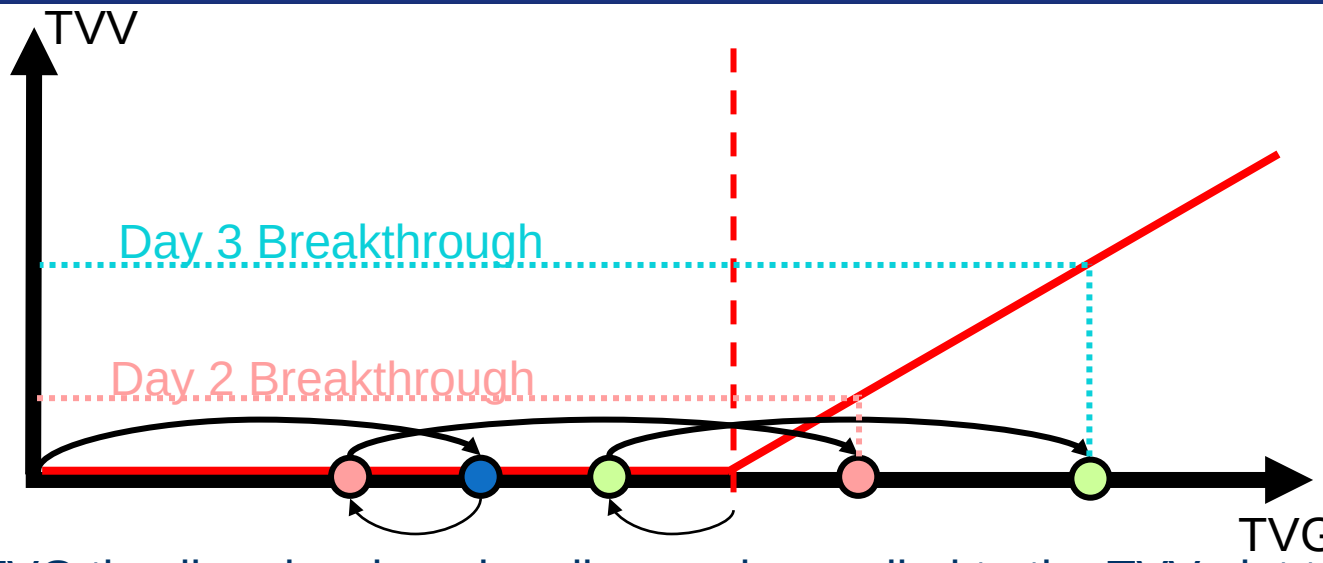
DELTA Methodology: TVV as a function of TVG



- Any vapor generated before the canister reaches capacity is captured; there is no TVV below canister capacity. (TVG < CC: TVV = 0)

- Vapor generated after the canister capacity is reached is completely vented to the environment; ie. all TVG after the canister is full becomes TVV (TVG > CC: TVV = TVG)

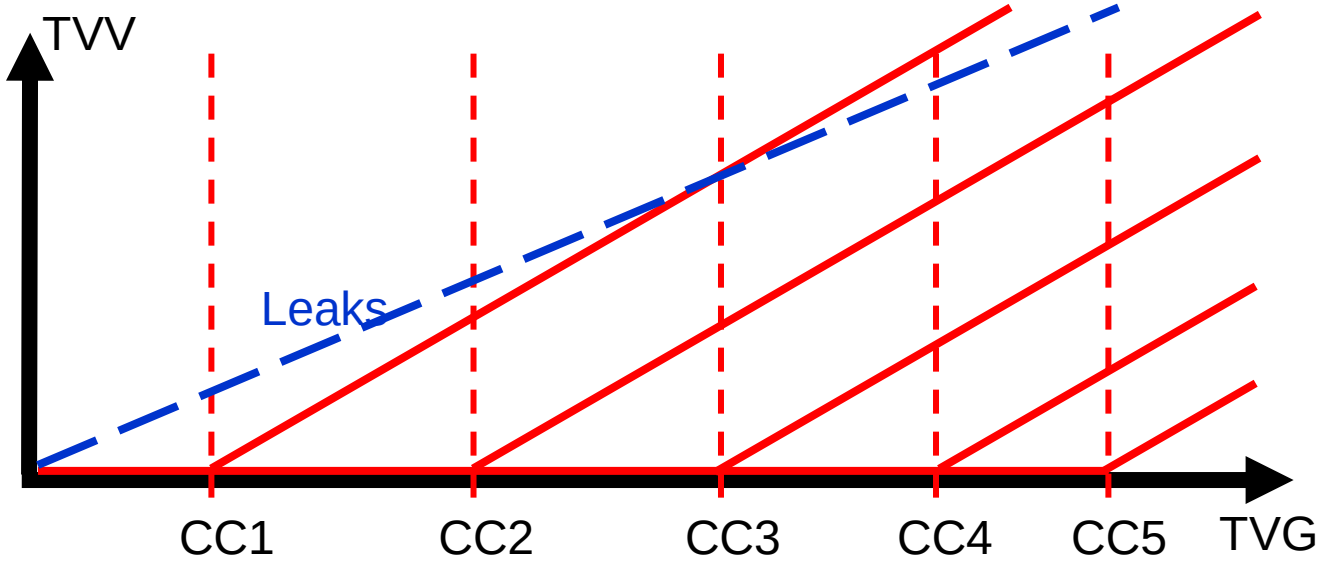
DELTA Methodology: Daily TVV using the TVG timeline



• The TVG timeline developed earlier can be applied to the TVV plot to determine the TVV per day

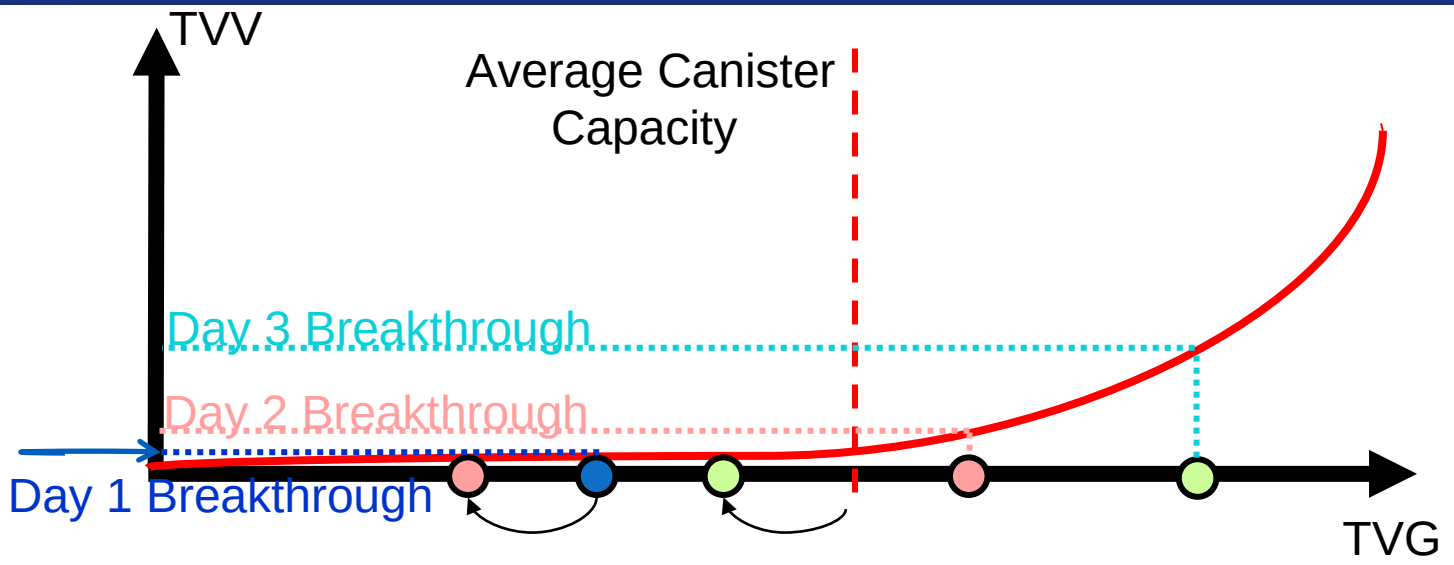
- Day 1: No TVV since all TVG is below the canister capacity
- Day 2: Total TVG has exceeded the canister capacity, some TVV occurs. Backpurge now starts from canister capacity.
- Day 3+: TVV has reached its maximum for this vehicle. Subsequent diurnals will also have the same TVV.

DELTA Methodology: Multiple Vehicles, Multiple TVG-TVV



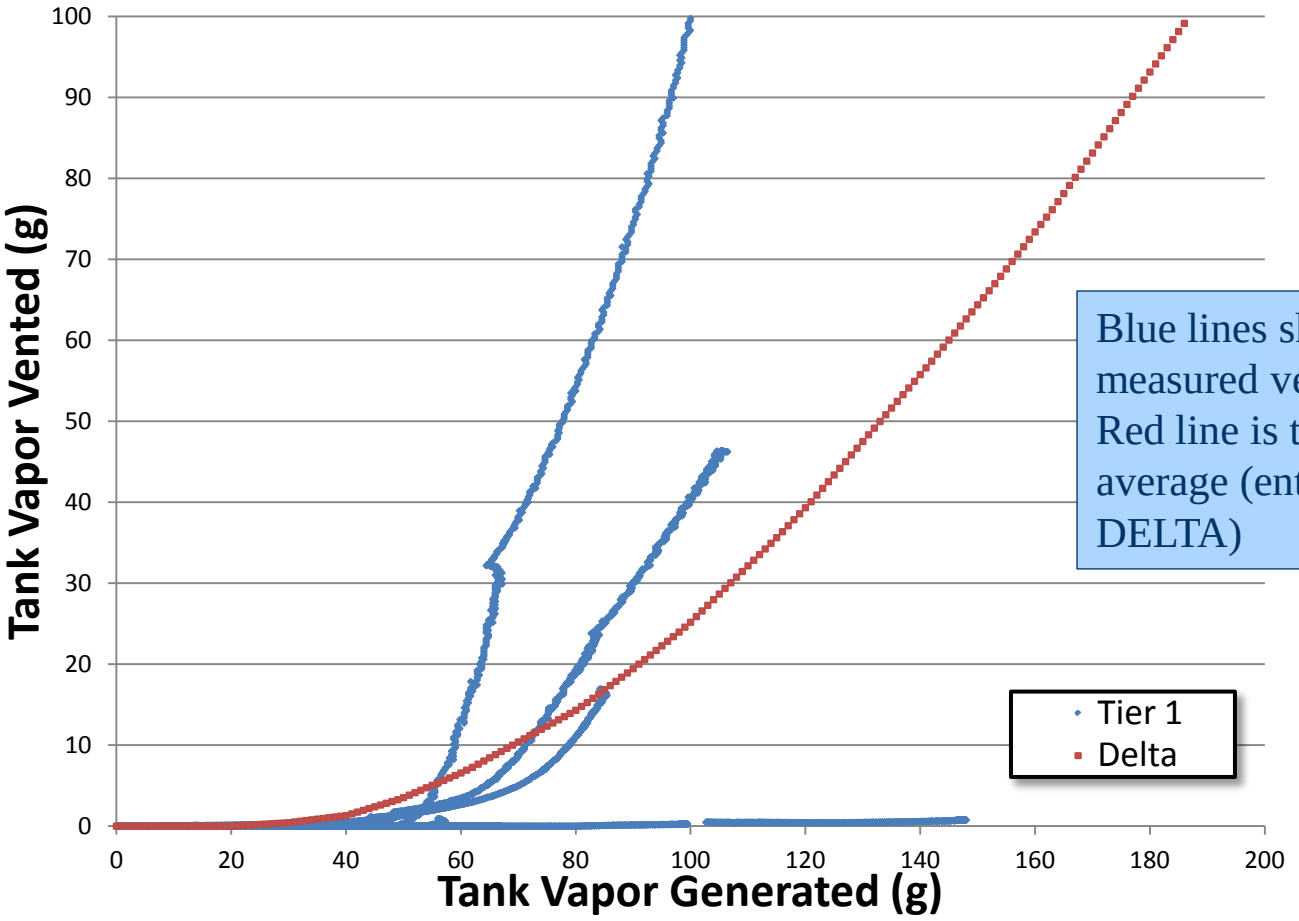
- Different models of vehicles have different canister capacities and therefore will have a different response to the amount of TVG. Some vehicles also leak, which adds to overall vapor venting to the environment.
- Canister capacities are based on the size of the tank in the vehicle as well as the inclusion/exclusion of ORVR etc… These features can vary even inside the same model year group (eg. truck vs. car).

DELTA Methodology: TVG-TVV in an average fleet



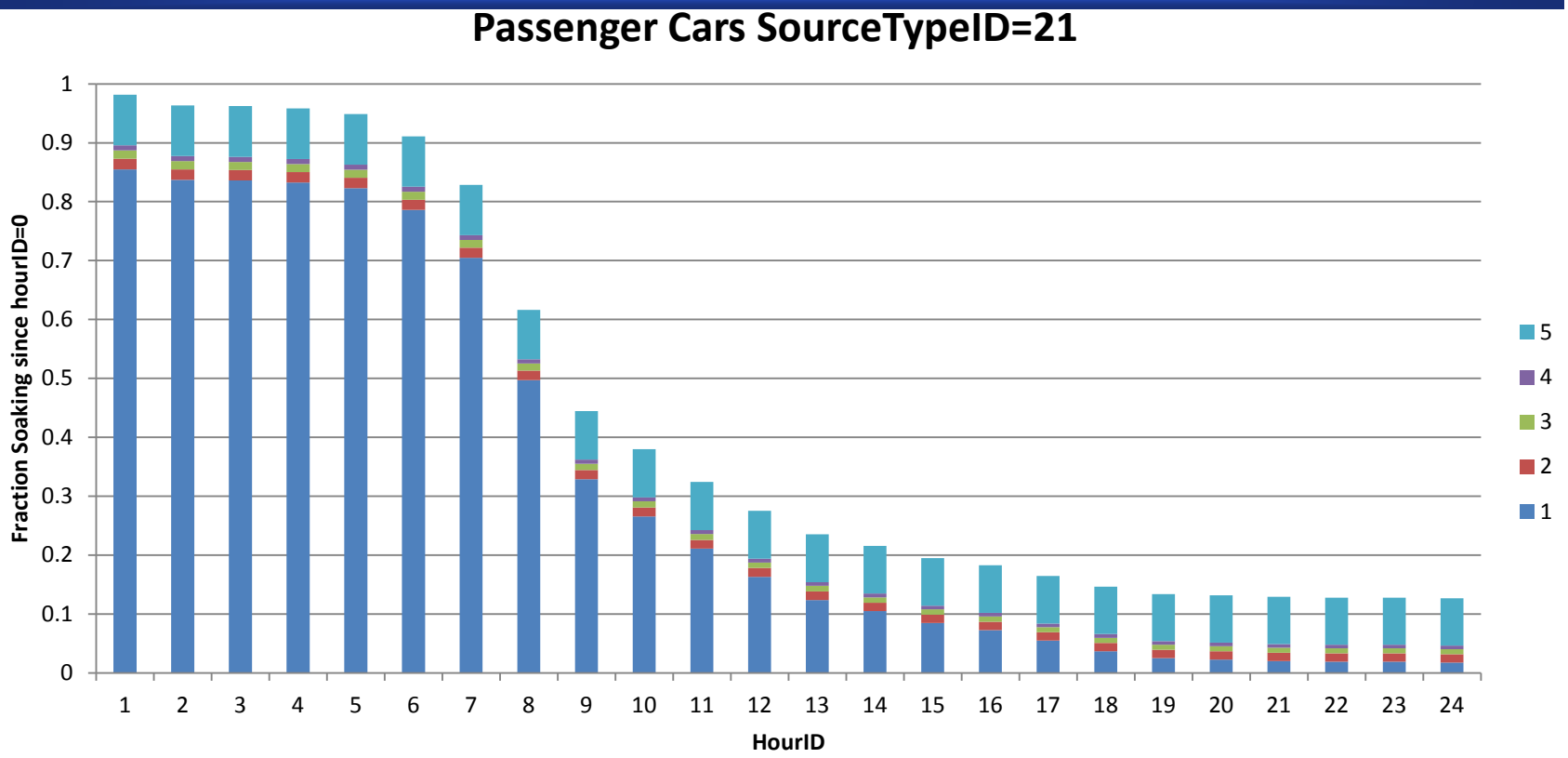
- Weighting the vehicles that comprise a model year group together, as well as leakers, generates a curved TVV plot. As more cars in the group break through, the curve becomes steeper.
- The average canister capacity represents where the average car in the fleet would begin to break through, as well as where it would backpurge from after its canister is full.

An example TVG- TVV curve, w/ E-77 testing 3-day soak results



Blue lines show measured vehicle data. Red line is their average (entered into DELTA)

Vehicle activity beyond three days



- Vehicle activity data based on 2006-2008 Georgia Tech activity study: ~300 households instrumented for ~ 1 year

DELTA Assumptions/Issues

- **Using average curves and canister capacities**
  - underestimates emissions for smaller vehicles and overestimates for larger vehicles
- **Canister adsorption is linear process**
  - Actual adsorption is not linear, some emissions will occur before 100% saturation (bleed emissions) and some capture can continue after saturation (hydrocarbon transfer)
- **All trips lead to complete canister purging**
  - Short trip patterns can cause incomplete canister regeneration, leading to shorter times before canister breakthrough during diurnals

More information about DELTA

- **The DELTA model will be built into the MOVES2013 code and database**
  - Model parameters are stored in the existing “cumTVVCoeffs” table
- **A peer-reviewed report on the DELTA model will be released soon**

Beyond MOVES2013: Super DELTA

- **Need for continued improvement to DELTA**
  - Evaporative process calculations require a significant portion of MOVES run time
  - Modeling cold soak on an individual vehicle level is not possible inside the MOVES model
- **Super DELTA will relocate evaporative calculations to a new tool outside the MOVES model**
  - Allows more complex calculations for cold soak, hot soak, permeation and running loss
  - Relieves MOVES model runs of long calculation steps involved with evaporative processes
  - MOVES will calculate Evap based on output from Super DELTA

MOVES

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Questions?