

Canister Degradation Study

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Canister Degradation Study

- ▶ Emission impacts large
- ▶ Evidence:
 - E-77 study saw breakthrough much earlier than design capacity
 - Indications from repair shops show evidence on many more compromised canisters
 - Top-down study says MOVES evap estimates too low
 - Texas A&M, Gunnar Schade report

Emissions Impacts

- ▶ Even 50% canister capacity is on the order of 100% vehicles with leaks
- ▶ 16 vehicles were randomly recruited in E-77
 - Enhanced evap vehicles showed **83%** canister capacity overall
 - Pre-enhanced evap vehicles showed **65%** canister capacity overall
 - Not clear if canister carbon condition or purge issue
 - **MOVES (DELTA Model) used E-77 to calibrate the real world working capacities**
 - Given the degree of influence more data is required to characterize the fleet

MOVES2014 Evap Case	HC per Vehicle (grams/day)
with addition of vapor leaks	3.0
Without addition of vapor leaks	2.0
100% of vehicles with vapor leaks	13.1
No Canister Capacity (for all vehicles)	24
50% Canister Capacity (of all vehicles)	12

Examples Found in Repair Shops



Three Part Study

- Test method development: Develop and evaluate tools to identify vehicles with elevated refueling emissions
 - Method 1 – for Study 1
 - Method 2 – for Study 2
- Study 1: Degraded canister frequency rates: Determine the frequency of degraded canisters in the field
- Study 2: Degraded canister emissions: Determine the emission rates of degraded canisters

EPA completed by contractor (ERG/SGS/HEAT) in 2014

ASD Canister Degradation Study Methods Development – Method 1



- ▶ EPA, with ERG, SGS, and HEAT, conducted a “sensor shoot out” in June 2014
 - Goal: Develop tools that could discern between emission levels of vehicles with functioning and non-functioning evaporative emissions canisters.
- ▶ Evaluated two different instruments
 - Different canister locations on vehicles
 - Ambient conditions – fuel spills and wind
- ▶ Proved methodology in controlled laboratory environment for larger field study
 - SGS Environmental Testing Corporation in Aurora, CO
- ▶ Outdoor tests to verify efficacy for field
- ▶ **Result: Both methods were useful and plausible ways of detecting elevated refueling vapor emissions**

Shootout Instruments

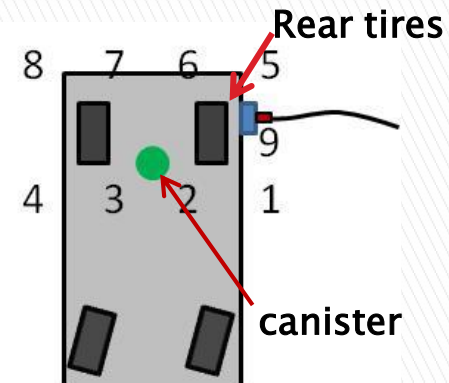
EDAR Infrared Laser

- ▶ Stuart Hager developed technology to detect GHG patterns from space
 - for NASA's ASCENDS satellite.
- ▶ LiDAR system uses principles of inelastic scattering of infrared to ultraviolet light.
 - Detects presence, relative concentrations and quantities of specific gases
 - Ranges of a few meters to even 100 meters (from 700K meters)
 - Measures CO₂, CO, NO_x, HC and PM opacity.
- ▶ Much more accurate than current remote sensing systems



Tiger HC Monitor

- Ion Science Photo-Ionization Detectors (PID) installed in handheld Ion Science Tiger HC monitors – refer to as “Tiger”
- PID uses a 10.6 electron-volt (eV) ultraviolet light to ionize HC molecules and generate ions. Measures the electric current produced by the ions.
- 9 units used , each uniquely numbered and placed in same location during study
 - 8 making a grid beneath vehicle
 - 1 at refueling nozzle



No vehicle, Fans off

No emissions seen

Figure A-1a. Run 1: No vehicle, Fans Off

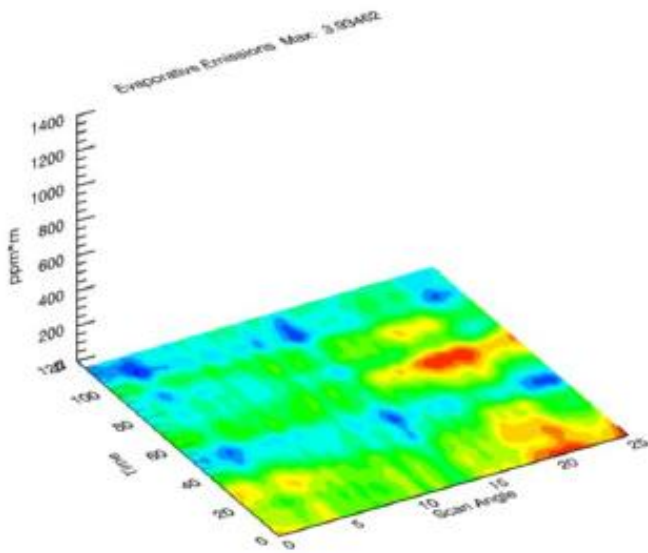


Figure A-1b. Run 1: No vehicle, Fans Off

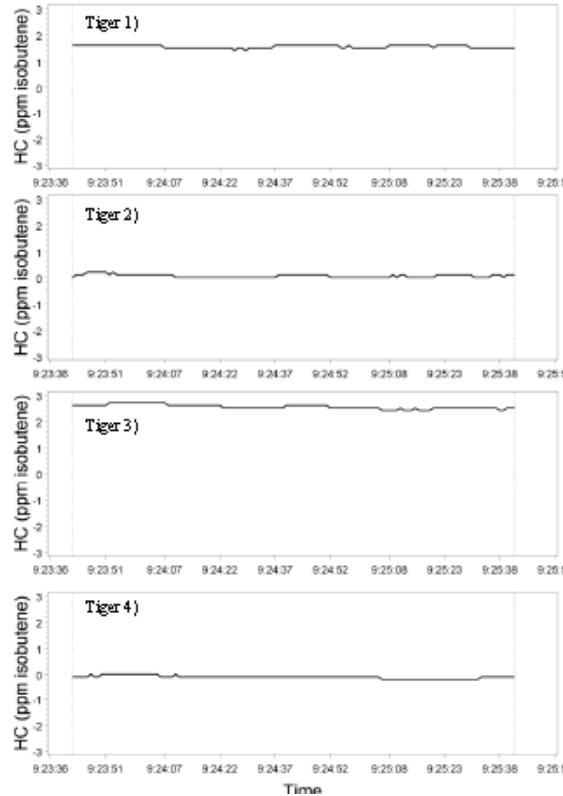
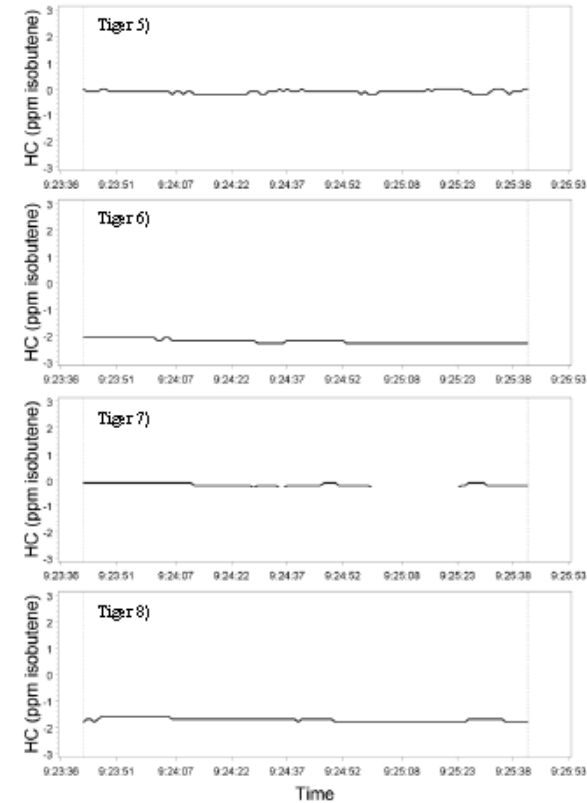
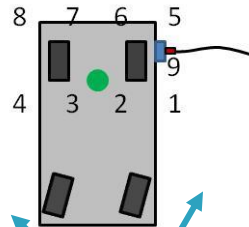


Figure A-1c. Run 1: No vehicle, Fans Off



EDAR



Tiger

EDAR beam

No vehicle, Fans off, Gasoline Mat

Figure A-2d. Run 2: No vehicle, Fans Off, 1 Gasoline Mat

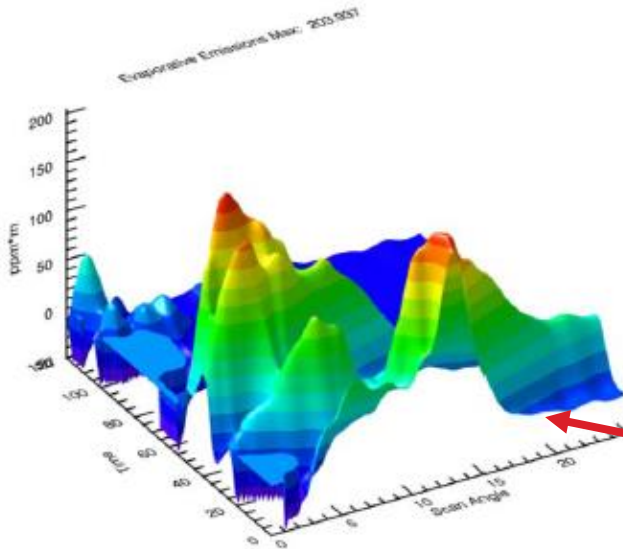


Figure A-2b. Run 2: No vehicle, Fans Off, 1 Gasoline Mat

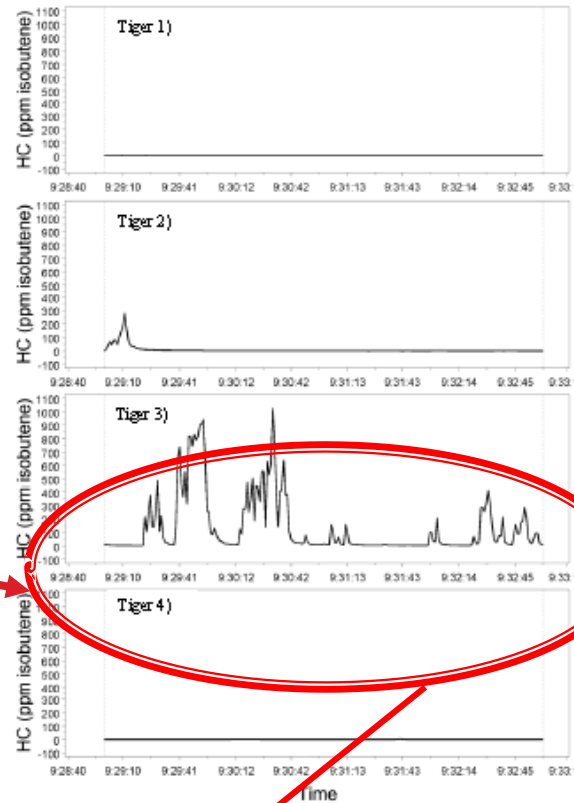
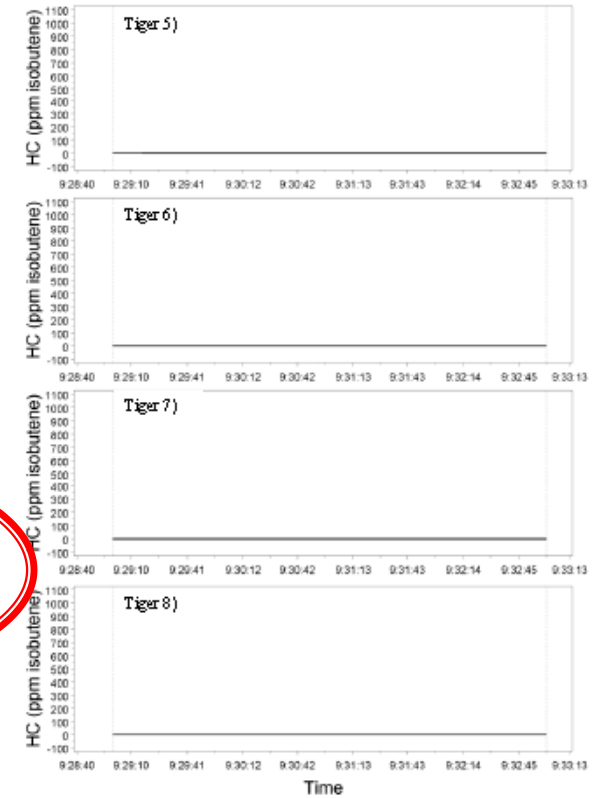
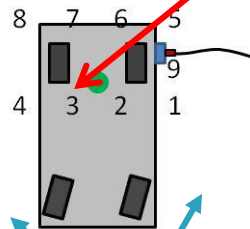


Figure A-2c. Run 2: No vehicle, Fans Off, 1 Gasoline Mat



EDAR

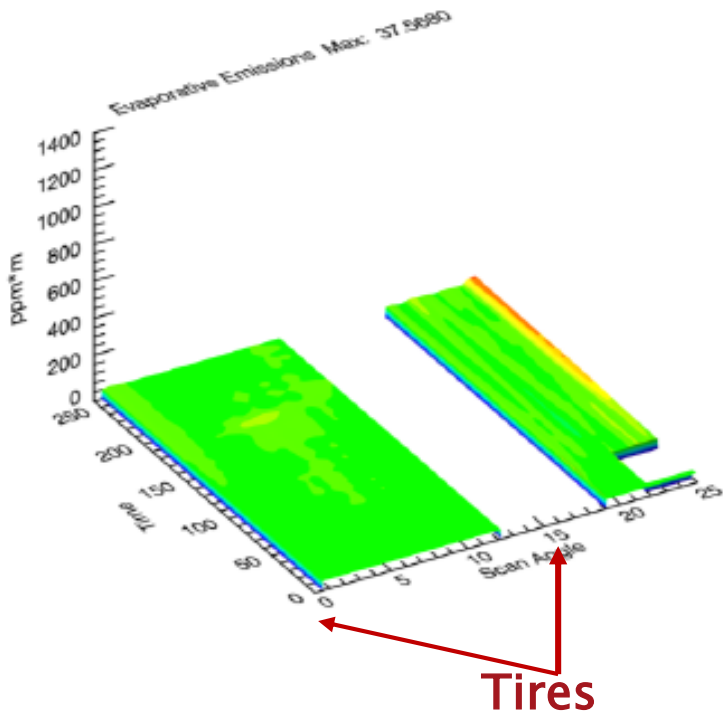
Tiger



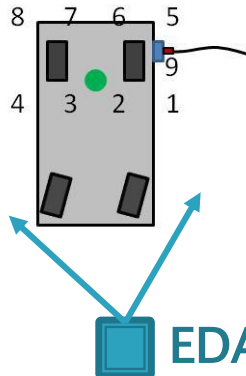
EDAR beam

Outlook, Purged Canister, Fans off

Figure A-4a. Run 28: Outlook (16.7 gal), Purged, Fans Off



EDAR



Tiger

Figure A-4b. Run 28: Outlook (16.7 gal), Purged, Fans Off

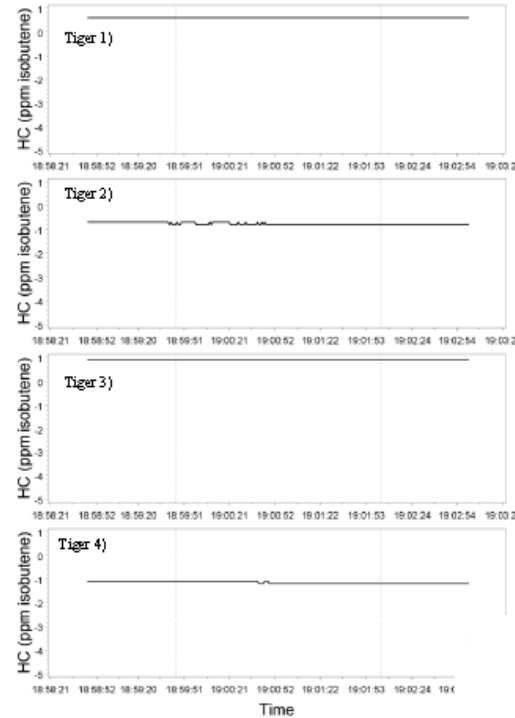
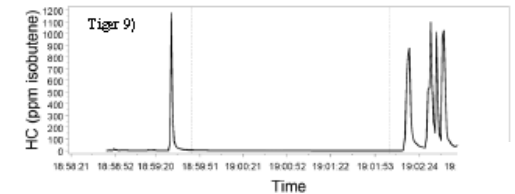
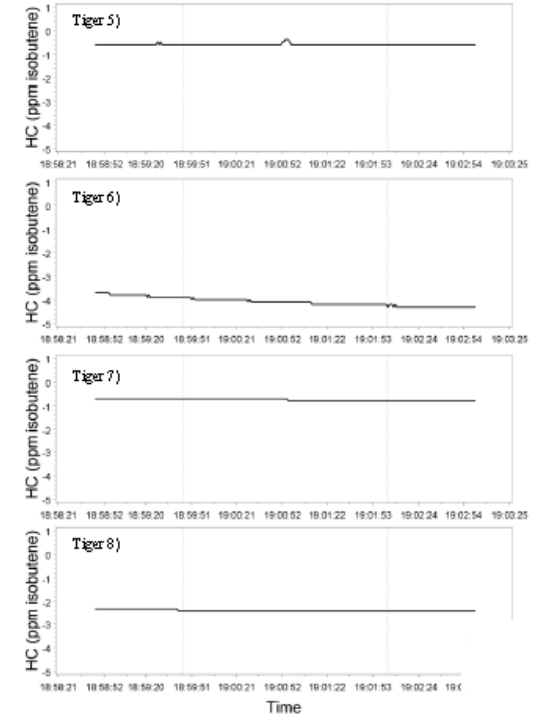
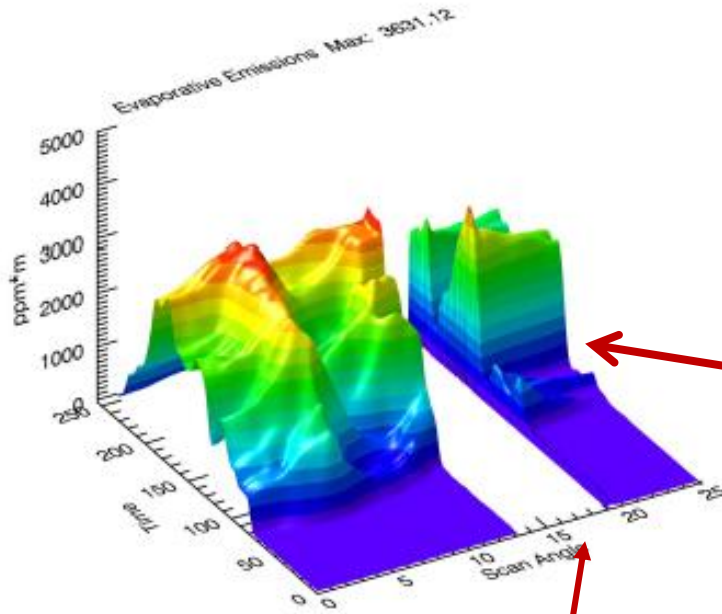


Figure A-4c. Run 28: Outlook (16.7 gal), Purged, Fans Off



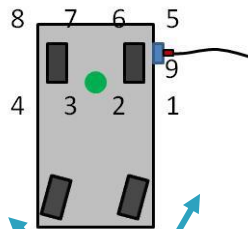
Outlook, Saturated Canister, Fans off

Figure A-5a. Run 8B: Outlook (17.0 gal), Saturated, Fans Off



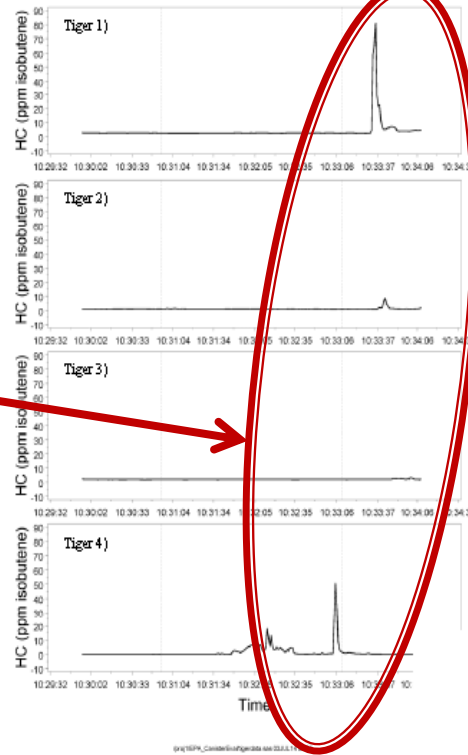
Tires

EDAR



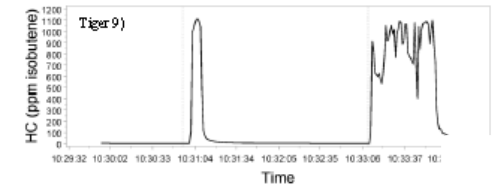
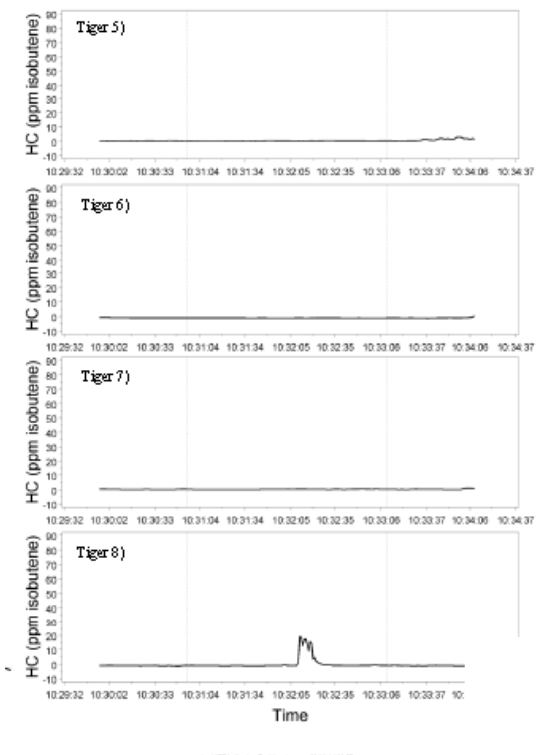
EDAR beam

Figure A-5b. Run 8B: Outlook (17.0 gal), Saturated, Fans Off



Tiger

Figure A-5c. Run 8B: Outlook (17.0 gal), Saturated, Fans Off



Outlook, Saturated Canister, Fans Low Transverse

Figure A-6d. Run 11: Outlook (16.8 gal), Saturated, Fans Low Transverse

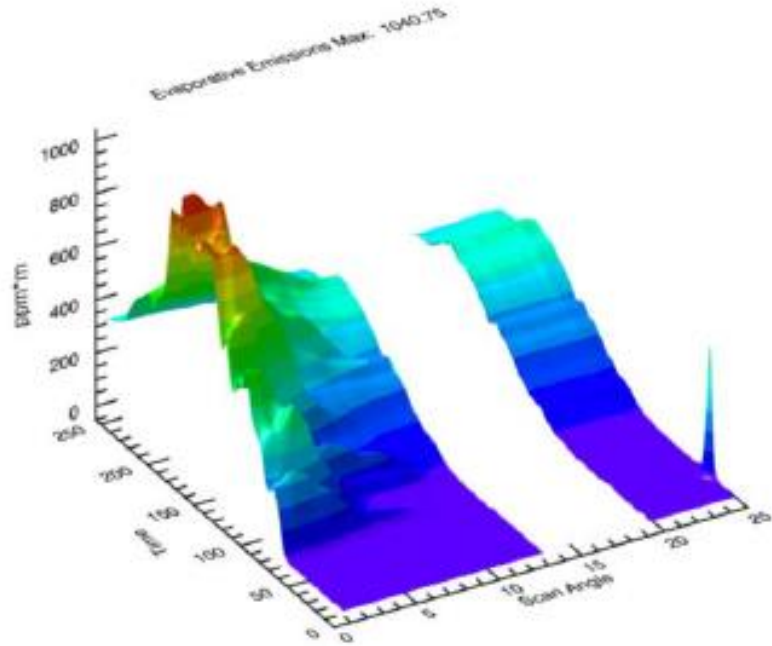


Figure A-6b. Run 11: Outlook (16.8 gal), Saturated, Fans Low Transverse

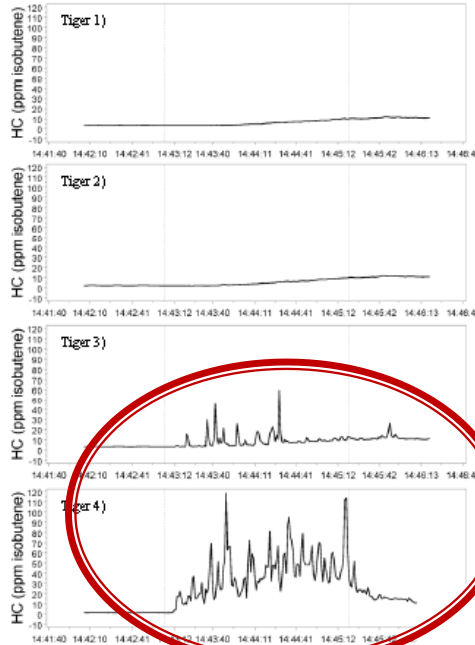
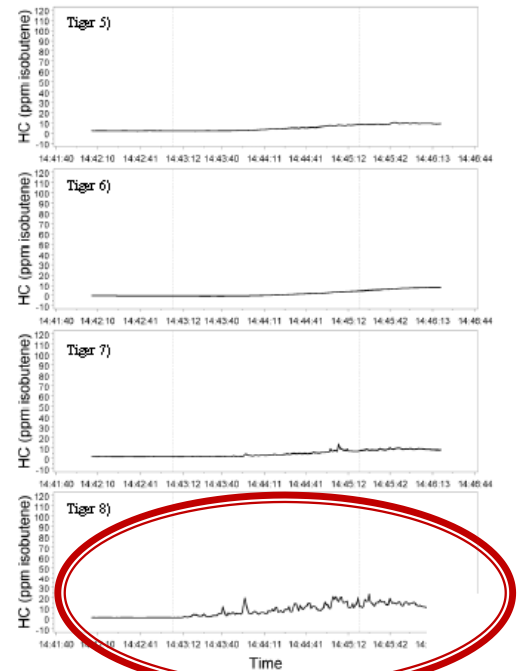
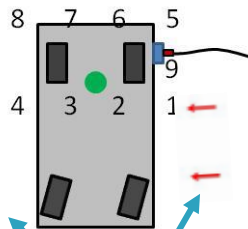


Figure A-6c. Run 11: Outlook (16.8 gal), Saturated, Fans Low Transverse



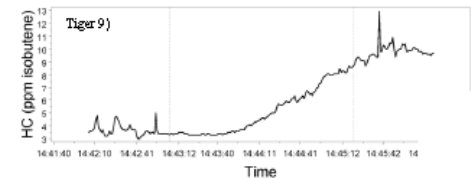
Both instruments picked up saturated canister in low wind condition

EDAR



Tiger

EDAR beam



Outlook, Saturated Canister, Fans Low Longitudinal

Figure A-7d. Run 9: Outlook (19.0 gal), Saturated, Fans Low Longitudinal

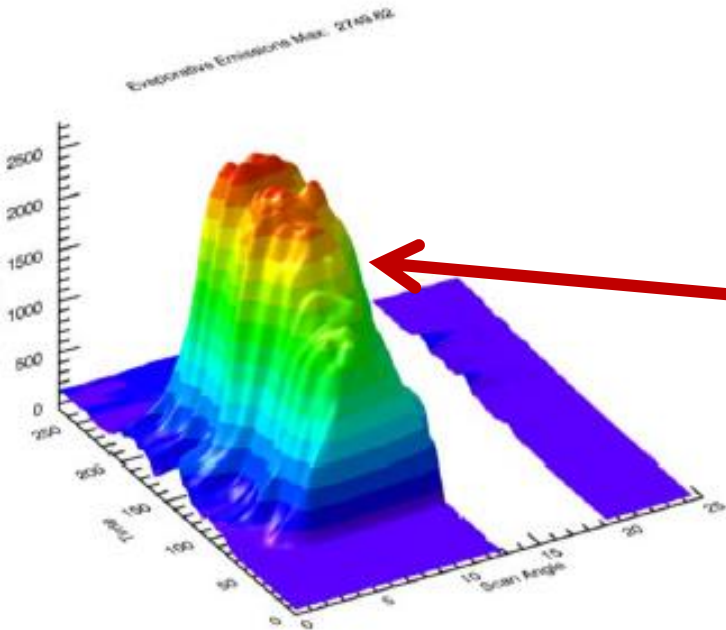


Figure A-7b. Run 9: Outlook (19.0 gal), Saturated, Fans Low Longitudinal

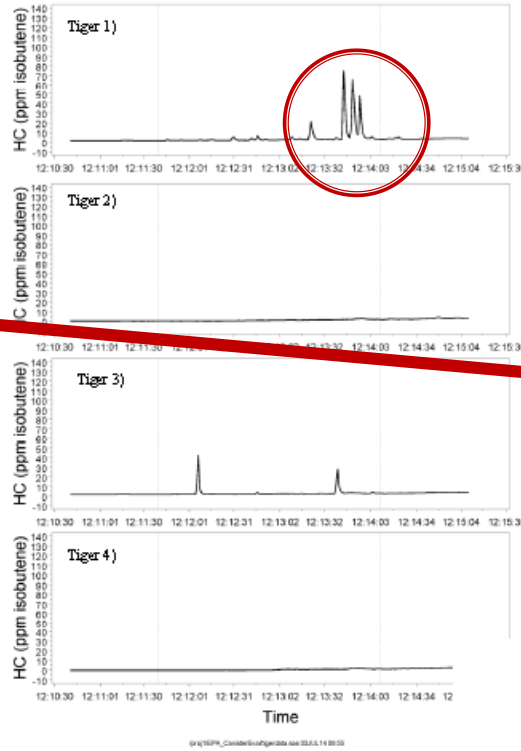
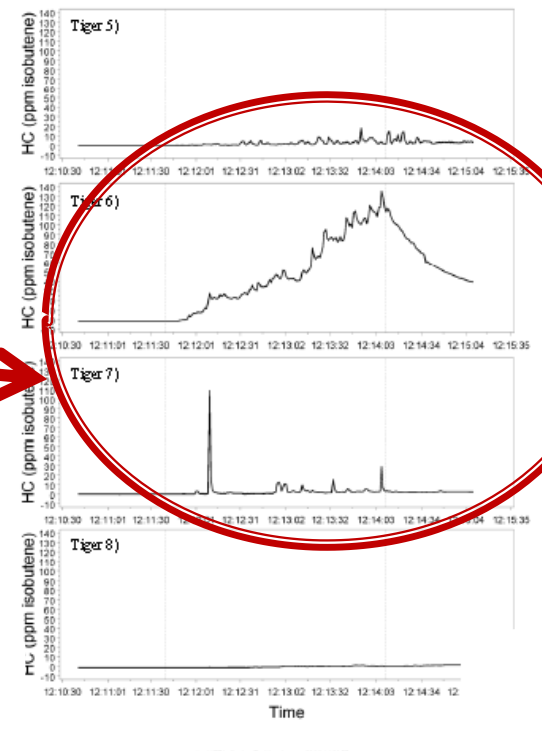
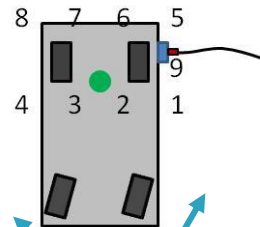


Figure A-7c. Run 9: Outlook (19.0 gal), Saturated, Fans Low Longitudinal

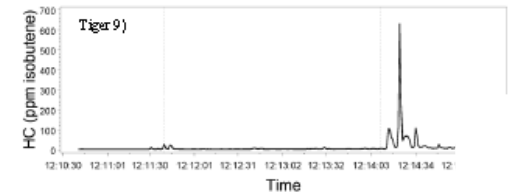


EDAR



Tiger

EDAR beam



Outlook, Saturated Canister, Fans Low Longitudinal

Figure A-9d. Run 13: Outlook (0.0 gal), Saturated, Fans Low Longitudinal, Dirty Background

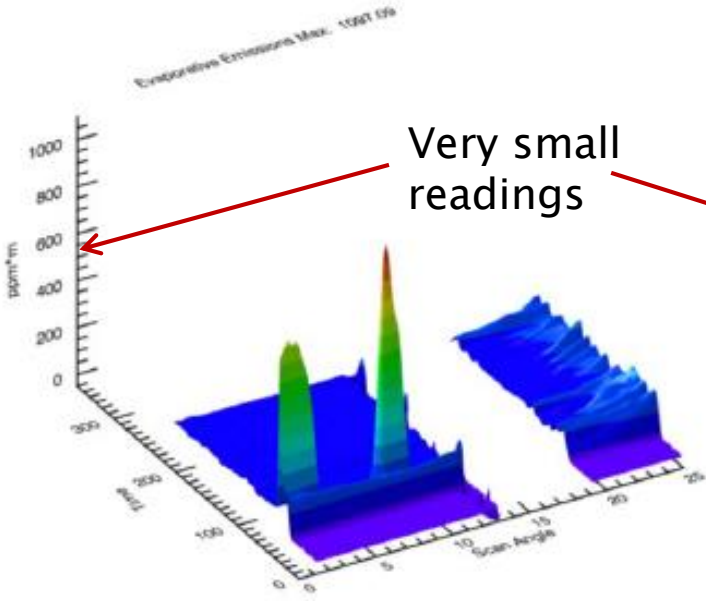


Figure A-9b. Run 13: Outlook (0.0 gal), Saturated, Fans Low Longitudinal, Dirty Background

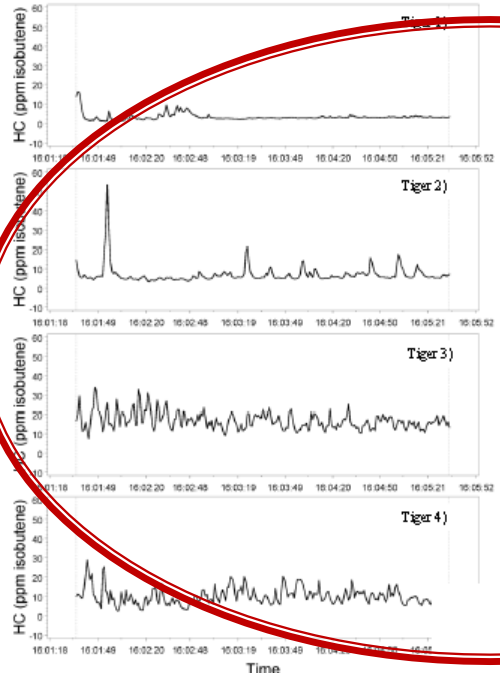
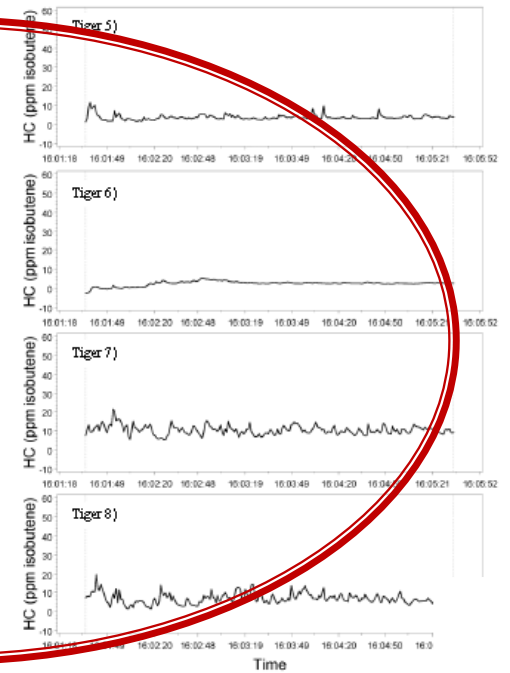
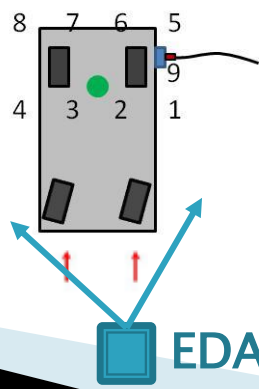


Figure A-9c. Run 13: Outlook (0.0 gal), Saturated, Fans Low Longitudinal, Dirty Background



Dirty background, No refueling event

EDAR

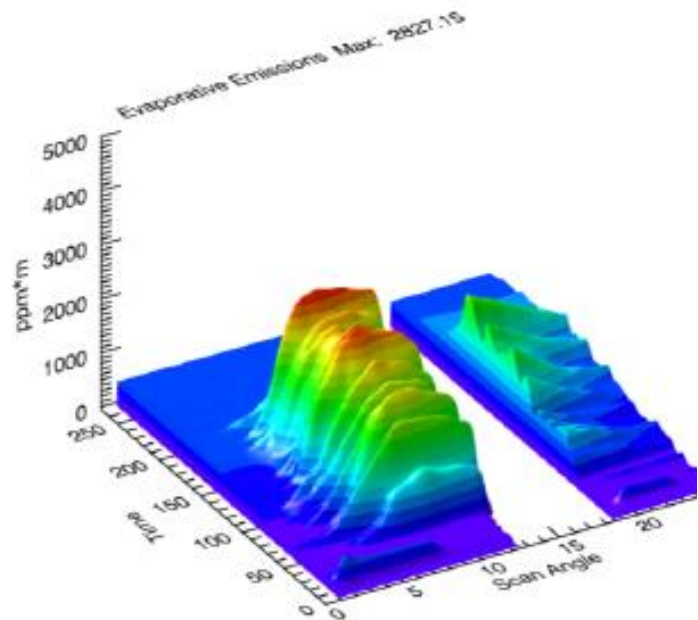


Tiger

All Tigers picked up a reading due to dirty background

Outlook, Saturated Canister, Fans Low Longitudinal

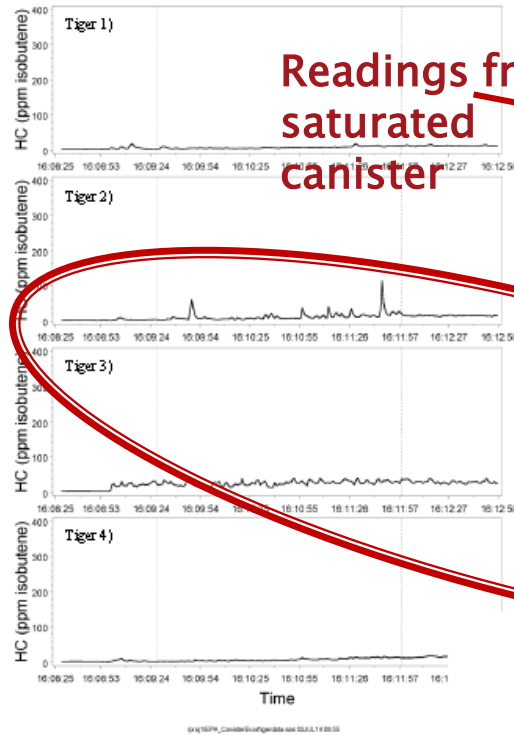
Figure A-10a. Run 14: Outlook (18.5 gal), Saturated, Fans Low Longitudinal Background



Refueling event
With Dirty background
Clear difference in emissions
level from dirty background
and saturated canister

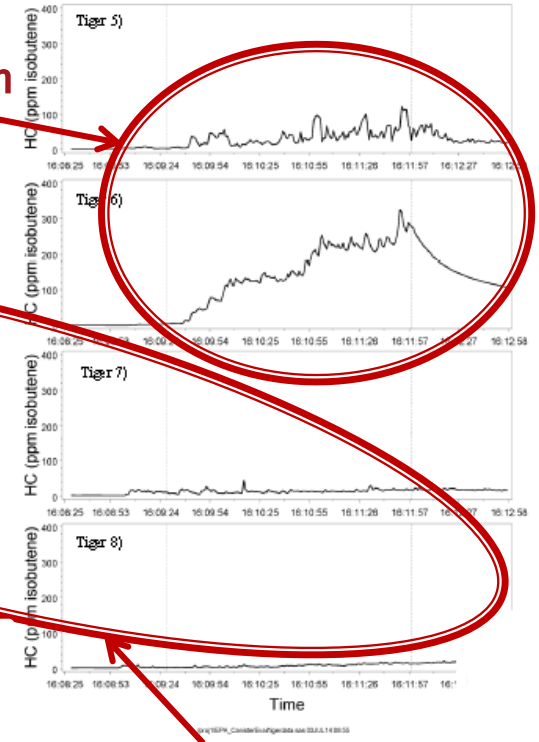
EDAR

Figure A-10b. Run 14: Outlook (18.5 gal), Saturated, Fans Low Longitudinal, Dirty Background

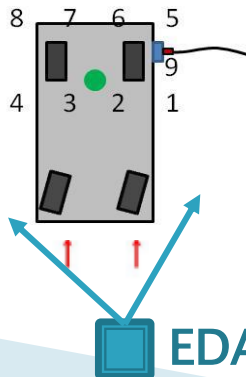


Readings from saturated canister

Figure A-10c. Run 14: Outlook (18.5 gal), Saturated, Fans Low Longitudinal, Dirty Background

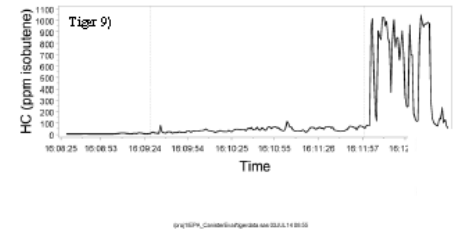


Readings from dirty background



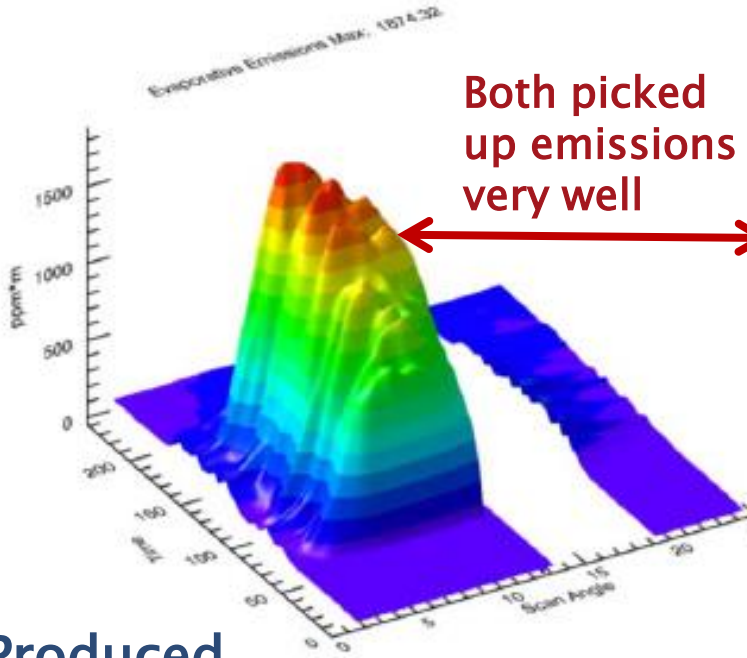
Tiger

EDAR beam



Outlook, Saturated Canister Outside

Figure A-11d. Run 52: Outlook (17.7 gal), Saturated, Outdoors



Both picked up emissions very well

Figure A-11b. Run 52: Outlook (17.7 gal), Saturated, Outdoors

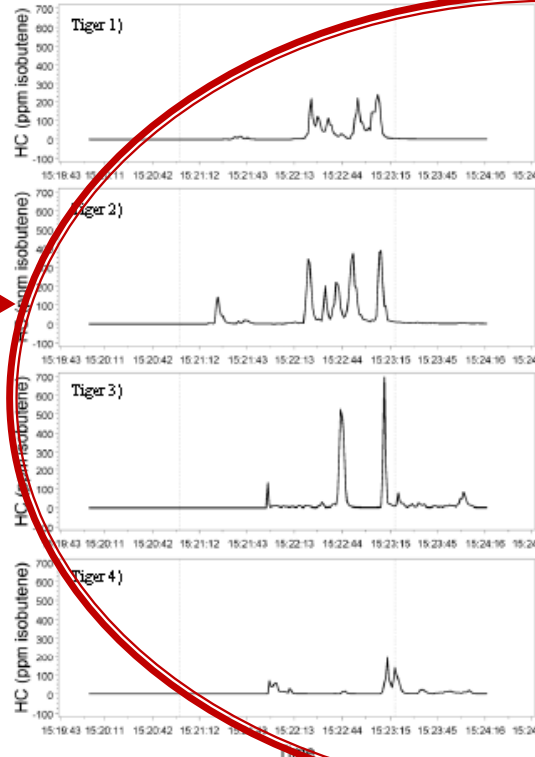
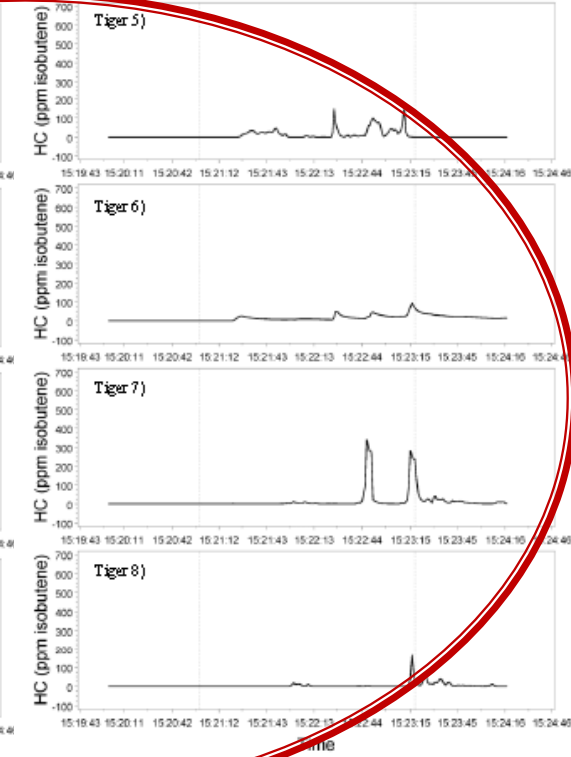
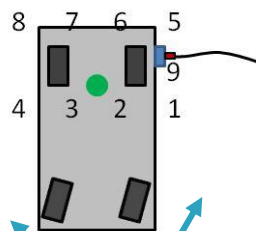


Figure A-11c. Run 52: Outlook (17.7 gal), Saturated, Outdoors



Produced comparable results outside as in lab



EDAR

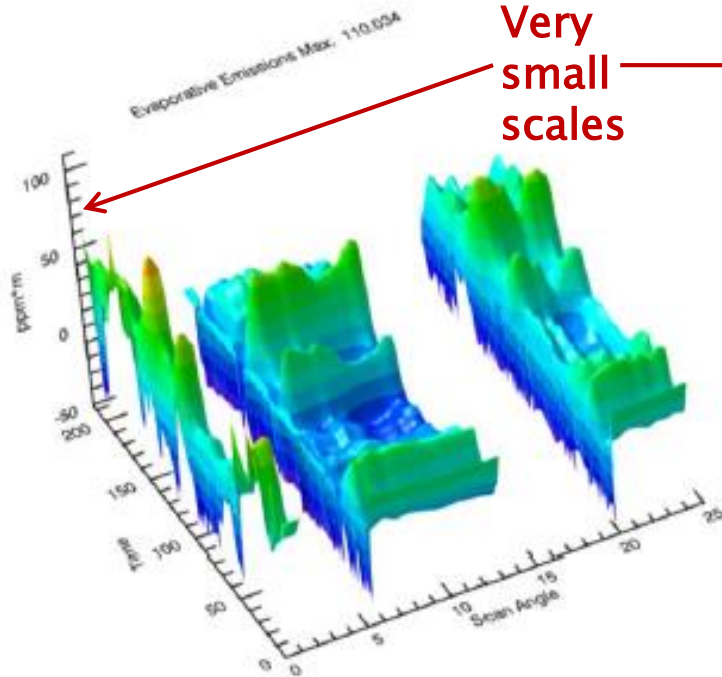
EDAR beam

Tiger



Focus, Purged Outside

Figure A-28d. Run 54: Focus (12.7 gal), Purged, Outdoors



Very small scales

Figure A-28b. Run 54: Focus (12.7 gal), Purged, Outdoors

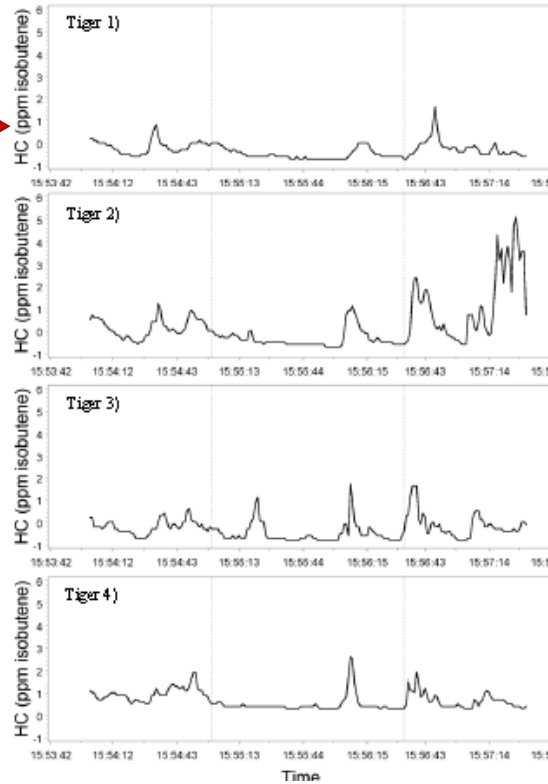
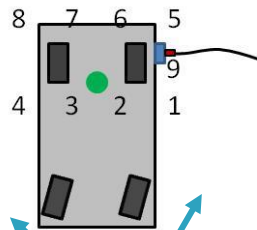
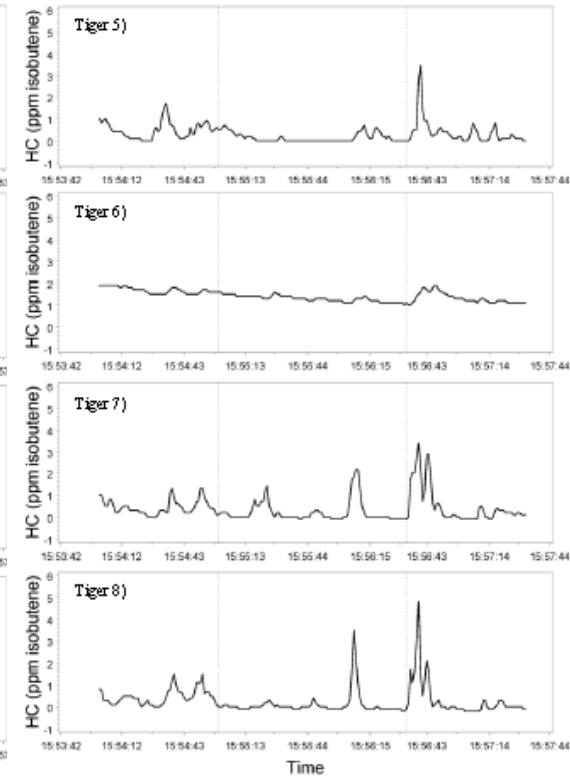


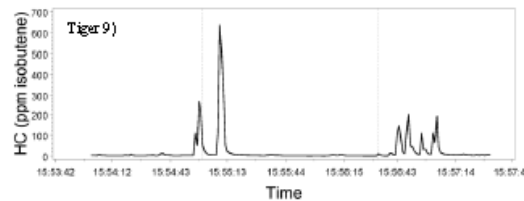
Figure A-28c. Run 54: Focus (12.7 gal), Purged, Outdoors



EDAR

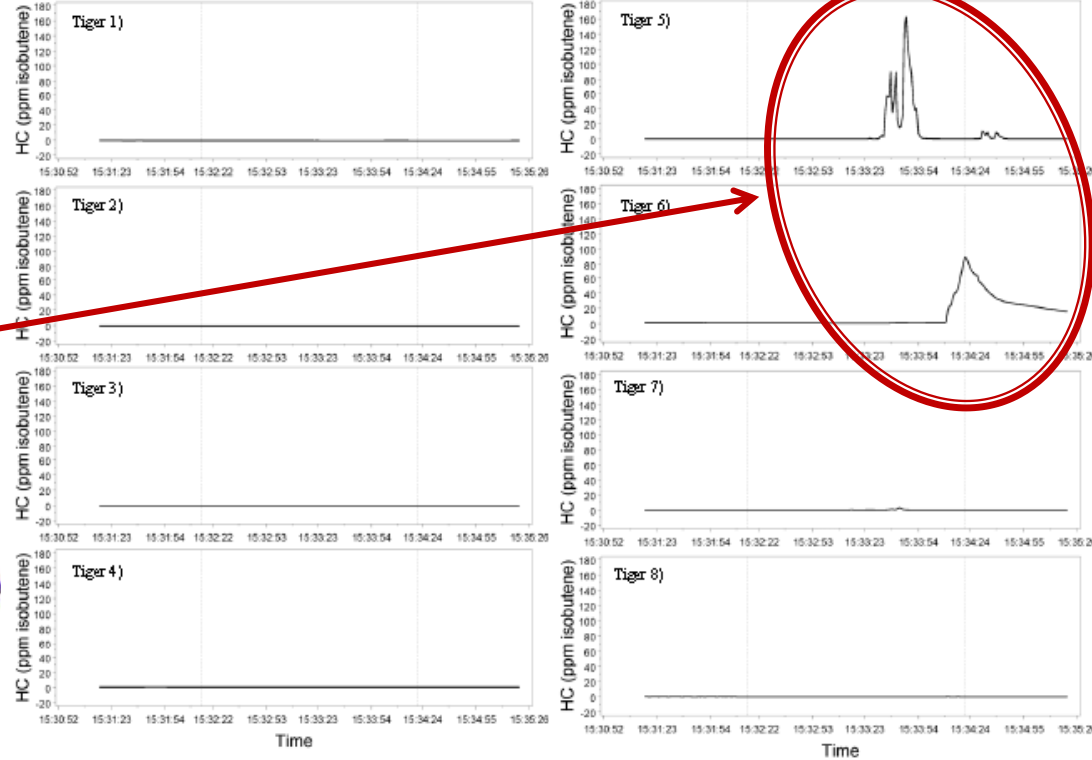
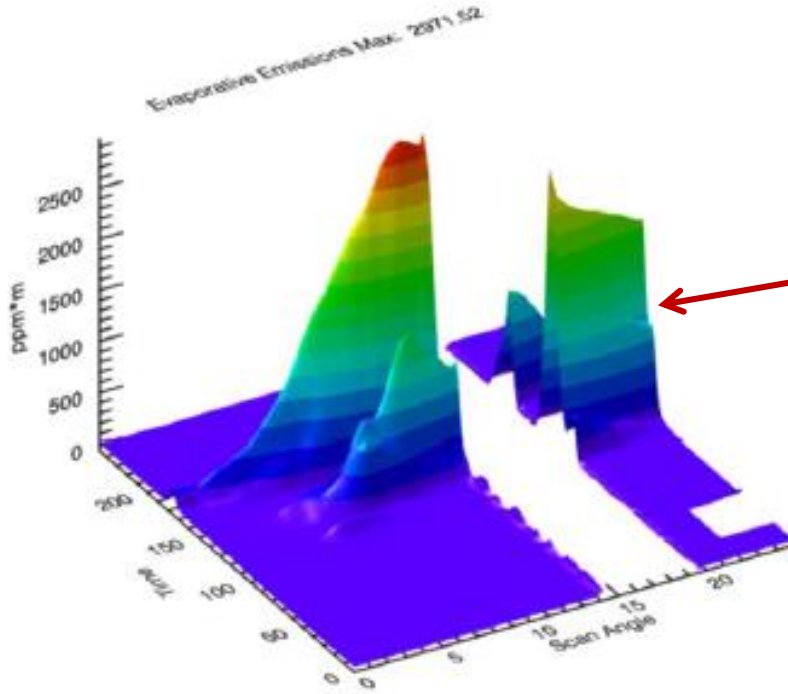
EDAR beam

Tiger

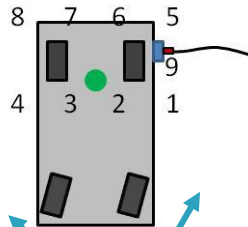


Wrangler, Saturated Outside

Figure A-17d. Run 53: Wrangler (17.3 gal), Saturated, Outdoors

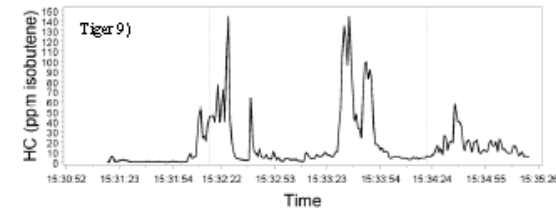


EDAR



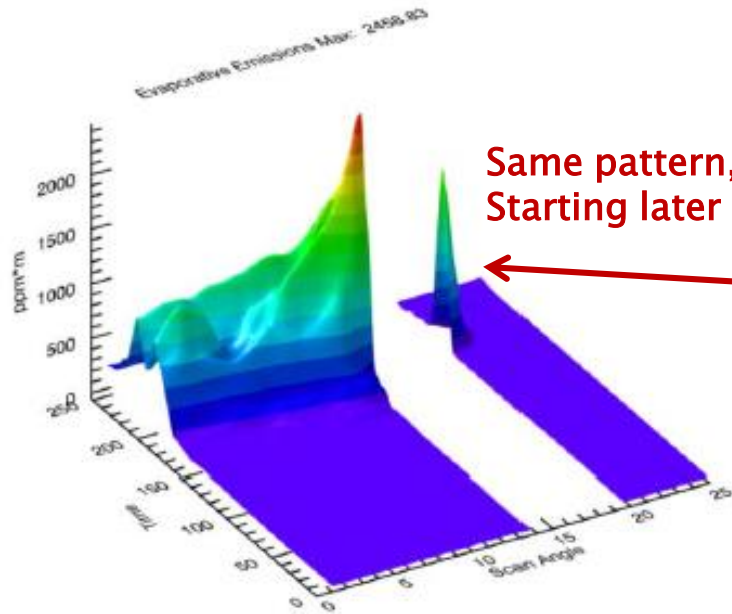
Tiger

EDAR beam

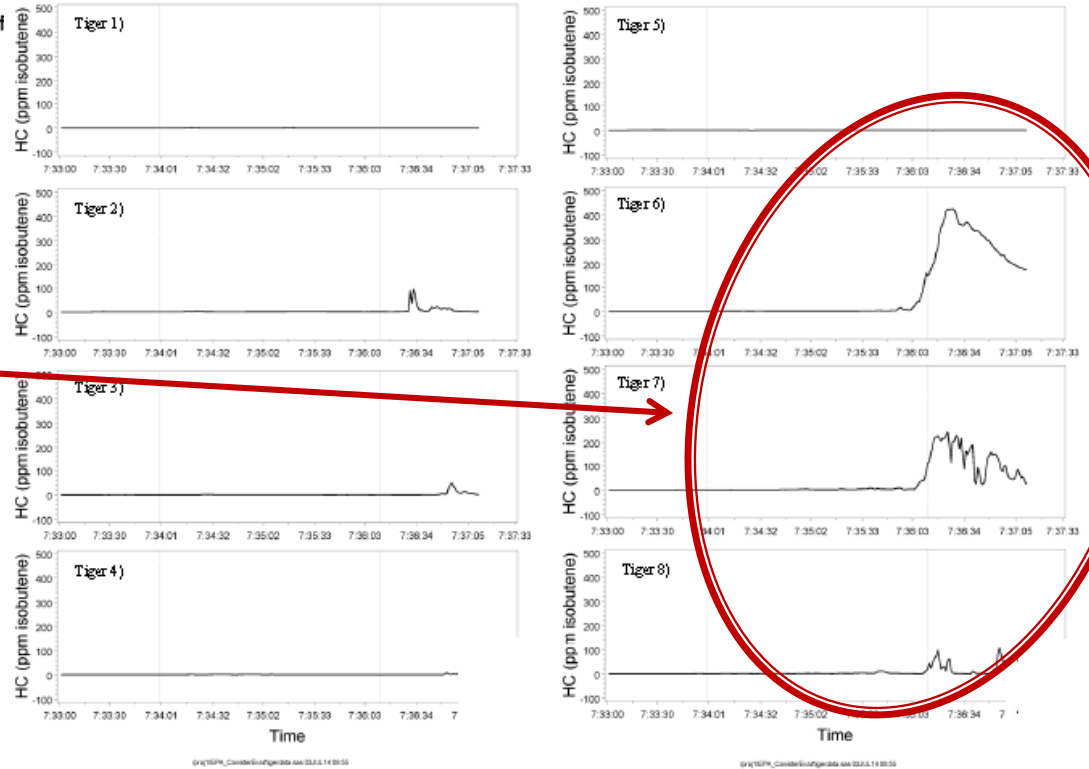


Wrangler, Partially Purged Outside

Figure A-30d. Run 27: Wrangler (17.4 gal), Suspected Partially Purged, Fans Off

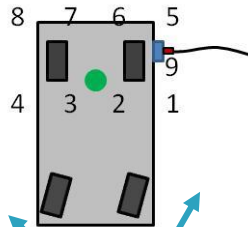


Same pattern,
Starting later



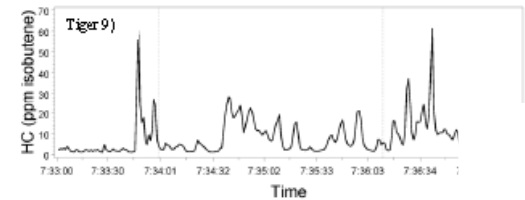
Both instruments
picked up partial
purged pattern

EDAR



EDAR beam

Tiger



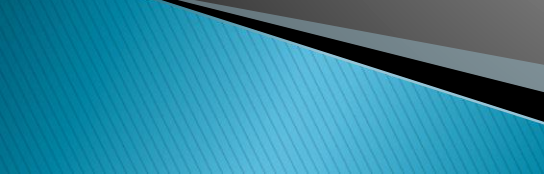
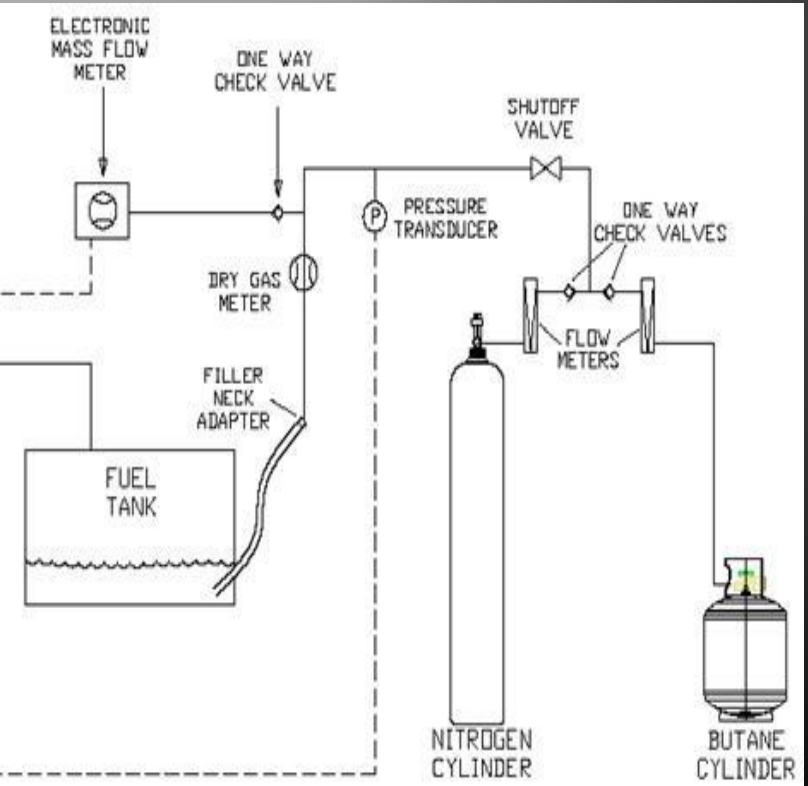
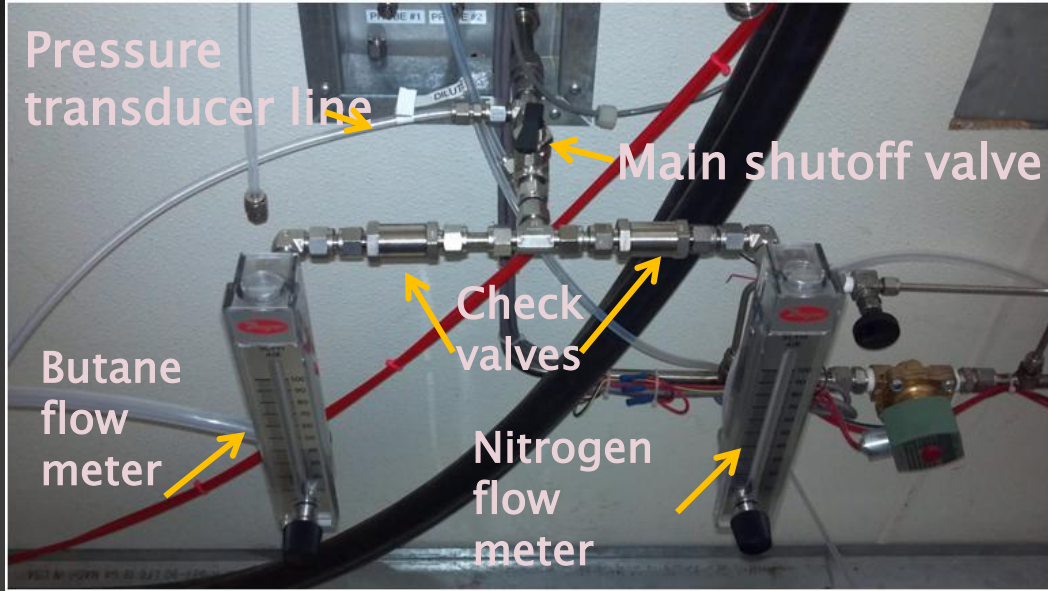
Methods Development – Method 2

- ▶ Purpose: To screen large numbers of canisters in the field to recruit problem canisters for further evaluation and emissions testing.
 - Step 1: Develop method for loading canisters in field that replicates refueling
 - Step 2: Develop method to detect canister breakthrough

Methodology for Loading Canisters in Field

Butane/Nitrogen Push Device

**Determined 50/50 blend
Of butane and nitrogen
optimal**



Choosing a Field Method

HC Monitor	Advantages	Disadvantages
Near canister vent	<ul style="list-style-type: none">•Fast response•More accurate if measure directly from canister vent	<ul style="list-style-type: none">•Difficult to find the vent location•Physical effort going under vehicles, jacking vehicles•May have to settle for “close enough”•Need a wind shield so HC can reach probe
Within enclosure	<ul style="list-style-type: none">•Blocks wind/ outside influences•More consistent	<ul style="list-style-type: none">•Need fans for rapid mixing and minimize time delay•Will also pick up leaks•Must physically handle enclosure

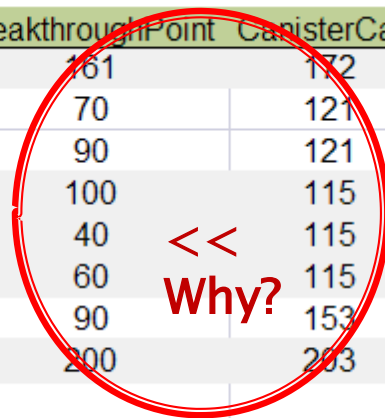
Next Steps

- ▶ Our next step is to develop a test program to determine the frequency of degraded canisters in the field
- ▶ Look at in-use canister capacities:
 - Different parts of country
 - Weather / temp conditions
- ▶ Contamination Types:
 - Dust, salt, sand, fuel, water, bumpy roads (crumbles carbon)
- ▶ We are seeking partners to coordinate with us to conduct a field study at a gas station where we would measure the refueling emissions of hundreds of vehicles
- ▶ Questions or comments, contact me:
 - Connie Hart hart.connie@epa.gov

Extra slides

CRC E-77-2 Programs: Breakthrough Point vs. Canister Capacity

Tier 2								Weather		
testNo	vehNo	rvp	BreakthroughPoint	CanisterCap	Diff	PercentCap	highTemp	lowTemp	dT	
7059	212	10	161	172	-11.05	93.58%	91	77	14	
7252	211	9	70	121	-50.9	57.90%	105	78	27	
7170	211	10	90	121	-30.9	74.44%	68	42	26	
7531	210	9	100	115	-15.32	86.72%	86	57	29	
7462	210	10	40	115	-75.32	34.69%	82	57	25	
7725	210	9	60	115	-55.32	52.03%	78	62	16	
7229	215	9	90	153	-63.45	58.65%	73	59	14	
7429	213	10	200	203	-2.74	98.65%	55	37	18	
						75.25%				
Tier 2 (Did not Breakthrough over 3-day Diurnal)								Weather		
TestNo	VehNo	rvp	Vapor Generated	CanisterCap	Diff	PercentCap	highTemp	lowTemp	dT	
7099	212	9	135	172	-37.05	78.47%	57	39	18	
7197	212	9	139	172	-33.05	80.79%	80	51	29	
7516	213	9	222	203	19.26	109.50%	84	60	24	
7803	213	9	237	203	34.26	116.90%	64	42	22	
7142	215	10	171	153	17.55	111.44%	51	33	18	
						99.42%				
Very small Vapor Emissions beyond breakthrough point when compared to amount Generated (Bleed?)										



83% of canister design capacity over all Tier 2 vehicles (enhanced evap) in study

65% of design capacity over all pre-enhanced evap vehicles in study

In some vehicles, **canisters** are breaking through much sooner than capacity

- Real world driving?
- Canister degradation?

EDAR Compared to RSD

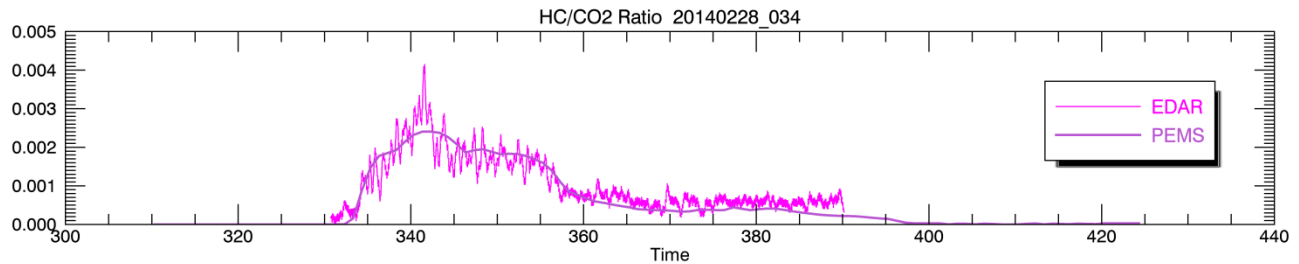
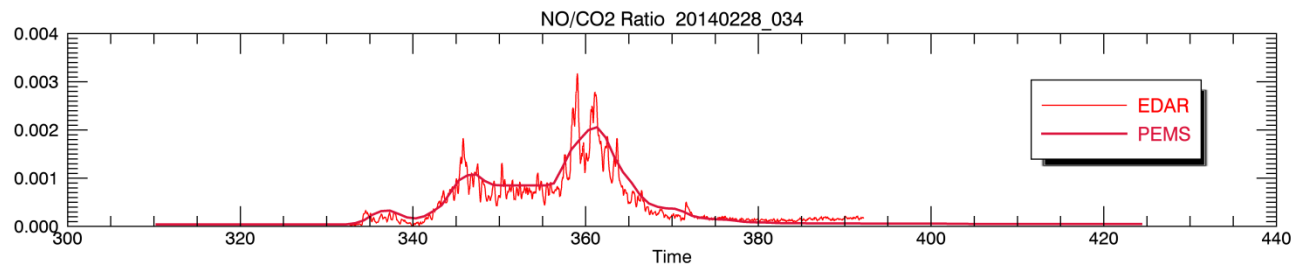
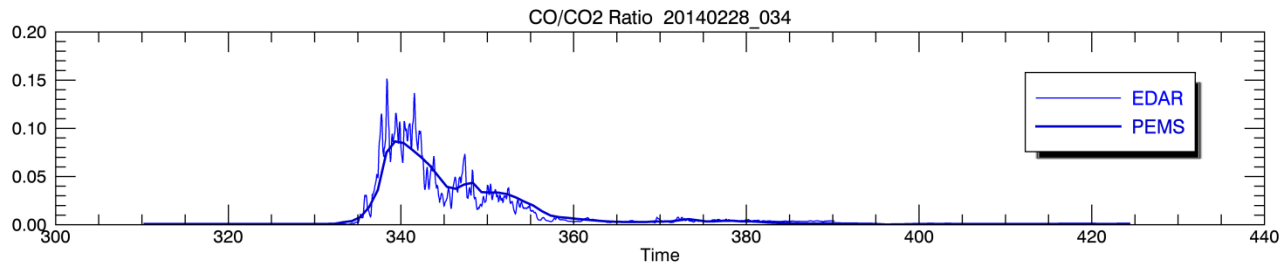
Technical	EDAR	NDIR
Reading Entire Plume (512 pixels per scan)	YES	NO
Multi spectral 3D imaging of entire exhaust plume	YES	NO
Single read validation per vehicle	YES	NO
Sampling rate	20,000 HZ	100 HZ
Periodic Equipment calibration NOT required	YES	NO
Utilizes laser technology vs. filter based technology	YES	NO

Operational	EDAR	NDIR
Unmanned System	YES	NO
Multilane capable	YES	NO
Operates 24/7	YES	NO
Operates in rain	NO	NO
Operates in windy conditions	<= 25 mph	<u>unknown</u>
Vehicle speed range	0-55 MPH	<u>unknown</u>
Small footprint/single pole solution	YES	NO
Same footprint for heavy-duty and light-duty traffic	YES	NO
Tailpipe readings regardless of physical location	YES	NO

NDIR – Non-dispersive infrared, current remote sensing technology (RSD)

EDAR system orders of magnitude above NDIR in capabilities

EDAR Compared to PEMS



Shootout Test Matrix

Run No.	Vehicle	Canister Loading	Laser Sweep	Fan Speed	Fan Direction with respect to vehicle	Air Speed (ft/min)	Background	Test Action	Fueling Volume (gal)	Date	Fueling Start Time
1	--	--	Horiz	Off	--	0	Clean	Background	0	6/25/2014	9:23:42
2	--	--	Horiz	Off	--	0	Dirty	Drops on 1 mat	0	6/25/2014	9:29:00
2B	--	--	Horiz	Off	--	0	Dirty	Drops on 4 mats	0	6/25/2014	9:37:06
28	Outlook	Purged	Horiz	Off	--	0	Clean	Fueling	16.7	6/25/2014	18:59:45
8B	Outlook	Saturated	Horiz	Off	--	0	Clean	Fueling	17.0	6/25/2014	10:30:55
11	Outlook	Saturated	Horiz	Low	Transverse	150-250	Clean	Fueling	16.8	6/25/2014	14:43:05
9	Outlook	Saturated	Horiz	Low	Longitudinal	200-300	Clean	Fueling	19.0	6/25/2014	12:11:40
10	Outlook	Saturated	Horiz	High	Longitudinal	400-450	Clean	Fueling	15.0	6/25/2014	13:44:25
13	Outlook	Saturated	Horiz	Low	Longitudinal	200-300	Dirty	Background	0	6/25/2014	16:01:35
14	Outlook	Saturated	Horiz	Low	Longitudinal	200-300	Dirty	Fueling	18.5	6/25/2014	16:09:28
52	Outlook	Saturated	Horiz	--	Outdoors	<40-200	Clean	Fueling	17.7	6/26/2014	15:21:00
27B	Wrangler	Purged	Horiz	Off	--	0	Clean	Fueling	17.0	6/26/2014	8:55:55
3B	Wrangler	Saturated	Horiz	Off	--	0	Clean	Fueling	15.0	6/25/2014	16:47:25
6	Wrangler	Saturated	Horiz	Low	Transverse	150-250	Clean	Fueling	17.1	6/25/2014	18:32:34
4	Wrangler	Saturated	Horiz	Low	Longitudinal	200-300	Clean	Fueling	15.1	6/25/2014	17:27:00
5	Wrangler	Saturated	Horiz	High	Longitudinal	500-600	Clean	Fueling	17.4	6/25/2014	18:03:00
53	Wrangler	Saturated	Horiz	--	Outdoors	<40-200	Clean	Fueling	17.3	6/26/2014	15:32:15
29B	Focus	Purged	Horiz	Off	--	0	Clean	Fueling	12.5	6/26/2014	14:11:45
15	Focus	Saturated	Horiz	Off	--	0	Clean	Fueling	10.8	6/25/2014	10:59:30
18	Focus	Saturated	Horiz	Low	Transverse	150-250	Clean	Fueling	10.4	6/25/2014	15:04:10
16	Focus	Saturated	Horiz	Low	Longitudinal	200-300	Clean	Fueling	12.3	6/25/2014	13:25:20
17	Focus	Saturated	Horiz	High	Longitudinal	400-450	Clean	Fueling	11.7	6/25/2014	14:04:57
44	Focus	Purged	Vert	Off	--	0	Clean	Fueling	12.4	6/26/2014	11:57:00
20	Focus	Saturated	Vert	Off	--	0	Clean	Fueling	11.1	6/26/2014	9:43:20
23	Focus	Saturated	Vert	Low	Transverse	150-250	Clean	Fueling	12.8	6/26/2014	10:15:15
21	Focus	Saturated	Vert	Low	Longitudinal	200-300	Clean	Fueling	12.2	6/26/2014	10:45:30
22	Focus	Saturated	Vert	High	Longitudinal	400-450	Clean	Fueling	12.5	6/26/2014	11:10:00
54	Focus	Purged	Horiz	--	Outdoors	<40-200	Dirty	Fueling	12.7	6/26/2014	15:55:00
3	Wrangler	Saturated ?	Horiz	Off	--	0	Clean	Fueling	16.0	6/25/2014	11:24:00
27	Wrangler	Purged ?	Horiz	Off	--	0	Clean	Fueling	17.4	6/26/2014	7:34:00
29	Focus	Purged ?	Horiz	Off	--	0	Clean	Fueling	12.6	6/26/2014	13:30:15