DRAFT

Enhanced Vapor Recovery Emissions Quantification

The vapor recovery system (VRS) at a gasoline dispensing facility (GDF) is subject to many factors which may affect its emissions. The purpose of this appendix is to present the assumptions and calculations regarding quantification of emissions at service stations or GDF which are being used to support the proposed changes to the vapor recovery progam.

The proposed changes include Onboard Refueling Vapor Recovery Compatibility (ORVRC), In-Station Diagnostics (ISD) and other Program Improvements (PI). All three of these components constitute the proposed "Enhanced Vapor Recovery" (EVR) program.

Emissions have been estimated for the following four cases:

(1) Baseline; No Onboard Refueling Vapor Recovery (ORVR) Vehicles (1995 Emission Inventory)
(2) Year 2007, 50% ORVR Penetration; without ORVRC, ISD, and PI
(3) Year 2007, 50% ORVR Penetration; with ORVRC and without ISD and PI
(4) Year 2007, 50% ORVR Penetration; with ORVRC, ISD, and PI

Estimates for Four Cases

(1) Baseline, No ORVR Vehicles (1995 Emission Inventory)

In the table below, the controlled values are from ARB's 1995 Emission Inventory. In this and other tables, the Uncontrolled values are Controlled / (1 - % Control).

Baseline	Controlled (tons/day)	Uncontrolled (tons/day)	% Control Assumed
Working Emissions	13.65	136.50	90%
Spillage Emissions	11.71	11.71	constant @ 0%
Displacement Emissions	19.64	140.29	86%
Breathing Emissions	2.84	20.29	86%
Totals	47.84	308.79	

The categories used in CARB's Emission Inventory (EI) and the emissions associated with each category are discussed below. The four categories in the EI which relate to GDF are Working Emissions, Spillage Emissions, Displacement Emissions, and Breathing Emissions. The calculations below are on a statewide basis in tons/day (ROG or TOG).

Working Emissions are caused by bulk fuel deliveries to the GDF. Working emissions are mostly caused by vent emissions due to the rapid loading rates (400 gallons/minute) pushing vapors out of the underground tank. As such, Working Emissions are not affected by assumptions about ORVR performance. CARB's EI Baseline for 1995 assumes 90% control on uncontrolled emissions of 136.50 tons/day to yield 13.65 tons/day.

Spillage Emissions are caused by customers using the nozzles at the GDF. VRS must meet a spillage performance standard of 0.42 #/1000 gallons. CARB's EI Baseline for 1995 assumes no control to yield 11.71 tons/day.

Displacement Emissions occur at the nozzle/fillpipe interface by liquid pushing vapors out of the vehicle tank as it is filled.CARB's EI Baseline for 1995 assumes 86% control on uncontrolled emissions of 140.29 tons per day to yield 19.64 tons/day. The 86% control factor is based on a 90% control efficiency for all Phase 1 & 2 systems (5% defect rate assumed) and 4% of the total dispensers are without Phase 2 controls.

Breathing Emissions are caused by condensation and evaporation and temperature variations in and ingestion of air into the VRS. The EI baseline assumes 86% control on uncontrolled emissions of 20.29 tons/day to yield 2.84 tons/day.

(2) Year 2007, 50% ORVR Penetration; without ORVRC, ISD, and PI

In the table below, the Displacement and Breathing Emissions are split 50/50 by vehicle type; but different efficiencies are assumed. Notice that 26.83 for Breathing Emissions for ORVR vehicles is 50% of the maximum value calculated below for the worst case fugitive emissions. The maximum value of 53.66 is realized if 100% of the vehicles are ORVR and no ORVRC has been employed.

w/o ORVRC, ISD, and PI	Controlled (tons/day)	Uncontrolled (tons/day)	% Control Assumed
Working Emissions	13.65	136.50	90%
Spillage Emissions	11.71	11.71	constant @ 0%
Displacement Emissions	9.82 3.51	70.15 70.15	50% @ 86% 50% @ 95%
Breathing Emissions	1.42 26.83	10.15 26.83	50% @ 86% 50% @ 0%
Totals	66.94	325.49	

Working Emissions

The working emissions are assumed to be unchanged from the Baseline Case (136.50 uncontrolled and 13.65 controlled).

Spillage Emissions

These are constant at 0% control (11.71).

Displacement Emissions

The uncontrolled Baseline Emissions are split in half (70.15) due to ORVR vehicle penetration and the non-ORVR half is assumed to be controlled at 86% (9.82) while the ORVR half is assumed to be controlled at 95% (3.51).

Breathing Emissions

Fifty percent, due to ORVR vehicle penetration, of the uncontrolled Baseline Emissions (10.15) are assumed controlled at 86% (1.42); and fifty percent of the uncontrolled fugitive ORVR emissions (26.83) are assumed to be uncontrolled at 0% (26.83).Breathing Emissions are potentially the largest category with ORVR vehicles but without ORVRC. Some extensive assumptions and calculations are needed to estimate the uncontrolled Breathing Emissions for ORVR w/o ORVRC. The problem is, that for vacuum-assist systems, the ORVR vehicle captures the vapors displaced from the vehicle fuel tank on a carbon canister, leaving the vacuum assist pump ingesting air and forcing it into the underground tank. This air will absorb vapors and "grow," pressurizing the underground tank and causing fugitive emissions if there is no vapor processor. The calculation below will assume that there is no vapor processor.

This will be a maximum or "worst case" estimate for the year 2007, when ORVR vehicles are expected to be 50% of the statewide vehicle fleet. First, assume that all GDFs have vacuum-assist systems without vapor processors. Second, assume 100% penetration of ORVR into the California vehicle fleet; this assumption is easily modified later. Third, assume that the yearly statewide throughput at California GDFs is 13.5E9 gallons/year. Fourth, assume that the fugitive emissions have a vapor density of 6.77 #HC/E3 gallons. Fifth, assume that the equilibrium concentration of vapors in air in the underground tank is 30%. For this worst case, the fugitive emissions are:

(13.5 E9 gal/yr) (yr/365 day) (6.77 #HC/E3 gal) (ton/2 E3 #) [30%/(100% - 30%)] =

53.66 tons/day

(3) Year 2007, 50% ORVR Penetration; with ORVRC and without ISD and PI

Here, again, in the split categories, the non-ORVR vehicle values are on top and the ORVR vehicle values are on the bottom.

w/ ORVRC w/o ISD and PI	Controlled (tons/day)	Uncontrolled (tons/day)	% Control Assumed
Working Emissions	13.65	136.50	90%
Spillage Emissions	11.71	11.71	constant @ 0%
Displacement Emissions	9.82 3.51	70.15 70.15	50% @ 86% 50% @ 95%
Breathing Emissions	1.42 1.34	10.15 26.83	50% @ 86% 50% @ 95%
Totals	41.45	325.49	

Working Emissions

The working emissions are assumed to be unchanged from the Baseline Case (136.50 uncontrolled and 13.65 controlled).

Spillage Emissions

These are constant at 0% control (11.71).

Displacement Emissions

The uncontrolled Baseline Emissions are split in half (70.15) due to ORVR vehicle penetration and the non-ORVR half is assumed to be controlled at 86% (9.82) while the ORVR half is assumed to be controlled at 95% (3.51).

Breathing Emissions

Fifty percent, due to ORVR vehicle penetration, of the uncontrolled Baseline Emissions (10.15) are assumed controlled at 86% (1.42); and fifty percent of the uncontrolled fugitive ORVR emissions (26.83) are assumed to be controlled at 95% (1.34).

(4) Year 2007, 50% ORVR Penetration; with ORVRC, ISD, and PI

Here, again, in the split categories, the non-ORVR vehicle values are on top and the ORVR vehicle values are on the bottom. All that is left is to turn up the control on the upper values using ISD and PI to obtain the lowest values in the next table.

w/ ORVRC, ISD, and PI	Controlled (tons/day)	Uncontrolled (tons/day)	% Control Assumed
Working Emissions	6.83	136.50	95%
Spillage Emissions	11.71	11.71	constant @ 0%
Displacement Emissions	3.51 3.51	70.15 70.15	50% @ 95% 50% @ 95%
Breathing Emissions	0.51 1.34	10.15 26.83	50% @ 95% 50% @ 95%
Totals	27.41	325.49	

Working Emissions

The application of ISD and PI is assumed to reduce this number (136.50) with 95% control (6.83). ORVRC is assumed to have no effect.

Spillage Emissions

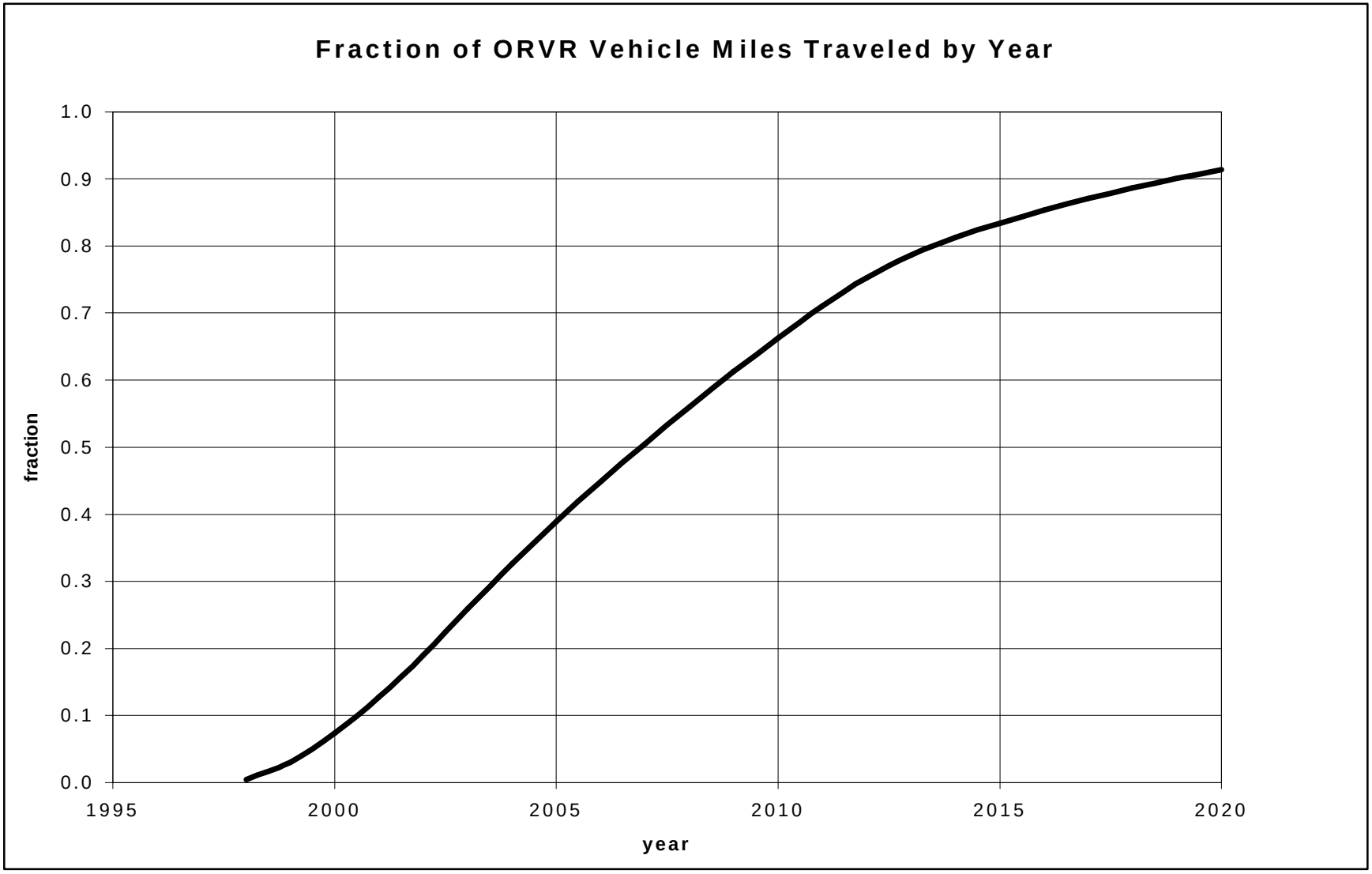
These are constant at 0% control (11.71).

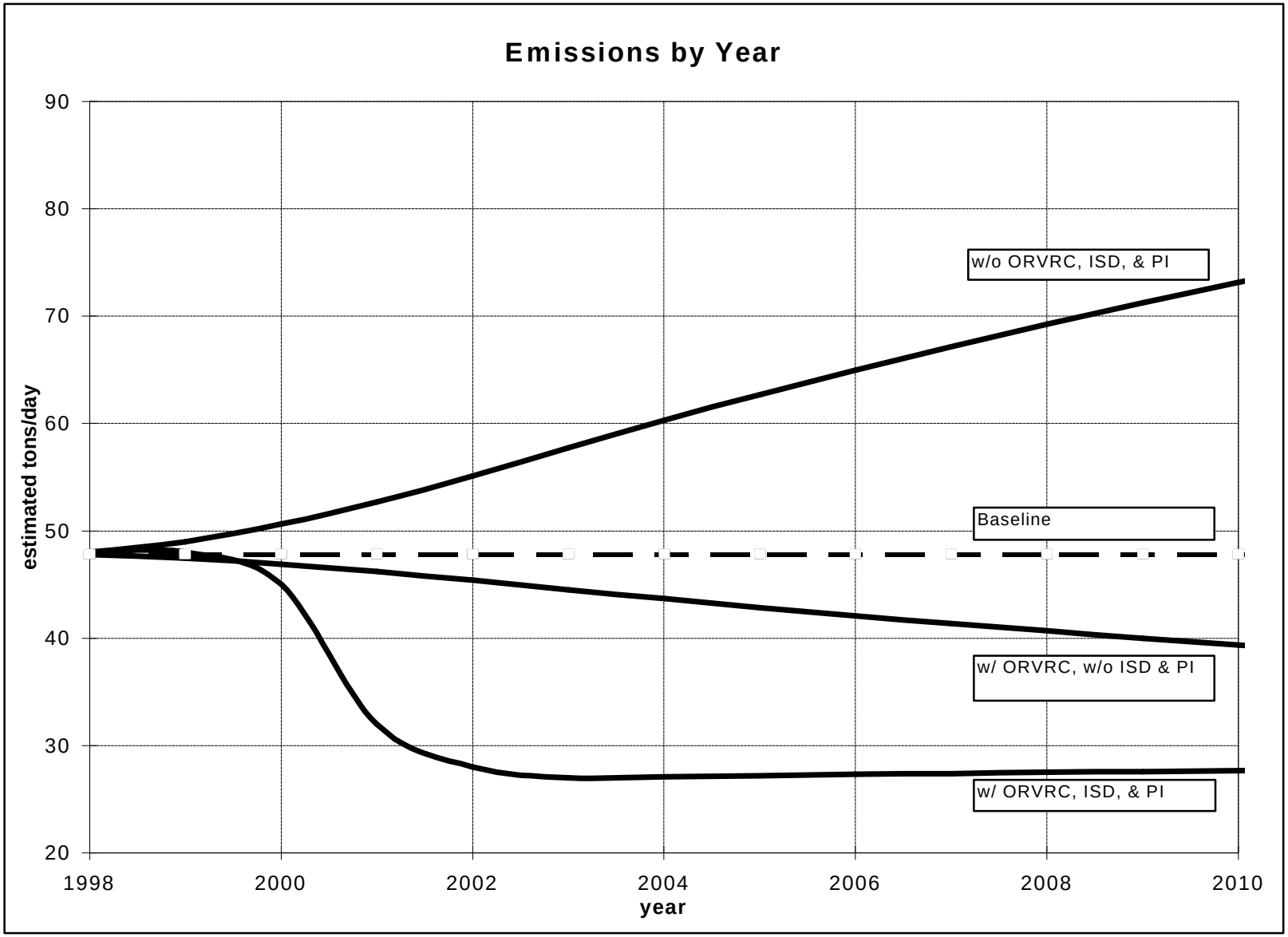
Displacement Emissions

The uncontrolled Baseline Emissions are split in half (70.15) due to ORVR vehicle penetration and each half is assumed controlled at 95% (3.51).

Breathing Emissions

Fifty percent, due to ORVR vehicle penetration, of the uncontrolled Baseline Emissions (10.15) are assumed controlled at 95% (0.51); and fifty percent of the uncontrolled fugitive ORVR emissions (26.83) are assumed to be controlled at 95% (1.34).


Fraction of ORVR Vehicle Miles Traveled by Year
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
fraction
1995
2000
2005
2010
2015
2020
year


Emissions by Year
90
80
70
60
50
40
30
20
estimated tons/day
1998
2000
2002
2004
2006
2008
2010
year
w/o ORVRC, ISD, & PI
Baseline
w/ ORVRC, w/o ISD & PI
w/ ORVRC, ISD, & PI

Model Year	Model Year (Fraction ORVR VMT)		Baseline	w/o ORVRC, ISD, & PI	w/ ORVRC, w/o ISD, & PI	w/ ORVRC, ISD, & PI
1998	0.0043		47.84	48.00	47.79	48.00
1999	0.0300		47.84	48.99	47.46	48.00
2000	0.0732		47.84	50.64	46.91	45.00
2001	0.1270		47.84	52.69	46.22	32.00
2002	0.1900		47.84	55.10	45.41	28.00
2003	0.2591		47.84	57.74	44.53	27.00
2004	0.3261		47.84	60.30	43.67	27.11
2005	0.3890		47.84	62.70	42.87	27.22
2006	0.4486		47.84	64.97	42.11	27.32
2007	0.5054		47.84	67.14	41.38	27.41
2008	0.5603		47.84	69.24	40.68	27.50
2009	0.6126		47.84	71.24	40.01	27.59
2010	0.6628		47.84	73.16	39.37	27.67
2011	0.7104		47.84	74.97	38.76	27.75
2012	0.7528		47.84	76.59	38.22	27.83
2013	0.7863		47.84	77.87	37.79	27.88
2014	0.8123		47.84	78.87	37.46	27.92
2015	0.8340		47.84	79.69	37.18	27.96
2016	0.8530		47.84	80.42	36.94	27.99
2017	0.8705		47.84	81.09	36.71	28.02
2018	0.8867		47.84	81.71	36.51	28.05
2019	0.9012		47.84	82.26	36.32	28.07
2020	0.9134		47.84	82.73	36.16	28.09

Values are forced to fit a smooth transition.