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The Colorado Remote Sensing Program
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Prepared for:

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I. Summary

The Colorado Department of Public Health & Environment (CDPHE) and the Department of Revenue (DOR) have operated an Enhanced Inspection and Maintenance (I/M) program in the Denver metropolitan area (DMA) since 1995. Operations for a remote sensing clean screening element commenced in 2003. Previous reports, "The Colorado Clean Screening Program' reports for July 2003 – December 2004 and annual reports for 2005-2012[1] described on-road measurement activities and the vehicles exempted from inspection. This report covers calendar year 2013.

The clean screening program uses remote sensing to measure the tailpipe emissions of vehicles as they drive by measuring equipment positioned on the side of the road. Vehicles that are determined to have low tailpipe emissions are granted an exemption from the I/M inspection. Clean screening improves convenience of the I/M program for vehicle owners.

In order to exempt vehicles from inspection, computer systems and procedures are required for administering the program and notifying vehicle owners of their inspection exemption. The I/M program is registration enforced and the administration of the clean screening program requires the transmission of information among the contractor, CDPHE and DOR who manage motor vehicle registrations.

Rapidscreen provided benefits to vehicle owners of $5.1M through reduced time and expense associated with eliminated inspection station visits. The reduction in station inspections also yielded net savings in greenhouse gases and over 195,000 gallons of gasoline.

Collection Activity

In 2013, eighteen RSD vans were deployed in the DMA with an additional 4 in the Northern Front Range (NFR). Twenty-four different RSD systems were used as some units were rotated for preventive or corrective maintenance and four RSD 5000s were used. Van's deployed at 63 locations in the DMA, 28 sites in the NFR and 2 sites in Colorado Springs for a total of 23,038 active collection hours. A total 7.1 million emission measurements were collected and successfully matched to Colorado registered vehicles. Additional remote sensing productivity information is provided in Section IV.

Expanded vehicle emissions testing began in parts of Weld and Larimer counties in late 2010. Vehicle owners with December 2010 renewal dates were the first required to get a test.

2012 vs 2013 Collection Comparison

In 2012, RSD performed over 6.7 million emission measurements at 80 locations in the DMA and 35 locations in the NFR. In 2013 there were 0.3 million more emission measurements. Despite the increase in the quantity of emission measurements the number of clean screens issued were 6% lower, being 280,310 in 2012 vs. 263,431 in 2013.

Vehicle Exemptions

Almost 274,000 vehicles measured on-road initially met the clean screening exemption criteria. Two percent of these were reserved to provide a program audit sample and others were eliminated during the QA reviews, for example, as a result of vehicle plate changes. The owners of the remaining 263,431 vehicles meeting the clean screening criteria were issued notices granting exemption from the I/M test at an inspection station. Of these vehicles, 233,760 (88.7%) owners took advantage of the Clean Screen exemption.

Two methods were used to qualify vehicles, 2-RSD and Hybrid. With the 2-RSD method, vehicles qualified for an exemption if they had two or more on-road measurements and the most recent two measurements both showed emissions within the clean screen standards. With the 'Hybrid' clean screening method vehicles measured once by remote sensing qualified for clean screening if the emissions measurement was within the clean screen standards and the vehicle model had a historically low rate of emissions problems.

A 2% random sample of vehicles that qualified was not issued exemption notices and 4,460 of these vehicles were subsequently inspected at an enhanced inspection station. The results of the station inspections were used to evaluate the effectiveness of the program. Additional information about vehicles mailed notices is provided in Section IV.

Clean Screen Program Effectiveness

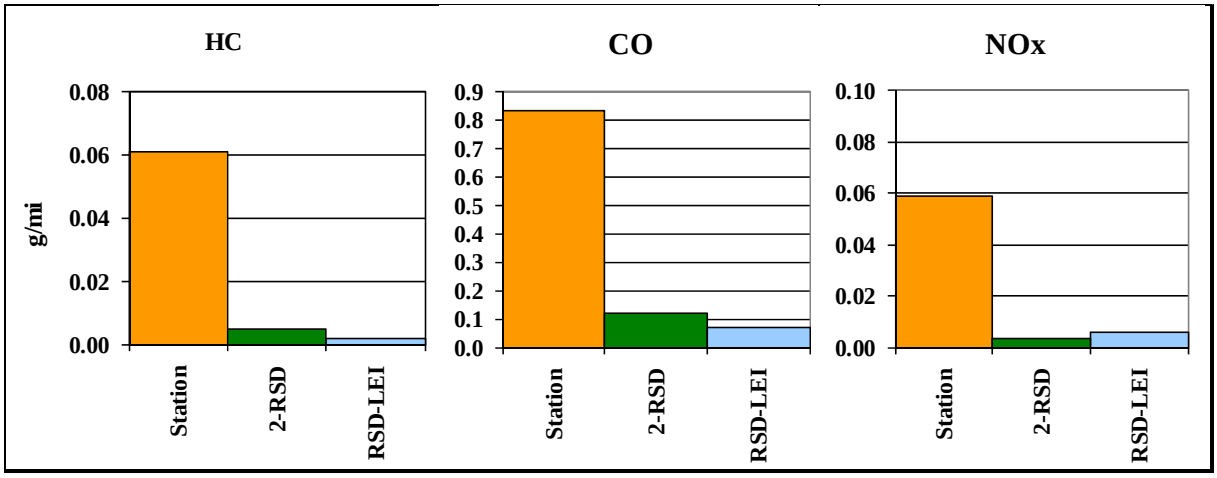
In a Clean Screen program, some vehicles passing the clean screen emissions criteria might have failed if inspected at an inspection station. Therefore, a Clean Screen program, while greatly improving convenience for vehicle owners, can slightly reduce the overall effectiveness of the I/M program.

On May 5th 2008, IM240 Denver Metro Area station test standards were tightened – especially for HC and NOx – to bring them into closer alignment with EPA final standards. The LEI table was updated with subsequent IM240 results to reflect consequent changes in inspection result statistics for vehicle models in December 2008, and annually thereafter. The RSD standards were updated in October 2010 with the addition of an RSD NO standard of 1000ppm that first applied to December 2010 registrants.

Figure I-1 compares the average IM240 exhaust reductions per vehicle inspected at stations to those of the 2-RSD audit sample and the Hybrid RSD-LEI audit sample. For HC and CO pollutants the RSD-LEI audit sample showed smaller reductions than 2-RSD while the 2-RSD method performed better for NOx.

For 2013, based on the 2% random audit vehicles tested with IM240, it was projected that 97.3%, 96.7% and 97.6% of HC, CO and NOx of program exhaust emission reductions were retained. The impact on gas cap related evaporative emissions was projected to be another 2.5% of HC reductions.

Figure I-1 Average IM240 Emissions Reductions



The methodology for estimating clean screen effectiveness only allows for a score of 100% or less and uses the IM240 test as a "gold' standard. Any variations in vehicle performance or the IM240 test procedure that produce an anomalous IM240 test failure are scored against Clean Screen. Therefore, it is possible the Clean Screen effectiveness was better than projected.

The recommendations section of the report suggests flexibility be added to Regulation 11 to prepare for program changes being implemented in 2015 and their effects on the remote sensing program.

II. Description of the Denver Clean Screening Program

A. I/M Program Overview

The Colorado Department of Public Health & Environment (CDPHE) operates an enhanced Inspection and Maintenance (I/M) program in the Denver metropolitan area (DMA) and the Northern Front Range (NFR). The clean screening component of the IM program uses remote sensing equipment to measure the tailpipe emissions of vehicles as they drive by the measuring equipment. Vehicles that are determined to have low tailpipe emissions are granted an exemption from their I/M inspection.

Operating rules for the Clean Screening program are contained in the Air Quality Control Commission's Regulation 11[2]. The Regulation defines the maximum percentages of vehicles that may be evaluated by the clean screen program in the enhanced I/M area. In 2006, the percentage of vehicles allowed to be evaluated using remote sensing was decreased from 80% to 50% as part of an Early Action Compact (EAC) to achieve an earlier attainment designation for ozone.

Clean Screening regulations were expanded in 2007 to allow use of a single RSD measurement combined with an index of low emitting vehicles to evaluate exemption candidates. The Low Emitter Index (LEI) was developed using I/M240 data to identify vehicle groups that historically have a very low probability of failing. The current requirement for a vehicle group to qualify as a low emitter is they must have an I/M240 pass rate of 98% or greater.

There are multiple requirements and restrictions for vehicles to participate in the Clean Screen program as defined in Regulation 11. The following are the primary elements for vehicles to qualify for a clean screen exemption.

- The applicable observations were within twelve months prior to the individual vehicles registration renewal date,
- The two most recent observation results are below, 200ppm, 0.5%, and 1000ppm for HC, CO, and NOx respectively, (NOx standard implemented October 2010)
- The two most recent observations must have occurred on a different day or on the same day at different site locations,

Contractor

Envirotest was contracted to operate the enhanced program by a competitive bid process and the contract was subsequently amended to include clean screening in the Denver area. Envirotest uses technology derived from that originally developed at Denver University with whom Envirotest has a royalty agreement.

Theory of operation

The RSD is a system designed for a non-intrusive measurement of vehicle emissions. It generates and monitors a non-dispersive infrared and dispersive ultra-violet beam emitted and

reflected approximately 10 to 18 inches above ground preferably across a single lane road. Gasoline, diesel, or other fossil fuel powered vehicles drive through this beam and the exhaust interferes with this transmission of the beam. Quantifying the interference enables the calculation of tailpipe concentrations of CO, HC, CO2, NO and particulate matter. A camera simultaneously captures a digitized video image of the rear of the vehicle and its license plate.

Equipment

The equipment initially deployed in the Northern Front Range counties were RSD-3000 mobile units also called AccuScan™. Successor RSD 4000 units were introduced in 2003. Both systems were based on a technical platform developed at the University of Denver by Dr. Donald Stedman. In 2007, additional RSD4600 units were added. The RSD4600 is very similar to the RSD4000-L3 system described below. The RSD4600 has a more compact speed and acceleration measurement bar and more diagnostic ports. Functionally, the two systems are the same. One RSD 5000, the latest generation of RSD systems, passed acceptance testing in 2011 and began data collection in December 2011. The RSD 5000 is more compact, requires less power and supports remote wireless operation.

AccuScan measures the exhaust of a passing motor vehicle in less than 0.7 seconds. Non-dispersive infrared (IR) spectroscopy, the same analytical technique used in garage based two-speed idle and ASM equipment is used to measure concentrations of CO, HC, and CO_2. Dispersive ultraviolet (UV) spectroscopy is used to measure NOx. The system is based on the original designs and patents of Dr. Donald Stedman, professor emeritus at the University of Denver.

The following elements comprise a complete RSD4600 unit:

- RSD 4-gas analyzer Source Detector Module
- Corner Cubed Mirror Module (CCM)
- Two Alignment stands, one each for SDM and CCM
- Speed/Acceleration subsystem consisting of:
  - Two Speed/Acceleration bars: one emitter and one detector bar with adjunct hardware
  - Speed/Acceleration computer
- Digital Video camera and speed subsystem
- Computer control console subsystem consisting of:
  - Video monitor
  - Pentium™–based PC
  - Additional PC cards and internal hardware PC cards:
    - Hard drive
    - Removable Mass Storage
    - Matrox video
    - Serial and COM port
- RSD operation (data collection) software
- RSD compatible license plate tag-editing software

- Calibration and auditing subsystem consisting of:
  - Calibration gas cell
  - Audit tube
  - Audit gas bottle
  - Pressure regulator
  - Hoses with quick disconnects
- RSD shipping container for SDM and CCM

The following elements comprise an AccuScan™ van:

- Ford one-ton truck
- Triton V-8 engine with 4-speed automatic transmission
- 12 – 14 foot box on bed of truck
- Roof-mounted 13,500 BTU Coleman air-conditioner
- 5 kW Onan generator
- Connector panel for quick connection of external cables and calibration gas hoses

The RSD unit takes multiple rapid readings for each vehicle to characterize the exhaust plume profile and evaluate whether a valid measurement of a vehicle's exhaust has been achieved. The criteria include how much vehicle exhaust plume is available for the duration of the sampling period, evaluation of whether plume measurements are consistent with normal plume dissipation, and correction for changes in background concentrations of emissions.

The RSD units comply with the CDPHE, "Colorado On-road Vehicle Emissions Remote Sensing System (COVERS) Specifications" Amended July 2010[3]: The COVERS accuracy specifications are consistent with the California BAR OREMS Specification:[1] and include:

Detector accuracy:

1. The CO_2% reading shall be within ± 10% of the Certified Gas Sample, or an absolute value of ± 0.25, or shall be within published manufacturer's specification – whichever is less restrictive. Negative values shall be included and shall not be rounded to zero.

2. The CO% reading shall be within ± 15% of the Certified Gas Sample, or an absolute value of ± 0.25 (whichever is greater). Negative values shall be included and shall not be rounded to zero.

3. The HC reading (ppm propane) shall be within ± 15% of the Certified Gas Sample, or an absolute value of ± 250ppm (whichever is greater). Negative values shall be

[1] On Road Emissions Measurement System OREMS) Specifications, Revision L, Bureau of Automotive Repair, Engineering and Technical Research Branch, 10240 Systems Parkway, Sacramento, CA 95827; 2001 California DCA/BAR; p. 5.

included and shall not be rounded to zero.

4. The NOx reading (ppm) shall be within ± 15% of the Certified Gas Sample, or an absolute value of ± 250 ppm (whichever is greater). Negative values shall be included and shall not be rounded to zero.

5. COVERS shall submit readings within the following limits:
   $CO + CO_2 \leq 21.0$ %, HC ≤ 35,000 ppm hexane, $CO_2 \leq 16.0$ %, and NO ≤ 7000 ppm.

6. The system shall record at least three and display at least two measures of plume characteristics, for example the maximum number of CO2 molecules seen, the average number of CO2 molecules seen, and the number of valid samples (measurements) made.

7. Each unit shall demonstrate during controlled acceptance testing the above criteria 98% of the time. Ninety-eight percent (98%) shall mean that one hundred percent (100%) of the valid records shall have the following fields filled correctly with accurate data, ninety-eight percent (98%) of the time:
   CO2%
   CO %
   HC ppm hexane
   NO ppm

Speed and Acceleration Accuracy:

1. The vehicle speed measurement should be accurately recorded within ± 1.0 mile per hour.

2. The vehicle acceleration measurement should be accurately recorded within ± 0.5 mile per hour / second.

3. The speed and acceleration system shall demonstrate during controlled acceptance testing the above criteria ninety-five percent 95% of the time. Ninety-five percent (95%) shall mean that one hundred percent (100%) of the valid records shall have the speed and acceleration fields filled correctly with accurate data, ninety-five percent (95%) of the time.

4. VSP shall be calculated during host processing using the most recent CDPHE approved equation.

Vehicle Identification

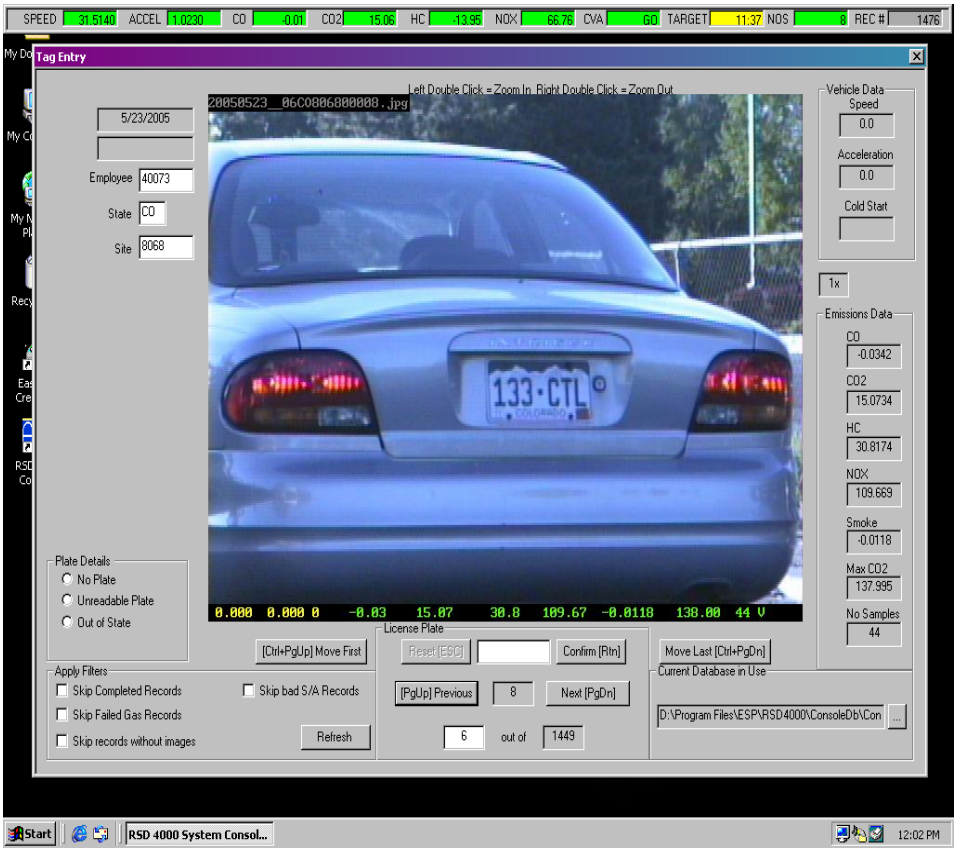
The system captures emissions readings and rear pictures of vehicles passing through the RSD infrared beam. The video and emissions readings taken are stored directly on a removable media disk and can be used for future reference.

Envirotest's TagEdit™ software is used to transcribe vehicle license plate information. Figure II-1 below shows an example of a TagEdit™ screen. This license plate editing service is superior to an automatic license plate reader because:

- All video images associated with valid emissions data get processed. This ensures the highest possible vehicle capture rate.
- Vehicles with special plates are also processed. This is especially important in areas where many unique license plates are issued. Failure to process all plate types can create a statistically skewed database that could be misinterpreted by the public as "targeting" only certain vehicle classes.

A special registration database was created for the Clean Screen program to allow vehicles to be identified (VINs) from Clean Screen license photos captured days prior to their data processing. This Clean Screen registration database is updated nightly with all the changes statewide that affect what VIN is associated with what plate. A lag time interval is incorporated to allow time for updates to get from the County Clerks Offices to the DOR database. The separate Clean Screen Registration Database on the Envirotest host contains all vehicle registration records statewide, even though only certain counties are expected to participate in the Clean Screen program. The future growth of registration could require some housekeeping, but there is plenty of hardware scalability to handle this growth.

Figure II-1: TagEdit™ Screen



B. Measurement Sites

Good remote sensing sites are critical for obtaining RSD measurements that are representative of vehicle operation. Recommended site attributes include:

(1) Absence of cold start vehicle operating conditions

(2) Sites where vehicles will generally be accelerating or driving at a steady speed uphill to ensure adequate engine power and exhaust plumes and avoid the problem of RSD not measuring vehicles that have virtually no exhaust under deceleration

(3) Absence of enrichment due to high load conditions

(4) Single lane operation

(5) High volume traffic

(6) Unobtrusive siting of the remote sensing equipment

(7) Adequate median space for safe operation of the RSD equipment.

Table II-1 lists the RSD sites in the Northern Front Range (NFR), the number of days each site was used, the total hours during which measurements were collected and the number of vehicles measured per hour. The hours shown do not include travel time to and from the site, equipment set-up and equipment takedown time.

Table II-2 lists the Denver Metro Area (DMA) site locations.

Table II-3 lists the El Paso County (Colorado Springs) locations where a small number of measurements are made annually.

Site locations in the NFR and DMA are illustrated in Figures II-2a and IIb. Blue sites are active. Red sites are no longer permitted. The X's represent HQ and other stations where RSD vans are housed.

Table II-1 Northern Front Range

Site Code	Location	City	Active Days	Total Active Hours	Registered Vehicles Measured	Veh's Per Hour
2144	NB STANDFORD FROM MONROE DR	FT COLLINS	2	10	802	78
3019	ON RAMP TO NB I-25 FROM 402 (CR-54)	LOVELAND	16	68	6,703	99
3020	ON RAMP TO SB I-25 FROM 402 (CR-54)	LOVELAND	20	109	12,974	119
3510	SB SHIELDS ST. AFTER FOSSIL CREEK	FT. COLLINS	3	18	3,613	200
3511	OFF-RAMP FROM NB I-25 TO WB MULBERRY ST.	FT. COLLINS	28	209	59,474	285
3513	NB SHIELDS RD. AFTER BON HOMME RD.	FT. COLLINS	4	23	1,122	50
3514	NB TAFT HILL RD. AFTER HARMONY RD.	FT. COLLINS	77	521	196,148	377
3515	ONRAMP TO NB I-25 FROM WB US-34	FT. COLLINS	32	236	34,364	146
3517	ONRAMP TO SB I-25 FROM CROSSROADS BLVD.	FT. COLLINS	4	29	2,963	102
3527	EB 392 AFTER INTERSECTION WITH CR-9	FT. COLLINS	19	149	23,993	161
8042	ONRAMP TO SB I-25 FROM EAST PROSPECT	FT COLLINS	71	521	123,542	237
8049	ONRAMP TO SB I-25 FROM HARMONY RD	FT COLLINS	23	160	42,080	264
8053	EB US-287 ABOUT 500' EAST OF LCR-17	BERTHOUD	14	80	3,205	40
2989	EB US 34 BYPASS FROM 23RD AVE	GREELEY	43	314	46,298	147
3506	ONRAMP TO NB US-85 FROM HWY 52	FT. LUPTON	2	12	558	48
3507	ONRAMP TO SB US-85 FROM HWY 52	FT. LUPTON	10	58	8,730	151
3518	ONRAMP TO SB I-25 FROM SR-60	LOVELAND	4	27	2,180	81
3519	ONRAMP TO SB I-25 FROM SR-56	BERTHOUD	5	21	866	41
3520	ONRAMP TO SB I-25 FROM SR-66	LONGMONT	1	5	542	118
3521	ONRAMP TO SB I-25 FROM SR-52	LONGMONT	44	256	63,414	247
3522	ONRAMP TO SB I-25 FROM CR-8	DACONO	10	49	3,692	75
3523	ONRAMP TO NB I-25 FROM CR-8	DACONO	1	4	31	7
3524	ONRAMP TO NB I-25 FROM SR-52	LONGMONT	2	9	845	94
3525	ONRAMP TO NB I-25 FROM SR-119	LONGMONT	11	49	6,455	133
3526	ONRAMP TO NB I-25 FROM SR-66	LONGMONT	5	28	2,291	81
8043	ONRAMP TO WB US-34 FROM 27TH ST	GREELEY	44	325	68,123	210
8044	ONRAMP TO EB US-34 FROM SH-257	GREELEY	36	262	29,980	115
8045	ONRAMP TO EB US-34 BYPASS FROM SH-257	GREELEY	38	289	35,233	122
Subtotal			569	3,839	780,221	203

Table II-2 Denver RSD Sites

Site Code	Location	City	Active Days	Total Active Hours	Registered Vehicles Measured	Veh's Per Hour
2819	ONRAMP TO SB 121 FROM WB 287	WESTMINSTER	87	815	206,075	253
2821	ONRAMP TO NB I-25 FROM 120TH AVE	WESTMINSTER	9	84	14,759	177
2971	EB DILLON RD EAST OF US-287	BROOMFIELD	54	381	118,851	312
8072	ONRAMP TO NB I-25 FROM 84TH AVE.	THORNTON	5	61	11,552	189
8073	ONRAMP TO NB I-25 FROM 104TH AVE.	NORTHGLENN	13	96	13,906	144
8087	ONRAMP TO WB I-70 FROM AIRPORT BLVD.	AURORA	20	160	31,262	195
8088	ONRAMP TO WB I-76 FROM 88TH AVE	COMMERCE CITY	12	97	12,445	128
8089	ONRAMP TO WB I-76 FROM 96TH AVE	COMMERCE CITY	12	101	23,263	230
8090	ONRAMP TO EB I-76 FROM PECOS ST.	DENVER	1	4	222	51
8091	ONRAMP TO WB I-76 FROM BROMLEY LN.	BRIGHTON	6	35	4,163	119
8093	ONRAMP TO WB I-70 FROM NB I-25	DENVER	219	2,196	1,196,269	545
8103	ONRAMP TO WB I-270 FROM SB SH-2	COMMERCE CITY	2	13	721	56
8107	ONRAMP TO WB US-36 FROM BROADWAY	DENVER	102	856	256,592	300
8115	ONRAMP TO EB I-76 FROM FEDERAL BLVD	DENVER	7	64	7,536	118
8129	ONRAMP TO WB I-76 FROM PECOS ST	DENVER	35	275	42,281	154
8098	ONRAMP TO NB I-225 FROM ILLIFF AVE	AURORA	22	152	26,200	173
8120	ONRAMP TO SB I-225 FROM ALAMEDA AVE	AURORA	24	191	27,896	146
2512	ONRAMP TO NB SH-157 FROM PEARL ST.	BOULDER	8	51	7,350	145
2514	ONRAMP TO 96TH AVE FROM SH-42.	BOULDER	41	269	54,507	202
2826	ONRAMP TO EB US-36 FROM MCCASLIN	LOUISVILLE	35	227	29,450	130
8057	ON-RAMP TO SB SH 157 FROM PEARL ST.	BOULDER	68	445	93,314	210
8064	ONRAMP TO NB SH 157 (FOOTHILLS PKAY) FROM EB TABLE MESA	BOULDER	2	12	2,040	171
2166	ONRAMP TO WB I-76 FROM WB I-270	DENVER	3	22	1,272	59
2171	ONRAMP TO WB I-70 FROM PECOS ST.	DENVER	1	1	177	185
2456	ONRAMP TO SB I-225 FROM PEORIA ST	DENVER	21	155	30,739	198
2560	ONRAMP TO EB US-6TH AVE FROM SB I-25	DENVER	8	84	14,773	175
3499	ONRAMP TO SB I-25 FROM WB I-76	DENVER	4	22	7,431	340
3504	ONRAMP TO EB I-70 FROM PEORIA ST.	DENVER	23	161	49,530	308
3505	ONRAMP TO WB I-70 FROM QUEBEC ST.	DENVER	59	441	175,540	398
8062	ONRAMP TO EB I-70 FROM FEDERAL BLVD	DENVER	4	48	8,481	177
8081	ONRAMP TO EB I-70 FROM HAVANA ST.	DENVER	20	158	33,522	212
8094	ONRAMP TO SB US-285 (HAMPDEN AVE) FROM FEDERAL BLVD	SHERIDAN	83	627	155,689	248
8097	ONRAMP TO WB US-6TH AVE FROM NB I-25	DENVER	171	1,222	864,160	707
8113	ONRAMP TO SB US-285 (HAMPDEN AVE) FROM SHERIDAN BLVD.	DENVER	22	175	36,436	208
8122	ONRAMP TO NB I-25 FROM PARK AVE	DENVER	126	1,173	391,149	334
8123	ONRAMP TO NB I-25 FROM 58TH AVE.	DENVER	91	878	239,905	273
2319	ONRAMP TO EB C-470 FROM LUCENT BLVD	HIGHLANDS RANCH	27	188	45,511	242
2320	ONRAMP TO EB C-470 FROM BROADWAY	HIGHLANDS RANCH	7	51	23,147	455
2321	ONRAMP TO EB C-470 FROM UNIVERSITY BLVD	HIGHLANDS RANCH	67	478	147,106	308
2322	ONRAMP TO WB C-470 FROM UNIVERSITY BLVD	HIGHLANDS RANCH	38	295	75,304	255
2576	ONRAMP TO SB I-25 FROM EB COUNTY LINE RD.	HIGHLANDS RANCH	33	230	52,309	227
2577	ONRAMP TO NB I-25 FROM EB COUNTY LINE RD.	HIGHLANDS RANCH	105	754	314,992	418
8077	ONRAMP TO EB C-470 FROM QUEBEC ST.	HIGHLANDS RANCH	95	652	340,218	522
8083	ONRAMP TO SB I-25 FROM FOUNDERS PARKWAY (EXIT 184)	CASTLE ROCK	44	310	53,427	172
8084	ONRAMP TO SB I-25 FROM LINCOLN AVE.	LITTLETON	17	113	14,001	124
8085	ONRAMP TO NB I-25 FROM WOLFENSBERGER RD. (EXIT 182)	CASTLE ROCK	42	286	86,777	304
8086	ONRAMP TO NB I-25 FROM FOUNDERS PARKWAY (EXIT 184)	CASTLE ROCK	39	261	73,439	281
2175	ONRAMP TO WB C-470 FROM KIPLING ST.	LAKEWOOD	1	8	1,845	232
2176	ONRAMP TO WB C-470 FROM KEN CARYL AVE	LAKEWOOD	93	620	155,578	251
2400	ONRAMP TO WB C-470 FROM NB US-285 (HAMPDEN AVE)	LAKEWOOD	1	4	785	210
2458	ONRAMP TO WB US-6TH AVE FROM SIMMS ST	LAKEWOOD	44	362	84,963	234
2461	ONRAMP TO WB US-6TH AVE FROM NB WADSWORTH BLVD	LAKEWOOD	12	122	23,617	193

Table II-2 Denver RSD Sites continued

Site Code	Location	City	Active Days	Total Active Hours	Registered Vehicles Measured	Veh's Per Hour
8058	ONRAMP TO WB I-76 FROM SHERIDAN BLVD.	ARVADA	44	330	68,067	206
8068	ONRAMP TO EB I-70 FROM HARLAN ST.	ARVADA	1	8	1,492	178
8069	ONRAMP TO WB I-70 FROM KIPLING ST.	WHEATRIDGE	65	535	131,941	247
8099	ONRAMP TO WB US-6TH AVE FROM SB WADSWORTH BLVD	LAKEWOOD	2	9	1,351	146
8100	ONRAMP TO WB US-6TH AVE FROM SB KIPLING ST.	LAKEWOOD	17	125	28,281	227
8104	ONRAMP TO SB US-285 (HAMPDEN AVE) FROM WADSWORTH BLVD.	DENVER	10	83	7,634	92
8105	ONRAMP TO SB US-285 (HAMPDEN AVE) FROM KIPLING BLVD.	DENVER	3	13	2,008	159
8106	ONRAMP TO NB US-285 (HAMPDEN AVE) FROM KIPLING BLVD.	DENVER	68	706	156,954	222
8111	ONRAMP TO EB SH-58 FROM MCINTYRE ST.	GOLDEN	65	597	162,453	272
8130	ONRAMP TO EB I-76 FROM SHERIDAN BLVD	ARVADA	19	153	33,771	221
8131	ONRAMP TO EB I-70 FROM SHERIDAN BLVD.	ARVADA	7	46	5,114	111
Subtotal			2,386	19,090	6,281,543	329

Table II-3 El Paso RSD Sites

Site Code	Location	City	Active Days	Total Active Hours	Registered Vehicles Measured	Veh's Per Hour
2518	ONRAMP TO E.PLATTE AVE FROM NB ACADEMY BLVD	COLORADO SPRINGS	8	53	7,876	148
2520	ONRAMP TO NB I-25 FROM N.ACADEMY BLVD	COLORADO SPRINGS	10	56	8,604	153
Subtotal			18	109	16,480	151
Total			**2,973**	**23,038**	**7,078,244**	**307**

Figure II-2 a: Site Locations Northern Front Range

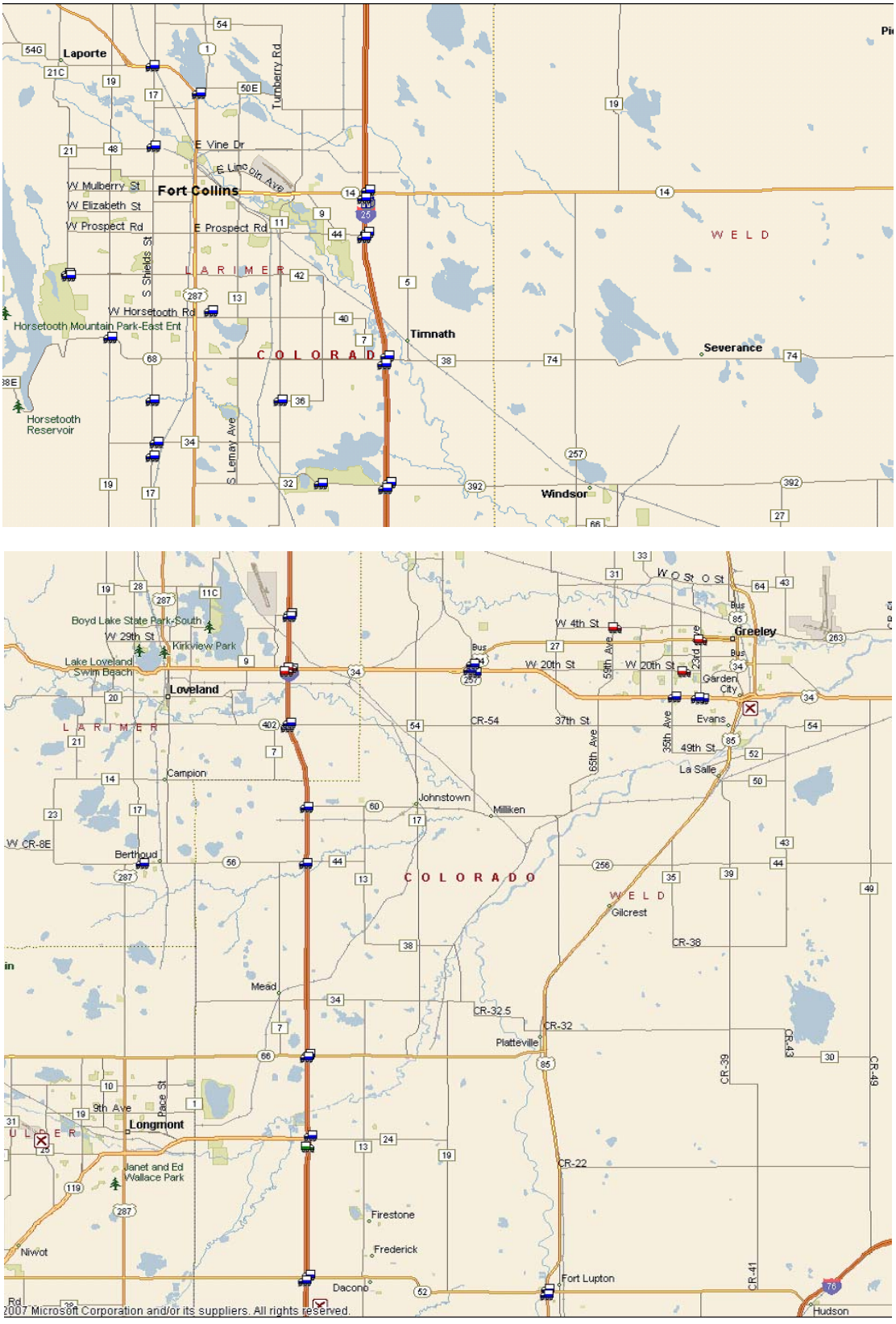
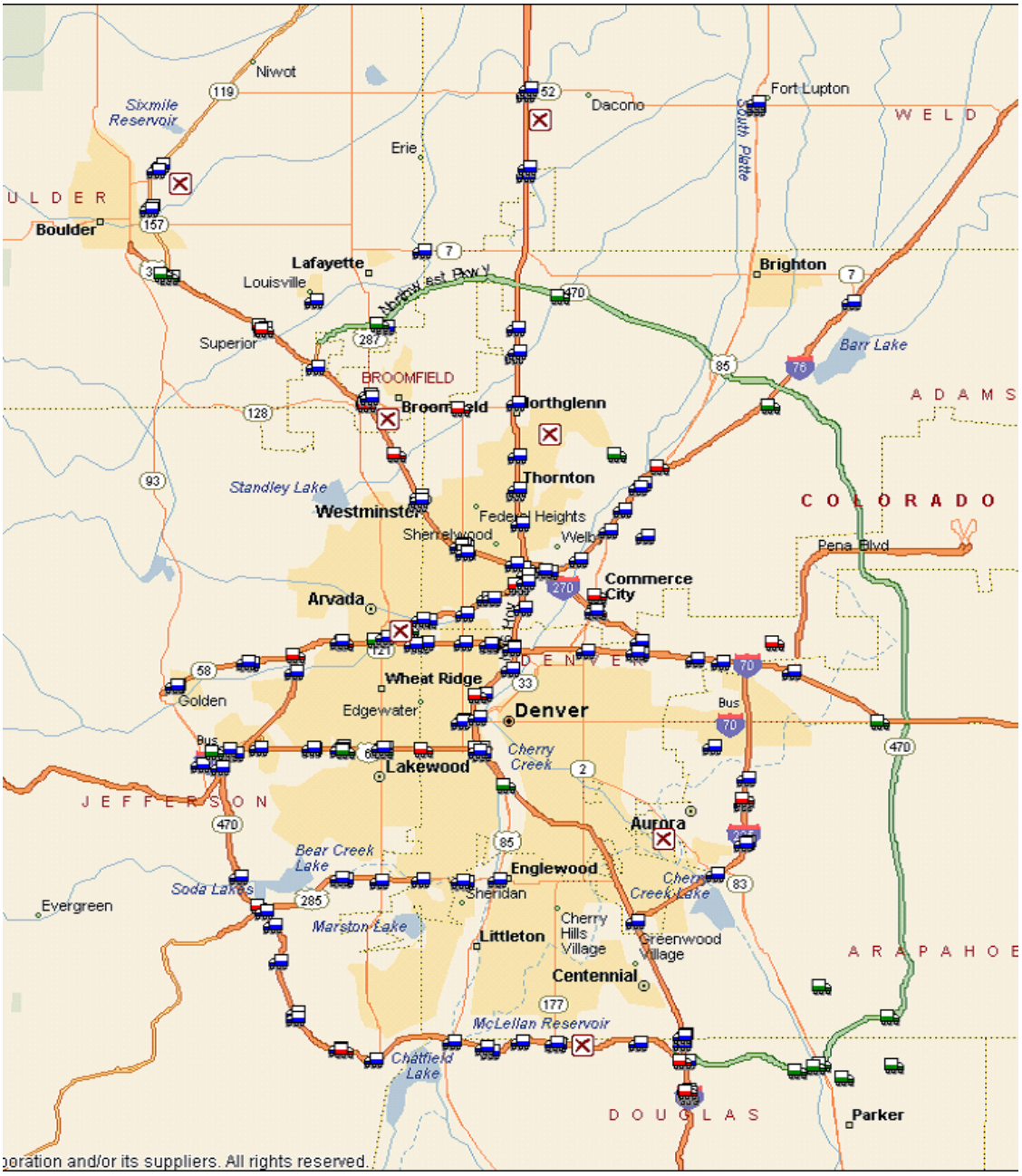


Figure II-2 b: Site Locations – Denver Metro Area



C. Sources of Data and Description of Elements

Data used in the analyses in this report come from three primary sources:

- Remote sensing unit measurements
- The DMV database maintained on the AIR program contractor host computer

- I/M test database maintained on the AIR program contractor host computer

Data from the RSD units are loaded into a database maintained by the centralized contractor, Envirotest. Using the vehicle plate identified by RSD, the registration file is accessed to determine the vehicle identification number (VIN) and vehicle registration information. Envirotest uses the Polk VIN Decoder to add additional information about each vehicle. The combined data fields are shown in Table II-4.

Table II-4 Vehicle Measurement Information

Field Name	Description
V_DATA_VER	Data version
V_DATE_TIME	Date and time of measurement
V_RSD_UNIT	RSD system number
V_SEQ_NUM	Measurement sequence number
V_SITE_CODE	Site reference
V_PROGRAM_CODE	I/M Program
V_VAN_OPERATOR_ID	
V_CO	Carbon monoxide emissions %
V_CO2	Carbon dioxide emissions %
V_MAX_CO2	Maximum observed CO2
V_CO2_VOLUME	Volume of CO2 observed
V_HC	Hydrocarbon emissions ppm hexane equivalent
V_NOX	Oxides of nitrogen emissions ppm (NOx)
V_NOX_FLAG	Validity of NOx measurement
V_OPAC	Opacity measurement
V_SPEED	Speed MPH
V_ACCEL	Acceleration MPH/S
V_SA_UNITS	Units of speed and acceleration
V_TEMPERATURE	Ambient temperature
V_HUMIDITY	Ambient humidity
V_WIND_SPEED	Ambient wind speed
V_WIND_DIRECTION	Ambient wind direction
V_WEATHER_UNITS	
V_PLATE_CONFIDENCE	Reserved for future use
V_ALPR_VENDOR	Reserved for future use
V_TEST_COUNTY	Reserved for future use
V_CRC	
V_TAG_EDIT_MODE	
V_TAG_EDIT_ID_1	
V_TAG_EDIT_ID_2	
V_TAG_EDIT_ID_3	
V_TAG_EDIT_EMP_1	
V_TAG_EDIT_EMP_2	
V_TAG_EDIT_EMP_3	
V_PLATE	License plate
V_PLATE_STATE	State issuing license plate
V_PLATE_TYPE	Type of plate
V_VIN	Vehicle Identification Number

Field Name	Description
V_LZIP	Zip code for legal owner address
V_STATE_MAKE	Make code
V_STATE_MODEL	Model code
V_COUNTY	County of registration
V_VEH_YEAR	Model year
V_EM_FLAG	Subject to emissions test
V_POLK_VEH_YEAR	Polk decoded model year
V_POLK_MAKE	Polk decoded make
V_POLK_VEH_TYPE	Polk decoded vehicle type (P-pass, T-truck, U-unknown)
V_POLK_MODEL	Polk decoded model
V_POLK_DISP	Polk decoded engine displacement
V_VSP	Calculated vehicle specific power during measurement

III. Summary of Data Collection

Up to 22 remote sensing units were deployed for 2,973 days during 2013 to collect 7.1M measurements having a visible plate and valid HC, CO, speed and acceleration values: 6.3M measurements in the Denver metropolitan area (DMA) Metro Area, 780,000 measurements in the Northern Front Range (NFR) and 16,000 measurements in El Paso County.

Clean screen exemption notices were issued for 263,432 vehicles scheduled to renew their registration in 2013 and due for emissions testing (Table III-1) comprising 221,334 DMA vehicles and 42,097 NFR vehicles.

Vehicles registered in the DMA accounted for over 5.6M measurements, the NFR for 743,000, and El Paso County 108,000. Another 253,000 measurements were of vehicles registered in other Colorado counties (Table III-2).

In 2012, RSD performed 6.7 million emission measurements and 280,310 clean screens were issued.

Table III-1 Collection Summary

Statistic	Denver Metro Area	Northern Front Range	Colorado Springs	Total
Sites Used	63	28	2	93
Collection Van Days	2,386	569	18	2,973
Active Collection Van Hours	19,090	3,839	109	23,038
Matched to Registration	6,281,543	780,221	16,480	7,078,244
Notices Generated for 2013 renewals	221,334	42,097		263,431

A. Monthly Collection Activity

Figure III-1 shows the monthly RSD measurements. Collection rates were lower during severe winter months.

B. Measurements by Hour of Day

Figure III-2 ‘Measurements by Hour of Day’ shows the number of vehicles measured during each hour of the day. The shape of the curve is indicative of when measurements were collected and does not represent the level of traffic during the day. Most measurements were collected between 7:00am and 7:00pm.

Figure III-1 Monthly RSD Measurements

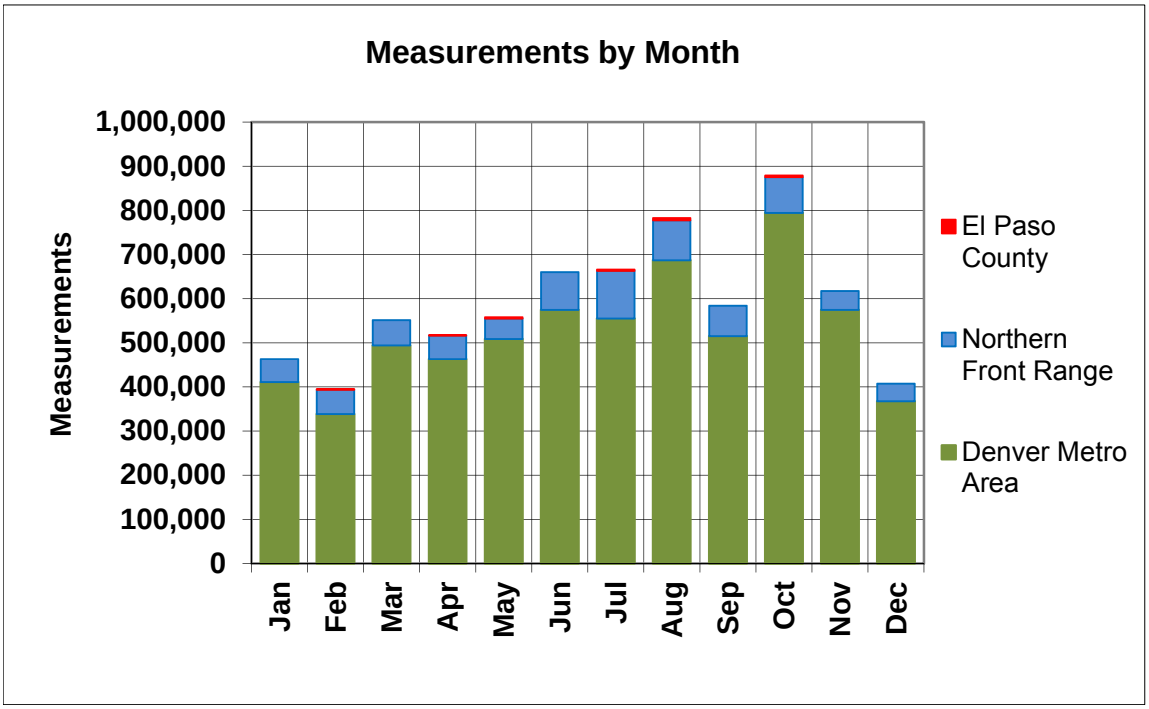
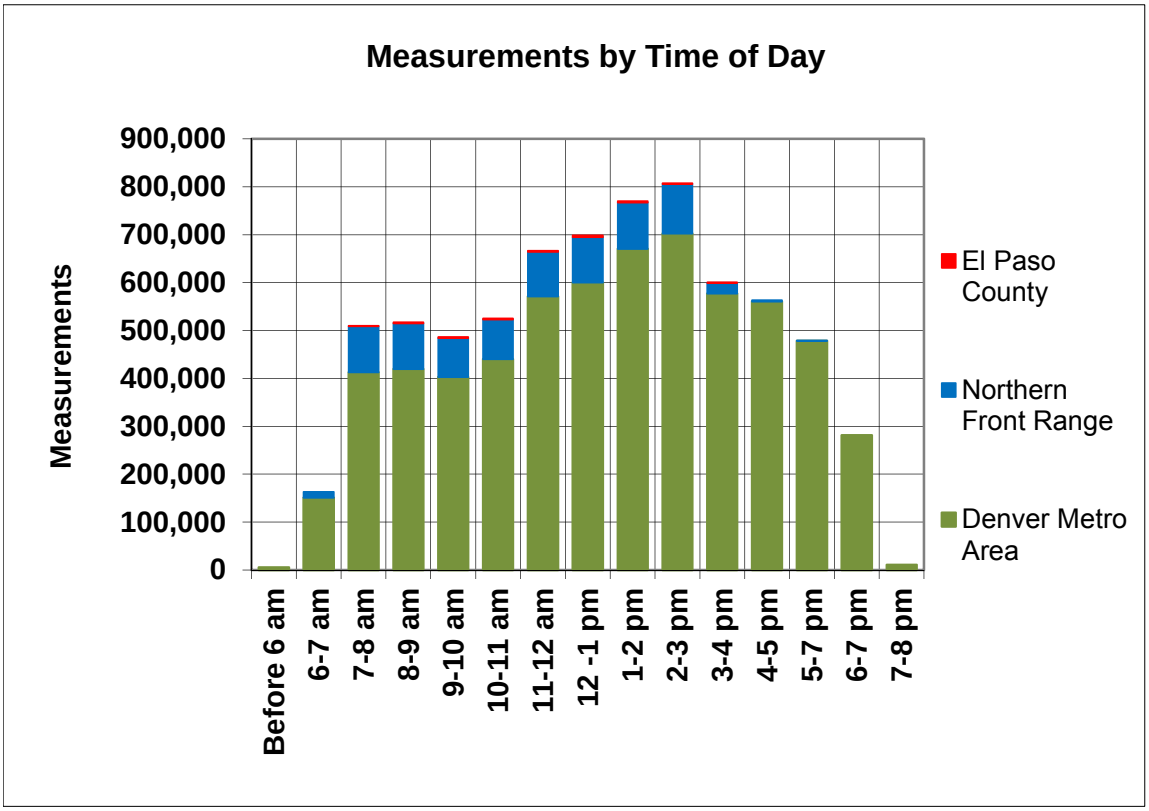


Figure III-2 Measurements by Time of Day



C. Composition of Vehicles Measured

Table III-2, Source of Vehicle Registrations Measured by RSD, shows the number of vehicles registered in each program area and the area where they were measured. The majority (98%) of Denver Metropolitan Area registered vehicles were measured within the DMA. A majority (79%) of Northern Front Range registered vehicles were measured in NFR with the remaining 21% being measured in the DMA.

Table III-3, Type of Vehicles Measured by RSD within Registration Jurisdiction, shows that 79.8% of vehicles measured were registered in the DMA, 10.5% in the NFR, 1.5% in El Paso County (Colorado Springs), 3.6% in other non-I/M counties, and 4.6% were not matched. This can occur when plates are transferred by an owner to a new vehicle. These numbers are indicative of on-road activity – not unique registrations. The same vehicle may be measured more than once.

Table III-4 shows the distribution of vehicle measurements by vehicle type, age group and registration jurisdiction. The vehicle types were identified by the Polk VIN decoder. The model years of 1980 and older vehicles and some of the newest models were determined from the registration information but the vehicle type was not available. These were classified as Unknown in Table III-3. One thousand and fifty-one measurements of motorcycles were also recorded.

Table III-2 Source of Vehicle Registrations Measured by RSD

Program	Registered County	Measured In						Total
		Denver Metro Area		Northern Front Range		El Paso		
Denver Metro Area	Adams	864,222	97%	25,472	3%	171	0%	889,865
	Arapahoe	735,400	97%	18,545	2%	443	0%	754,388
	Boulder	254,639	91%	25,191	9%	54	0%	279,884
	Broomfield	145,837	97%	3,772	3%	17	0%	149,626
	Denver	1,001,642	98%	20,474	2%	453	0%	1,022,569
	Douglas	792,648	99%	8,379	1%	406	0%	801,433
	Jefferson	1,694,294	99%	16,974	1%	216	0%	1,711,484
	State of Colorado	34,896	87%	4,925	12%	326	1%	40,147
Subtotal Denver Metro		**5,523,578**	**98%**	**123,732**	**2%**	**2,086**	**0%**	5,649,396
Northern Front Range	Larimer	52,049	13%	349,857	87%	63	0%	401,969
	Weld	102,899	30%	238,738	70%	52	0%	341,689
Subtotal Northern Front Range		**154,948**	**21%**	**588,595**	**79%**	**115**	**0%**	**743,658**
El Paso	El Paso	88,199	81%	7,484	7%	12,813	12%	108,496
Non I/M		228,114	90%	24,015	9%	785	0%	252,914
Not Matched								323,780
Total		**5,994,839**		**743,826**		**15,799**		**7,078,244**

Table III-3 Type of Vehicles Measured by RSD within Registration Jurisdiction

Program	County	Pass	Truck	Unknown	Total	%
Denver Metro	Adams	342,518	543,312	4,035	889,865	12.6%
	Arapahoe	298,728	452,936	2,724	754,388	10.7%
	Boulder	123,825	154,957	1,102	279,884	4.0%
	Broomfield	63,807	85,382	437	149,626	2.1%
	Denver	423,627	593,954	4,988	1,022,569	14.4%
	Douglas	275,290	524,629	1,514	801,433	11.3%
	Jefferson	664,064	1,041,676	5,744	1,711,484	24.2%
	State of Colorado	10,134	27,952	2,061	40,147	0.6%
Denver Metro		**2,201,993**	**3,424,798**	**22,605**	**5,649,396**	**79.8%**
Northern Front Range	Larimer	159,649	240,134	2,186	401,969	5.7%
	Weld	132,518	207,381	1,790	341,689	4.8%
Subtotal North Front Range		**292,167**	**447,515**	**3,976**	**743,658**	**10.5%**
El Paso	El Paso	44,634	63,022	840	108,496	1.5%
Non I/M		87,634	162,314	2,966	252,914	3.6%
Not Matched					323,780	4.6%
Total		**2,626,428**	**4,097,649**	**30,387**	**7,078,244**	**100.0%**

Table III-4 Registered Jurisdiction and Age of Vehicles Measured by RSD

Vehicle Type	Model Year	Denver Metro Area	Northern Front Range	El Paso	Non-I/M	Total
Pass	1981 & older	279	46	18	45	388
	1982-1990	31,028	5,224	761	2,056	39,069
	1991-1995	114,582	17,789	2,456	5,872	140,699
	1996-2000	374,788	52,498	7,442	15,992	450,720
	2001-2005	651,081	90,678	13,540	27,185	782,484
	2006-2010	656,463	84,211	13,163	24,525	778,362
	2011 & newer	373,772	41,721	7,254	11,959	434,706
Light Truck	1981 & older	409	86	13	126	634
	1982-1990	27,146	5,053	646	2,766	35,611
	1991-1995	108,010	16,889	2,425	7,381	134,705
	1996-2000	480,961	64,364	8,781	25,025	579,131
	2001-2005	1,051,982	138,572	19,945	49,776	1,260,275
	2006-2010	1,107,505	141,135	20,405	50,151	1,319,196
	2011 & newer	648,785	81,416	10,807	27,089	768,097
Unknown	1981 & older	10,619	1,920	354	1,358	14,251
	1982-1990	364	91	43	135	633
	1991-1995	562	111	32	113	818
	1996-2000	1,516	328	52	300	2,196
	2001-2005	2,806	514	102	313	3,735
	2006-2010	2,841	530	109	355	3,835
	2011 & newer	2,872	346	57	181	3,456
Motorcycles		613	136	91	211	1,051
Total		5,648,984	743,658	108,496	252,914	6,754,052

IV. Clean Screening Program Performance

A. Vehicles Selected, Notices and Redemptions

In 2013, there were 273,824 vehicles qualifying for participation in the clean screen program. Table IV-1 summarizes the monthly number of vehicles meeting screening criteria each month, including the number withheld for the random sample and the number rejected through QA checks.

A random sample of two percent of vehicles meeting Clean Screen criteria are not mailed notices. These vehicles are required to go to a test station to obtain the station-based emission inspection. This random sample of vehicles is used to evaluate the effectiveness of the Clean Screen program.

Not all vehicles notified for clean screen or withheld in the random sample redeem the clean screen or obtain a test at that time, for example vehicles changing owner were likely to have obtained an earlier station inspection. Compared to the 263,431 vehicles notified in the year, fewer vehicles 233,760 (88.7%) obtained a clean screen.

Table IV-1 Vehicles Qualified As Meeting Clean Screening Criteria by Status

Reg Year	Reg Month	Random Sample	QA failed	Notified	Total Qualified	Random % of Qualified
2013	Jan	482	787	22,880	24,149	2.0%
2013	Feb	462	463	22,235	23,160	2.0%
2013	Mar	486	272	23,425	24,183	2.0%
2013	Apr	432	242	20,840	21,514	2.0%
2013	May	450	324	21,660	22,434	2.0%
2013	Jun	463	274	22,577	23,314	2.0%
2013	Jul	494	293	23,362	24,149	2.0%
2013	Aug	497	361	23,961	24,819	2.0%
2013	Sep	484	615	22,332	23,431	2.1%
2013	Oct	496	559	23,770	24,825	2.0%
2013	Nov	393	414	18,539	19,346	2.0%
2013	Dec	363	287	17,850	18,500	2.0%
Total		5,502	4,891	263,431	273,824	2.0%

Table IV-2 lists the number of vehicles by month and city notified via the Department of Revenue. Table IV-3 shows inspection results of the audit sample. Just 0.6% of the audit sample failed their exhaust emissions inspection down from 0.9% in 2012. Gas cap pressure test failures of 3.4% were up from 3.3% in 2012.

Table IV-2 Notifications Transmitted to DOR

	Registration Renewal Month												
City	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
DENVER	3,743	3,539	4,033	3,559	3,808	4,125	4,291	4,112	3,888	4,067	3,390	3,339	45,894
AURORA	1,680	1,553	1,656	1,479	1,435	1,442	1,511	1,655	1,431	1,634	1,235	1,197	17,908
LITTLETON	1,262	1,245	1,264	1,175	1,140	1,335	1,390	1,447	1,257	1,454	1,102	1,102	15,173
FT COLLINS	1,247	1,153	1,259	1,126	1,191	1,222	1,201	1,311	1,195	1,342	1,027	895	14,169
ARVADA	1,062	1,112	1,149	1,093	1,132	1,228	1,271	1,348	1,252	1,349	1,011	1,030	14,037
LAKEWOOD	1,097	1,080	1,127	1,040	1,093	1,094	1,122	1,241	1,266	1,293	1,044	988	13,485
HIGHLAND RCH	998	1,092	1,041	908	1,008	971	1,080	1,181	1,106	1,176	842	821	12,224
WESTMINSTER	961	833	910	776	795	905	883	903	855	831	682	715	10,049
THORNTON	893	874	893	782	869	859	820	836	752	859	643	625	9,705
CENTENNIAL	800	769	819	703	697	716	750	805	807	835	728	615	9,044
CASTLE ROCK	676	622	664	560	600	683	716	688	684	673	528	476	7,570
GREELEY	554	610	663	611	593	572	653	619	577	627	457	409	6,945
BROOMFIELD	683	671	664	568	614	591	596	584	540	544	440	428	6,923
BOULDER	777	708	645	598	550	588	577	564	478	516	346	423	6,770
LOVELAND	507	560	609	528	600	579	568	581	575	596	429	376	6,508
GOLDEN	538	495	471	437	473	539	570	573	521	604	493	452	6,166
PARKER	548	498	533	477	480	492	528	559	521	548	406	411	6,001
LONGMONT	427	459	469	376	414	377	402	389	316	371	275	263	4,538
ENGLEWOOD	387	374	375	383	365	351	377	430	371	383	267	316	4,379
WHEAT RIDGE	238	238	266	266	253	230	252	267	293	274	221	237	3,035
BRIGHTON	252	244	271	236	246	224	234	235	236	244	214	192	2,828
NORTHGLENN	277	250	240	253	250	260	255	242	186	263	177	153	2,806
WINDSOR	226	204	238	211	228	231	272	282	275	245	201	157	2,770
COMMERCE CITY	227	230	227	183	196	207	221	251	214	217	175	128	2,476
LAFAYETTE	171	170	177	171	160	189	209	198	183	212	153	143	2,136
LOUISVILLE	166	180	167	145	152	168	186	174	172	183	135	130	1,958
ERIE	178	175	199	165	179	170	174	162	156	157	102	123	1,940
EVERGREEN	141	137	148	126	172	159	179	176	151	165	133	150	1,837
MORRISON	175	148	124	125	131	148	151	137	139	161	103	111	1,653
GREENWOOD VLG	139	130	138	108	150	130	119	156	165	166	108	97	1,606
LONE TREE	153	143	133	116	114	128	103	142	116	145	103	103	1,499
EVANS	104	138	133	106	127	125	117	113	110	104	103	84	1,364
CASTLE PNS N	106	114	114	100	100	138	126	145	100	123	108	86	1,360
JOHNSTOWN	96	89	104	100	96	100	112	110	122	109	93	81	1,212
SUPERIOR	104	121	113	69	90	87	91	105	90	73	86	80	1,109
FREDERICK	80	71	88	66	61	88	94	110	104	107	82	88	1,039
BERTHOUD	90	79	92	79	77	72	71	69	75	65	55	56	880
FIRESTONE	70	100	83	57	61	77	73	66	71	95	63	45	861
CONIFER	78	99	82	61	76	69	63	57	63	65	54	42	809
OTHER	969	928	1,044	918	884	908	954	938	919	895	725	683	10,765
Total	**22,880**	**22,235**	**23,425**	**20,840**	**21,660**	**22,577**	**23,362**	**23,961**	**22,332**	**23,770**	**18,539**	**17,850**	**263,431**

Table IV-3 Clean Screen Audit Test Pass / Fail Statistics

Vehicle Type	Vehicles	Fail Emissions	Fail Gas Cap / Pressure	Fail Inspection
Passenger	1,827	9	68	75
Light Truck	2,633	18	85	102
Total	4,460	27	153	177
Percentage		0.6%	3.4%	4.0%

B. Clean Screen Program Effectiveness

The emissions reductions obtained during the station testing of the audit sample vehicles are used to project the total emissions reductions foregone as a result of the Clean Screen program.

Pass / Fail Statistics

Matching initial tests for audit vehicles were limited to those occurring after the second RSD measurement and before expiration of the assigned Clean Screen period. Matching re-inspections following an initial failure were sought through the end of February 2014. The inspections identified for audit sample vehicles and the inspection results are tabulated in Table IV-3. As noted earlier, some of the anticipated random vehicles did not obtain a test within the Clean Screen period. In aggregate, 0.6% of the tested audit vehicles failed their tailpipe emissions inspection, and 3.4% of the tested audit vehicles failed their gas cap pressure test[2].

Following sections describe in detail how these results are used to evaluate the emissions impact of the Clean Screen program.

Tailpipe Emissions

Over 93% of inspected vehicles, and 95% of the clean screen audit vehicles, were tested using IM240. Models inspected using the idle test included 1981-and-older models and 1982-and-newer trucks over 8500 lbs GWWR plus some four-wheel drive and traction control vehicles. Few of these were clean screened. The IM240 test provides a more accurate estimate of in-use vehicle exhaust emissions than the idle tailpipe test. Therefore, the results of the clean screen audit sample vehicles tested using IM240 were used to evaluate the exhaust emissions effectiveness of the clean screen program.

Vehicle test results were sorted by VIN and test date. Vehicles were then further classified based on their first and last test result during the period. To avoid potential double counting of emissions reductions, the emissions analysis only considered the first and last result for each vehicle during the year and interim results were ignored.

In the list below, the first and last results are indicated in parenthesis, where P is pass, F is fail, W is waiver and null indicates there was only a single test result for a particular vehicle. The expected combinations applying to the vast majority of vehicles are underlined.

- P – Passed initial test (P/null, P/P, P/F, P/W)
- R – Failed and successfully repaired (F/P)
- U – Failed unresolved (F/null, F/F)
- W – Failed and wavered (F/W)

[2] Note that the number of emissions fails plus the number of Gas Cap / Gas Cap Pressure failures does not always equal the total number of inspection failures. In a few cases a vehicle may fail both Emissions and Gas Cap. In a few cases, vehicles fail for other reasons.

The difference between the initial and final tests is used to determine the percentage of tailpipe emissions reduction of each group. For vehicles with only one test, the final result is the same as the initial result.

Adjustment of Fast-Pass Results

A majority of vehicles tested on IM240 fast pass the test in less than the 240-second driving cycle. To allow for comparison of emissions of vehicles tested over different durations of the IM240 test cycle, the emission results for vehicles fast-passing the IM240 inspection must be extrapolated. A method for projecting full test emissions was developed and implemented in the I/M program in 1996[4] and the projected full test emissions values are stored in the test records and reported as the emissions results.

Unresolved Vehicles

When vehicles fail their initial inspection, they must obtain a repair and return for re-inspection. This process is normally completed in 30 days, but can take longer. Vehicles having initial tests in late 2013 but completing repair and final test after February of the following year are treated as unresolved. Thus, the "Fail unresolved" category may be somewhat over-stated.

A number of vehicles never complete the repair/re-inspection process. In most cases, these vehicles are either scrapped or removed from the non-attainment area, which does reduce emissions in the area. Surveys in Arizona[5] and Colorado[6] found that some vehicles continued to operate in the area in violation of the program rules, either with expired license plates or with stolen license plates or license plate stickers. In this report, it is assumed that two-thirds of these unresolved vehicles leave the area and one third continues to operate. Recent studies in Colorado indicate the percentage leaving the area may be as high as 80%.

To minimize the number of unresolved Clean Screen audit vehicles, retests of audit vehicles were included through the end of February 2014 and the audit vehicles were all assumed to remain in the area.

First and Final Emissions Results

Table IV-4 contains an example of the initial and final tailpipe results for 1982 to 1985 passenger vehicles inspected using the IM240 test. The table shows the average initial and average final emissions for each group of vehicles together with the percentage reduction.

For example, of the 1,428 1985 model year passenger vehicles tested using the IM240 transient test, 15.8% of vehicles initially failed inspection and were repaired (Pass) with HC, CO and NOx reductions of 50.7%, 68.7% and 8.8%. Another 7.4% of vehicles failed their initial inspection and had not successfully passed a retest by end February 2014 (Unresolved). Reductions from these vehicles are estimated to be approximately 66% for HC, CO and NOx, because follow-up studies have shown that more than two thirds cease operating in the area. Finally, 0.1% of vehicles were waived (Waiver) with CO reductions of 35.6% and increases in HC and NOx. In aggregate, including vehicles passing their initial inspection, emission reductions for 1985 passenger vehicles were 24.9% for HC, 35.6% for CO and 6.2% for NOx.

Complete tables by model year and vehicle type are provided in Appendix A for vehicles tested using the IM240. Tables are also provided for the Clean Screen audit sample vehicles.

Table IV-4 Transient Test Emission Reductions for 1982-1985 Passenger Vehicles

Appendix A1 Colorado 2013 Transient Test Emissions Reductions													
Unresolved fails remaining in area					33%								
Model	First	Last			Initial			Final			Reduction %		
Year/Type	Result	Result	Vehicles	Fail%	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX
1982	Pass	-	258		1.62	19.18	2.02	1.62	19.18	2.02	0.0%	0.0%	0.0%
P	Fail	Pass	59	17.2%	4.56	51.09	2.02	1.52	19.35	1.88	66.6%	62.1%	7.0%
	Fail	Unresolv.	26	7.6%	5.59	85.27	1.92	1.99	29.03	0.65	64.4%	66.0%	66.0%
	Fail	Waiver	1	0.3%	1.49	70.11	0.38	1.49	70.11	0.38	0.0%	0.0%	0.0%
Total	Fail%		344	25.0%	2.42	29.80	2.00	1.63	20.10	1.88	32.7%	32.5%	6.0%
1983	Pass	-	462		1.29	12.26	2.07	1.29	12.26	2.07	0.0%	0.0%	0.0%
P	Fail	Pass	98	16.0%	2.32	36.51	2.06	1.24	14.85	1.79	46.7%	59.3%	13.2%
	Fail	Unresolv.	49	8.0%	4.46	73.11	1.91	1.56	24.31	0.57	65.1%	66.7%	69.9%
	Fail	Waiver	3	0.5%	4.50	140.30	1.08	4.73	146.55	0.24	-5.0%	-4.5%	77.6%
Total	Fail%		612	24.5%	1.73	21.65	2.05	1.32	14.30	1.89	23.5%	33.9%	7.5%
1984	Pass	-	619		1.23	11.35	1.92	1.23	11.35	1.92	0.0%	0.0%	0.0%
P	Fail	Pass	147	17.3%	2.86	39.51	1.97	1.44	14.26	2.05	49.7%	63.9%	-4.4%
	Fail	Unresolv.	79	9.3%	5.47	75.77	1.82	1.73	23.32	0.59	68.4%	69.2%	67.3%
	Fail	Waiver	6	0.7%	5.14	112.15	1.64	4.98	116.14	1.55	3.2%	-3.6%	5.9%
Total	Fail%		851	27.3%	1.94	22.90	1.92	1.34	13.70	1.82	30.7%	40.2%	5.2%
1985	Pass	-	1,094		1.05	10.84	1.89	1.05	10.84	1.89	0.0%	0.0%	0.0%
P	Fail	Pass	226	15.8%	2.21	31.01	2.12	1.09	9.71	1.93	50.7%	68.7%	8.8%
	Fail	Unresolv.	106	7.4%	3.92	58.15	1.79	1.34	19.49	0.58	65.8%	66.5%	67.5%
	Fail	Waiver	2	0.1%	5.59	85.44	1.10	11.43	58.43	1.41	-104.5%	31.6%	-27.3%
Total	Fail%		1,428	23.4%	1.45	17.65	1.92	1.09	11.37	1.80	24.9%	35.6%	6.2%

Audit Sample Reductions and Projected Impact

Table IV-5 shows the aggregate first and final results for the 95% of inspected audit sample vehicles tested using IM240. The average per vehicle emissions reductions from the audit sample are multiplied by the number of exempted clean screen vehicles to project the reductions that could have been achieved if the clean screen vehicles had instead been inspected at the stations. This amount is then compared to the total emission reductions from vehicles tested at stations to determine the impact of the Clean Screen program and the percentage of emissions reductions retained.

For vehicles subject to the IM240 test, the Clean Screen program retained 98.4%, 96.9% and 98.1% of the exhaust HC, CO and NOx reductions respectively. These reductions assume all vehicles are driven the same number of miles each year. Mileage adjusted emission reductions are calculated in section V.

Table IV-5 Clean Screen Emissions Impact for Tailpipe Emissions

	Vehicles	**HC g/mi**	**CO g/mi**	**NOx g/mi**
Audit Sample	4,234			
Mean Initial		0.093	1.744	0.277
Mean Final		0.090	1.638	0.272
Emissions reduction		0.004	0.106	0.004
Clean Screens	222,368			
Potential Reductions		863	23,507	992
Station Vehicles	869,433			
Mean Initial		0.290	3.967	0.623
Mean Final		0.229	3.132	0.564
Emissions reduction		0.061	0.835	0.059
In station reductions		53,088	726,166	51,003
Combined CS & Stn	1,091,801	53,951	749,673	51,995
Clean Screen Impact		1.6%	3.1%	1.9%
Retained Reductions		98.4%	96.9%	98.1%

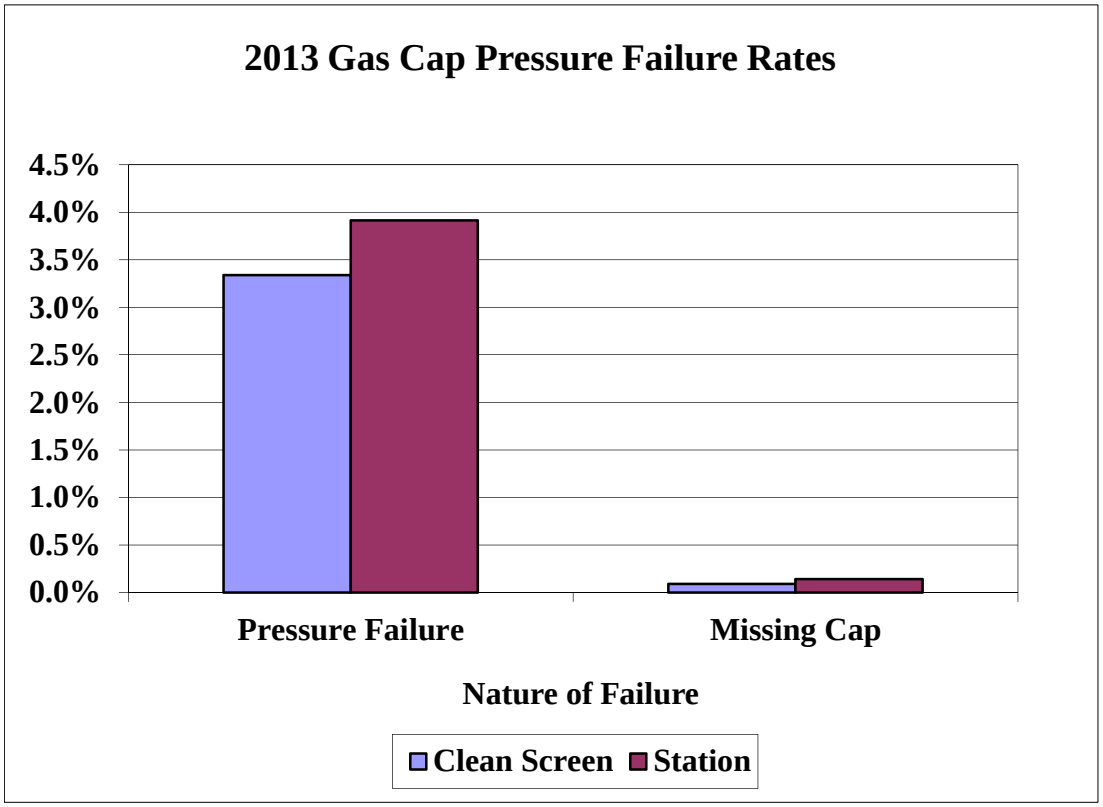
C. Gas Cap Evaporative Emissions

The evaporative emissions test used in the I/M Program is a gas cap pressure test. Leaking gas caps allow evaporated gasoline (HC) to escape from vehicle gas tanks into the

atmosphere. The impact of leaking gas caps on the Clean Screen program is only evaluated in this report in terms of the failure rate, not in terms of repairable gas cap emissions reductions[3].

Figure IV-1 compares the average gas cap failure rate of the Clean Screen audit sample vehicles to the average failure rate of the non-audit vehicles tested at stations. The failure rate of vehicles exempted via Clean Screen methods was 15% lower than the failure rate of vehicles receiving a station-based test (See Figure IV-1). This result is expected because remote sensing is directed towards measuring tailpipe emissions. A gas cap evaporative leak has to be quite large to be detected by RSD units. Clean screen models were newer than the overall tested fleet.

Figure IV-1 Gas Cap Pressure Failure Rates



Using the fail rates identified in the audit sample, Table IV-6 shows the projected gas cap failures that would have been found in the exempted clean screen vehicles. These projected gas cap failures are added to the actual gas cap failures identified in initial inspections at the test stations to provide the total possible gas cap failure rate for the program. Vehicle counts in Figure IV-6 are higher than IV-5 because they include gas cap tests on vehicles tested using idle tests as well as those tested using IM240. Vehicles with a redeemed Clean Screen notice account for 17.1% of the total possible gas cap failures. Therefore, 82.9% of evaporative gas cap HC emission reductions were retained.

[3] Although the gas cap leak rates are measured in the I/M Program, it is not clear that leak rates are directly related to the amount of evaporative HC emissions released from the gas tank. A small pressure leak may have the same effect as a large pressure leak, as long as it is sufficient to release internal gas tank pressure over a period of an hour or so.

In general, it is desirable to use direct measurements of emissions to evaluate program performance rather than a model. Unlike exhaust emissions that are directly measured using tailpipe tests, however, emissions rates from gas caps cannot easily be directly measured. Emissions rates of vapor leaks are typically determined in a test laboratory by enclosing a vehicle in a sealed compartment and measuring the emissions released into the compartment over time, which is impractical for testing many vehicles. Therefore, the EPA mobile source emissions model, MOVES, was used to estimate the fraction of emissions benefits derived from gas cap inspections.

CDPHE provided results from MOVES models of the benefits of the I/M program for 2013. The projected average reduction in HC emissions of the area fleet was 0.128 g/mi. This was comprised of 0.118 g/mi resulting from exhaust emissions inspections and 0.010 g/mi from the Gas Cap testing. The measured I/M exhaust reductions (see section V) were 498.8 tons. Assuming the 0.118 g/mi corresponded to 498.8 tons, the Gas Cap related HC reductions were projected to be 40.8 tons. These results are shown in Table IV-7. The RapidScreen impact was projected as 7.0 tons or 1.3% of the I/M program reductions.

Table IV-6 Clean Screen Impact on Evaporative HC Emissions

	Initial Tests	Pressure Failure	Missing Cap	Total Fails
RapidScreen Audit	4,460	149	4	153
		3.3%	0.1%	3.4%
Projected RapidScreen	233,760	7,809	210	8,019
Station GC Tests	958,107	37,491	1,345	38,836
		3.9%	0.1%	4.1%
Total Program	1,191,867	45,300	1,555	46,855
RapidScreen Impact	19.6%	17.2%	13.5%	17.1%
Retained Reductions	80.4%	82.8%	86.5%	82.9%

Table IV-7 Gas Cap Related Benefit Tons

MOVES Estimates (from CDPHE)		2013 MOVES g/mi HC	I/M 2013 HC tons
I/M Exhaust emission reductions		0.118	498.8
Projected Gas Cap Evap Emissions reductions		0.010	40.7
I/M Program total HC reductions		0.128	539.6
Gas Cap Evap RapidScreen impact	17.1%	0.002	7.0
% of I/M program HC benefit			**1.3%**

D. Hybrid RSD-LEI vs. 2-hit RSD

Envirotest compared the effectiveness of the 'Hybrid' and '2-RSD' screening methods. The Hybrid method uses a single RSD measurement and a low emitter index (LEI) table. The 2-RSD method uses two RSD measurements.

The audit sample of vehicles with IM240 tests contained 2,832 vehicles screened using the 2-RSD method and 1,402 vehicles screened using Hybrid RSD-LEI method. Table IV-8 shows the emissions reductions for these two samples and the average for all vehicles inspected at stations. Figures IV-2 and IV-3 show the average initial emissions and emissions reductions for each sample.

The 2-RSD method audit vehicles had initial emissions that were 41%, 53% and 54% of the overall I/M fleet average for HC and CO and NOx respectively. These percentages were similar to the equivalent percentages in 2012 of 42%, 50% and 56% respectively.

The Hybrid RSD-LEI method audit vehicles had lower initial emissions that were 30%, 44% and 42% of the I/M fleet average for HC and CO and NOx respectively. These percentages were higher than the 2012 equivalents of 26%, 38% and 39%

Average I/M emissions reductions for the 2-RSD audit vehicles were 1.9%, 3.5% and 0.7% of fleet average initial emissions for HC and CO and NOx respectively. The comparable percentages in 2012 were 3.8%, 3.4% and 3.0%.

Average emissions reductions for the Hybrid RSD-LEI audit vehicles were 0.8%, 2.1% and 1.1% of fleet average initial emissions for HC and CO and NOx respectively. The comparable 2012 percentages were 0.8%, 0.9% and 0.1%. Average reductions in station tested vehicles were 24.4%, 23.9% and 10.7% for HC, CO and NOx respectively.

The Hybrid RSD-LEI audit vehicles had lower initial emissions of HC, CO and NOx and smaller reductions than the 2-RSD audit vehicles. Consideration should be given to adjusting the 2-RSD standards. The RSD-LEI method standards are in part automatically adjusted by annual updates to the LEI table.

Table IV-8 Average Emissions per Vehicle

Vehicle Sample	IM240 Tailpipe Emissions Vehicles	HC g/mi	CO g/mi	NOx g/mi
I/M vehicle initial mean emissions		0.248	3.496	0.549
2-RSD Audits	2,832			
Mean Initial		0.103	1.845	0.299
Mean Final		0.098	1.723	0.296
Emissions reduction		0.005	0.122	0.004
% of I/M vehicle initial mean emission		1.9%	3.5%	0.7%
Hybrid Audits	1,402			
Mean Initial		0.075	1.540	0.231
Mean Final		0.073	1.466	0.225
Emissions reduction		0.002	0.074	0.006
% of I/M vehicle initial mean emission		0.8%	2.1%	1.1%
All Station Tests	869,433			
Mean Initial		0.290	3.967	0.623
Mean Final		0.229	3.132	0.564
Emissions reduction		0.061	0.835	0.059
% of I/M vehicle initial mean emission		24.6%	23.9%	10.7%

Figure IV-2 Average Initial IM240 Emissions

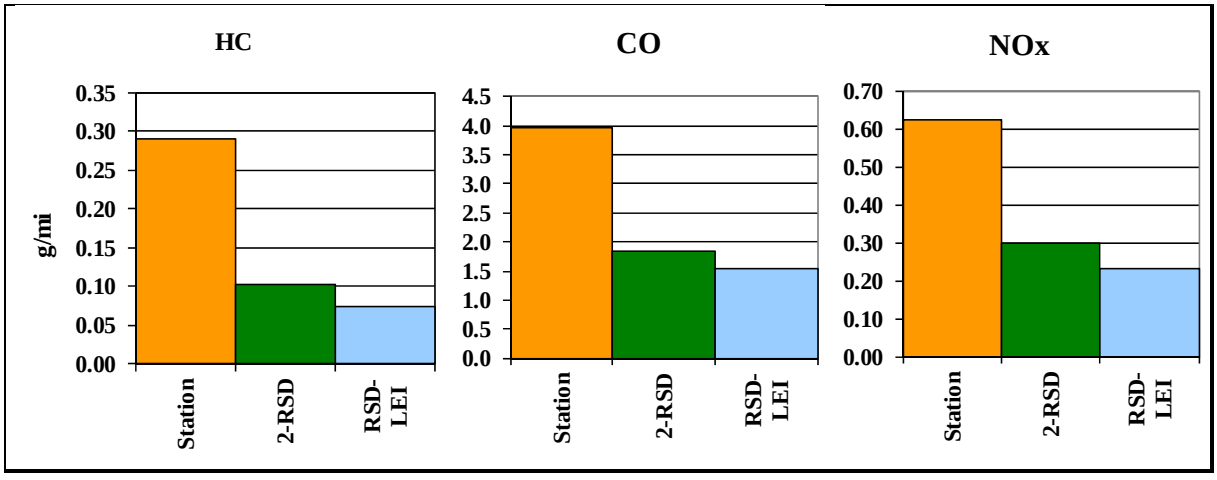
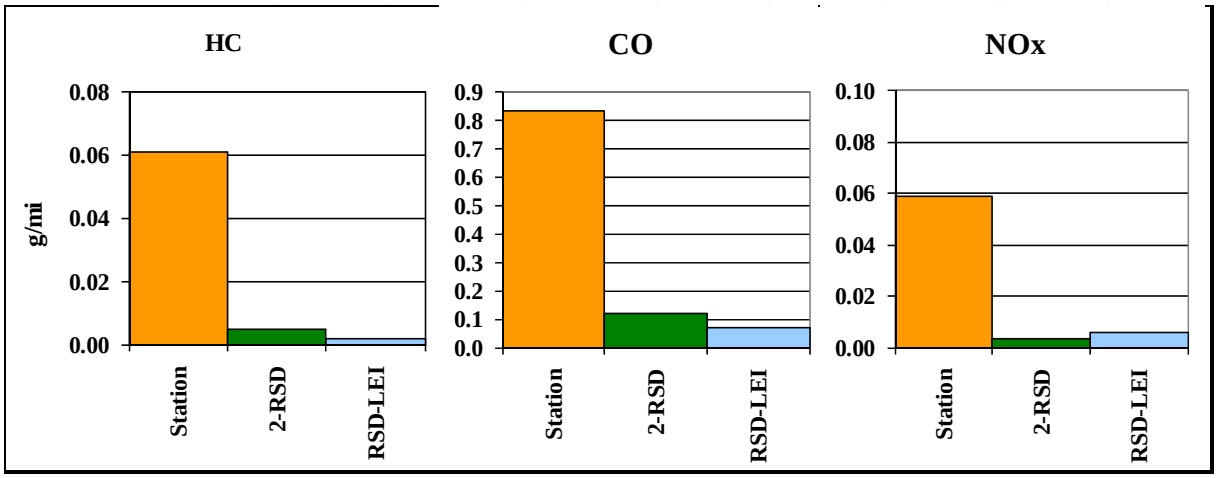


Figure IV-3 Average IM240 Emissions Reductions



V. Estimate of Overall I/M Program Benefits and Clean Screen Impact

Overall I/M program emission reductions derive from two main components:

- Reductions resulting directly from I/M inspections and consequent repairs;
- Reductions from repair activities performed in anticipation of an I/M inspection.

In previous years, it was assumed the vast majority of emissions reductions were directly measurable by comparing the initial and final I/M inspection emissions results, i.e. the first component described above. This report uses the same methodology. However, most vehicles tested were equipped with OBD-II malfunction indicator lights and many repairs of these vehicles are performed in response to warning lights before the initial inspection. The benefits of these repairs are not directly measurable in the program testing.

The Clean Screen disbenefit can be projected directly from the emissions testing of the audit sample. There may be unmeasured offsetting benefits if the Clean Screen program encourages owners to maintain malfunctioning vehicles sooner than otherwise.

For this report, measured I/M exhaust emissions benefits were projected from the IM240 and Idle emissions tests. In the case of Idle tests, idle test emission concentrations were converted to equivalent IM240 g/mi emissions.

For each model year, the IM240 g/mi emissions values were weighted by the annual vehicle miles traveled to project the emissions inventory for initial and final test and, hence, the direct program benefits.

The following sections project the directly measured tons of emissions and reductions

A. Conversion of Idle Tests to IM240 Equivalent emissions

On-road remote sensing emissions of vehicles inspected at I/M stations have been used to project IM240 equivalent values for Idle test emissions.

The idle test procedure includes a low-speed idle and a high speed idle at 2500rpm. Vehicles model year 1980 and older are required to pass the low-speed idle while 1981 and newer models must pass both the low-speed and the high-speed tests.

Figures V-1 and V-2 show the correlation between Idle tests and on-road HC and CO emissions of the same vehicles. Results are averaged by model year. Average initial and final test emissions were used for vehicles initially failing and retested. Model years were grouped together for 1965-and-older, 1966 to 1970, 1971 to 1975, 1976 to 1981, 1982 to 1985, 1986 to 1990 and 2004-and-newer. Even with these groups, there were less than 100 matching RSD measurements for Passenger vehicles in groups from 1982 to 1998. There were several hundred matching RSD measurements for each truck group. Trend lines were plotted with an intercept of zero to obtain RSD / Idle Test emissions ratios.

Similarly, Figure V-3 shows the correlation between IM240 and on-road emissions. Trend lines were plotted with an intercept of zero for HC and CO emissions to obtain IM240 / RSD emissions ratios. The results are summarized in Tables V-1 and V-2.

Figure V-1 RSD vs. Idle Test Emissions

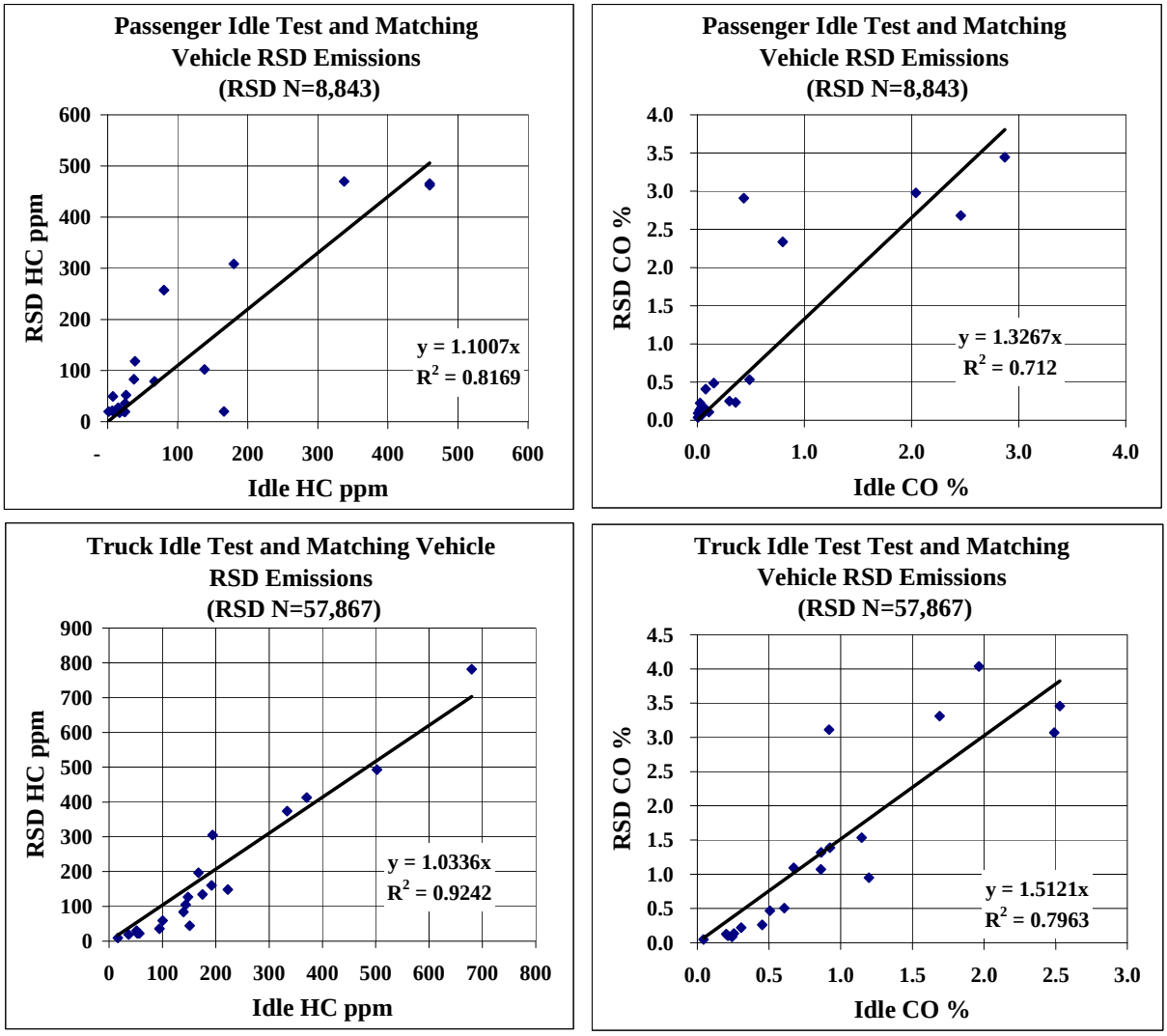


Table V-1 Low Speed Idle to IM240

Low Speed Idle test to IM240 Projection				
Passenger	**HC**	**HC R2**	**CO**	**CO R2**
RSD / Idle	1.1007	0.81	1.3267	0.71
IM240 / RSD	0.0087	0.98	15.947	0.92
IM240 / Idle	0.0096		21.1569	
Truck	**HC**	**HC R2**	**CO**	**CO R2**
RSD / Idle	1.0336	0.92	1.5121	0.8
IM240 / RSD	0.0111	0.98	18.765	0.94
IM240 / Idle	0.0115		28.3746	

Figure V-2 RSD vs. 2500 Idle Test Emissions

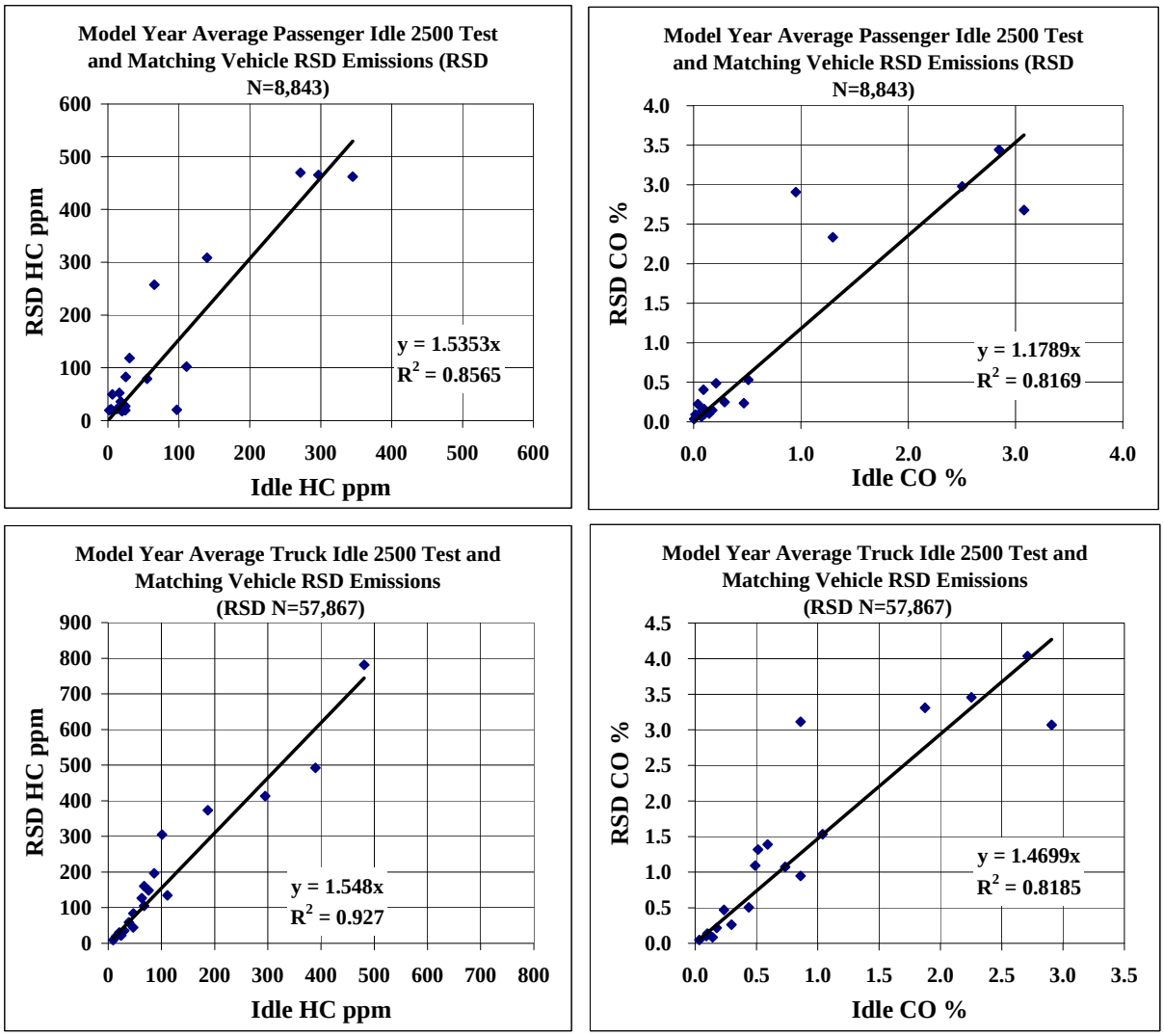
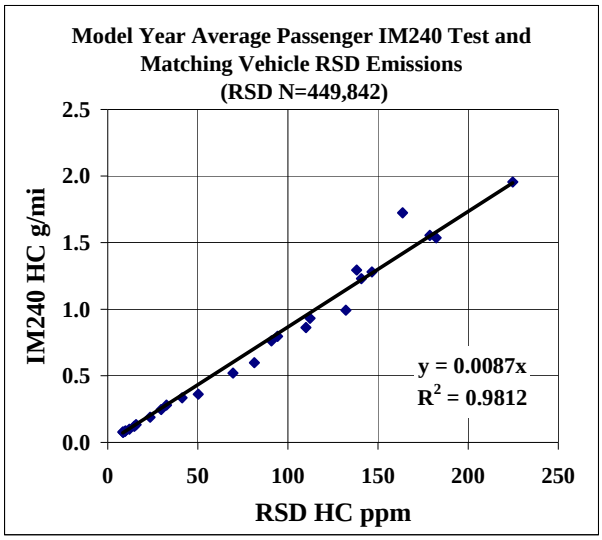


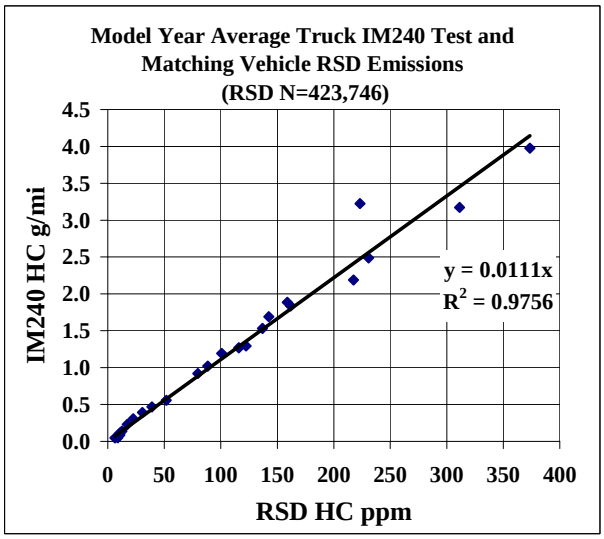
Table V-2 High Speed Idle to IM240

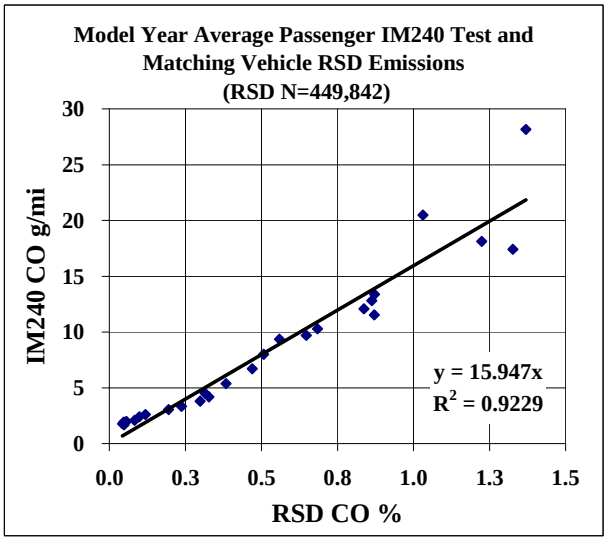
2500 RPM Idle test to IM240 Projection				
Passenger	**HC**	**HC R2**	**CO**	**CO R2**
RSD / 2500	1.5353	0.86	1.1789	0.82
IM240 / RSD	0.0087	0.98	15.947	0.92
IM240 / 2500	0.0134		18.7999	
Truck	**HC**	**HC R2**	**CO**	**CO R2**
RSD / 2500	1.548	0.93	1.4699	0.82
IM240 / RSD	0.0111	0.98	18.765	0.94
IM240 / 2500	0.0172		27.5827	

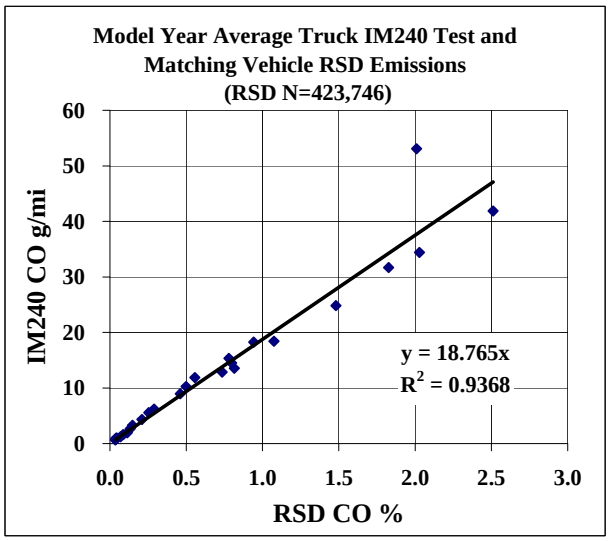
Using the ratios derived above, IM240 g/mi equivalent emissions were projected for the vehicles tested with the idle test procedure. The low speed idle results were used to estimate emissions reductions as all model year vehicles tested at idle were required to pass the low speed idle test.

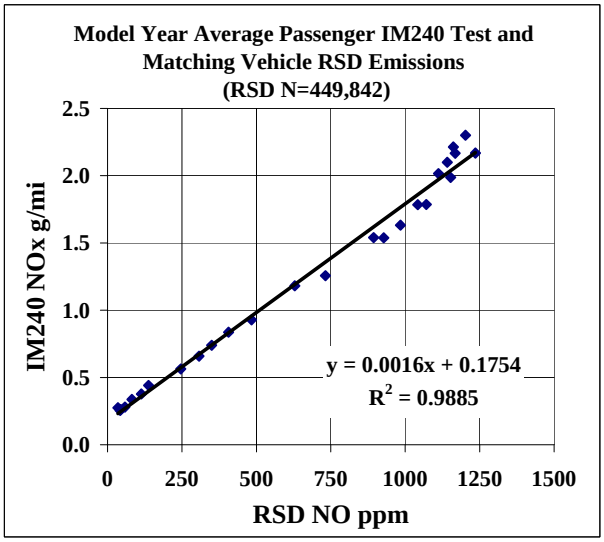
Figure V-3 RSD vs. IM240 Test Emissions

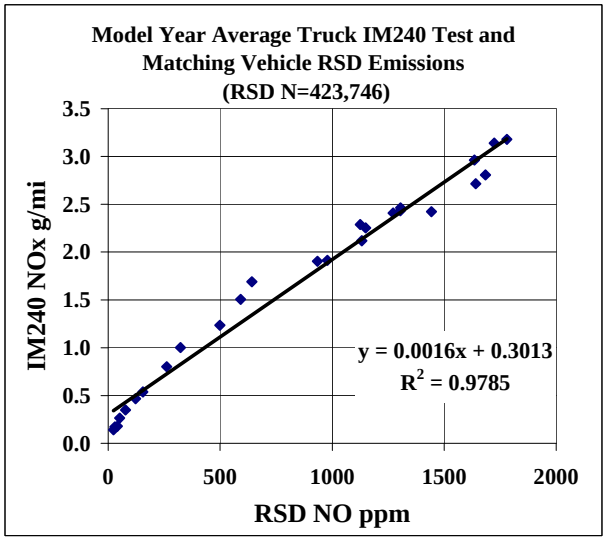












B. Annual Mileage Weighting

Because of data entry errors and odometer rollover on older, high mileage vehicles, obtaining estimates of annual mileage from the I/M Program odometer readings for each model year and type of vehicle is not recommended. To avoid these problems, annual mileages for vehicles were taken from the 2008 ERG report on Colorado mileage accumulation rates[7].

The estimated annual mileages are shown in Table V-3 for LDGVs and LDGTs. In Table VI-3 the mileage accumulation rates for LDGT2, 3 and 4 were weighted together to obtain a single LDGT value. This table indicates that newer model year vehicles are driven more miles annually than older vehicles. It also indicates that 1998 and newer model year LDGTs, which emit greater masses of pollution than LDGVs are driven more miles annually than 1998 and newer model year LDGVs.

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Table V-3 Estimated Annual Mileage in 2013

Year	LDGV	LDGT
1983	4,304	4,550
1984	4,304	4,554
1985	4,304	4,562
1986	4,434	4,583
1987	4,481	4,630
1988	4,502	4,668
1989	4,552	4,741
1990	4,780	4,851
1991	5,088	5,019
1992	5,430	5,256
1993	5,672	5,519
1994	6,002	5,824
1995	6,331	6,135
1996	6,653	6,471
1997	6,974	6,940
1998	7,369	7,437
1999	7,764	7,863
2000	8,188	8,345
2001	8,613	8,900
2002	9,032	9,502
2003	9,450	10,087
2004	9,905	10,727
2005	10,360	11,245
2006	10,746	11,817
2007	11,132	12,303
2008	11,870	12,834
2009	12,023	13,215
2010	12,307	13,433
2011	12,357	13,514
2012	11,600	12,428
2013	9,650	8,995

C. Annual Emissions Reductions

Annual tons of emissions were projected for vehicle type and model year by multiplying the numbers of vehicles by annual mileage and average g/mi emission levels. Results were projected for initial tests and final tests to determine the initial and final tons of emissions and, therefore, the tons of reduction. The results are listed in Appendix B for IM240 and Idle tests.

Table V-4 first shows the reductions from the Clean Screen audit tests. Based on the audit tests, the second part of the table projects the potential reductions from the Clean Screen vehicles if all vehicles with redeemed Clean Screen notices had been tested at a station. The third part of the table shows the reductions from the vehicles tested at inspection stations, which includes the Clean Screen audit vehicles. The total potential reductions from the program are the combination of the potential reductions from the Clean Screened vehicles plus the actual reductions from the vehicles tested at stations.

In Table IV-4, Clean Screen effectiveness was expressed without reference to the annual vehicle miles traveled (VMT) by each model year of vehicles. The more complete analysis in Table V-4 shows the Clean Screen program effectiveness when the VMT and Gas Cap[4] estimates are factored in. During 2013, the Clean Screen program retained 97.3%, 96.7% and 97.6% respectively of potential HC, CO and NOx emission reductions in vehicles subject to testing.

For vehicles initially tested in calendar year 2013, the I/M Program is projected to have eliminated 559.0 tons of HC, 6,924.4 tons of CO and 414.8 tons of NOx for one year of vehicle travel – based on the IM240 driving cycle.

Because the program is biennial, these reductions are approximately half of the reductions that would be measured over a full two-year cycle of the program.

The tons of reductions cited here do not relate directly to the total mobile emissions inventory. The reductions cited are for tailpipe emissions and are in terms of the IM240 driving cycle. State Implementation Plan reductions are based on different driving cycles, are subject to many adjustments for speed, road type, temperature, air conditioning loads, etc., and therefore are larger than the IM240 measured reductions.

As noted earlier, the reductions shown do not include reductions from maintenance actions performed on vehicles before their initial inspection. These may be quite substantial, especially for OBD-II vehicles that turn on the check engine light to alert owners to problems.

[4] The evaporative emissions have not been adjusted for mileage but the effect of an adjustment would be small. Gas cap failures are more evenly distributed by age than tailpipe failures and only part of the evaporative emissions are running losses dependent on miles traveled.

Table V-4 Estimated Annual Tons of Reduction (IM240 and Idle Tested Vehicles

Audit Vehicle Reductions (IM240 tons/yr)				
Audit Tests	**Unique Vehicles**	**HC**	**CO**	**NOx**
Enhanced IM240	4,234	0.14	4.33	0.18
Potential from RS Vehicles (IM240 tons/yr)				
RapidScreen	**Unique Vehicles**	**HC**	**CO**	**NOx**
Enhanced Area	233,760	8.0	239.2	10.1
Gas Cap estimate from Mobile6		7.4		
Station Reductions (IM240 tons/yr)				
Station I/M Vehicles	**Unique Vehicles**	**HC**	**CO**	**NOx**
Enhanced IM240	869,433	368.9	5,133.9	414.8
Enhanced Idle*	81,682	154.2	1,790.5	
Gas Cap scaled from MOVES		35.9		
	951,115	559.0	6,924.4	414.8
Total Potential Reductions		**574.4**	**7,163.6**	**424.8**
RapidScreen Exhaust Impact		*1.4%*	*3.3%*	*2.4%*
Rapidscreen Gas Cap Impact		*1.3%*		
Retained Reductions		***97.3%***	***96.7%***	***97.6%***

* NOx is not reported for idle tests.

Table V-4 also shows that, during calendar year 2013, 233,760 vehicles were exempted through Clean Screen, and 951,115 vehicles received a station test. Therefore, 19.7% of the 1,184,875 unique vehicles were Clean Screened.

If the fraction of Clean Screen vehicles had been 30% of vehicles subject to inspection there would have been 355,463 Clean Screens and 829,413 Station tests. Assuming this increase was achieved by increasing on-road fleet coverage rather than by relaxing the Clean Screen standards, the projected emissions retained would have been 95.9%, 94.5% and 95.9% respectively of potential HC, CO and NOx tailpipe emission reductions.

VI. IM240 Projected Emissions by Model Year

Figures VI-1 through VI-6 show the annual emissions inventories and reductions by model year and vehicle type for the vehicles tested in 2013 at stations, based on the IM240 driving cycle. The projected exhaust emissions inventory for the Clean Screen vehicles and Idle tested vehicles are also shown. The biennial testing cycle of the Enhanced area causes the difference between the sizes of the bars for odd model year vehicles vs. even model year vehicles.

Not included in these charts:

- most 2010 and newer models not yet subject to inspection;
- any estimate of pre-inspection emission reductions;
- NOx emissions for 81,682 vehicles tested with the idle test: 1981 and older models 12,891 (16%), 1982 and newer trucks 64,174 (78%), and 1982 & newer passenger vehicles 4,617 (6%).

The Figures VI-1 to 6 illustrate that 1995 and older vehicles, which are fewer in number and driven fewer miles each year, still contribute many tons of excess emissions in the I/M area – especially old trucks.

Figure VI-1 LDGV HC Reductions and Remaining Emissions

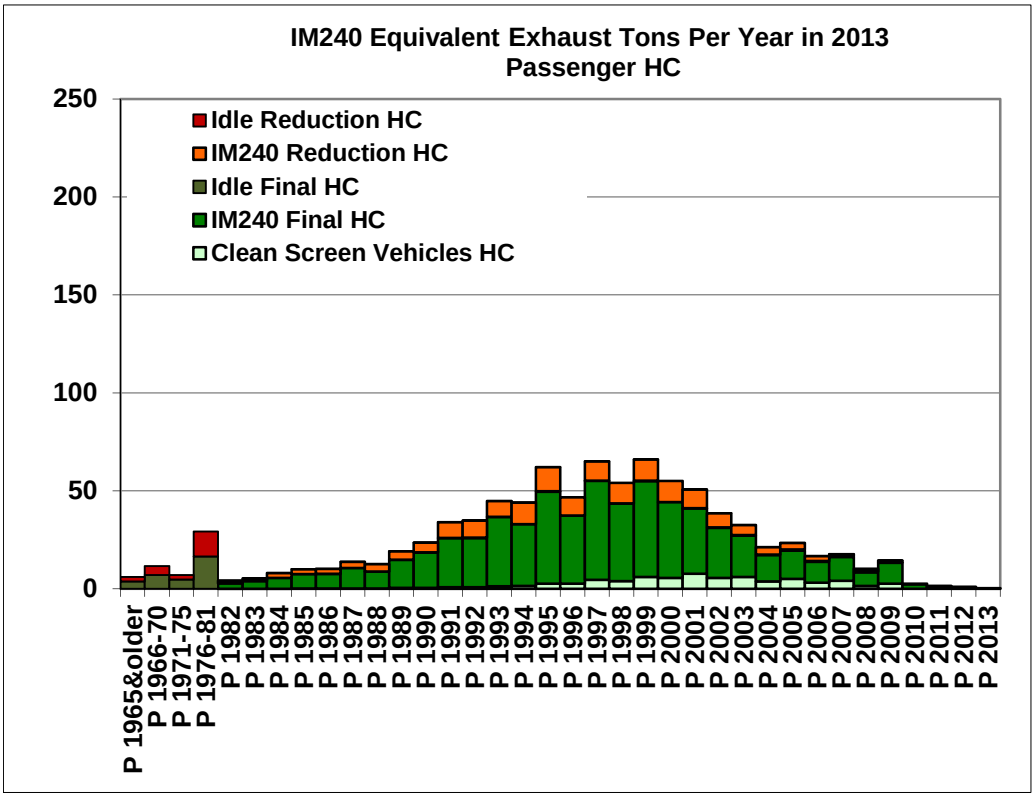


Figure VI-2 LDGT HC Reductions and Remaining Emissions

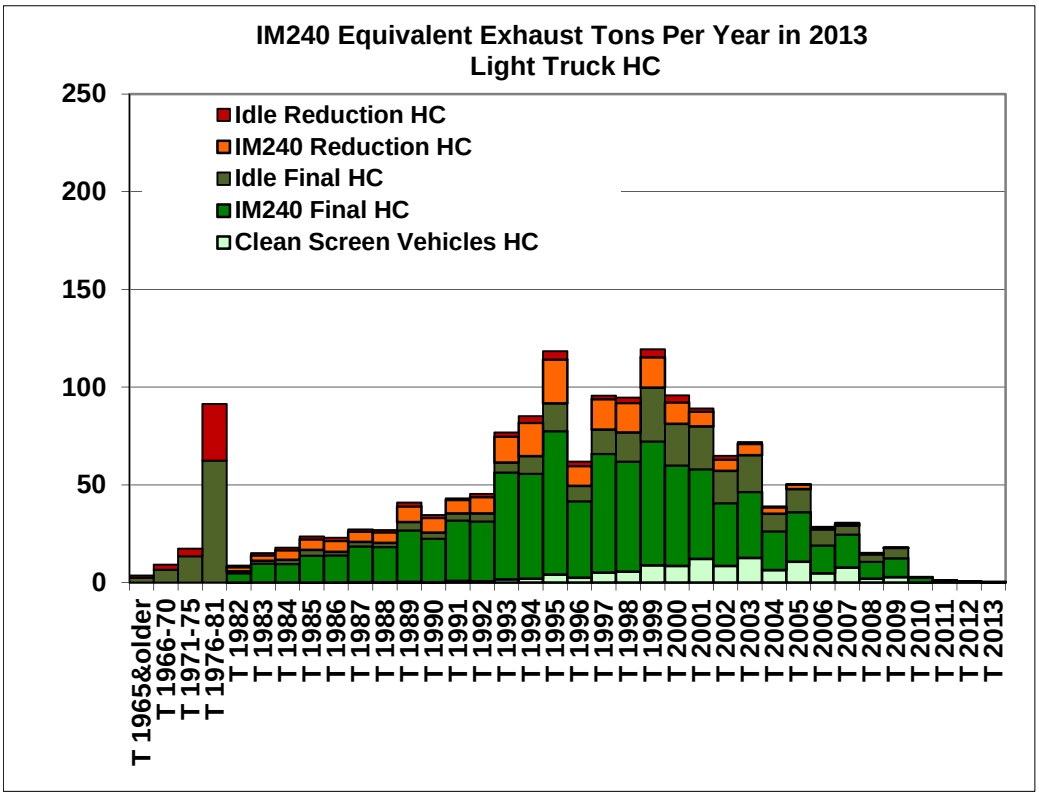


Figure VI-3 LDGV CO Reductions and Remaining Emissions

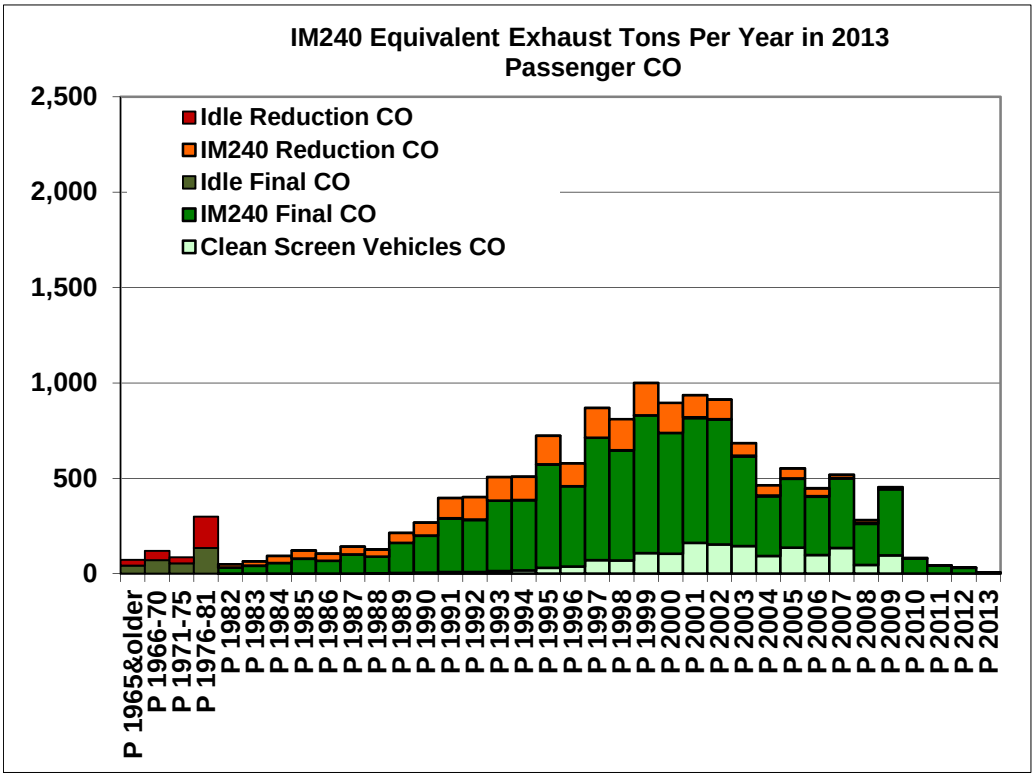


Figure VI-4 LDGT CO Reductions and Remaining Emissions

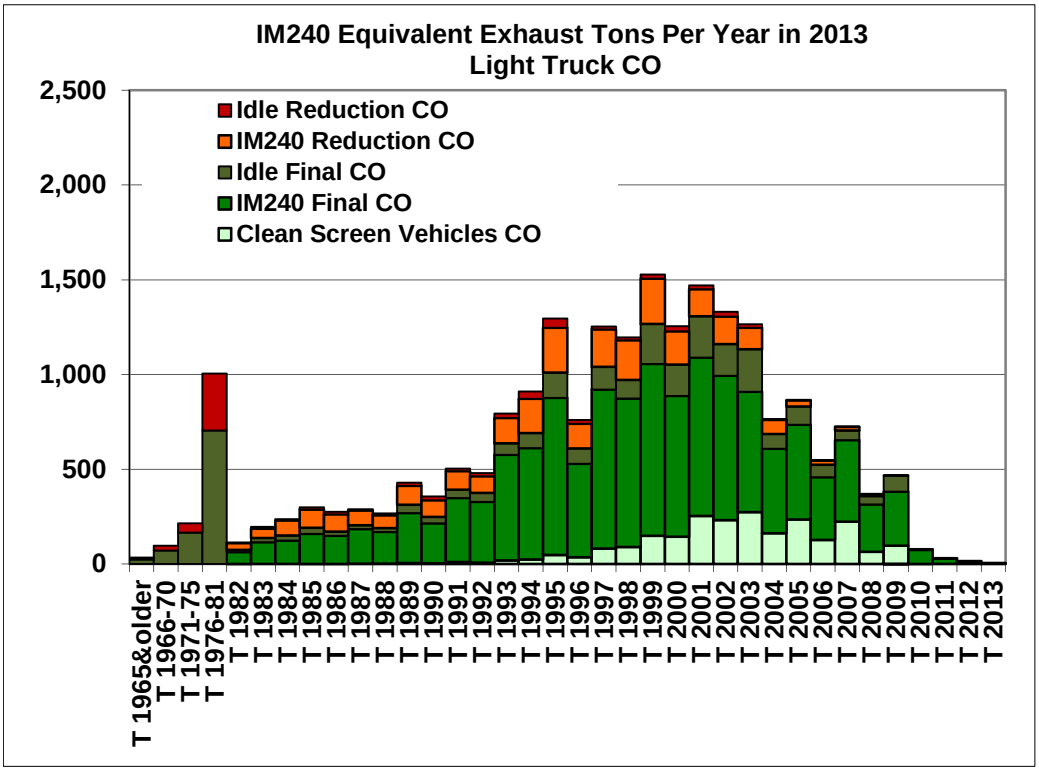


Figure VI-5 LDGV NOx Reductions and Remaining Emissions

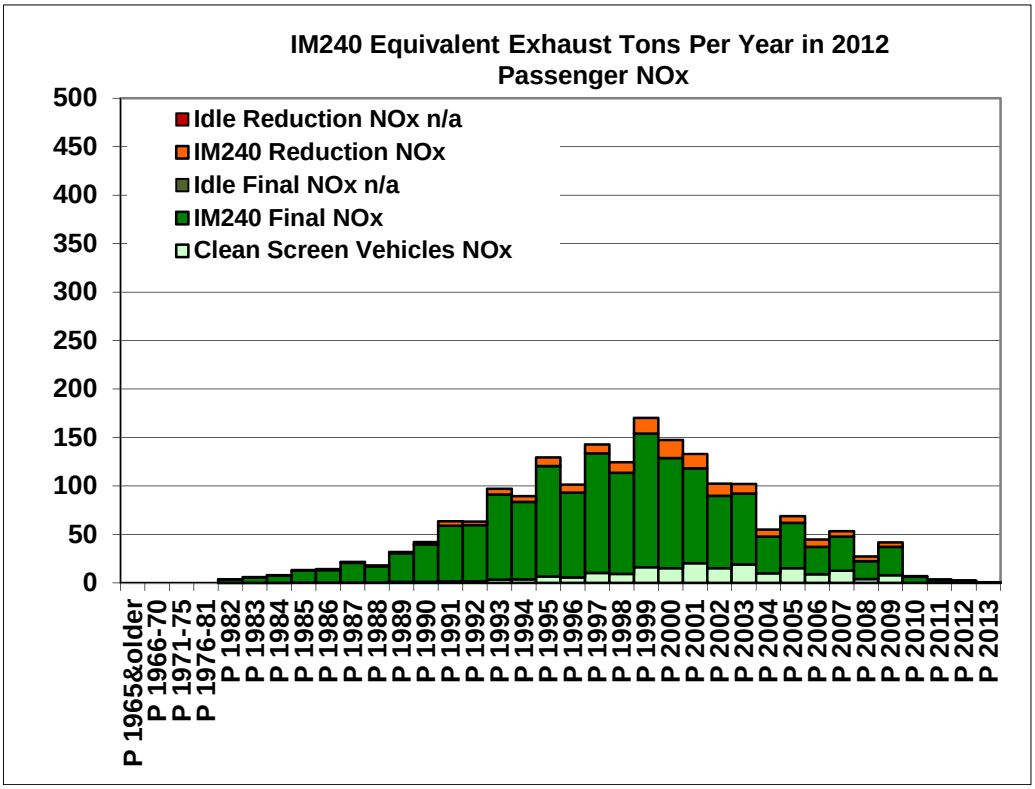
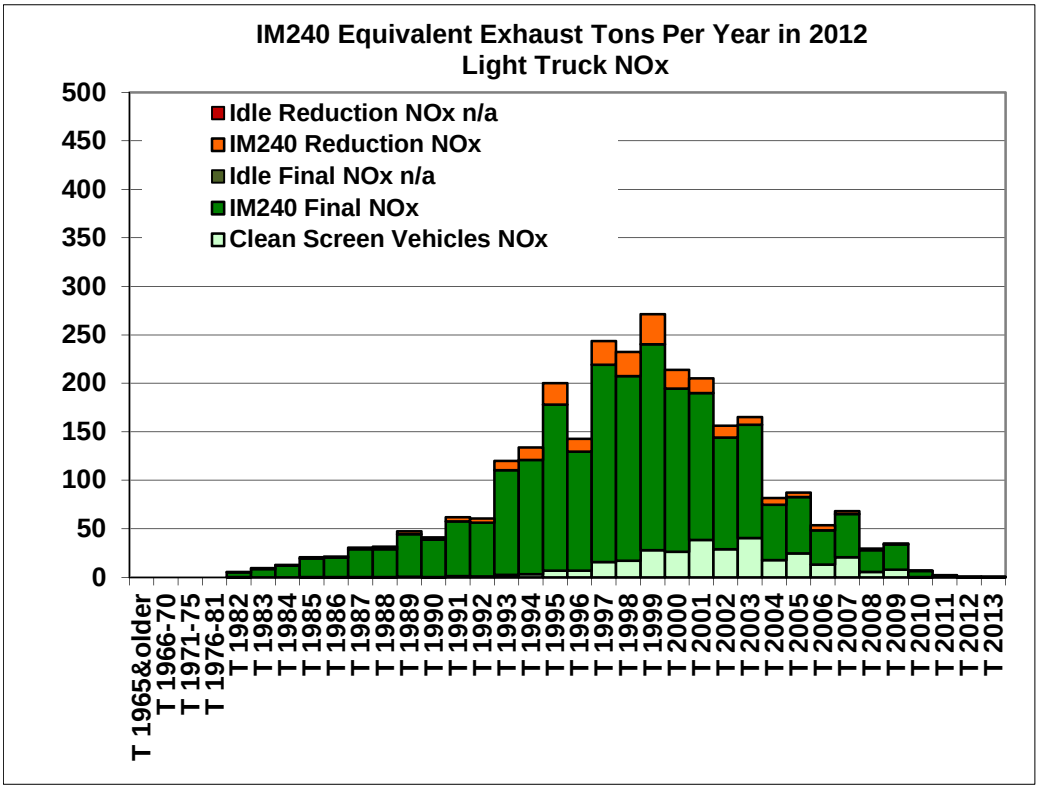


Figure VI-6 LDGT NOx Reductions and Remaining Emissions



VII. RapidScreen Benefits

Rapidscreen provided benefits to vehicle owners of $5.15M through reduced time and expense associated with eliminated inspection station visits. The elimination of station inspections also yielded net savings in greenhouse gases and 195,600 gallons of gasoline. This section summarizes the operational costs and benefits of the Rapidscreen program.

A. Greenhouse Gas and Pollutants from Clean Screen Operations

The following were considered in deriving the net emissions, greenhouse gas and fuel use associated with the RapidScreen program:

- RSD van operations;
- RSD generators;
- RSD unit calibration and audit gases;
- Reductions from eliminated trips to inspection stations.

Table VII-1 summarizes these amounts.

Table VII-1 Reductions in Greenhouse Gases and Pollutants from RapidScreen Operations

Activity	HC t/yr	CO t/yr	NOx t/yr	CO2 t/yr	Fuel gal.
RapidScreen Operations					
RapidScreen operating vehicles (vans, audit trucks, maintenance)	0.132	1.64	0.027	91.1	10,208
Generators	0.943	24.08	0.081	59.4	10,097
Calibration and audit gases	0.005	0.05	0.003	0.5	
Total Rapidscreen operations	1.080	25.77	0.111	150.9	20,305
RapidScreen Vehicle Emission Reductions					
Station trip, waiting & testing	0.445	12.24	2.148	1925.9	215,905
Net benefit (cost)	(0.63)	(13.53)	2.037	1774.9	195,600

1. RapidScreen Operating Vehicles

Emissions and fuel usage of RSD vans, audit trucks and maintenance vehicles associated with the RapidScreen program were developed from the average IM240 emissions of each vehicle from the most recent inspections performed from 2010 through 2013. Idle test emissions were converted to IM240 g/mi using the conversion factors described in Section V. Emissions were scaled up to match MOVES estimates of running emissions vs. IM240 using scaling factors of 1.0 for hydrocarbons, 1.92 for CO and 2.23 for NO_x. Odometer changes were pro-rated to provide annual mileages. Fuel use was calculated using EPA city fuel

economies for the vehicle models or similar models. CO_2 tons were calculated at the rate of 8.92×10^{-3} tons per gallon (http://www.epa.gov/cleanenergy/energy-resources/refs.html).

2. Generators

Typical emissions and CO_2 grams over a four minute period were obtained by collecting emissions from two generators using lane IM240 equipment. Emissions were collected from the generator while another vehicle was driven on the dynamometer. Emissions and CO_2 grams were then multiplied by 15 to obtain g/hour and by the Active Collection Van Hours from Table III-1. Fuel gallons were back calculated from CO_2 tons.

Envirotest is in the process of replacing existing generators with newer, lower emitting models that would eliminate 67% of HC emissions and up to 98% of the generator NOx emissions.

3. Calibration and Audit Gases

Calibration and Audit Gas emissions were calculated directly from the use estimates presented in Table VII-2. The liters of calibration and audit gases at 70F and normal pressure were multiplied by the pollutant concentration percentages and by the pollutant mass per liter to obtain tons.

Table VII-2 Calibration and Audit Gas Emissions

RSD VANS	AL Cyls	BL Cyls	CL Cyls	Liters at 70F NP	CO %	CO2 %	HC %	NO %	HC PPM	NOX PPM	CO tons	CO2 tons	HC tons	NO tons
Calibration	240	30	0	1,028,820	3.00	12.90	0.15	0.15	1500	1500	0.0425	0.2874	0.0033	0.0023
2 Point Audit	80	10		342,940	0.50	14.70	0.04	0.10	400	1000	0.0024	0.1092	0.0003	0.0005
ATP / DOR														
A	12	0		47,916	0.00	15.05	0.00	0.00	0	0	0.0000	0.0156	0.0000	0.0000
F	12	0	16	61,964	5.00	11.55	0.60	0.03	6000	250	0.0043	0.0155	0.0008	0.0000
G	12	0		47,916	0.20	14.91	0.01	0.15	100	1500	0.0001	0.0155	0.0000	0.0001
H	12	0		47,916	0.30	14.84	0.02	0.10	200	1000	0.0002	0.0154	0.0000	0.0001
J	12	0	16	61,964	0.50	14.70	0.04	0.10	400	1000	0.0004	0.0197	0.0001	0.0001
K	12	0		47,916	1.00	14.34	0.05	0.03	500	300	0.0007	0.0149	0.0001	0.0000
L	12	0		47,916	1.50	13.99	0.07	0.01	700	100	0.0010	0.0145	0.0001	0.0000
Q	12	0	16	61,964	3.00	12.92	0.11	0.05	1100	500	0.0026	0.0173	0.0001	0.0000
Total	**416**	**40**	**48**	**1,797,232**							**0.0541**	**0.5249**	**0.0048**	**0.0031**

Capacities and g/l	AL Cyls	BL Cyls	CL Cyls		CO %	CO2 %	HC %	NO %
Cylinder L @2000psi	29.5	15.7	5.9	Mol. Wt	28	44	44	30
Liters gas at 70F NP	3993	2350	878	g/l	1.3	2.0	2.0	1.3

4. RapidScreen Vehicle Emissions Reductions

The RapidScreen program eliminated the need for 233,760 station inspections that would otherwise require travel, waiting and inspection.

The average round trip to a station was estimated to be 9.5 miles. For every two minutes a car is idling, it uses about the same amount of fuel it takes to go about one mile according to the Consumer Energy Center (http://www.consumerenergycenter.org/myths/idling.html). This implies the average waiting time of 13.5 minutes was equivalent to 6.8 miles of driving. The equivalent of another equivalent 2.2 miles of driving was spent moving through the inspection lane for a total equivalent of 18.5 miles per inspection. Eliminated trip/inspection emissions tons were calculated from the inspection mileage multiplied by the average IM240 g/mi emissions of the RapidScreen audit sample and the number of exempted vehicles. As noted above, IM240 emissions were scaled up to match MOVES estimates of running emissions vs. IM240. Gallons of fuel saved were estimated using an average of 20mpg.

B. RapidScreen Vehicle Owner Savings

Table VII-3 quantifies the RapidScreen benefits to vehicle owners. The average round trip to an inspection station was assumed to take an average of 28.5 minutes (9.5 miles at 20mph). Average wait and test times were both 13.5 minutes. The waiting and testing fuel consumption was estimated to be the equivalent of driving another 8.4 miles. Vehicle owner time was assumed to be worth half the Denver area average hourly wage of $25.05 per hour, or $12.53 per hour.

Travel savings from were calculated at the IRS rate of 56.5c per mile per IRS Notice IR-2012-95, Nov. 21, 2012.

Total savings were $5.15M or $22.02 per vehicle.

Table VII-3 RapidScreen Vehicle Owner Savings

Activity	Vehicles	Minutes	Hours	Unit $	$'M
Station round trip @ 20mph	233760	28.5	111036	$ 12.53	$ 1.39
Testing	233760	13.5	52479	$ 12.53	$ 0.66
Waiting	233760	13.5	52596	$ 12.53	$ 0.66
		Miles			
Driving miles equiv.	233760	18.5		$ 0.565	$ 2.44
Total vehicle owner savings					**$ 5.15**

VIII. Recommendations

In 2015, several program changes will be implemented that will affect the vehicles subject to testing and test procedures:

- New models will be exempt for seven years vs. four years currently;
- Models 8 to 11 years old will be tested by scanning the OBD status with a fallback to IM240 allowed for vehicles with no more than one out of a select group of OBD system monitors not set ready;
- Models over 11 years old will continue to be tailpipe tested using IM240 or Idle.

Currently clean screen notices are issued to 30% of subject vehicles due to renew registration. Unless changes are made to clean screen criteria, the 2015 program changes will act to reduce this percentage in two ways:

- The percentage of vehicles qualifying for clean screen is highest among the newest three model years that will now be exempt and will reduce current clean screens by at least one third;
- If/when the LEI is updated with OBD failure rates for 8 to 11 year old vehicles, the percentage of passing the screen will decrease dramatically.

It is desirable to increase clean screen productivity provided the program remains compliant with the clean screen goals modeled using Mobile6.

MIL-on rates in Colorado are currently higher than observed in other state I/M programs. As owners realize MIL-on is required, Colorado observed MIL-on rates should fall. Modeling using existing MIL-on rates therefore overstates the impacts of the transition for OBD inspected models. OBD testing of 8-11 year olds will affect fail rates but the extent will depend on the number of pre-inspection repairs obtained by vehicle owners in response to the new program rules.

It is suggested 2015 should be a transitional year. The year will start using the current clean screen criteria with only minor changes such as a potential increase in the existing 2% RSD-LEI fail cutpoint. This will be evaluated to determine whether adjusting the threshold, e.g. to 5%, in fall of 2014 for 2015 renewal candidates, could increase motorist convenience and clean screens without materially affecting program emission reductions.

In addition:

- Recommended Reg 11 changes:
  - Permit periodic adjustments of the LEI fail % cutpoints as approved by CDPHE, e.g. in 2014 for IM240 tested models, and during 2015 for OBD tested models;
  - Allow a separate LEI OBD fail % cutpoint for the OBD tested RSD-LEI models;

- In order to provide emissions data on clean screen OBD tested models in 2015, set registration table flags set to force dual OBD and IM240 inspection of 8-11 year old models selected for clean screen audit. The IM240 being either a normal IM240 with fast-pass allowed, or, if operationally acceptable, a full IM240. These OBD model vehicles selected as part of the random 2% clean screen audit sample IM240's may form part of the independently required 5% OBD-IM240 sample;

- In order to create an adequate audit sample by end of June 2015 for a mid-year evaluation, and provided doing so will not materially increase wait times, increase the clean screen audit percentage to 3.5% or 4% during the first half of 2015 and reduce it to 0.5% or 0% during the second half year. This will allow appropriate LEI cutpoints to be developed in fall of 2015 for 2016 renewals.

References

[1] "The Colorado Remote Sensing Program January – December 2011", Envirotest report for the Colorado Department of Public Health and Environment, November 2012

[2] Colorado Air Quality Control Commission, "Regulation Number 11, Motor Vehicle Emissions Inspection Program", http://www.cdphe.state.co.us/regulations/airregs/5CCR1001-13.pdf

[3] Colorado Department Of Public Health and Environment, Air Pollution Control Division, Mobile Sources Section, "Colorado On-road Vehicle Emissions Remote Sensing System (COVERS) Specifications" Amended July 2010

[4] Klausmeier R., "Technical Note: Estimating Full IM240 Emissions Based on Fast Pass Emission Results", November 2005

[5] Wenzel, T. "Evaluation of Arizona's Enhanced I/M Program", Presented at the 9th CRC On-Road Vehicle Emissions Workshop. April 1999.

[6] McClintock, P. "The Denver Remote Sensing Clean Screening Pilot", Envirotest report for the Colorado Department of Health and Environment, December 1999.

[7] "Colorado Mileage Accumulation Rates from VID Odometer Readings Draft Report" for CDPHE by Eastern Research Group, Inc. June 30, 2008

Appendix A1 Colorado 2013 Transient Test Emissions Reductions

Unresolved fails remaining in area 33%

Model	First	Last			Initial			Final			Reduction %		
Year/Type	Result	Result	Vehicles	Fail%	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX
1982	Pass	-	258		1.62	19.18	2.02	1.62	19.18	2.02	0.0%	0.0%	0.0%
P	Fail	Pass	59	17.2%	4.56	51.09	2.02	1.52	19.35	1.88	66.6%	62.1%	7.0%
	Fail	Unresolv.	26	7.6%	5.59	85.27	1.92	1.99	29.03	0.65	64.4%	66.0%	66.0%
	Fail	Waiver	1	0.3%	1.49	70.11	0.38	1.49	70.11	0.38	0.0%	0.0%	0.0%
Total	Fail%		344	25.0%	2.42	29.80	2.00	1.63	20.10	1.88	32.7%	32.5%	6.0%
1983	Pass	-	462		1.29	12.26	2.07	1.29	12.26	2.07	0.0%	0.0%	0.0%
P	Fail	Pass	98	16.0%	2.32	36.51	2.06	1.24	14.85	1.79	46.7%	59.3%	13.2%
	Fail	Unresolv.	49	8.0%	4.46	73.11	1.91	1.56	24.31	0.57	65.1%	66.7%	69.9%
	Fail	Waiver	3	0.5%	4.50	140.30	1.08	4.73	146.55	0.24	-5.0%	-4.5%	77.6%
Total	Fail%		612	24.5%	1.73	21.65	2.05	1.32	14.30	1.89	23.5%	33.9%	7.5%
1984	Pass	-	619		1.23	11.35	1.92	1.23	11.35	1.92	0.0%	0.0%	0.0%
P	Fail	Pass	147	17.3%	2.86	39.51	1.97	1.44	14.26	2.05	49.7%	63.9%	-4.4%
	Fail	Unresolv.	79	9.3%	5.47	75.77	1.82	1.73	23.32	0.59	68.4%	69.2%	67.3%
	Fail	Waiver	6	0.7%	5.14	112.15	1.64	4.98	116.14	1.55	3.2%	-3.6%	5.9%
Total	Fail%		851	27.3%	1.94	22.90	1.92	1.34	13.70	1.82	30.7%	40.2%	5.2%
1985	Pass	-	1,094		1.05	10.84	1.89	1.05	10.84	1.89	0.0%	0.0%	0.0%
P	Fail	Pass	226	15.8%	2.21	31.01	2.12	1.09	9.71	1.93	50.7%	68.7%	8.8%
	Fail	Unresolv.	106	7.4%	3.92	58.15	1.79	1.34	19.49	0.58	65.8%	66.5%	67.5%
	Fail	Waiver	2	0.1%	5.59	85.44	1.10	11.43	58.43	1.41	-104.5%	31.6%	-27.3%
Total	Fail%		1,428	23.4%	1.45	17.65	1.92	1.09	11.37	1.80	24.9%	35.6%	6.2%
1986	Pass	-	1,228		0.92	7.91	1.80	0.92	7.91	1.80	0.0%	0.0%	0.0%
P	Fail	Pass	199	13.1%	2.11	25.18	2.17	1.08	9.10	1.89	48.7%	63.9%	13.2%
	Fail	Unresolv.	90	5.9%	5.07	66.22	2.13	1.48	19.40	0.73	70.9%	70.7%	65.7%
	Fail	Waiver	3	0.2%	8.87	78.05	1.85	8.39	69.96	1.92	5.4%	10.4%	-4.1%
Total	Fail%		1,520	19.2%	1.34	13.76	1.87	0.99	8.87	1.75	26.0%	35.5%	6.4%
1987	Pass	-	1,974		0.84	7.71	1.81	0.84	7.71	1.81	0.0%	0.0%	0.0%
P	Fail	Pass	273	11.6%	2.30	26.86	2.08	1.04	9.26	1.72	55.0%	65.5%	17.3%
	Fail	Unresolv.	96	4.1%	4.37	54.71	2.10	1.45	19.04	0.64	66.8%	65.2%	69.5%
	Fail	Waiver	7	0.3%	3.36	49.60	2.75	4.28	55.88	2.81	-27.6%	-12.7%	-1.9%
Total	Fail%		2,350	16.0%	1.16	11.98	1.85	0.90	8.49	1.75	22.7%	29.1%	5.5%
1988	Pass	-	1,798		0.74	7.84	1.59	0.74	7.84	1.59	0.0%	0.0%	0.0%
P	Fail	Pass	266	12.3%	2.69	27.10	1.87	0.94	8.74	1.66	65.1%	67.8%	10.9%
	Fail	Unresolv.	91	4.2%	4.34	39.25	2.05	1.37	12.28	0.68	68.4%	68.7%	67.0%
	Fail	Waiver	5	0.2%	4.45	31.72	3.32	4.45	39.36	1.99	0.1%	-24.1%	39.9%
Total	Fail%		2,160	16.8%	1.14	11.59	1.65	0.80	8.21	1.56	29.8%	29.2%	5.2%
1989	Pass	-	3,208		0.72	7.90	1.61	0.72	7.90	1.61	0.0%	0.0%	0.0%
P	Fail	Pass	405	10.8%	2.12	24.65	1.86	0.89	8.60	1.61	58.1%	65.1%	13.4%
	Fail	Unresolv.	131	3.5%	3.84	42.15	2.14	1.16	14.00	0.74	69.8%	66.8%	65.4%
	Fail	Waiver	4	0.1%	4.00	119.43	0.31	4.01	119.56	0.36	-0.1%	-0.1%	-15.3%
Total	Fail%		3,748	14.4%	0.99	11.03	1.65	0.76	8.31	1.58	23.0%	24.7%	4.6%

Appendix A1 Colorado 2013 Transient Test Emissions Reductions

Unresolved fails remaining in area 33%

Model	First	Last			Initial			Final			Reduction %		
Year/Type	Result	Result	Vehicles	Fail%	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX
1990	Pass	-	3,890		0.70	7.69	1.60	0.70	7.69	1.60	0.0%	0.0%	0.0%
P	Fail	Pass	526	11.4%	1.79	23.38	2.14	0.86	8.23	1.71	52.0%	64.8%	19.9%
	Fail	Unresolv.	176	3.8%	3.52	38.36	2.39	1.13	12.27	0.79	68.0%	68.0%	66.9%
	Fail	Waiver	8	0.2%	4.74	49.18	2.96	1.85	36.29	3.19	60.9%	26.2%	-7.8%
Total	Fail%		4,600	15.4%	0.94	10.73	1.70	0.74	7.98	1.59	21.6%	25.7%	6.5%
1991	Pass	-	6,006		0.59	6.73	1.45	0.59	6.73	1.45	0.0%	0.0%	0.0%
P	Fail	Pass	832	11.7%	1.75	22.18	1.97	0.72	7.04	1.55	59.0%	68.3%	21.7%
	Fail	Unresolv.	273	3.8%	3.16	33.84	2.37	1.02	11.29	0.76	67.6%	66.6%	68.0%
	Fail	Waiver	18	0.3%	3.14	47.36	1.76	3.09	40.87	1.51	1.4%	13.7%	14.3%
Total	Fail%		7,129	15.8%	0.83	9.67	1.55	0.62	7.02	1.44	24.5%	27.4%	7.3%
1992	Pass	-	5,812		0.57	6.25	1.42	0.57	6.25	1.42	0.0%	0.0%	0.0%
P	Fail	Pass	790	11.5%	1.68	23.39	1.81	0.67	6.52	1.52	59.9%	72.1%	16.2%
	Fail	Unresolv.	256	3.7%	3.66	37.50	2.07	1.23	12.93	0.66	66.3%	65.5%	68.1%
	Fail	Waiver	15	0.2%	4.18	45.81	1.76	2.51	35.38	1.59	39.9%	22.8%	9.6%
Total	Fail%		6,873	15.4%	0.82	9.47	1.49	0.61	6.60	1.41	25.7%	30.4%	5.8%
1993	Pass	-	8,487		0.54	5.76	1.44	0.54	5.76	1.44	0.0%	0.0%	0.0%
P	Fail	Pass	995	10.1%	1.37	19.52	2.02	0.63	6.23	1.58	54.0%	68.1%	21.6%
	Fail	Unresolv.	330	3.4%	2.76	29.61	2.22	1.00	10.29	0.73	63.7%	65.2%	67.2%
	Fail	Waiver	18	0.2%	2.90	30.61	2.62	4.91	27.55	2.49	-69.3%	10.0%	4.9%
Total	Fail%		9,830	13.7%	0.71	8.00	1.53	0.57	6.00	1.43	18.5%	25.0%	6.2%
1994	Pass	-	9,146		0.42	5.10	1.16	0.42	5.10	1.16	0.0%	0.0%	0.0%
P	Fail	Pass	961	9.2%	1.50	17.95	1.71	0.52	5.60	1.26	65.0%	68.8%	26.2%
	Fail	Unresolv.	328	3.1%	3.13	29.41	2.19	1.01	9.47	0.72	67.9%	67.8%	67.3%
	Fail	Waiver	11	0.1%	5.19	39.70	2.36	4.78	34.41	2.28	8.0%	13.3%	3.4%
Total	Fail%		10,446	12.4%	0.61	7.08	1.24	0.45	5.31	1.16	25.6%	25.0%	7.0%
1995	Pass	-	14,190		0.40	4.70	1.01	0.40	4.70	1.01	0.0%	0.0%	0.0%
P	Fail	Pass	1,398	8.7%	1.23	15.74	1.61	0.48	5.10	1.19	60.7%	67.6%	25.7%
	Fail	Unresolv.	443	2.8%	2.38	22.40	2.31	0.78	7.60	0.75	67.2%	66.0%	67.7%
	Fail	Waiver	18	0.1%	1.69	15.15	3.01	1.77	9.66	2.60	-5.1%	36.3%	13.7%
Total	Fail%		16,049	11.6%	0.53	6.16	1.10	0.42	4.82	1.02	20.7%	21.8%	7.3%
1996	Pass	-	12,780		0.31	3.82	0.82	0.31	3.82	0.82	0.0%	0.0%	0.0%
P	Fail	Pass	1,301	9.0%	0.97	13.35	1.47	0.39	4.48	0.95	59.7%	66.5%	35.2%
	Fail	Unresolv.	309	2.1%	2.41	22.58	2.06	0.78	6.84	0.70	67.7%	69.7%	66.2%
	Fail	Waiver	15	0.1%	1.18	30.39	1.99	1.27	33.86	1.76	-7.6%	-11.4%	11.7%
Total	Fail%		14,405	11.3%	0.42	5.11	0.90	0.33	3.98	0.83	20.9%	22.2%	8.4%
1997	Pass	-	19,145		0.30	3.79	0.75	0.30	3.79	0.75	0.0%	0.0%	0.0%
P	Fail	Pass	1,691	8.0%	0.83	12.81	1.28	0.36	4.43	0.88	57.0%	65.4%	31.1%
	Fail	Unresolv.	391	1.8%	1.93	24.10	2.02	0.66	8.29	0.66	66.0%	65.6%	67.6%
	Fail	Waiver	10	0.0%	2.26	23.14	2.84	4.10	29.06	2.91	-81.5%	-25.6%	-2.5%
Total	Fail%		21,237	9.9%	0.37	4.89	0.81	0.31	3.94	0.76	16.2%	19.5%	7.0%

Appendix A1 Colorado 2013 Transient Test Emissions Reductions

Unresolved fails remaining in area 33%

Model Year/Type	First Result	Last Result	Vehicles	Fail%	Initial HC	Initial CO	Initial NOX	Final HC	Final CO	Final NOX	Reduction % HC	Reduction % CO	Reduction % NOX
1998	Pass	-	18,012		0.23	3.41	0.63	0.23	3.41	0.63	0.0%	0.0%	0.0%
P	Fail	Pass	1,762	8.7%	0.77	12.26	1.18	0.28	3.87	0.70	63.3%	68.5%	40.6%
	Fail	Unresolv.	377	1.9%	1.66	21.08	1.91	0.55	7.23	0.63	66.7%	65.7%	67.1%
	Fail	Waiver	13	0.1%	0.86	12.40	2.00	0.30	6.56	2.07	65.5%	47.1%	-3.6%
Total	Fail%		20,164	10.7%	0.30	4.52	0.70	0.24	3.52	0.64	20.9%	22.0%	9.4%
1999	Pass	-	24,969		0.20	2.97	0.57	0.20	2.97	0.57	0.0%	0.0%	0.0%
P	Fail	Pass	2,307	8.3%	0.64	9.93	1.24	0.24	3.37	0.66	62.5%	66.1%	46.7%
	Fail	Unresolv.	399	1.4%	1.30	17.42	2.08	0.43	6.05	0.70	66.8%	65.3%	66.5%
	Fail	Waiver	9	0.0%	0.75	7.59	2.46	0.79	8.92	2.70	-4.5%	-17.5%	-9.7%
Total	Fail%		27,684	9.8%	0.25	3.76	0.65	0.21	3.05	0.58	18.1%	18.9%	10.5%
2000	Pass	-	24,217		0.15	2.52	0.46	0.15	2.52	0.46	0.0%	0.0%	0.0%
P	Fail	Pass	2,120	7.9%	0.58	9.32	1.29	0.21	3.23	0.58	63.9%	65.3%	55.5%
	Fail	Unresolv.	387	1.4%	1.45	16.73	2.20	0.46	5.52	0.72	68.6%	67.0%	67.3%
	Fail	Waiver	15	0.1%	2.13	22.26	2.20	0.62	10.64	2.59	70.7%	52.2%	-17.9%
Total	Fail%		26,739	9.4%	0.20	3.28	0.55	0.16	2.62	0.47	21.8%	19.9%	14.2%
2001	Pass	-	29,978		0.10	2.08	0.31	0.10	2.08	0.31	0.0%	0.0%	0.0%
P	Fail	Pass	1,936	6.0%	0.55	7.65	1.05	0.16	2.63	0.42	70.4%	65.6%	59.7%
	Fail	Unresolv.	256	0.8%	1.21	14.44	2.07	0.38	4.81	0.71	68.3%	66.7%	65.7%
	Fail	Waiver	15	0.0%	2.72	9.24	3.07	0.80	8.45	3.06	70.7%	8.6%	0.5%
Total	Fail%		32,185	6.9%	0.14	2.52	0.37	0.11	2.14	0.32	22.0%	15.0%	13.1%
2002	Pass	-	25,025		0.09	2.42	0.27	0.09	2.42	0.27	0.0%	0.0%	0.0%
P	Fail	Pass	1,808	6.7%	0.45	7.05	0.88	0.13	2.38	0.37	70.8%	66.3%	58.6%
	Fail	Unresolv.	205	0.8%	1.06	13.39	2.33	0.36	4.11	0.78	65.7%	69.3%	66.5%
	Fail	Waiver	12	0.0%	0.49	9.61	2.63	0.67	8.74	2.51	-36.1%	9.0%	4.9%
Total	Fail%		27,050	7.5%	0.12	2.82	0.32	0.09	2.43	0.28	21.9%	13.6%	14.3%
2003	Pass	-	30,739		0.06	1.34	0.21	0.06	1.34	0.21	0.0%	0.0%	0.0%
P	Fail	Pass	1,576	4.9%	0.34	5.21	0.78	0.11	2.00	0.31	68.2%	61.6%	60.8%
	Fail	Unresolv.	137	0.4%	1.33	13.03	2.25	0.47	4.78	0.75	65.0%	63.3%	66.8%
	Fail	Waiver	4	0.0%	0.35	12.14	2.46	0.35	6.12	2.18	2.5%	49.6%	11.6%
Total	Fail%		32,456	5.3%	0.08	1.58	0.24	0.06	1.39	0.22	19.5%	12.1%	12.0%
2004	Pass	-	20,421		0.05	1.26	0.15	0.05	1.26	0.15	0.0%	0.0%	0.0%
P	Fail	Pass	1,172	5.4%	0.33	5.40	0.65	0.10	2.01	0.24	69.6%	62.8%	63.4%
	Fail	Unresolv.	111	0.5%	1.03	12.82	2.31	0.38	3.74	0.76	62.8%	70.8%	67.0%
	Fail	Waiver	6	0.0%	0.92	10.41	3.08	0.80	8.73	2.80	13.2%	16.2%	9.3%
Total	Fail%		21,710	5.9%	0.07	1.55	0.19	0.06	1.32	0.16	21.8%	14.9%	15.9%
2005	Pass	-	30,699		0.04	0.95	0.12	0.04	0.95	0.12	0.0%	0.0%	0.0%
P	Fail	Pass	1,444	4.5%	0.21	4.00	0.54	0.07	1.36	0.18	67.7%	65.9%	66.9%
	Fail	Unresolv.	73	0.2%	1.56	14.57	1.80	0.44	4.67	0.56	71.7%	68.0%	68.9%
	Fail	Waiver	1	0.0%	0.15	8.57	2.66	0.38	7.40	2.95	-156.2%	13.6%	-10.8%
Total	Fail%		32,217	4.7%	0.05	1.12	0.15	0.04	0.98	0.13	18.4%	12.6%	13.0%

Appendix A1 Colorado 2013 Transient Test Emissions Reductions

Unresolved fails remaining in area 33%

Model Year/Type	First Result	Last Result	Vehicles	Fail%	Initial HC	Initial CO	Initial NOX	Final HC	Final CO	Final NOX	Reduction % HC	Reduction % CO	Reduction % NOX
2006	Pass	-	21,813		0.04	1.12	0.10	0.04	1.12	0.10	0.0%	0.0%	0.0%
P	Fail	Pass	828	3.6%	0.26	4.99	0.87	0.07	1.48	0.18	73.6%	70.4%	79.7%
	Fail	Unresolv.	46	0.2%	1.60	13.86	2.56	0.49	4.35	0.77	69.4%	68.6%	69.8%
	Fail	Waiver	0	0.0%	-	-	-	-	-	-	-	-	-
Total	Fail%		22,687	3.9%	0.05	1.29	0.13	0.04	1.14	0.11	19.1%	11.5%	21.4%
2007	Pass	-	30,994		0.03	0.92	0.09	0.03	0.92	0.09	0.0%	0.0%	0.0%
P	Fail	Pass	759	2.4%	0.15	2.69	0.68	0.05	1.27	0.12	66.1%	52.5%	82.8%
	Fail	Unresolv.	27	0.1%	0.88	11.45	2.33	0.28	3.45	0.79	68.4%	69.9%	66.0%
	Fail	Waiver	0	0.0%	-	-	-	-	-	-	-	-	-
Total	Fail%		31,780	2.5%	0.03	0.97	0.11	0.03	0.93	0.09	8.3%	4.2%	14.1%
2008	Pass	-	15,681		0.03	1.00	0.08	0.03	1.00	0.08	0.0%	0.0%	0.0%
P	Fail	Pass	489	3.0%	0.23	3.40	0.85	0.06	1.39	0.12	75.7%	59.3%	85.6%
	Fail	Unresolv.	17	0.1%	0.92	9.54	2.71	0.30	3.07	0.92	68.0%	67.8%	66.0%
	Fail	Waiver	1	0.0%	0.56	7.45	3.42	0.49	7.89	3.27	11.4%	-5.8%	4.6%
Total	Fail%		16,188	3.1%	0.04	1.08	0.11	0.03	1.02	0.09	15.3%	6.2%	21.6%
2009	Pass	-	26,667		0.03	0.95	0.08	0.03	0.95	0.08	0.0%	0.0%	0.0%
P	Fail	Pass	483	1.8%	0.15	2.36	0.72	0.05	1.33	0.09	67.8%	43.6%	87.1%
	Fail	Unresolv.	15	0.1%	1.36	15.55	3.10	0.46	5.75	0.91	66.4%	63.0%	70.5%
	Fail	Waiver	0	0.0%	-	-	-	-	-	-	-	-	-
Total	Fail%		27,165	1.8%	0.03	0.98	0.09	0.03	0.96	0.08	7.4%	2.4%	13.1%
2010	Pass	-	5,971		0.03	0.96	0.07	0.03	0.96	0.07	0.0%	0.0%	0.0%
P	Fail	Pass	90	1.5%	0.18	3.42	0.62	0.05	1.28	0.08	71.8%	62.5%	86.6%
	Fail	Unresolv.	9	0.1%	1.46	11.75	1.53	0.40	3.76	0.49	72.9%	68.0%	68.3%
	Fail	Waiver	0	0.0%	-	-	-	-	-	-	-	-	-
Total	Fail%		6,070	1.6%	0.03	1.01	0.08	0.03	0.97	0.07	11.4%	4.3%	11.5%
2011	Pass	-	3,138		0.03	0.99	0.07	0.03	0.99	0.07	0.0%	0.0%	0.0%
P	Fail	Pass	53	1.7%	0.10	1.64	0.31	0.04	1.23	0.08	54.8%	24.8%	74.6%
	Fail	Unresolv.	8	0.3%	0.14	3.70	0.57	0.05	1.22	0.19	67.0%	67.0%	67.0%
	Fail	Waiver	0	0.0%	-	-	-	-	-	-	-	-	-
Total	Fail%		3,199	1.9%	0.03	1.00	0.07	0.03	0.99	0.07	3.9%	1.3%	6.6%
2012	Pass	-	2,356		0.02	1.01	0.06	0.02	1.01	0.06	0.0%	0.0%	0.0%
P	Fail	Pass	29	1.2%	0.06	3.51	0.17	0.02	0.83	0.03	75.8%	76.4%	80.1%
	Fail	Unresolv.	4	0.2%	0.03	1.21	0.09	0.01	0.40	0.03	67.0%	67.0%	67.0%
	Fail	Waiver	0	0.0%	-	-	-	-	-	-	-	-	-
Total	Fail%		2,389	1.4%	0.03	1.04	0.06	0.02	1.01	0.06	2.4%	3.3%	2.9%
2013	Pass	-	633		0.02	0.75	0.06	0.02	0.75	0.06	0.0%	0.0%	0.0%
P	Fail	Pass	3	0.5%	0.01	0.71	0.23	0.02	0.24	0.01	-65.3%	65.8%	93.6%
	Fail	Unresolv.	4	0.6%	0.59	6.58	1.10	0.49	2.20	0.36	18.5%	66.5%	66.7%
	Fail	Waiver	0	0.0%	-	-	-	-	-	-	-	-	-
Total	Fail%		640	1.1%	0.02	0.79	0.07	0.02	0.76	0.06	2.6%	3.7%	8.6%
2014	Pass	-	21		0.03	0.85	0.06	0.03	0.85	0.06	0.0%	0.0%	0.0%
P	Fail	Pass	0	0.0%	-	-	-	-	-	-	-	-	-
	Fail	Unresolv.	0	0.0%	-	-	-	-	-	-	-	-	-
	Fail	Waiver	0	0.0%	-	-	-	-	-	-	-	-	-
Total	Fail%		21	0.0%	0.03	0.85	0.06	0.03	0.85	0.06	0.0%	0.0%	0.0%

Appendix A1 Colorado 2013 Transient Test Emissions Reductions

Unresolved fails remaining in area 33%

Model Year/Type	First Result	Last Result	Vehicles	Fail%	Initial HC	Initial CO	Initial NOX	Final HC	Final CO	Final NOX	Reduction % HC	Reduction % CO	Reduction % NOX
Total Passenger Vehicles													
All	Pass	-	401,431		0.17	2.51	0.45	0.17	2.51	0.45	0.0%	0.0%	0.0%
P	Fail	Pass	27,026	6.2%	0.84	11.75	1.25	0.33	3.94	0.75	60.9%	66.5%	39.5%
	Fail	Unresolv.	5,249	1.2%	2.42	27.28	2.14	0.79	9.03	0.70	67.1%	66.9%	67.2%
	Fail	Waiver	220	0.1%	2.67	33.53	2.36	2.50	30.24	2.26	6.2%	9.8%	4.3%
Total	Fail%		433,926	7.5%	0.24	3.40	0.52	0.19	2.69	0.47	21.5%	20.9%	9.3%

Appendix A1 Colorado 2013 Transient Test Emissions Reductions

Unresolved fails remaining in area 33%

Model	First	Last			Initial			Final			Reduction %		
Year/Type	Result	Result	Vehicles	Fail%	HC	CO	NOX	HC	CO	NOX	HC	CO	NOX
1982	Pass	-	247		2.44	30.88	2.88	2.44	30.88	2.88	0.0%	0.0%	0.0%
T	Fail	Pass	103	25.9%	4.34	68.97	2.61	2.35	30.83	2.58	45.8%	55.3%	1.2%
	Fail	Unresolv.	46	11.6%	6.88	103.08	2.42	2.10	33.75	0.83	69.5%	67.3%	65.6%
	Fail	Waiver	1	0.3%	3.57	10.40	6.82	1.89	137.67	0.12	46.9%	#######	98.2%
Total	Fail%		397	37.8%	3.45	49.08	2.76	2.38	31.47	2.56	31.1%	35.9%	7.6%
1983	Pass	-	482		2.90	32.87	2.53	2.90	32.87	2.53	0.0%	0.0%	0.0%
T	Fail	Pass	165	22.9%	4.03	59.42	3.02	2.40	28.71	2.65	40.6%	51.7%	12.3%
	Fail	Unresolv.	71	9.9%	5.48	98.37	2.22	1.78	33.12	0.72	67.6%	66.3%	67.5%
	Fail	Waiver	1	0.1%	2.15	66.24	2.48	2.15	66.24	2.48	0.0%	0.0%	0.0%
Total	Fail%		719	33.0%	3.41	45.48	2.61	2.67	31.99	2.38	21.7%	29.7%	8.9%
1984	Pass	-	603		1.96	24.05	2.65	1.96	24.05	2.65	0.0%	0.0%	0.0%
T	Fail	Pass	240	24.9%	3.94	58.19	2.68	2.04	24.85	2.75	48.3%	57.3%	-2.7%
	Fail	Unresolv.	116	12.0%	6.19	98.68	2.48	1.79	32.53	0.82	71.1%	67.0%	66.8%
	Fail	Waiver	6	0.6%	4.21	39.05	5.43	3.92	39.02	5.49	6.9%	0.1%	-1.0%
Total	Fail%		965	37.5%	2.98	41.60	2.65	1.97	25.36	2.47	33.7%	39.0%	6.8%
1985	Pass	-	1,011		1.84	19.25	2.78	1.84	19.25	2.78	0.0%	0.0%	0.0%
T	Fail	Pass	322	21.7%	3.39	53.69	3.04	1.87	22.16	2.88	44.7%	58.7%	5.4%
	Fail	Unresolv.	144	9.7%	5.67	93.91	2.12	1.85	31.34	0.66	67.3%	66.6%	68.8%
	Fail	Waiver	4	0.3%	7.34	131.13	1.03	3.68	94.91	0.68	49.9%	27.6%	34.2%
Total	Fail%		1,481	31.7%	2.56	34.30	2.77	1.85	21.27	2.59	27.7%	38.0%	6.4%
1986	Pass	-	1,127		1.64	16.23	2.55	1.64	16.23	2.55	0.0%	0.0%	0.0%
T	Fail	Pass	355	21.8%	3.26	45.75	2.83	1.78	18.18	2.79	45.3%	60.3%	1.7%
	Fail	Unresolv.	136	8.4%	6.06	89.08	2.28	1.89	28.87	0.78	68.8%	67.6%	65.8%
	Fail	Waiver	7	0.4%	4.41	82.89	2.29	3.25	82.94	2.60	26.3%	-0.1%	-13.7%
Total	Fail%		1,625	30.6%	2.37	29.07	2.59	1.70	18.01	2.45	28.5%	38.1%	5.2%
1987	Pass	-	1,865		1.49	14.20	2.41	1.49	14.20	2.41	0.0%	0.0%	0.0%
T	Fail	Pass	405	16.8%	2.86	35.71	2.70	1.47	13.51	2.52	48.4%	62.2%	6.8%
	Fail	Unresolv.	138	5.7%	4.75	67.54	2.45	1.40	22.80	0.80	70.5%	66.2%	67.3%
	Fail	Waiver	8	0.3%	4.18	73.16	3.05	3.27	71.94	2.68	21.7%	1.7%	12.0%
Total	Fail%		2,416	22.8%	1.92	21.05	2.46	1.49	14.77	2.33	22.2%	29.8%	5.1%
1988	Pass	-	1,990		1.34	12.12	2.25	1.34	12.12	2.25	0.0%	0.0%	0.0%
T	Fail	Pass	429	16.7%	2.63	30.85	2.78	1.37	12.50	2.25	48.0%	59.5%	19.0%
	Fail	Unresolv.	144	5.6%	5.17	54.41	2.91	1.69	17.71	0.96	67.4%	67.4%	67.2%
	Fail	Waiver	5	0.2%	5.75	102.88	0.92	4.93	97.83	0.62	14.2%	4.9%	32.5%
Total	Fail%		2,568	22.5%	1.78	17.79	2.38	1.37	12.66	2.18	23.0%	28.8%	8.4%
1989	Pass	-	3,146		1.24	12.48	2.13	1.24	12.48	2.13	0.0%	0.0%	0.0%
T	Fail	Pass	610	15.4%	2.77	31.58	2.75	1.32	11.99	2.37	52.5%	62.0%	13.9%
	Fail	Unresolv.	186	4.7%	5.00	55.35	2.95	1.57	17.62	0.98	68.5%	68.2%	66.8%
	Fail	Waiver	11	0.3%	4.32	60.42	3.42	4.26	62.47	3.57	1.3%	-3.4%	-4.2%
Total	Fail%		3,953	20.4%	1.66	17.58	2.27	1.27	12.79	2.12	23.2%	27.3%	6.7%

Appendix A1 Colorado 2013 Transient Test Emissions Reductions

Unresolved fails remaining in area 33%

Model Year/Type	First Result	Last Result	Vehicles	Fail%	Initial HC	Initial CO	Initial NOX	Final HC	Final CO	Final NOX	Reduction % HC	Reduction % CO	Reduction % NOX
1990	Pass	-	2,587		1.22	11.73	2.21	1.22	11.73	2.21	0.0%	0.0%	0.0%
T	Fail	Pass	561	17.0%	2.91	33.43	2.66	1.32	11.87	2.30	54.8%	64.5%	13.6%
	Fail	Unresolv.	137	4.2%	5.17	48.25	2.97	1.61	15.99	0.96	68.8%	66.9%	67.6%
	Fail	Waiver	9	0.3%	5.27	43.78	3.24	3.03	32.88	2.72	42.5%	24.9%	16.1%
Total	Fail%		3,294	21.5%	1.68	17.03	2.32	1.26	11.99	2.17	25.3%	29.6%	6.3%
1991	Pass	-	4,396		1.01	11.35	1.91	1.01	11.35	1.91	0.0%	0.0%	0.0%
T	Fail	Pass	771	14.4%	2.19	26.67	2.64	1.10	10.49	2.09	49.9%	60.7%	20.8%
	Fail	Unresolv.	168	3.1%	3.98	47.34	2.96	1.53	15.89	0.98	61.4%	66.4%	66.8%
	Fail	Waiver	8	0.1%	3.02	36.74	4.75	3.34	34.74	3.54	-10.4%	5.5%	25.5%
Total	Fail%		5,343	17.7%	1.28	14.73	2.05	1.04	11.41	1.91	18.3%	22.6%	7.0%
1992	Pass	-	3,999		1.04	11.07	1.95	1.04	11.07	1.95	0.0%	0.0%	0.0%
T	Fail	Pass	738	15.0%	2.32	24.54	2.63	1.15	11.10	2.12	50.5%	54.8%	19.4%
	Fail	Unresolv.	173	3.5%	4.78	45.77	3.00	1.38	14.67	0.98	71.1%	68.0%	67.3%
	Fail	Waiver	7	0.1%	3.38	36.17	2.06	4.50	45.47	1.92	-33.1%	-25.7%	6.7%
Total	Fail%		4,917	18.7%	1.37	14.35	2.09	1.08	11.25	1.94	21.5%	21.6%	7.1%
1993	Pass	-	7,277		1.01	10.52	2.08	1.01	10.52	2.08	0.0%	0.0%	0.0%
T	Fail	Pass	1,108	12.8%	2.45	24.76	2.98	1.12	10.54	2.10	54.0%	57.4%	29.4%
	Fail	Unresolv.	249	2.9%	4.17	36.68	3.29	1.35	12.33	1.09	67.7%	66.4%	66.8%
	Fail	Waiver	13	0.2%	3.51	24.19	4.86	3.06	24.65	3.86	13.0%	-1.9%	20.6%
Total	Fail%		8,647	15.8%	1.29	13.12	2.23	1.04	10.60	2.05	19.5%	19.2%	7.9%
1994	Pass	-	8,368		0.78	8.74	1.80	0.78	8.74	1.80	0.0%	0.0%	0.0%
T	Fail	Pass	1,494	14.6%	1.99	21.24	2.73	0.87	9.12	1.89	56.1%	57.1%	30.7%
	Fail	Unresolv.	376	3.7%	3.86	38.24	3.19	1.26	11.98	1.07	67.5%	68.7%	66.5%
	Fail	Waiver	14	0.1%	2.62	23.34	3.88	1.84	22.04	3.81	29.7%	5.6%	1.8%
Total	Fail%		10,252	18.4%	1.07	11.66	1.99	0.81	8.93	1.79	24.2%	23.4%	10.1%
1995	Pass	-	11,703		0.73	8.53	1.79	0.73	8.53	1.79	0.0%	0.0%	0.0%
T	Fail	Pass	1,987	14.0%	1.92	20.98	2.88	0.83	8.58	1.86	56.6%	59.1%	35.3%
	Fail	Unresolv.	501	3.5%	3.32	29.87	3.70	1.08	9.66	1.22	67.6%	67.7%	67.1%
	Fail	Waiver	29	0.2%	4.24	30.42	2.66	3.26	26.07	2.74	23.1%	14.3%	-3.1%
Total	Fail%		14,220	17.7%	1.00	11.07	2.01	0.76	8.61	1.78	23.4%	22.2%	11.4%
1996	Pass	-	10,587		0.42	5.41	1.37	0.42	5.41	1.37	0.0%	0.0%	0.0%
T	Fail	Pass	1,576	12.6%	1.03	13.86	2.28	0.45	5.71	1.51	56.2%	58.8%	33.7%
	Fail	Unresolv.	292	2.3%	2.58	26.11	3.22	0.87	8.98	1.04	66.3%	65.6%	67.6%
	Fail	Waiver	15	0.1%	3.07	36.78	2.97	1.94	25.26	3.08	36.8%	31.3%	-3.7%
Total	Fail%		12,470	15.1%	0.55	7.00	1.53	0.44	5.56	1.38	20.7%	20.6%	9.7%
1997	Pass	-	17,878		0.36	5.13	1.26	0.36	5.13	1.26	0.0%	0.0%	0.0%
T	Fail	Pass	2,593	12.4%	0.94	13.06	2.19	0.41	5.57	1.38	55.9%	57.4%	37.3%
	Fail	Unresolv.	434	2.1%	2.24	21.21	3.55	0.70	6.89	1.16	68.9%	67.5%	67.5%
	Fail	Waiver	22	0.1%	1.70	24.08	3.51	1.49	20.97	3.27	12.5%	12.9%	6.7%
Total	Fail%		20,927	14.6%	0.48	6.47	1.42	0.38	5.24	1.27	20.5%	19.0%	10.6%

Appendix A1 Colorado 2013 Transient Test Emissions Reductions

Unresolved fails remaining in area 33%

Model Year/Type	First Result	Last Result	Vehicles	Fail%	Initial HC	Initial CO	Initial NOX	Final HC	Final CO	Final NOX	Reduction % HC	Reduction % CO	Reduction % NOX
1998	Pass	-	17,654		0.32	4.53	1.11	0.32	4.53	1.11	0.0%	0.0%	0.0%
T	Fail	Pass	2,432	11.8%	0.89	12.62	2.12	0.38	4.98	1.27	57.9%	60.5%	40.0%
	Fail	Unresolv.	461	2.2%	1.92	22.04	3.22	0.64	6.97	1.05	66.9%	68.4%	67.4%
	Fail	Waiver	18	0.1%	1.11	18.94	3.15	1.05	17.76	3.21	5.9%	6.2%	-1.9%
Total	Fail%		20,565	14.2%	0.42	5.90	1.28	0.33	4.65	1.13	21.2%	21.1%	11.7%
1999	Pass	-	25,874		0.24	3.45	0.81	0.24	3.45	0.81	0.0%	0.0%	0.0%
T	Fail	Pass	3,088	10.5%	0.70	10.58	1.84	0.30	3.88	1.00	57.3%	63.3%	45.7%
	Fail	Unresolv.	527	1.8%	1.51	18.26	2.78	0.49	6.11	0.93	67.7%	66.6%	66.7%
	Fail	Waiver	28	0.1%	1.46	26.61	2.80	0.87	11.94	2.80	40.0%	55.1%	0.1%
Total	Fail%		29,517	12.3%	0.31	4.48	0.95	0.25	3.55	0.83	19.8%	20.8%	12.8%
2000	Pass	-	22,666		0.21	3.04	0.70	0.21	3.04	0.70	0.0%	0.0%	0.0%
T	Fail	Pass	2,390	9.4%	0.58	9.64	1.54	0.26	3.72	0.89	54.7%	61.4%	42.1%
	Fail	Unresolv.	322	1.3%	1.99	23.04	2.63	0.59	8.00	0.87	70.0%	65.3%	66.8%
	Fail	Waiver	15	0.1%	1.14	17.08	3.48	1.56	17.63	3.24	-37.0%	-3.2%	7.0%
Total	Fail%		25,393	10.7%	0.27	3.93	0.80	0.22	3.18	0.72	17.7%	19.1%	10.4%
2001	Pass	-	29,019		0.14	2.61	0.47	0.14	2.61	0.47	0.0%	0.0%	0.0%
T	Fail	Pass	2,370	7.5%	0.42	8.31	1.14	0.19	3.20	0.63	54.8%	61.5%	45.0%
	Fail	Unresolv.	182	0.6%	1.93	21.89	2.85	0.67	8.34	0.91	65.4%	61.9%	68.1%
	Fail	Waiver	13	0.0%	0.94	15.88	3.35	1.39	11.77	3.72	-47.5%	25.9%	-11.2%
Total	Fail%		31,584	8.1%	0.17	3.16	0.54	0.15	2.69	0.49	14.2%	14.7%	9.2%
2002	Pass	-	23,316		0.11	2.81	0.42	0.11	2.81	0.42	0.0%	0.0%	0.0%
T	Fail	Pass	1,740	6.9%	0.39	9.38	1.10	0.17	3.13	0.60	56.0%	66.7%	45.2%
	Fail	Unresolv.	163	0.6%	1.53	26.31	2.57	0.52	8.64	0.83	66.2%	67.2%	67.7%
	Fail	Waiver	15	0.1%	0.95	15.60	2.86	0.90	14.11	2.61	5.9%	9.5%	8.7%
Total	Fail%		25,234	7.6%	0.14	3.43	0.48	0.12	2.88	0.44	15.1%	15.9%	9.5%
2003	Pass	-	31,096		0.09	1.66	0.31	0.09	1.66	0.31	0.0%	0.0%	0.0%
T	Fail	Pass	1,774	5.4%	0.34	7.40	0.77	0.13	2.60	0.43	61.6%	64.8%	43.8%
	Fail	Unresolv.	89	0.3%	2.02	24.68	2.44	0.59	8.21	0.82	70.7%	66.7%	66.3%
	Fail	Waiver	5	0.0%	2.36	60.00	2.74	1.63	28.55	4.12	30.8%	52.4%	-50.4%
Total	Fail%		32,964	5.7%	0.11	2.04	0.34	0.09	1.73	0.32	14.2%	15.1%	6.5%
2004	Pass	-	23,967		0.06	1.42	0.18	0.06	1.42	0.18	0.0%	0.0%	0.0%
T	Fail	Pass	1,378	5.4%	0.28	6.45	0.63	0.11	2.43	0.28	62.6%	62.3%	54.7%
	Fail	Unresolv.	71	0.3%	0.84	15.58	2.56	0.28	5.19	0.84	66.3%	66.7%	67.0%
	Fail	Waiver	1	0.0%	0.02	0.33	2.74	0.01	0.77	2.05	28.9%	-131.1%	25.0%
Total	Fail%		25,417	5.7%	0.08	1.73	0.21	0.07	1.48	0.19	14.3%	14.3%	11.0%
2005	Pass	-	35,394		0.05	1.06	0.12	0.05	1.06	0.12	0.0%	0.0%	0.0%
T	Fail	Pass	1,266	3.4%	0.21	3.70	0.46	0.09	1.85	0.21	59.5%	49.9%	54.8%
	Fail	Unresolv.	48	0.1%	0.80	11.81	1.90	0.27	3.80	0.66	66.4%	67.8%	65.4%
	Fail	Waiver	7	0.0%	0.81	10.55	2.79	0.73	18.26	2.54	10.0%	-73.0%	9.1%
Total	Fail%		36,715	3.6%	0.06	1.17	0.14	0.06	1.10	0.13	8.3%	6.2%	7.6%

Appendix A1 Colorado 2013 Transient Test Emissions Reductions

Unresolved fails remaining in area 33%

Model Year/Type	First Result	Last Result	Vehicles	Fail%	Initial HC	Initial CO	Initial NOX	Final HC	Final CO	Final NOX	Reduction % HC	Reduction % CO	Reduction % NOX
2006	Pass	-	23,116		0.04	1.03	0.11	0.04	1.03	0.11	0.0%	0.0%	0.0%
T	Fail	Pass	935	3.9%	0.15	2.78	0.53	0.07	1.39	0.18	52.9%	49.9%	66.6%
	Fail	Unresolv.	32	0.1%	1.01	20.90	2.94	0.38	7.25	1.00	62.7%	65.3%	65.9%
	Fail	Waiver	0	0.0%	-	-	-	-	-	-	-	-	-
Total	Fail%		24,083	4.0%	0.05	1.12	0.13	0.05	1.05	0.11	7.8%	6.4%	12.6%
2007	Pass	-	35,304		0.03	0.85	0.09	0.03	0.85	0.09	0.0%	0.0%	0.0%
T	Fail	Pass	1,272	3.5%	0.09	2.37	0.26	0.04	1.36	0.11	55.4%	42.7%	59.9%
	Fail	Unresolv.	10	0.0%	0.59	7.81	2.75	0.20	2.58	0.91	67.0%	67.0%	67.0%
	Fail	Waiver	0	0.0%	-	-	-	-	-	-	-	-	-
Total	Fail%		36,586	3.5%	0.04	0.91	0.10	0.03	0.87	0.09	5.4%	4.0%	6.2%
2008	Pass	-	18,094		0.03	0.90	0.09	0.03	0.90	0.09	0.0%	0.0%	0.0%
T	Fail	Pass	745	4.0%	0.09	2.41	0.20	0.04	1.65	0.08	51.4%	31.6%	60.2%
	Fail	Unresolv.	12	0.1%	0.38	15.52	0.96	0.13	5.21	0.33	65.3%	66.4%	65.9%
	Fail	Waiver	0	0.0%	-	-	-	-	-	-	-	-	-
Total	Fail%		18,851	4.0%	0.03	0.97	0.09	0.03	0.93	0.08	5.9%	3.8%	5.8%
2009	Pass	-	23,024		0.03	0.82	0.08	0.03	0.82	0.08	0.0%	0.0%	0.0%
T	Fail	Pass	655	2.8%	0.03	1.08	0.15	0.03	1.12	0.06	12.7%	-3.8%	60.9%
	Fail	Unresolv.	6	0.0%	0.56	4.79	0.84	0.18	1.58	0.28	67.0%	67.0%	67.0%
	Fail	Waiver	0	0.0%	-	-	-	-	-	-	-	-	-
Total	Fail%		23,685	2.8%	0.03	0.83	0.08	0.03	0.83	0.07	0.7%	0.0%	3.4%
2010	Pass	-	6,327		0.03	0.77	0.07	0.03	0.77	0.07	0.0%	0.0%	0.0%
T	Fail	Pass	147	2.3%	0.06	2.25	0.07	0.02	0.95	0.05	59.7%	57.9%	21.3%
	Fail	Unresolv.	4	0.1%	0.56	6.18	1.61	0.19	2.04	0.53	67.0%	67.0%	67.0%
	Fail	Waiver	0	0.0%	-	-	-	-	-	-	-	-	-
Total	Fail%		6,478	2.3%	0.03	0.81	0.07	0.03	0.78	0.07	3.6%	4.0%	1.5%
2011	Pass	-	2,239		0.03	0.84	0.06	0.03	0.84	0.06	0.0%	0.0%	0.0%
T	Fail	Pass	54	2.3%	0.04	1.82	0.17	0.02	1.16	0.08	33.8%	36.1%	53.0%
	Fail	Unresolv.	5	0.2%	0.06	2.30	0.20	0.02	0.76	0.07	67.0%	67.0%	67.0%
	Fail	Waiver	0	0.0%	-	-	-	-	-	-	-	-	-
Total	Fail%		2,298	2.6%	0.03	0.86	0.06	0.03	0.85	0.06	1.3%	2.2%	4.0%
2012	Pass	-	1,302		0.03	0.77	0.05	0.03	0.77	0.05	0.0%	0.0%	0.0%
T	Fail	Pass	13	1.0%	0.04	0.74	0.06	0.02	0.63	0.06	53.0%	14.8%	-9.8%
	Fail	Unresolv.	0	0.0%	-	-	-	-	-	-	-	-	-
	Fail	Waiver	0	0.0%	-	-	-	-	-	-	-	-	-
Total	Fail%		1,315	1.0%	0.03	0.77	0.05	0.03	0.77	0.05	0.7%	0.1%	-0.1%
2013	Pass	-	594		0.03	0.70	0.05	0.03	0.70	0.05	0.0%	0.0%	0.0%
T	Fail	Pass	3	0.5%	0.02	0.65	0.04	0.01	0.71	0.02	65.5%	-9.4%	42.8%
	Fail	Unresolv.	1	0.2%	0.47	8.07	2.35	0.16	2.66	0.78	67.0%	67.0%	67.0%
	Fail	Waiver	0	0.0%	-	-	-	-	-	-	-	-	-
Total	Fail%		598	0.7%	0.03	0.72	0.05	0.03	0.71	0.05	2.0%	1.2%	5.1%
2014	Pass	-	30		0.02	0.52	0.05	0.02	0.52	0.05	0.0%	0.0%	0.0%
T	Fail	Pass	0	0.0%	-	-	-	-	-	-	-	-	-
	Fail	Unresolv.	0	0.0%	-	-	-	-	-	-	-	-	-
	Fail	Waiver	0	0.0%	-	-	-	-	-	-	-	-	-
Total	Fail%		30	0.0%	0.02	0.52	0.05	0.02	0.52	0.05	0.0%	0.0%	0.0%

Appendix A1 Colorado 2013 Transient Test Emissions Reductions

Unresolved fails remaining in area 33%

Model Year/Type	First Result	Last Result	Vehicles	Fail%	Initial HC	Initial CO	Initial NOX	Final HC	Final CO	Final NOX	Reduction % HC	Reduction % CO	Reduction % NOX
Total Trucks													
All	Pass	-	396,282		0.24	3.25	0.61	0.24	3.25	0.61	0.0%	0.0%	0.0%
T	Fail	Pass	33,719	7.7%	1.06	14.33	1.73	0.49	5.81	1.15	53.6%	59.5%	33.6%
	Fail	Unresolv.	5,244	1.2%	3.19	37.07	2.98	1.02	12.22	0.98	68.0%	67.0%	67.1%
	Fail	Waiver	262	0.1%	2.70	33.90	3.19	2.22	29.85	3.06	17.7%	11.9%	4.3%
Total	Fail%		435,507	9.0%	0.34	4.54	0.73	0.27	3.57	0.66	20.8%	21.2%	9.5%
Fleet Total													
All	Pass	-	797,713		0.20	2.88	0.53	0.20	2.88	0.53	0.0%	0.0%	0.0%
All	Fail	Pass	60,745	7.0%	0.96	13.18	1.51	0.42	4.98	0.97	56.4%	62.2%	35.8%
	Fail	Unresolv.	10,493	1.2%	2.80	32.17	2.56	0.91	10.62	0.84	67.6%	67.0%	67.1%
	Fail	Waiver	482	0.1%	2.68	33.74	2.81	2.35	30.03	2.69	12.5%	11.0%	4.3%
Total	Fail%		869,433	8.2%	0.29	3.97	0.62	0.23	3.13	0.56	21.1%	21.1%	9.4%

Appendix B Colorado 2013

Enhanced IM240 Test Reduction Tons

Type	Annual Miles	Unique Vehicles	Initial Tons/Yr			Final Tons/Yr			Reduction Tons/Yr		
			HC	CO	NOx	HC	CO	NOx	HC	CO	NOx
P 1982	4,304	344	4.0	48.6	3.3	2.7	32.8	3.1	1.3	15.8	0.2
P 1983	4,304	612	5.0	62.9	5.9	3.8	41.5	5.5	1.2	21.3	0.4
P 1984	4,304	851	7.8	92.5	7.7	5.4	55.3	7.3	2.4	37.2	0.4
P 1985	4,304	1,428	9.8	119.6	13.0	7.4	77.0	12.2	2.4	42.5	0.8
P 1986	4,434	1,520	10.0	102.3	13.9	7.4	65.9	13.0	2.6	36.3	0.9
P 1987	4,481	2,350	13.5	139.0	21.5	10.4	98.6	20.3	3.1	40.4	1.2
P 1988	4,502	2,160	12.2	124.2	17.7	8.6	88.0	16.8	3.7	36.2	0.9
P 1989	4,552	3,748	18.5	207.4	31.1	14.3	156.3	29.7	4.3	51.1	1.4
P 1990	4,780	4,600	22.8	260.1	41.2	17.8	193.4	38.5	4.9	66.7	2.7
P 1991	5,088	7,129	33.1	386.7	61.9	25.0	280.8	57.4	8.1	105.8	4.5
P 1992	5,430	6,873	33.6	389.7	61.4	25.0	271.4	57.8	8.6	118.4	3.6
P 1993	5,672	9,830	43.4	491.5	93.9	35.3	368.6	88.1	8.0	122.8	5.8
P 1994	6,002	10,446	42.2	489.4	85.9	31.4	367.2	79.8	10.8	122.2	6.1
P 1995	6,331	16,049	59.0	690.4	122.8	46.8	540.1	113.9	12.2	150.3	8.9
P 1996	6,653	14,405	44.0	540.2	95.5	34.8	420.3	87.5	9.2	119.9	8.0
P 1997	6,974	21,237	60.3	798.6	132.9	50.5	642.5	123.6	9.8	156.1	9.3
P 1998	7,369	20,164	49.9	740.5	115.1	39.5	577.3	104.3	10.4	163.2	10.8
P 1999	7,764	27,684	59.7	890.6	154.1	48.8	722.4	138.0	10.8	168.2	16.1
P 2000	8,188	26,739	49.4	790.6	132.4	38.7	633.4	113.6	10.8	157.2	18.9
P 2001	8,613	32,185	42.7	769.7	112.5	33.3	653.9	97.7	9.4	115.8	14.8
P 2002	9,032	27,050	32.7	758.8	87.3	25.5	655.6	74.8	7.2	103.2	12.5
P 2003	9,450	32,456	26.1	534.8	82.8	21.0	470.0	72.9	5.1	64.8	10.0
P 2004	9,905	21,710	17.1	366.5	45.1	13.4	312.0	37.9	3.7	54.5	7.2
P 2005	10,360	32,217	17.6	411.3	53.5	14.4	359.6	46.5	3.2	51.7	7.0
P 2006	10,746	22,687	13.1	345.9	36.1	10.6	306.3	28.4	2.5	39.6	7.7
P 2007	11,132	31,780	13.3	380.1	41.0	12.2	364.3	35.2	1.1	15.8	5.8
P 2008	11,870	16,188	8.2	229.5	23.4	7.0	215.1	18.3	1.3	14.3	5.0
P 2009	12,023	27,165	11.4	353.5	33.7	10.5	345.0	29.3	0.8	8.5	4.4
P 2010	12,307	6,070	2.5	83.1	6.9	2.3	79.6	6.1	0.3	3.6	0.8
P 2011	12,357	3,199	1.2	43.7	3.2	1.2	43.2	3.0	0.0	0.6	0.2
P 2012	11,600	2,389	0.8	31.7	1.8	0.7	30.7	1.8	0.0	1.0	0.1
P 2013	9,650	640	0.2	5.4	0.4	0.2	5.2	0.4	0.0	0.2	0.0
P Total		433,905	765.1	11678.8	1739.0	605.8	9473.3	1562.7	159.3	2205.5	176.3
T 1982	4,550	397	6.9	97.7	5.5	4.7	62.7	5.1	2.1	35.1	0.4
T 1983	4,550	719	12.3	164.0	9.4	9.6	115.4	8.6	2.7	48.6	0.8
T 1984	4,554	965	14.4	201.5	12.8	9.6	122.8	12.0	4.9	78.7	0.9
T 1985	4,562	1,481	19.1	255.5	20.6	13.8	158.4	19.3	5.3	97.1	1.3
T 1986	4,583	1,625	19.5	238.6	21.2	13.9	147.8	20.1	5.6	90.8	1.1
T 1987	4,630	2,416	23.6	259.6	30.3	18.4	182.1	28.8	5.3	77.5	1.6
T 1988	4,668	2,568	23.5	235.1	31.4	18.1	167.3	28.8	5.4	67.8	2.6
T 1989	4,741	3,953	34.3	363.2	46.9	26.3	264.2	43.8	8.0	99.0	3.1
T 1990	4,851	3,294	29.6	300.0	40.9	22.1	211.2	38.3	7.5	88.8	2.6
T 1991	5,019	5,343	37.8	435.5	60.7	30.8	337.2	56.5	6.9	98.3	4.2
T 1992	5,256	4,917	39.0	408.8	59.6	30.6	320.5	55.4	8.4	88.3	4.2
T 1993	5,519	8,647	67.8	690.1	117.4	54.6	557.4	108.0	13.2	132.7	9.3
T 1994	5,824	10,252	70.6	767.4	130.7	53.6	587.7	117.6	17.1	179.7	13.2
T 1995	6,135	14,220	95.7	1064.3	193.3	73.3	828.3	171.3	22.4	236.0	22.0
T 1996	6,471	12,470	49.3	622.9	136.0	39.1	494.3	122.8	10.2	128.5	13.2
T 1997	6,940	20,927	76.1	1035.3	227.8	60.6	838.6	203.5	15.6	196.7	24.2
T 1998	7,437	20,565	71.5	993.9	215.3	56.4	784.5	190.2	15.2	209.4	25.1
T 1999	7,863	29,517	78.8	1146.5	243.4	63.2	908.0	212.4	15.6	238.5	31.1
T 2000	8,345	25,393	62.4	916.9	187.8	51.3	742.2	168.3	11.0	174.7	19.5
T 2001	8,900	31,584	53.4	977.7	166.7	45.8	834.2	151.3	7.6	143.6	15.4
T 2002	9,502	25,234	37.9	905.6	127.3	32.2	761.2	115.2	5.7	144.4	12.1
T 2003	10,087	32,964	39.3	747.8	124.8	33.7	635.1	116.6	5.6	112.7	8.2
T 2004	10,727	25,417	23.2	520.0	63.9	19.9	445.8	56.9	3.3	74.2	7.0
T 2005	11,245	36,715	27.6	531.7	62.7	25.3	498.6	57.9	2.3	33.1	4.7
T 2006	11,817	24,083	15.4	352.6	40.5	14.2	330.1	35.4	1.2	22.6	5.1
T 2007	12,303	36,586	17.8	450.0	47.4	16.8	431.8	44.4	1.0	18.2	3.0
T 2008	12,834	18,851	9.2	258.9	24.1	8.6	249.1	22.7	0.5	9.8	1.4
T 2009	13,215	23,685	9.7	286.7	26.8	9.6	286.8	25.9	0.1	-0.1	0.9
T 2010	13,433	6,478	2.7	77.5	6.6	2.6	74.4	6.5	0.1	3.1	0.1
T 2011	13,514	2,298	1.0	29.6	2.0	1.0	28.9	2.0	0.0	0.6	0.1
T 2012	12,428	1,315	0.5	13.8	1.0	0.5	13.8	1.0	0.0	0.0	0.0
T 2013	8,995	598	0.2	4.2	0.3	0.2	4.2	0.3	0.0	0.1	0.0
T Total		435,477	1070.3	15352.9	2485.0	860.7	12424.6	2246.6	209.6	2928.4	238.4
Total		869,382	1835.4	27031.8	4224.0	1466.5	21897.9	3809.3	368.9	5133.9	414.8

Appendix B - Colorado 2011

RapidScreen Audit IM240 Test Reduction Tons

Type	Annual Miles	Unique Vehicles	Initial Tons/Yr			Final Tons/Yr			Reduction Tons/Yr		
			HC	CO	NOx	HC	CO	NOx	HC	CO	NOx
P 1982	4,304	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P 1983	4,304	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P 1984	4,304	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P 1985	4,304	1	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0
P 1986	4,434	2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P 1987	4,481	2	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0
P 1988	4,502	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P 1989	4,552	4	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0
P 1990	4,780	2	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0
P 1991	5,088	4	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0
P 1992	5,430	6	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0
P 1993	5,672	5	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0
P 1994	6,002	9	0.0	0.3	0.1	0.0	0.3	0.1	0.0	0.0	0.0
P 1995	6,331	27	0.1	0.7	0.2	0.1	0.7	0.2	0.0	0.0	0.0
P 1996	6,653	21	0.0	0.6	0.1	0.0	0.6	0.1	0.0	0.0	0.0
P 1997	6,974	54	0.1	1.3	0.3	0.1	1.3	0.3	0.0	0.0	0.0
P 1998	7,369	49	0.1	1.8	0.3	0.1	1.3	0.2	0.0	0.5	0.0
P 1999	7,764	80	0.2	2.1	0.4	0.2	2.1	0.4	0.0	0.1	0.0
P 2000	8,188	76	0.1	1.6	0.3	0.1	1.6	0.3	0.0	0.0	0.0
P 2001	8,613	141	0.1	2.6	0.4	0.1	2.6	0.4	0.0	0.0	0.0
P 2002	9,032	132	0.1	4.4	0.4	0.1	3.0	0.4	0.0	1.4	0.0
P 2003	9,450	206	0.1	3.0	0.5	0.1	3.0	0.5	0.0	0.0	0.0
P 2004	9,905	114	0.1	1.5	0.2	0.1	1.5	0.2	0.0	0.0	0.0
P 2005	10,360	246	0.1	2.6	0.3	0.1	2.5	0.3	0.0	0.2	0.0
P 2006	10,746	127	0.0	1.4	0.1	0.0	1.4	0.1	0.0	0.0	0.0
P 2007	11,132	278	0.1	3.1	0.3	0.1	3.1	0.3	0.0	0.0	0.0
P 2008	11,870	61	0.0	0.7	0.1	0.0	0.7	0.1	0.0	0.0	0.0
P 2009	12,023	152	0.1	1.9	0.2	0.1	1.8	0.2	0.0	0.0	0.0
P 2010	12,307	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P Total		1,799	1.5	30.4	4.1	1.4	28.3	4.1	0.1	2.1	0.0
T 1982	4,550	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T 1983	4,550	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T 1984	4,554	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T 1985	4,562	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T 1986	4,583	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T 1987	4,630	1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T 1988	4,668	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T 1989	4,741	3	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0
T 1990	4,851	1	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0
T 1991	5,019	2	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0
T 1992	5,256	4	0.0	0.3	0.0	0.0	0.3	0.0	0.0	0.0	0.0
T 1993	5,519	3	0.0	0.2	0.0	0.0	0.2	0.0	0.0	0.0	0.0
T 1994	5,824	4	0.0	0.3	0.0	0.0	0.2	0.0	0.0	0.1	0.0
T 1995	6,135	5	0.0	0.3	0.0	0.0	0.3	0.0	0.0	0.0	0.0
T 1996	6,471	19	0.1	1.1	0.1	0.1	0.8	0.1	0.0	0.3	0.0
T 1997	6,940	39	0.1	1.7	0.4	0.1	1.6	0.4	0.0	0.0	0.1
T 1998	7,437	59	0.2	2.1	0.5	0.2	2.0	0.5	0.0	0.1	0.0
T 1999	7,863	101	0.2	3.0	0.7	0.2	2.7	0.6	0.0	0.3	0.0
T 2000	8,345	86	0.1	2.0	0.5	0.1	2.0	0.5	0.0	0.0	0.0
T 2001	8,900	195	0.3	4.5	0.9	0.3	4.4	0.9	0.0	0.1	0.0
T 2002	9,502	135	0.2	3.9	0.6	0.1	3.1	0.6	0.0	0.7	0.0
T 2003	10,087	270	0.2	4.8	0.9	0.2	4.7	0.9	0.0	0.1	0.0
T 2004	10,727	181	0.1	2.7	0.4	0.1	2.8	0.4	0.0	-0.2	0.0
T 2005	11,245	419	0.3	6.0	0.7	0.3	5.8	0.7	0.0	0.2	0.0
T 2006	11,817	192	0.1	2.5	0.2	0.1	2.5	0.2	0.0	0.0	0.0
T 2007	12,303	459	0.2	5.7	0.6	0.2	5.1	0.6	0.0	0.6	0.0
T 2008	12,834	78	0.0	0.9	0.1	0.0	1.0	0.1	0.0	0.0	0.0
T 2009	13,215	179	0.1	2.3	0.2	0.1	2.4	0.2	0.0	0.0	0.0
T 2010	13,433	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
T Total		2,435	2.3	44.7	7.2	2.2	42.4	7.1	0.1	2.2	0.2
Total		4,234	3.8	75.1	11.3	3.6	70.8	11.2	0.1	4.3	0.2