Colorado Rail Relocation Implementation Study

Air Quality Analysis

Presented By

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Introduction

This report looks at the air quality emissions as a result of the R2C2 project. The R2C2 project examines the rerouting of a significant number of freight rail trips away from the urban Front Range area in Colorado to counties within the eastern plains. The air quality emissions are estimated for Alignments A and B as increments against the No Build alignment emissions.

A planning horizon for this study covers twenty years, 2012 to 2032. Emissions were estimated for each of these years.

Existing Conditions

The EPA air quality monitoring is confined to areas with the potential for exceeding the National Ambient Air Quality Standards (NAAQS). In the eastern plains, the only criteria pollutant examined was particulate matter in the neighboring Prowers County. The town of Lamar in Prowers County (which borders Bent County) had a problem meeting the PM_{10} (particulate matter smaller than 10 microns in the aerodynamic diameter) standard due to the area's semiarid nature and fugitive dust largely from agricultural operations. Lamar has not violated the standard since 1992 and was re-designated to an attainment status in 2005, i.e., the monitored PM_{10} levels were consistently below the standard, but the area remains under observation (i.e., currently a maintenance area). There are two PM_{10} monitors in Prowers County in Lamar, one in the residential area in the city, the other in the industrial/commercial rural area. Table 1 presents the highest PM_{10} monitored levels at both monitors for the last complete 3 years (2005-2007). The levels in Table 1 indicate that PM_{10} concentrations in Lamar were below the 24-hour PM_{10} NAAQS of 150 $\mu g/m^3$ in the last three years.

Table 1: Highest PM_{10} Concentrations Monitored at Lamar, Prowers County, CO ($\mu g/m^3$)

Site Address	Land Use	NAAQS	Year		
			2005	2006	2007
104 Parmenter Street, Lamar	Residential, Urban	150	108	116	58
10 North 2nd Avenue, Lamar	Commercial, Rural	150	116	136	93

Train Emissions

The bypass of freight trains is expected to shorten train routes and allow the trains to move faster. These changes are expected to result in significant time savings for the train operations. Table 2 presents the estimated annual time reductions (in comparison with the No Build under both proposed relocation alignments).

Table 2: Annual Rail Time Reductions Relative to the No Build (hours)

Year	Alignment A			Alinment B		
	BNSF	UP	Total savings	BNSF	UP	Total savings
2012	28,994	534	29,528	45,719	1,721	47,440
2013	29,527	544	30,072	46,560	1,753	48,313
2014	30,071	554	30,625	47,417	1,785	49,202
2015	30,624	565	31,188	48,290	1,818	50,107
2016	31,187	575	31,762	49,178	1,851	51,029
2017	31,761	585	32,347	50,083	1,885	51,968
2018	32,346	596	32,942	51,005	1,920	52,924
2019	32,941	607	33,548	51,943	1,955	53,898
2020	33,547	618	34,165	52,899	1,991	54,890
2021	34,164	630	34,794	53,872	2,028	55,900
2022	34,793	641	35,434	54,863	2,065	56,929
2023	35,433	653	36,086	55,873	2,103	57,976
2024	36,085	665	36,750	56,901	2,142	59,043
2025	36,749	677	37,426	57,948	2,181	60,129
2026	37,425	690	38,115	59,014	2,221	61,236
2027	38,114	703	38,816	60,100	2,262	62,362
2028	38,815	715	39,530	61,206	2,304	63,510
2029	39,529	729	40,258	62,332	2,346	64,678
2030	40,256	742	40,999	63,479	2,389	65,868
2031	40,997	756	41,753	64,647	2,433	67,080
2032	41,752	770	42,521	65,836	2,478	68,315

Time savings will translate into emission savings: the less time the locomotive is in operation, the less emissions it should exhaust. Emission savings were estimated under both alignments relative to the No Build alignment under the assumption that locomotive operating conditions under all three alignments would be the same.

It was assumed that the freight trains under consideration will have three locomotives (on average) of 6000 horse power (hp) each. The average locomotive load factor was assumed to be 0.275. This load factor is the same as used for the line-haul locomotives in the *Regulatory Impact Analysis* carried out by the EPA in support of the final *Locomotive Emission Standards* (June, 2008). The load factor is the ratio of the average horsepower in use to the rated horsepower of the engine.

Locomotive emissions are regulated by emission standards set up for the year of manufacture or re-manufacture. Denver Regional Council of Governments (DRCOG) suggested that Tier 2 emission standards should be used in this study. Locomotives that are subjected to the Tier 2 emission standards had to be manufactured or remanufactured between years 2005 and 2011. Tier 2 locomotive emissions were conservatively assumed for all years of analysis in this study (see Attachments 1 and 2 for locomotive emission standards for all tiers). Locomotives for tier 3 (i.e., those manufactured between 2012 – 2014) require significant reductions in particulate matter, and those for Tier 4 (i.e., those manufactured after 2015) are to continue reductions in particulate matter as well as in all other measured pollutants with the exception of CO and SO_2.

Locomotive emission standards are applied to the exhaust hydrocarbon emissions (HC). However, regional emissions are estimated for volatile organic compounds (VOC) that include some small additional amount of volatile dust particles not of hydrocarbon origin. To account for them, an additional 0.53 percent was added to total HC emissions following the methodology in the *Regulatory Impact Analysis*.

It was assumed that locomotive particulate emissions consist entirely of PM_{10}. In order to estimate $PM_{2.5}$ (particulate matter smaller than 2.5 microns in the aerodynamic diameter) emissions from the total particulate emissions that are regulated for locomotives are adjusted by a factor of 0.97. These assumptions followed the *Regulatory Impact Analysis* assumptions.

Sulfur dioxide (SO_2) emissions from locomotives were estimated following the methodology described in the EPA's *Non Road Model*. The use of ultra low sulfur fuel is mandated to locomotives after 2012 thus covering all analysis years. Sulfur content of the diesel fuel considered in this analysis was 15 ppm.

Locomotive emission factors used in this study are presented in the Table 3 for all pollutants that were considered.

Table 3: Locomotive Emission Factors

Pollutant	**Tier 2 Emission Factor**
	g/bhp-hr
CO	1.5
NO_x	5.5
VOC	0.32
PM_{10}	0.14
$PM_{2.5}$	0.136
SO_2	0.45
Year of Manufacture	2005-2011

Annual emissions under both Alignments A and B will be lower than the No Build for all years of analysis due to the savings in train operation time. Reductions from the No Build are presented in Table 4 as savings in emissions compared to emissions under the No Build alignment.

Table 4: Annual Train Emission Reductions under the Build Alignments over the No Build Alignment (in metric tons)

Year	Annual Emission Decrease Under Alternative A						Annual Emission Decrease Under Alternative B					
	CO	PM_{10}	$PM_{2.5}$	NO_x	VOC	SO_2	CO	PM_{10}	$PM_{2.5}$	NO_x	VOC	SO_2
2012	219.2	20.5	19.8	803.9	46.2	66.3	352.2	32.9	31.9	1291.6	74.2	106.5
2013	223.3	20.8	20.2	818.7	47.0	67.5	358.7	33.5	32.5	1315.3	75.5	108.5
2014	227.4	21.2	20.6	833.8	47.9	68.8	365.3	34.1	33.1	1339.5	76.9	110.5
2015	231.6	21.6	21.0	849.1	48.8	70.0	372.0	34.7	33.7	1364.2	78.4	112.5
2016	235.8	22.0	21.4	864.7	49.7	71.3	378.9	35.4	34.3	1389.3	79.8	114.6
2017	240.2	22.4	21.7	880.6	50.6	72.6	385.9	36.0	34.9	1414.8	81.3	116.7
2018	244.6	22.8	22.1	896.8	51.5	74.0	393.0	36.7	35.6	1440.9	82.8	118.8
2019	249.1	23.2	22.6	913.3	52.5	75.3	400.2	37.4	36.2	1467.4	84.3	121.0
2020	253.7	23.7	23.0	930.1	53.4	76.7	407.6	38.0	36.9	1494.4	85.8	123.2
2021	258.3	24.1	23.4	947.3	54.4	78.1	415.1	38.7	37.6	1521.9	87.4	125.5
2022	263.1	24.6	23.8	964.7	55.4	79.5	422.7	39.5	38.3	1549.9	89.0	127.8
2023	267.9	25.0	24.3	982.4	56.4	81.0	430.5	40.2	39.0	1578.4	90.7	130.2
2024	272.9	25.5	24.7	1000.5	57.5	82.5	438.4	40.9	39.7	1607.4	92.3	132.5
2025	277.9	25.9	25.2	1018.9	58.5	84.0	446.5	41.7	40.4	1637.0	94.0	135.0
2026	283.0	26.4	25.6	1037.7	59.6	85.6	454.7	42.4	41.2	1667.1	95.8	137.5
2027	288.2	26.9	26.1	1056.8	60.7	87.1	463.0	43.2	41.9	1697.8	97.5	140.0
2028	293.5	27.4	26.6	1076.2	61.8	88.7	471.6	44.0	42.7	1729.1	99.3	142.6
2029	298.9	27.9	27.1	1096.0	63.0	90.4	480.2	44.8	43.5	1760.9	101.1	145.2
2030	304.4	28.4	27.6	1116.2	64.1	92.0	489.1	45.6	44.3	1793.3	103.0	147.9
2031	310.0	28.9	28.1	1136.7	65.3	93.7	498.1	46.5	45.1	1826.3	104.9	150.6
2032	315.7	29.5	28.6	1157.6	66.5	95.5	507.2	47.3	45.9	1859.9	106.8	153.4

Idling at Rail Crossings

Relocating a majority of the freight rail traffic from the Front Range to the less populated areas in the East Colorado is expected to significantly decrease rail crossing delays both because the rail will intersect with less congested highways and because the trains will be able to achieve faster speeds.

Table 5 shows the delay reductions for the proposed alignments compared with the future No Build alignment for the years of analysis.

Table 5: Annual Rail Crossings Idle Time Reductions Relative to No Build

Year	Reductions in hours	
	Alignment A	Alignment B
2012	60,528	59,408
2013	61,570	60,429
2014	62,629	61,469
2015	63,706	62,526
2016	64,801	63,601
2017	65,916	64,695
2018	67,050	65,808
2019	68,203	66,940
2020	69,376	68,091
2021	70,569	69,263
2022	71,783	70,454
2023	73,018	71,666
2024	74,274	72,898
2025	75,551	74,152
2026	76,851	75,428
2027	78,173	76,725
2028	79,517	78,045
2029	80,885	79,387
2030	82,276	80,752
2031	83,691	82,141
2032	85,131	83,554

In order to estimate emission reductions that will result from the decrease of delays at the crossings, emission factors from the latest version of the EPA vehicle emission model, Mobile 6.2.03, were used. Emission factors were estimated for the light and the heavy-duty vehicles utilizing the current Colorado inspection and maintenance and vehicle classification information obtained from the Colorado Department of Public Health and Environment. Idle emission factors used in this study are presented in Attachment 3. The resultant emission reductions as savings over emissions under the No Build alignment are shown in Table 6.

Table 6: Annual Idle Emission Reductions under the Build Alignments over the No Build Alignment (in metric tons)

Year	Annual Idle Emission Reduction under Alternative A					Annual Idle Emission Reduction under Alternative B				
	VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	VOC	CO	NO_x	PM_{10}	$PM_{2.5}$
2012	1.21	4.92	0.33	0.067	0.062	1.19	4.83	0.33	0.066	0.061
2013	1.13	4.79	0.31	0.067	0.062	1.11	4.70	0.30	0.066	0.061
2014	1.05	4.68	0.29	0.068	0.062	1.04	4.59	0.28	0.067	0.061
2015	1.01	4.62	0.27	0.066	0.061	0.99	4.53	0.26	0.065	0.060
2016	0.98	4.56	0.25	0.067	0.062	0.96	4.47	0.25	0.066	0.060
2017	0.96	4.53	0.23	0.068	0.062	0.94	4.44	0.23	0.067	0.061
2018	0.95	4.49	0.22	0.067	0.062	0.93	4.41	0.22	0.066	0.061
2019	0.93	4.48	0.21	0.068	0.063	0.91	4.40	0.20	0.067	0.062
2020	0.81	4.49	0.20	0.070	0.064	0.80	4.41	0.20	0.068	0.063
2021	0.80	4.51	0.20	0.071	0.065	0.78	4.43	0.19	0.070	0.064
2022	0.77	4.55	0.19	0.072	0.066	0.76	4.46	0.19	0.071	0.065
2023	0.77	4.59	0.18	0.073	0.067	0.76	4.51	0.18	0.072	0.066
2024	0.78	4.64	0.18	0.075	0.069	0.77	4.56	0.17	0.073	0.067
2025	0.79	4.65	0.17	0.076	0.070	0.77	4.57	0.17	0.074	0.068
2026	0.80	4.70	0.17	0.077	0.071	0.78	4.62	0.17	0.076	0.070
2027	0.81	4.75	0.17	0.078	0.072	0.79	4.67	0.16	0.077	0.071
2028	0.82	4.74	0.16	0.080	0.073	0.80	4.66	0.16	0.078	0.072
2029	0.83	4.83	0.16	0.081	0.075	0.81	4.74	0.16	0.080	0.073
2030	0.84	4.90	0.16	0.083	0.076	0.83	4.81	0.16	0.081	0.075
2031	0.85	4.97	0.16	0.084	0.077	0.84	4.87	0.15	0.082	0.076
2032	0.87	5.04	0.16	0.085	0.079	0.85	4.95	0.15	0.084	0.077

Total Emission Savings

The total emission reductions for all future years are presented in Table 7. The total reduction is a sum of reductions in train emissions and reductions in vehicular idle emissions at the rail crossings. It should be noted that rail emission decreases are much greater than decreases in vehicular emissions at rail crossings. This is in part because freight train emissions are orders of magnitude higher than vehicular emissions. Locomotive engines are more powerful than vehicular and the three locomotives (on average) per train were assumed necessary to move the heavy cargo. In addition, the time savings for the rail operations and at the rail crossings are comparable in scale.

Statewide Emissions

According to the 2008 EPA's *Report on the Environment* criteria pollutant emissions will decline in the State of Colorado along with emissions in the rest of the US. Figures 1 through 6 that are taken from this report indicate that all regions demonstrate decrease in emissions for criteria pollutants in the most recent years when data is available. Colorado is in the EPA's Region 8. The states within Region 8 have consistently lower emissions than most others – see Figures 1 through 6. The proposed relocation will additionally reduce emissions in the State of Colorado under both proposed alignments as estimated in this study.

Future Local Conditions in Eastern Colorado

Most emission sources in the state of Colorado are located in the Front Range area. The Eastern Plain counties are assumed to contribute small amounts to the state-wide emissions as is indicated by the attainment with the health-related NAAQS examined and by the lack of industries and man-induced uses which are known to contribute to poor air quality (i.e., significant roadway congestion). Relocation of the some of the freight rail to the eastern counties will increase emissions but this increase is not anticipated to be of the magnitude to compromise air quality in the region. The only problematic pollutant in the Eastern Plains was particulate matter (PM_{10}). The PM_{10} levels in the border county to the study area (i.e., Prowers County) had concentrations below the PM_{10} NAAQS in the recent years. Several state PM_{10} monitors in the area were discontinued because concentrations that they monitored were below the PM_{10} standard and had a downward trend. It is not anticipated, therefore, that emissions of the freight rail will increase concentrations of PM_{10} to the level that would be close or exceed the PM_{10} standard. Concentrations of all analyzed pollutants in the Front Range corridor will decrease with the proposed relocation of the freight rail away from this area.

Conclusions

The proposed re-routing of the freight rail to the Eastern Plains is anticipated to bring significant reductions in state-wide emissions in Colorado. CO, NO_x, PM, SO_2 and VOC emissions analyzed in this study demonstrated reductions in the range from tens to thousands of metric tons annually. Air quality in the Front Range corridor will improve with the proposed relocation, while local concentrations in Eastern Colorado may increase but are anticipated to remain below the appropriate ambient air quality standards due to the following factors:

- The air quality levels in Eastern Colorado are currently well below standards.
- EPA only monitors for PM_{10} in Prowers County because it is a maintenance area for PM_{10}, but the monitored PM_{10} concentrations did not exceed the standard there since 1998.
- Air quality levels at the Front Range monitors located close to the project corridor currently do not exceed the standards for the pollutants of concern considered in this study.

References

1. Colorado Front Range Rail Relocation Implementation Study, Benefit Analysis Update, Revised Draft, Second Revision, September 8, 2008.
2. 40 CFR parts 9, 85, et al. Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less Than 30 Liters per Cylinder, Republication, Final Rule; June 2008.
3. USEPA, Regulatory Impact Analysis: Control of Emissions of Air Pollution from Locomotive Engines and Marine Compression-Ignition Engines Less Than 30 Liters per Cylinder; EPA420-R-08-001a, May 2008.
4. Public Benefit and Cost Study of the Proposed BNSF/UP Front Range Railroad Infrastructure Rationalization Project, Technical Memorandum Number 5, May 2005.
5. USEPA, Mobile 6.2.03: Mobile Source Emission Model, EPA, May, 2004.
6. USEPA, 2008 Report on the Environment, EPA/600/R-07/045F, May 2008.
7. http://www.cdphe.state.co.us/ap/down/RTTP07-08web.pdf
8. EPA Airdata Database, October, 2008

Table 7: Annual Total Emission Reductions under the Build Alignments over the No Build Alignment (in metric tons)

	Annual Emission Reduction under Alternative A						Annual Emission Reduction under Alternative B					
Year	VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2	VOC	CO	NO_x	PM_{10}	$PM_{2.5}$	SO_2
2012	47.4	224.2	804.2	20.5	19.9	66.3	75.4	357.1	1,291.9	32.9	32.0	106.5
2013	48.1	228.1	819.0	20.9	20.3	67.5	76.7	363.4	1,315.6	33.5	32.5	108.5
2014	48.9	232.1	834.0	21.3	20.6	68.8	78.0	369.9	1,339.8	34.2	33.1	110.5
2015	49.8	236.2	849.4	21.7	21.0	70.0	79.3	376.6	1,364.4	34.8	33.7	112.5
2016	50.6	240.4	865.0	22.1	21.4	71.3	80.8	383.4	1,389.5	35.4	34.4	114.6
2017	51.5	244.7	880.9	22.5	21.8	72.6	82.2	390.3	1,415.1	36.1	35.0	116.7
2018	52.5	249.1	897.1	22.9	22.2	74.0	83.7	397.4	1,441.1	36.7	35.6	118.8
2019	53.4	253.6	913.6	23.3	22.6	75.3	85.2	404.6	1,467.6	37.4	36.3	121.0
2020	54.2	258.2	930.4	23.7	23.0	76.7	86.6	412.0	1,494.6	38.1	37.0	123.2
2021	55.2	262.9	947.5	24.2	23.5	78.1	88.2	419.5	1,522.1	38.8	37.6	125.5
2022	56.2	267.6	964.9	24.6	23.9	79.5	89.8	427.2	1,550.1	39.5	38.3	127.8
2023	57.2	272.5	982.6	25.1	24.3	81.0	91.4	435.0	1,578.6	40.2	39.0	130.2
2024	58.2	277.5	1,000.7	25.5	24.8	82.5	93.1	442.9	1,607.6	41.0	39.8	132.5
2025	59.3	282.5	1,019.1	26.0	25.2	84.0	94.8	451.0	1,637.2	41.7	40.5	135.0
2026	60.4	287.7	1,037.8	26.5	25.7	85.6	96.5	459.3	1,667.3	42.5	41.2	137.5
2027	61.5	293.0	1,056.9	27.0	26.2	87.1	98.3	467.7	1,698.0	43.3	42.0	140.0
2028	62.6	298.3	1,076.4	27.5	26.6	88.7	100.1	476.2	1,729.2	44.1	42.8	142.6
2029	63.8	303.7	1,096.2	28.0	27.1	90.4	102.0	485.0	1,761.0	44.9	43.6	145.2
2030	65.0	309.3	1,116.3	28.5	27.6	92.0	103.8	493.9	1,793.4	45.7	44.4	147.9
2031	66.1	315.0	1,136.9	29.0	28.1	93.7	105.7	502.9	1,826.4	46.6	45.2	150.6
2032	67.4	320.8	1,157.8	29.6	28.7	95.5	107.7	512.2	1,860.0	47.4	46.0	153.4

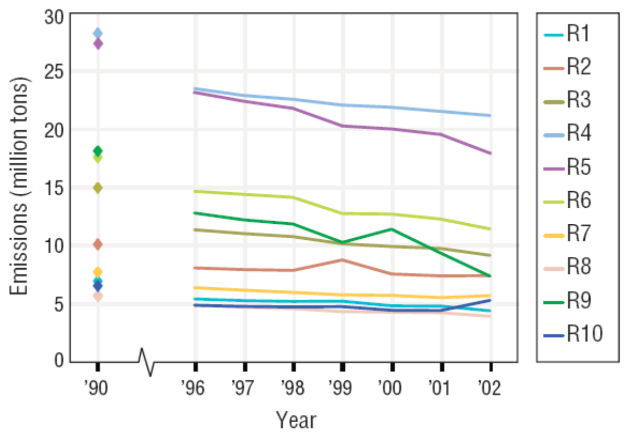

Figure 1: CO emissions, 1990 and 1996-2002

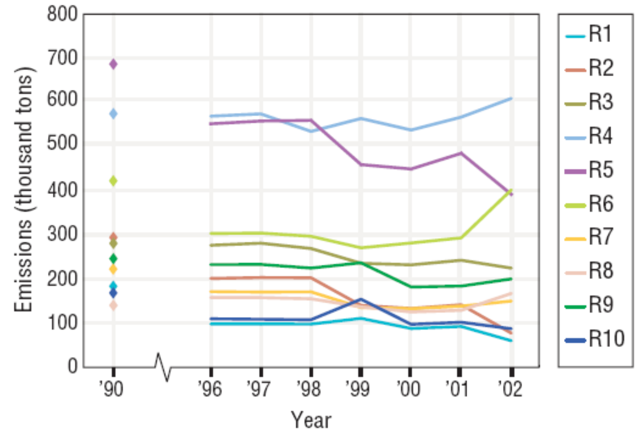

Figure 3: PM_{10} emissions, 1990 and 1996-2002

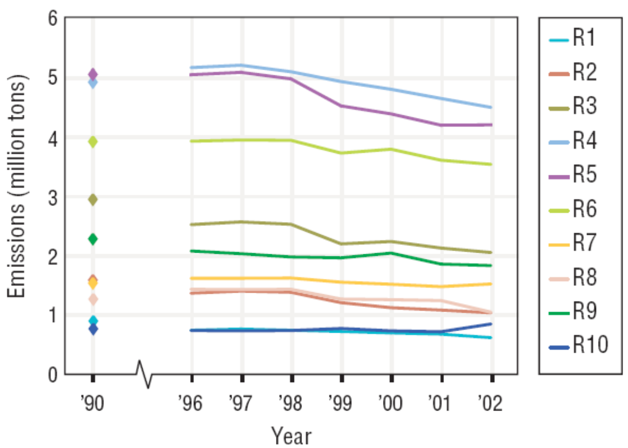

Figure 2: NO_x emissions, 1990 and 1996-2002

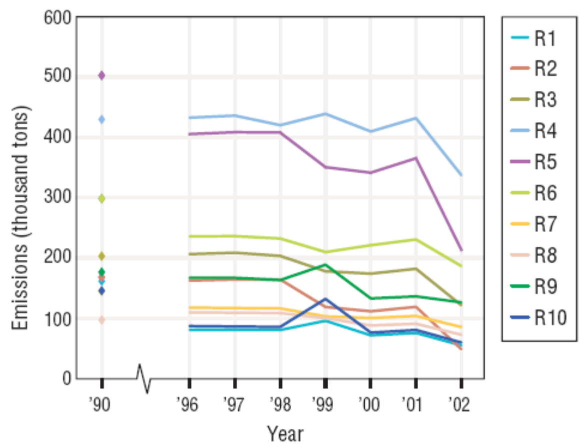

Figure 4: $PM_{2.5}$ emissions, 1990 and 1996-2002

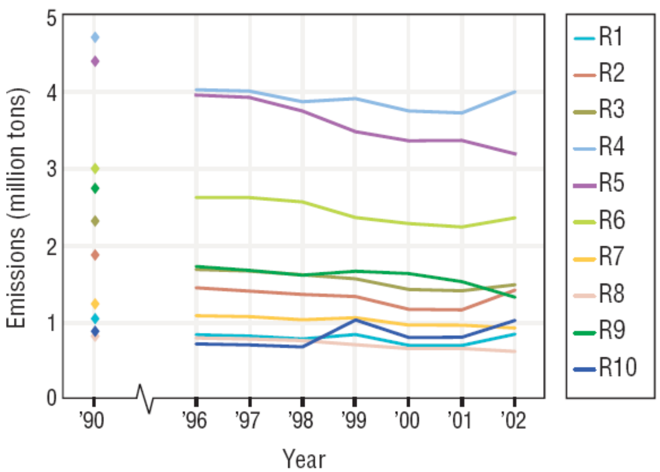

Figure 5: VOC emissions, 1990 and 1996-2002

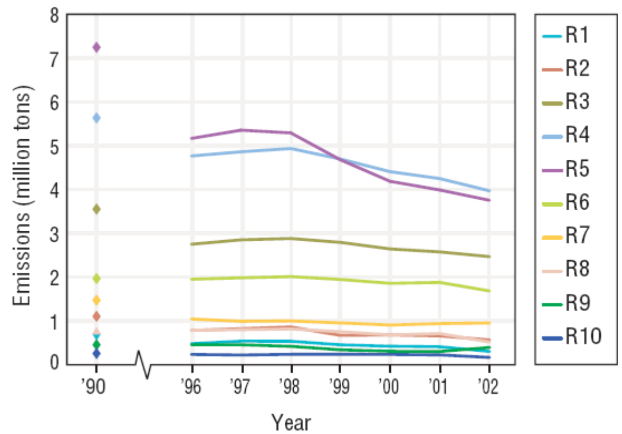

Figure 6: SO_2 emissions, 1990 and 1996-2002

ATTACHMENTS

Attachment 1:

(j) Subpart J of this part contains definitions and other reference information.

§ 1033.15 Other regulation parts that apply for locomotives.

(a) Part 1065 of this chapter describes procedures and equipment specifications for testing engines. Subpart F of this part 1033 describes how to apply the provisions of part 1065 of this chapter to test locomotives to determine whether they meet the emission standards in this part.

(b) The requirements and prohibitions of part 1068 of this chapter apply to everyone, including anyone who manufactures, remanufactures, imports, maintains, owns, or operates any of the locomotives subject to this part 1033. See § 1033.601 to determine how to apply the part 1068 regulations for locomotives. Part 1068 of this chapter describes general provisions, including the following areas:

(1) Prohibited acts and penalties for locomotive manufacturer/remanufacturers and others.

(2) Exclusions and exemptions for certain locomotives.

(3) Importing locomotives.

(4) Selective enforcement audits of your production.

(5) Defect reporting and recall.

(6) Procedures for hearings.

(c) Other parts of this chapter apply if referenced in this part.

Subpart B—Emission Standards and Related Requirements

§ 1033.101 Exhaust emission standards.

See §§ 1033.102 and 1033.150 to determine how the emission standards of this section apply before 2023.

(a) *Emission standards for line-haul locomotives.* Exhaust emissions from your new locomotives may not exceed the applicable emission standards in Table 1 to this section during the useful life of the locomotive. (**Note:** § 1033.901 defines locomotives to be "new" when originally manufactured and when remanufactured.) Measure emissions using the applicable test procedures described in subpart F of this part.

TABLE 1 TO § 1033.101.—LINE-HAUL LOCOMOTIVE EMISSION STANDARDS

Year of original manufacture	Tier of standards	Standards (g/bhp-hr)			
		NO_X	PM	HC	CO
1973–1992 [a]	Tier 0 [b]	8.0	0.22	1.00	5.0
1993 [a]–2004	Tier 1 [b]	7.4	0.22	0.55	2.2
2005–2011	Tier 2 [b]	5.5	[e] 0.10	0.30	1.5
2012–2014	Tier 3 [c]	5.5	0.10	0.30	1.5
2015 or later	Tier 4 [d]	1.3	0.03	0.14	1.5

[a] Locomotive models that were originally manufactured in model years 1993 through 2001, but that were not originally equipped with a separate coolant system for intake air are subject to the Tier 0 rather than the Tier 1 standards.
[b] Line-haul locomotives subject to the Tier 0 through Tier 2 emission standards must also meet switch standards of the same tier.
[c] Tier 3 line-haul locomotives must also meet Tier 2 switch standards.
[d] Manufacturers may elect to meet a combined NO_X+HC standard of 1.4 g/bhp-hr instead of the otherwise applicable Tier 4 NO_X and HC standards, as described in paragraph (j) of this section.
[e] The PM standard for newly remanufactured Tier 2 line-haul locomotives is 0.20 g/bhp-hr until January 1, 2013, except as specified in § 1033.150(a).

(b) *Emission standards for switch locomotives.* Exhaust emissions from your new locomotives may not exceed the applicable emission standards in Table 2 to this section during the useful life of the locomotive. (**Note:** § 1033.901 defines locomotives to be "new" when originally manufactured and when remanufactured.) Measure emissions using the applicable test procedures described in subpart F of this part.

TABLE 2 TO § 1033.101.—SWITCH LOCOMOTIVE EMISSION STANDARDS

Year of original manufacture	Tier of standards	Standards (g/bhp-hr)			
		NO_X	PM	HC	CO
1973–2001	Tier 0	11.8	0.26	2.10	8.0
2002–2004	Tier 1 [a]	11.0	0.26	1.20	2.5
2005–2010	Tier 2 [a]	8.1	[b] 0.13	0.60	2.4
2011–2014	Tier 3	5.0	0.10	0.60	2.4
2015 or later	Tier 4	[c] 1.3	0.03	[c] 0.14	2.4

[a] Switch locomotives subject to the Tier 1 through Tier 2 emission standards must also meet line-haul standards of the same tier.
[b] The PM standard for new Tier 2 switch locomotives is 0.24 g/bhp-hr until January 1, 2013, except as specified in § 1033.150(a).
[c] Manufacturers may elect to meet a combined NO_X+HC standard of 1.3 g/bhp-hr instead of the otherwise applicable Tier 4 NO_X and HC standards, as described in paragraph (j) of this section.

(c) *Smoke standards.* The smoke opacity standards specified in Table 3 to this section apply only for locomotives certified to one or more PM standards or FELs greater than 0.05 g/bhp-hr. Smoke emissions, when measured in accordance with the provisions of Subpart F of this part, shall not exceed these standards.

TABLE 3 TO § 1033.101.—SMOKE STANDARDS FOR LOCOMOTIVES (PERCENT OPACITY)

	Steady-state	30-sec peak	3-sec peak
Tier 0	30	40	50
Tier 1	25	40	50

Attachment 2:
Locomotive Emission Factors for Tiers 2, 3 and 4

Locomotive Emission Factors

Pollutant	Tier 2	Tier 3	Tier 4
	g/bhp-hr	g/bhp-hr	g/bhp-hr
CO	1.5	1.5	1.5
NOx	5.5	5.5	1.3
HC	0.3	0.3	0.14
VOC	0.32	0.32	0.15
PM10	0.14	0.04	0.03
PM2.5	0.136	0.039	0.029
SO2	0.45	0.45	0.45
Year of manufacture	2005-2011	2012-2014	after 2015

Train Information

Locomotives per train	3
HP per Locomotive	6,000
Average locomotive load factor	0.275
Average Train HP	4,950

Notes:

1.Emission factors -- 73 CFR part 126, subpart B: 1033.101

2. VOC EF = 1.053 times HC EF (Regulatory Impact Analysis, USEPA May 2008)

3. PM2.5 EF= 0.97 times PM10 EF (Regulatory Impact Analysis, USEPA May 2008)

4. The use of ultra-low sulfur fuel is mandated for locomotives after 2012. According to EPA Reguatory Impact Analysis PM10 EF will be 0.06 g/bhp-hr lower for Tier 2 and 3.

5. SO2 EF were estimated following EPA NonRoad Model approach based on brake-specific fuel consumption and content of sulfur in fuel.

Locomotive ave fuel	20.8	bhp-hr/gal
consumption	154.97	g/hp-hr
Diesel fuel density	7.1	lb/gal
fract. S conv to PM	0.02247	g PM S/g fuel S
fract. S conv to SO2	2	g SO2/g S
S content of diesel	0.0015	eqv 15 ppm

Attachment 3: Colorado Idle Emission Factors

Year	***at 2.5 mph (g/veh-ml)***					***Idle EF(g/hr)***				
	VOC	CO	NOx	PM10	PM2.5	VOC	CO	NOx	PM10	PM2.5
2012	8.01	32.51	2.2	1.1127	1.0237	*20.03*	*81.28*	*5.50*	*1.1127*	*1.0237*
2013	7.32	31.11	2.01	1.0954	1.0077	*18.30*	*77.78*	*5.03*	*1.0954*	*1.0077*
2014	6.74	29.89	1.84	1.0829	0.9963	*16.85*	*74.74*	*4.59*	*1.0829*	*0.9963*
2015	6.34	28.98	1.69	1.0406	0.9574	*15.85*	*72.45*	*4.23*	*1.0406*	*0.9574*
2016	6.05	28.14	1.55	1.0331	0.9504	*15.13*	*70.35*	*3.87*	*1.0331*	*0.9504*
2017	5.83	27.47	1.42	1.0282	0.9459	*14.56*	*68.69*	*3.56*	*1.0282*	*0.9459*
2018	5.64	26.78	1.31	1.004	0.9237	*14.10*	*66.94*	*3.27*	*1.0040*	*0.9237*
2019	5.45	26.28	1.22	1.004	0.9237	*13.63*	*65.71*	*3.06*	*1.0040*	*0.9237*
2020	4.69	25.91	1.17	1.004	0.9237	*11.71*	*64.76*	*2.91*	*1.0040*	*0.9237*
2021	4.51	25.56	1.11	1.004	0.9237	*11.27*	*63.89*	*2.77*	*1.0040*	*0.9237*
2022	4.30	25.34	1.05	1.004	0.9237	*10.76*	*63.34*	*2.63*	*1.0040*	*0.9237*
2023	4.22	25.16	1.00	1.004	0.9237	*10.56*	*62.90*	*2.51*	*1.0040*	*0.9237*
2024	4.21	25.00	0.96	1.004	0.9237	*10.52*	*62.51*	*2.40*	*1.0040*	*0.9237*
2025	4.17	24.63	0.91	1.004	0.9237	*10.41*	*61.57*	*2.28*	*1.0040*	*0.9237*
2026	4.15	24.48	0.88	1.004	0.9237	*10.38*	*61.20*	*2.20*	*1.0040*	*0.9237*
2027	4.14	24.32	0.85	1.004	0.9237	*10.35*	*60.81*	*2.13*	*1.0040*	*0.9237*
2028	4.11	23.86	0.81	1.004	0.9237	*10.27*	*59.66*	*2.03*	*1.0040*	*0.9237*
2029	4.10	23.86	0.79	1.004	0.9237	*10.25*	*59.66*	*1.98*	*1.0040*	*0.9237*
2030	4.09	23.84	0.78	1.004	0.9237	*10.23*	*59.59*	*1.94*	*1.0040*	*0.9237*
2031	4.08	23.73	0.75	1.004	0.9237	*10.21*	*59.33*	*1.88*	*1.0040*	*0.9237*
2032	4.08	23.69	0.74	1.004	0.9237	*10.20*	*59.24*	*1.86*	*1.0040*	*0.9237*