SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Final Staff Report
Proposed Rule 3502 - Minimization of Emissions from Locomotive Idling

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BACKGROUND

Rail operations, characterized primarily by activities associated with operation of diesel locomotives, are a significant source of diesel particulate matter (PM) emissions and other criteria pollutants such as oxides of nitrogen (NO_x), volatile organic compounds (VOC), carbon monoxide (CO), and oxides of sulfur (SO_x). The 2003 Air Quality Management Plan (AQMP) estimates freight locomotive particulate matter less than 10 microns (PM_{10}) emissions of 0.90 tons per day and emissions of particulate matter less than 2.5 microns ($PM_{2.5}$) of 0.82 tons per day, in addition to NO_x, VOC, CO, and SO_x emissions of 32.98, 1.70, 6.04, and 2.83 tons per day, respectively.[1] Diesel exhaust is a complex mixture of gases and fine particles emitted by diesel-fueled internal combustion engines. Diesel exhaust also contains many carcinogenic compounds, including, but not limited to, arsenic, benzene, formaldehyde, 1-3-butadiene, and ethylene dibromide.[2] In 1998, the California Air Resources Board (CARB) identified diesel exhaust as a Toxic Air Contaminant (TAC) based on its cancer causing potential.

Proposed Rule (PR) 3502 – Minimization of Emissions from Locomotive Idling establishes idling limits for freight locomotives operated in the District. The purpose of PR 3502 is to minimize emissions from unnecessary idling of locomotives operating in the District.

PROPOSED RULE 3502 REQUIREMENTS

PR 3502 is applicable to Class I freight railroads and switching and terminal railroads that operate in the District. There are two Class I freight railroads, Burlington Northern Santa Fe and Union Pacific and two switching and terminal railroads, Los Angeles Junction Railway (LAJ) and Pacific Harbour Line, Inc. (PHL) in the district. LAJ is wholly owned by BNSF.

Passenger railroads operating in the District, such as Amtrak and Metrolink, would not be subject to the requirements of PR 3502. Preliminary data indicates that these operations contribute less than ten percent of NOx and PM emissions from rail operations. Passenger operations are different than freight operations because they are characterized by very little, if any, switching and cargo handling activities, in addition to considerably lower traffic volumes. In addition, in most cases commuter rail has the right of way over freight locomotives and thus is not required to idle as frequently as freight locomotives. Also, passenger railroads operate on a more predictable schedule such that crew changes and breaks can occur at specified time periods and locations to avoid delays and idling associated with such activities. District staff understands that federal law limits railroad workers to working 12 hour shifts to prevent fatigue, even if they have not reached their destination. Due to their lower emissions, passenger railyard operations pose proportionally lower health risks than freight railyards. However, the District will continue

[1] South Coast Air Quality Management District, 2003. 2003 Air Quality Management Plan: Appendix III – Base and Future Year Emission Inventories.

[2] California Environmental Protection Agency, Air Resources Board and Office of Environmental Health Hazard Assessment, 1998. Executive Summary for the "Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant."

to evaluate passenger rail operations and idling. If warranted, passenger operations may be considered for regulation in the future.

PR 3502 would establish the following requirements:

- Idling Requirement (effective six months from date of adoption)
  - Unless a locomotive is equipped with an anti-idling device that is set at 15 minutes or less, engaged, and not tampered with, an operator shall not idle an unattended lead or trailing locomotive for more than 30 minutes if:
    - the crew of the locomotive consist has been relieved and the relief crew has not arrived;
    - the crew of the locomotive consist has left for a meal or personal break or for personal reasons;
    - the locomotive is within the railyard;
    - queuing of a locomotive for fueling, maintenance, or servicing; or
    - maintenance or diagnostics conducted on the locomotive that do not require operation of the engine.
  - Unless a locomotive is equipped with an anti-idling device that is set at 15 minutes or less, is engaged, and not tampered with, an operator shall not idle a trailing locomotive for more than 30 minutes if:
    - the dispatcher or yardmaster notifies the operator of a delay that will exceed 30 minutes; or
    - there is a locomotive failure or breakdown that will result in a delay of more than 30 minutes
- An Emissions Equivalency Plan, demonstrating equivalent or greater annual emission reductions to what would be achieved by not idling locomotives for more than 30 minutes for the events specified above in the same calendar years, can be submitted in lieu of complying with idling requirements. The methodology used to quantify emissions shall be consistent with the most recent revision to the District's Railyard Emissions Inventory Methodology (Attachment C).
- Exemption from idling prohibition allowed under specific conditions, such as locomotives used during emergencies, when ambient temperatures are at or below 40^{o}F, and when idling is needed to maintain sufficient battery charge to start locomotives.

CHAPTER 1: BACKGROUND

INTRODUCTION

Rail operations, characterized primarily by activities associated with operation of diesel locomotives, are a significant source of diesel particulate matter (PM) emissions and criteria pollutants (oxides of nitrogen (NO_x), volatile organic compounds (VOC), carbon monoxide (CO), and oxides of sulfur(SO_x)). The 2003 Air Quality Management Plan (AQMP) estimates freight locomotive particulate matter less than 10 microns (PM_{10}) emissions of 0.90 tons per day and emissions of particulate matter less than 2.5 microns ($PM_{2.5}$) of 0.82 tons per day, in addition to NO_x, VOC, CO, and SO_x emissions of 32.98, 1.70, 6.04, and 2.83 tons per day, respectively.[3] Diesel exhaust is a complex mixture of gases and fine particles emitted by diesel-fueled internal combustion engines. Diesel exhaust also contains many carcinogenic compounds, including, but not limited to, arsenic, benzene, formaldehyde, 1-3-butadiene, and ethylene dibromide.[4] In 1998, the California Air Resources Board (CARB) identified diesel exhaust as a Toxic Air Contaminant (TAC) based on its cancer causing potential.

Proposed Rule (PR) 3502 – Minimization of Emissions from Locomotive Idling establishes idling limits for locomotives operating in the District. The purpose of PR 3502 is to minimize emissions from unnecessary idling of locomotives. PR 3502 would limit to 30 minutes the non-essential idling of unattended lead or trailing locomotives. Under PR 3501 paragraph (k)(1) a railroad would be exempted from compliance for any locomotive equipped with anti-idling devices that are set at 15 minutes or less, engaged, and not tampered with. A railroad would also be exempt from idling limits if the operator has received approval for an Emission Equivalency Plan for diesel PM and NOx proposing alternative control strategies demonstrating no increase in total cancer potency-weighted emissions of toxic air contaminants as well as emission reductions greater than or equal to implementing idling prohibitions in PR 3502.

DIESEL PARTICULATE MATTER

Diesel exhaust is listed by the California Air Resources Board (CARB) as a Toxic Air Contaminant (TAC) and has the potential to cause cancer in humans. Long-term exposure to diesel PM poses the highest cancer risk of any toxic air contaminant evaluated by the Office of Environmental Health Hazard Assessment (OEHHA).[5] The second Multiple Air Toxics Exposure Study (MATES-II), released in 2000, shows that approximately 70 percent of the cancer risk from air toxics in the Basin is due to diesel PM.[6] Exposure to diesel exhaust can

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[3] South Coast Air Quality Management District, 2003. 2003 Air Quality Management Plan: Appendix III – Base and Future Year Emission Inventories.

[4] California Environmental Protection Agency, Air Resources Board and Office of Environmental Health Hazard Assessment, 1998. Executive Summary for the "Proposed Identification of Diesel Exhaust as a Toxic Air Contaminant."

[5] Office of Environmental Health Hazard Assessment and The American Lung Association of California. Health Effects of Diesel Exhaust.

[6] South Coast Air Quality Management District, 2000. Final Report – Multiple Air Toxics Exposure Study in the South Coast Air Basin – MATES – II.

irritate the eyes, nose, throat and lungs and can cause coughs, headaches, light-headedness, and nausea.[3]

In addition to cancer risks, exposure to diesel PM has been shown to increase susceptibility to allergens (e.g., dust and pollen) and can aggravate chronic respiratory problems, such as asthma. Diesel engines are major sources of fine particle pollution and can particularly affect sensitive people, such as the elderly and people with emphysema, asthma, and chronic heart and lung disease. Children, whose lungs and respiratory systems are still developing, are also more susceptible than healthy adults to fine particles. Exposure to fine particles is associated with increased frequency of illness and reduced growth in lung function in children.[3, 4]

Studies on diesel exhaust have focused on non-cancer health effects from short-term and long-term exposure, reproductive and developmental effects, immunological effects, genotoxic effects, and cancer health effects.[2] Overall, the available literature does not confirm whether exposure to diesel exhaust causes reproductive or developmental effects in humans.[7] In terms of immunological effects, studies show that diesel exhaust exposure increases antibody production and causes localized inflammation of lung and respiratory tract tissues, particularly when exposure accompanies other known respiratory allergens.[2]

Diesel exhaust particles and diesel exhaust extracts have been determined to be genotoxic and may be involved in initiation of human pulmonary carcinogenesis. In terms of cancer health effects, over 30 epidemiological studies have investigated the potential carcinogenicity of diesel exhaust.[2] The National Institute of Occupational Health and Safety recommended in 1988 that diesel exhaust be regarded as a potential occupational carcinogen based on animal and human evidence. The Health Effects Institute (1995) and the World Health Organization (1996) also evaluated the carcinogenicity of diesel exhaust and found the epidemiological data to show associations between exposure to diesel exhaust and lung cancer.[2]

In 1998, CARB identified diesel exhaust as a TAC based on available information on diesel exhaust-induced noncancer and cancer health effects.[3, 5] As part of the TAC identification process, CARB concluded that based on information available on diesel exhaust-induced non-cancer and cancer health effects, diesel exhaust meets the legal definition of a TAC which is an air pollutant "which may cause or contribute to an increase in mortality and serious illness, or which may pose a present or potential hazard to human health" (Health and Safety Code Section 39655).[2] In addition, in 2001, pursuant to the requirements of Senate Bill 25 (Stats. 1999, ch. 731), OEHHA identified diesel PM as one of the TACs that may cause children or infants to be more susceptible to illness. Senate Bill 25 also requires CARB to adopt control measures, as appropriate, to reduce the public's exposure to these special TACs (Health and Safety Code section 39669.5).

[7] Office of Environmental Health Hazard Assessment, 2000. Health Effects of Diesel Exhaust Fact Sheet, August 2000.

REGULATORY HISTORY

Federal Standards for Locomotive Engines

In April 1998, the U.S. EPA promulgated a rulemaking, entitled, "Emission Standards for Locomotives and Locomotive Engines." This rulemaking establishes emission standards and associated regulatory requirements for the control of emissions from locomotives and locomotive engines as required by the Clean Air Act section 213(a)(5). The primary focus of the emission standards, which became effective in 2000, is NOx. In addition, standards for hydrocarbons (HC), carbon monoxide (CO), particulate matter (PM) and smoke were also promulgated. The rulemaking established a 3-tiered emissions limit matrix based on the year of locomotive manufacture: Tier 0 (manufactured from 1973 through 2001), Tier 1 (manufactured from 2002 through 2004), and Tier 2 (manufactured in 2005 and later). Within each tier are separate emission limits for a line-haul duty cycle and a switch duty cycle. With some exceptions, locomotives are required to meet both the line-haul and switch duty cycle emission limits. A summary of the U.S. EPA limits is shown in Table 1-1.

Table 1-1
Summary of U.S. EPA Locomotive Emission Standards

U.S. EPA Tier	Line Haul Duty Cycle (g/bhp-hr)				Switch Duty Cycle (g/bhp-hr)			
	HC	CO	NOx	PM	HC	CO	NOx	PM
0	1.00	5.0	9.5	0.60	2.10	8.0	14.0	0.72
1	0.55	2.2	7.4	0.45	1.20	2.5	11.0	0.54
2	0.30	1.5	5.5	0.20	0.60	2.4	8.1	0.24

The U.S. EPA rulemaking also includes a variety of provisions, including certification test procedures and assembly line and in-use compliance testing requirements, to implement the emission standards and to ensure rule compliance. The rule also includes an emissions averaging, banking, and trading program to provide flexibility.

Ultra-Low-Sulfur Diesel Fuel for Locomotives

In November 2004, CARB approved amendments extending California standards for motor vehicle diesel fuel to diesel fuel used in intrastate locomotives. Under this rulemaking, effective January 1, 2007, intrastate diesel locomotives will be required to use ultra-low sulfur diesel fuel which meets the 15 parts per million by weight (ppmw) sulfur requirement currently in place for motor vehicles. Current U.S. EPA requirements, finalized in June 2004, specify that 15 ppmw fuel be used in locomotives in 2012. However, because the aromatic content in U.S. EPA's fuel specification (35 percent by volume) is higher than in CARB's specification (10 percent by volume), CARB staff has estimated that the use of CARB diesel will provide NOx and PM emissions benefits of 6 and 14 percent, respectively, compared with U.S. EPA fuel. CARB's rulemaking requires the use of low-sulfur diesel fuel six years earlier than is required federally.[8]

[8] California Environmental Protection Agency, Air Resources Board, 2004. Staff Report: Initial Statement of Reasons – Public Hearing to Consider Proposed Regulatory Amendments Extending the California Standards for Motor Vehicle Diesel Fuel to Diesel Fuel Used in Harborcraft and Intrastate Locomotives.

Agreements with Class I Railroads

1998 CARB Memorandum of Understanding. California's 1994 State Implementation Plan (SIP) control measure M14 assumes that cleaner federally-complying locomotives will be operated in California and the Basin. As a result of measure M14, CARB staff developed a memorandum of understanding (MOU) with The Burlington Northern and Santa Fe Railway Company (BNSF) and Union Pacific Railroad Company (UP) that was signed in July 1998 (1998 CARB MOU). The 1998 CARB MOU includes provisions for early introduction of clean locomotives, with requirements for a NOx fleet average in the Basin equivalent to U.S. EPA's Tier 2 locomotive standard by 2010.[9]

2005 CARB Statewide Agreement. In June 2005, CARB staff developed a statewide agreeement with BNSF and UP to establish a PM emissions reduction program at California railyards. Under this agreement, the railroads would reduce locomotive idling by installing idling-reduction devices on their intrastate locomotive fleets by June 2008. In addition, the railroads agreed to develop inventories of diesel emissions with CARB, in turn, conducting HRAs for most railyards statewide.[10] CARB conducted a public hearing on October 27, 2005 to consider the 2005 statewide agreement and committed to revisit the item at its January 26, 2006 meeting, at which time the agreement may be upheld, modified, or rescinded.

REGULATORY AUTHORITY

The District's Authority to Adopt Rules Applicable to Emissions from Railroads and Locomotives, and Railyards

The authority to regulate air pollution in California is divided between the California Air Resources Board and the local and regional air pollution control districts. Under state law "local and regional authorities[11] have the primary responsibility for control of air pollution from all sources, other than emissions from motor vehicles. The control of emissions from motor vehicles, except as otherwise provided in this division, shall be the responsibility of the State board." (Health & Safety Code §40000). Locomotives are not motor vehicles. The law defines "motor vehicle" as "a vehicle that is self-propelled." (Veh. Code §415(a)). A "vehicle" is "a device by which any person or property may be propelled, moved, or drawn upon a highway, excepting a device moved exclusively by human power or used exclusively upon stationary rails or tracks." (Veh. Code §670). Because they do not operate on the highway and because they operate on stationary tracks, locomotives are not "vehicles." Since they are not motor vehicles, they are under the jurisdiction of the districts. (Health & Safety Code §40000.) CARB was also granted authority to regulate locomotives by Health & Safety Code §43013(b), as amended in 1988. However, even after the enactment of this statute, the districts retain concurrent authority

[9] Memorandum of Mutual Understandings and Agreements, South Coast Locomotive Fleet Average Emissions Program, 1998.

[10] ARB/Railroad Statewide Agreement, Particulate Emissions Reduction Program at California Railyards, 2005.

[11] The term "local or regional authority" means the governing body of any city, county or district. Health & Safety Code §39037. "District" means an air pollution control district or air quality management district created or continued in existence pursuant to provisions of Part 3 (commencing with Section 40000). Health & Safety Code §39025.

to regulate nonvehicular sources, including locomotives. (Manaster & Selmi, *California Environmental Law and Land Use Practice*, §41.06 (2)).

District staff has determined that much of the non-locomotive equipment operated by railroads at their yards is also non-vehicular in nature. Accordingly, it also would be subject to the jurisdiction of the air districts, including the District.

The districts also have general authority under state law to regulate "indirect sources," which are sources that attract mobile sources.[12] This includes the authority to regulate railyards where trucks are used to deliver or distribute freight, locomotives are used to carry freight, and non-road equipment is used to handle freight. Pursuant to Health & Safety Code §40716(a)(1), a district may adopt and implement regulations to "reduce or mitigate emissions from indirect and areawide sources of air pollution." Therefore, under state law the district may regulate railyards to reduce or mitigate emissions resulting from the mobile sources associated with or attracted to the railyard.

State law generally grants districts the authority to "adopt rules and regulations and do such acts as may be necessary or proper to execute the powers and duties granted to, and imposed upon, the district by this division and other statutory provisions." (Health & Safety Code §40702). This statute grants broad authority to districts to adopt rules and regulations for sources within their jurisdiction. This statute also includes a limited exemption with respect to locomotives. It provides:

> No order, rule, or regulation of any district shall, however, specify the design of equipment, type of construction, or particular method to be used in reducing the release of air contaminants from railroad locomotives. (Health & Safety Code §40702).

The provision makes clear that the legislature believed that districts had the authority to regulate locomotives by means other than specifying equipment design, construction, or other particular methods. (*See* Manaster & Selmi, *supra*, §41.06(2) n. 11 (this section impliedly recognizes district authority to regulate locomotive emissions)). PR 3502 does not specify any requirement respecting the design of equipment or type of construction of locomotives. Nor does it specify the particular method to be used. The reference to "particular method to be used" should be construed as referring to methods that are similar to those methods specifically enumerated in the statute, i.e. methods affecting the design or construction of locomotives. The Civil Code, §3534, states that "particular expressions qualify those which are general." The California Supreme Court has held that a general term is "restricted to those things that are similar to those which are enumerated specifically." (*Harris v. Capital Growth Investors XIV* (1991) 52 Cal. 3rd. 1142, 1160 n. 7, *see also Friends of Davis v. City of Davis* (2000) 83 Cal. App. 4th 1004, 1013 (same)). PR 3502 does not specify construction, design, or control equipment and thus does not specify a particular "method" to be used. Thus, it is not precluded by Health & Safety Code §40702.

[12] State law does not contain a definition for indirect source, but the federal Clean Air Act provides that the term "indirect source" means "a facility, building, structure, installation, real property, road, or highway which attracts, or may attract, mobile sources of pollution." 42 U.S.C. §7410(a)(5)(C).

Furthermore, even if the term "method" could be construed to refer to techniques that do not affect design or construction of locomotives, the rule does not specify a "particular method to be used." PR 3502 allows compliance either by reducing idling or by adopting technologies to achieve equivalent emission reductions.

One of the duties imposed upon the districts is the duty to enforce Health & Safety Code §41700. That section provides:

> Except as otherwise provided in section 41705,[13] no person shall discharge from any source whatsoever such quantities of air contaminants or other material which cause injury, detriment, nuisance or annoyance to any considerable number of persons or to the public, or which endanger the comfort, repose, health or safety of any such persons or the public, or which cause, or have a natural tendency to cause, injury or damage to business or property.

The district may regulate locomotives to prevent public nuisance (potential health impacts from toxic air contaminants or annoyance to neighbors) as well as to reduce the emissions of criteria air pollutants in order to achieve and maintain state and federal ambient air quality standards. The California Supreme Court has upheld the districts' authority to regulate air toxic emissions from sources within their jurisdiction. *Western Oil & Gas Assoc. v. Monterey Bay Unified Air Pollution Control Dist*. (1989) 49 Cal. 3rd 408.

The district may also regulate to require railroads to gather information regarding their emissions of both criteria and toxic pollutants. (Health & Safety Code §§41511, 41700). There is evidence that railyards may emit significant quantities of toxic air contaminants (especially diesel PM) as well as evidence that locomotives engage in substantial amounts of idling. According to the CARB's "Roseville Railyard Study" (October 14, 2004), locomotive idling accounted for 10.2-10.4 tons per year of diesel particulate at the Roseville yard (Table IV.3, p.34), amounting to about 45% of the total diesel PM emissions from the railroad operations. (p.14). Areas adjacent to the railyard experienced a maximum off-site cancer risk of 900 to 1,000 in a million from the yard alone, in addition to background concentrations. (p.54). Risk levels between 100 and 500 in a million occurred over about 700 to 1600 acres in which 14,000 to 26,000 people live, and risk levels between 10 and 100 in a million occurred over a 46,000 to 56,000 acre area in which about 140,000 to 155,000 people live. (p. 63). About 40 acres experience a cancer risk level between 500 and 1000 in a million. (p. H-6). Besides diesel PM, locomotives are significant sources of NOx, a precursor of $PM_{2.5}$, PM_{10}, and ozone. Since several railyards are located in urban areas, the District has a strong interest in identifying emissions and health risks imposed by railyards, and in reducing emissions from unnecessary idling.

[13] Section 41705, relating to agricultural operations and compost-handling operations, is not relevant to the present context.

Preemption of District Authority to Adopt Rules Applicable to Emissions from Railroads, Locomotives and Railyards.

The railroads contend that PR 3502 may be prohibited by principles of federal preemption. PR 3502, however, does not establish or require installation of any control device. Moreover, the restriction on idling is limited to idling that is not essential to the safe and efficient operation of the railroad. Accordingly, PR 3502 is not preempted by federal law.

The federal Clean Air Act provides that no state or political subdivision may adopt or attempt to enforce "any standard or other requirement relating to the control of emissions" from new locomotives or new engines used in locomotives. (42 U.S.C. § 7543(e)(1)(B)). EPA has promulgated regulations setting forth what it believes is the scope of preemption under this section. EPA stated: "Any state control that would affect how a manufacturer designs or produces new (including remanufactured) locomotives or locomotive engines is preempted…." (63 Fed. Reg. 18978, 18994.) EPA's regulation states that among the types of state or local rules that are preempted are "emission standards, mandatory fleet average standards, certification requirements, aftermarket equipment requirements, and nonfederal in-use testing requirements." (40 CFR §85.1603(c)(2).) The EPA regulation provides that such rules are preempted whether they apply to new or other locomotives or engines. (*Id*.) The proposed rule is not preempted by the Clean Air Act because they it does not regulate how the manufacturer designs or produces a locomotive or engine. Certainly PR 3502 does not affect the design or production of locomotives. A railroad may reduce idling without affecting the design or production of the locomotive, simply by limiting the length of time idling occurs under specified circumstances.

The Interstate Commerce Commission Termination Act (ICCTA), Title 49 U.S.C. §10501(b), provides that the jurisdiction of the federal Surface Transportation Board (STB) is exclusive over "transportation by rail carriers, and the remedies provided in this part with respect to rates, classifications, rules (including car service, interchange, and other operating rules) practices, routes, services and facilities of such carriers…." Section 10501(b) further provides that the remedies provided under the ICCTA are exclusive and preempt the remedies provided under federal or state law. While it has been held that the scope of preemption under this statute is "broad" (*City of Auburn v. U.S. Government*, 154 F. 3rd 1025, 1030 (9^{th} Cir. 1998)), the Surface Transportation Board itself has ruled that not all state and local regulation is preempted. Citing an earlier decision, the STB stated: "In particular, we stated that state or local regulation is permissible where it does not interfere with interstate rail operations, and that localities retain certain police powers to protect public health and safety." *Borough of Riverdale Petition for Declaratory Order re The New York Susquehanna and Western Railway Corporation*, STB Fin. Docket No. 33466 (September 9, 1999), 1999 STB Lexis 531, p.4. In that decision, the STB noted that an environmental permitting requirement that set up a prerequisite to the railroads' use, maintenance, or upgrading of their facilities would be preempted because such requirements would of necessity impinge upon the federal regulation of interstate commerce. (*Borough of Riverdale*, p.5.)

PR 3502 does not impose any permitting or other "prerequisite" to rail operations. PR 3502 idling requirements do not interfere with railroad operations and the rule does not seek to limit essential idling. Rather, the reasons specified in PR 3502 for which idling for more than 30 minutes would not be allowed are clearly not essential to railroad operations. As set forth by the decision of the Surface Transportation Board, PR 3502 would therefore not be preempted.

Case law also supports this view. In *Jones v. Union Pacific Railroad Company*, 79 Cal. App. 4th 1053 (2000), the Court of Appeal held that "state and local regulation of Union Pacific's trains is permissible if it does not interfere with Union Pacific's interstate rail operations." (*Jones, supra*, p. 1060.) In that case, the court stated that if idling was necessary to operate the railroads, attempts to control it would be preempted, but if the idling did not further rail operations, attempts to control it would not be preempted. (*Id*.) Thus, the District may require the railroads to reduce unnecessary idling unless the activities causing such emissions further rail operations. Based on conversations with rail operators, District staff believes that methods exist to reduce unnecessary idling without interfering with rail operations. Indeed, to comply with Proposition 65 the railroads have initiated a number of measures to reduce the amount of diesel exhaust generated by their operations. Accordingly, feasible measures exist to reduce rail emissions. The idling requirements of PR 3502 are reasonable because they do not burden the railroads or impede their ability to conduct their operations in a safe and efficient manner. For example, PR 3502 prohibits idling of locomotive consists for more than 30 minutes if left unattended for crew changes, meal breaks, or for any reason within railyards. District staff believes that this limit provides a reasonable time margin, while preventing excessive idling. Similarly, the PR 3502 prohibition of idling for more than 30 minutes while locomotives are queuing or undergoing services which do not require the engine to be running is intended to address situations where idling is clearly unnecessary, while providing a reasonable time margin. In addition, District staff believes that trailing locomotives should be shut down for delays exceeding 30 minutes. In this instance, lead locomotives would not be expected to be shut down in order to allow for crew comfort cooling and heating and to enable the lead locomotive to maintain brake pressure for attached railcars.

CHAPTER 2: SUMMARY OF PROPOSED RULE 3502

OVERVIEW

Proposed Rule (PR) 3502 – Minimization of Emissions from Locomotive Idling is applicable to Class I freight railroads and switching and terminal railroads in the District. The rule establishes idling limits for locomotives operating in the District. The purpose of PR 3502 is to minimize emissions from unnecessary idling of locomotives. PR 3502 would limit to 30 minutes the non-essential idling of unattended lead or trailing locomotives unless specifically exempted.

PUBLIC PROCESS

The District staff began development of PR 3502 in September 2004. To facilitate communication with affected parties, the Proposed Regulation XXXV Working Group was formed, consisting of District staff, CARB staff, freight railroads with operations in the District, environmental groups, and community groups. The District staff met with the Proposed Regulation XXXV Working Group four times – on February 9, 2005, March 23, 3005, October 6, 2005, and November 9, 2005 to discuss PR 3502. A public workshop to present rule concepts was held on March 8, 2005. A second public workshop and California Environmental Quality Act (CEQA) scoping session for Proposed Rule 3502 was held on October 12, 2005.

On September 15, 2005, the District staff released a Notice of Preparation (NOP) of a draft program environmental assessment (PEA) for PR 3501 and PR 3502 – Minimization of Emissions from Locomotive Idling. On September 16, 2005 the District staff released a revised version of PRs 3501 and 3502 and preliminary draft staff reports for each rule. The public comment period for the NOP closed on October 14, 2005.

Through the development of Proposed Rule 3502, the public and stakeholders provided comments through the Working Group Meetings, public workshops, and through written comments. Public comments from the workshop to the draft rules and draft staff reports are summarized in Attachment A.

LOCOMOTIVE TESTING

In developing rules to address idling by locomotive engines, the District funded two separate locomotive testing projects in support of PR 3502. The District staff received initial comments from the railroad industry that increased start-ups prompted by idling restrictions could result in a trade-off in emissions. Subsequently, the railroads acknowledged that startups would not cancel out the benefits of reducing idling. The railroads commented that they believe that cold starting of locomotives in the District is not an issue due to the typically warm temperatures and that emissions from District cold starts would be inconsequential.[14]

[14] E-mail from Peter Okurowski, representing the Association of American Railroads, to Susan Nakamura (District), Mark Stehly (BNSF), Mark Elliott (Pillsbury, Winthrop, Shaw, Pittman), and Lanny Schmid (UP), October 19, 2005.

The studies, which were completed in November and December 2005, measured start-up and idling emissions from several locomotives (See Attachment B for a more detailed description of the source test results). One study was conducted by Southwest Research Institute (SwRI) using two locomotives, one owned by Union Pacific Railroad (EMD MP15AC, 1500 Hp, 2 stroke, 12 cylinder, 645 series engine) and one owned by Burlington Northern Santa Fe (GE DASH9-44CW, 4400 Hp, four stroke, 16 cylinder, turbocharged). The second study was conducted by Engine, Fuel, and Emissions Engineering, Inc. (EF&EE) on two locomotives owned by Metrolink (EMD SD 60, 3800 Hp, 2 stroke, 16 cylinder, 710 series engine; EMD F40, 3000 Hp, 2 stroke, 16 cylinder, 645 series engine), using EF&EE's Ride-Along Vehicle Emission Measurement (RAVEM) System.

In both studies, the locomotives were tested using specially designed test procedures to measure start-up emissions, since start-up emissions testing does not have an accepted test procedure protocol. The results from the SwRI and EF&EE locomotive tests show that there is an increase in emission from a locomotive start-up after a ½-, 1-, 2- and 4-hour shut down periods exhibited a spike in emissions for a period of less than 3 minutes, in most cases the spike lasted less than 15 seconds, at the beginning of the test, thereafter, the emission rates moved to levels that would be exhibited by a stabilized idling situation.

Conservatively, the emissions data shows that emissions due to start-up in relationship to stabilized idling mode are very low (i.e., start-up emissions would contribute very little to the overall emission when compared with stabilized idling). Therefore, a benefit to air quality would be had with the locomotive shut down and not idling for a period exceeding 8 minutes, and combined with a start-up whenever needed for operational necessities.

PROPOSED RULE 3502 REQUIREMENTS

PR 3502 establishes idling limits for locomotives operating in the District. The purpose of PR 3502 is to minimize emissions from idling of locomotives. PR 3502 would limit the non-essential idling of unattended lead or trailing locomotives to 30 minutes or less under specific conditions, which will be discussed later in this chapter. The PR 3502 idling limit would not apply to locomotives equipped with engaged anti-idling devices set at 15 minutes. Railroads would be exempt from idling limits for a number of operational reasons or if the operator has received approval for an Emission Equivalency Plan proposing alternative control strategies that can achieve emission reductions equivalent to implementing idling prohibitions.

Following is a summary of key elements of PR 3502.

Purpose

The District staff has received numerous complaints from the public regarding idling trains. Comments have been made directly to the District through its complaint hotline, through town meetings, and written comments. Between 2002 and 2005, the District has received approximately 300 complaints regarding locomotives and locomotive idling. During site visits at railyards during the rule development process for Proposed Rule 3502, District staff witnessed first hand unattended locomotives idling as they queued for service, maintenance and fueling. In addition, there have been reports of locomotives idling for hours as crews would leave a locomotive for a break or waiting for a replacement crew to arrive. In San Diego, a train was left idling for 1½ hours due to a crew change. A representative from Burlington Northern Santa Fe commented that even if it takes hours for a crew change, a train is left idling. [15]

Locomotives idle for a variety of reasons. Some reasons for idling are necessary for the safety and operation of the locomotive, while some reasons are unnecessary. There are a number of reasons that a locomotive will need to idle such as for safety, to provide air pressure to railcar brakes, to provide voltage to the battery to start the locomotive, to provide comfort heating and cooling for the crew, etc. The District is not seeking to place restrictions on idling for those purposes. However, there are situations when it is not necessary for rail operations to idle the locomotive. The purpose of PR 3502 is to minimize emissions from unnecessary idling of locomotives. As a result, PR 3502 limits the idling of locomotives during specific situations where idling the locomotive is not necessary.

Applicability

PR 3502 applies to Class I freight railroads and switching and terminal freight railroads in the District. The proposed rule would affect two Class I railroad companies (BNSF and UP) and two switching and terminal railroads, Los Angeles Junction Railway (LAJ) and Pacific Harbor Line, Inc. (PHL) in the district. LAJ is wholly owned by BNSF.

Passenger railroad operating in the District, such as Amtrak and Metrolink, would not be subject to the requirements of PR 3502, as a preliminary data indicates that these operations contribute less than ten percent of NOx and PM emissions from rail operations. Passenger operations are also sufficiently different than freight operations because they are characterized by very little, if any, switching and cargo handling activities, in addition to considerably lower traffic volumes. In addition, in most cases commuter rail has the right of way over freight locomotives and thus is not required to idle as frequently as freight locomotives. Also, passenger railroads operate on a more predictable schedule such that crew changes and breaks can occur at specified time periods and locations to avoid delays and idling associated with such activities. Due to their lower emissions, passenger operations pose proportionally lower health risks than freight operations. However, the District will continue to evaluate passenger rail operations and idling. If warranted, passenger operations may be considered for regulation in the future.

Definitions

PR 3502 includes a series of definitions. Key definitions are discussed below in the discussion of rule concepts. Please refer to the attached proposed rule for a complete list of definitions.

Idling Requirement

Under PR 3502, beginning six months from date of rule adoption, except for locomotives equipped with anti-idling devices that are set at 15 minutes, engaged, and not tampered with, an operator shall not idle a lead or trailing locomotive for more than 30 minutes under specified

[15] San Diego Union Tribune, July 9, 2005.

conditions. By definition under Proposed Rule 3502, an anti-idling device would "automatically restart the engine when parameters are no longer at acceptable levels". This means that the anti-idling device would check parameters before restarting instead of restarting the locomotive on time intervals to check parameters. Restarting the locomotive on time intervals to check parameters would restart the locomotive unnecessarily. Based on discussions with representatives from the railroads at Working Group meetings and site visits at railyards, it is the District staff's understanding that 30 minutes is sufficient time for the railroad personnel to shutdown the locomotive consist. In addition, the 30 minute idling requirement is consistent with other idling restrictions including those in the State of Massachusetts.[16] Thus, under Proposed Rule 3502, an operator shall not idle an unattended locomotive for more than 30 minutes under the following conditions:

- The crew has been relieved and the relief crew has not arrived;
- The crew has left for a meal or personal break or for personal reasons;
- The locomotive is within the railyard;
- Queuing for fueling, maintenance, or servicing;
- Maintenance or diagnostics conducted on the locomotive that do not require operation of the engine. These activities include things such as changing air and oil filters, as well as those which are typically done in enclosed shops.

Limiting idling during these limited, well-defined, events has been determined by the District as an effective means to reduce overall idling-related emissions in the Basin while not interfering with the safe and efficient operation of the railroads. The idling requirement specified under Proposed Rule 3502 are based on information obtained from CARB's Roseville study, discussions with representatives from the railroads, site visits to railyards, environmental and community groups, and public complaints regarding idling. District staff believes that it is unnecessary for any locomotives in an unoccupied consist to be left running while no crew member is on board or for single locomotives to idle in railyards while unoccupied, or for idling of locomotives in railyards while queuing for fueling, maintenance, or service, or during maintenance or diagnostics activities which can be conducted while the locomotive is not running. Idling is unnecessary under each of those circumstances because there is no need for crew comfort cooling or heating and does not affect operations. If adopted, District Proposed Rule (PR) 3501 – Recordkeeping for Locomotive Idling could be used to identify additional reasons for operationally unnecessary idling.

At the September 22, 2005 Working Group meeting for PR3502, railroad representatives acknowledged that excessive idling is routinely not anticipated when it occurs. Examples were given or when a crew stops the train to go to lunch, which could unexpectedly take longer than anticipated, or where there is a crew change and the departing crew did not anticipate the arriving crew being stuck in traffic. Under PR 3502, in both cases the railroads would be in violation of the idling requirements if the idling events exceeded 30 minutes, regardless of whether the events were anticipated or not. In short, PR 3502 has been structured to not consider anticipated versus unanticipated idling events because this consideration is so vague and broad that it virtually

[16] Title 310 of the Massachusetts Code of Regulations Section 7.11.

prevents effective enforcement unless the railroads admit that the idling beyond 30 minutes was intentional,

Also beginning six months from date of rule adoption, unless a locomotive is equipped with an anti-idling device that is set at 15 minutes, engaged, and not tampered with, an operator shall not idle an unattended trailing locomotive for more than 30 minutes if:

- The dispatcher or yardmaster notifies the operator of a delay that will exceed 30 minutes. Under this circumstance, it is assumed that trailing locomotives can be shut down and restarted following instruction from the dispatcher or yardmaster. There are no requirements for the lead locomotive under this circumstance, recognizing that the lead locomotive may need to operate to provide comfort cooling or heating, air pressure for railcar brakes, or other parameters addressed by the lead locomotive. During this time, it is assumed that the lead locomotive would continue to run, unless directed to be shutdown by the dispatcher or yardmaster; or
- There is a failure or breakdown of a locomotive or attached railcars that will result in a delay of more than 30 minutes. Failures or breakdowns may be either to the operator's train itself or to another train, resulting in the operator's train being impeded and delayed. Since in either instance, the operator's train would be stopped until replacement power could be brought in or a field repair made, District staff believes that all idling locomotives in the consist should be shut down for as long as the entire train cannot be moved.

Based on discussions with representatives of the railroads, it is District staff's understanding that in the situations presented above, air pressure is needed for the brakes for the railcars and allowing the lead locomotive to idle will provide the necessary pressure for the brakes.

Overall, the purpose of this requirement is to ensure that trailing locomotives are shut down for unnecessary idling events longer than 30 minutes.. As described previously, records collected under PR 3501 could be used to identify additional situations where it is unnecessary to idle for more than 2 hours.

Submittal of Emission Equivalency Plan

Under PR 3502, a railroad may elect to voluntarily submit an Emission Equivalency Plan to be exempted from idling limitations. Under this alternative, the Emission Equivalency Plan is to be submitted within 90 days before its intended use. Under the Plan, equivalency is to be demonstrated specifically for diesel particulate matter and NOx. The Plan is to include the following information:

- Identify control technology(ies) to be implemented;
- Quantify locomotive emission reductions, demonstrating that:
    - the reductions are greater than or equal to the emission reductions that would be achieved by not idling locomotives for more than 30 minutes for the events specified in the rule in the same calendar year; and
    - there is no increase in cancer potency emissions of toxic air contaminants, and hazard index is less than or equal to 1 for acute and chronic health effects;
- Identify locomotive(s) to be included;
- Specify an implementation schedule; and

- Identify the mechanism to be employed to ensure that emissions reductions are enforceable.

The intent of the Emissions Equivalency Plan option is to allow railroads to implement emission reduction measures in lieu of complying with PR 3502 idling requirements. Measures may include things such as low emissions alternatives to conventional diesel locomotives (e.g., liquefied natural gas, emulsified diesel fuel, biodiesel, battery dominant hybrid systems with diesel engines, such as the RailPower's Green Goat). The methodology used to quantify emissions shall be consistent with the most recent revision to the District's Railyard Emissions Inventory Methodology. Estimates of acute and chronic noncancer health effects shall be consistent with the most recent revision to the District's Health Risk Assessment Guidance for Railyards and Intermodal Facilities. These documents, which were included with the October 7, 2005 Board package for Rule 3503 – Emissions Inventory and Health Risk Assessment for Railyards are included as Attachments C and D of this staff report. The cancer potency-weighted emission calculations would use OEHHA's adopted cancer risk value multiplied by total emissions for the compound in question.

Approval of the Emission Equivalency Plan

Under PR 3502, Emission Equivalency Plans will be approved or disapproved within 90 days. Plans will be approved if they demonstrate that equivalent emission reductions will be obtained over the same calendar year as would have been achieved through compliance with the PR 3502 idling requirement.

Fees and Right of Appeal

The Emission Equivalency Plan shall constitute a plan for the purpose of fees assessed under Rule 306 – Plan Fees. The disapproval of an Alternative Compliance Plan can be appealed to the Hearing Boar-d under Rule 216 – Appeals and Rule 221 – Plans. If its appeal is denied, the operator must revise its Emission Equivalency Plan consistent with any direction of the Hearing Board, correctingany deficiencies, and resubmit the Plan within 90 days of the Hearing Board's decision.

Circumvention

Under PR 3502, the moving of locomotives solely for the purpose of preventing idling for more than the length of time for which recordkeeping is required shall be considered circumvention and a violation of this rule.

Penalties

Under PR 3502, failure to comply with any requirement, or any provision of an approved Emissions Equivalency Plan, is a violation of this rule and subject to penalties. Failure to comply with any requirement of this rule will result in a separate violation for each locomotive for each day of non-compliance.

The District intends to dedicate at least one full time employee for enforcement of Regulation XXXV rules, including PR 3502.

Exemptions

Under PR 3502, specific locomotive idling events are exempt from idling prohibitions under certain conditions. In order to be exempt, one or more of the following conditions must be met:

- The locomotive is being used in an emergency; or
- Ambient temperatures of 40^{o}F or lower occur or are predicted. Since antifreeze is not used in locomotives, the railroads typically enforce rules against shutting down locomotives during freezing weather. Although temperatures in most Southern California locations with rail activity rarely drop below freezing, this exemption is provided to enable the railroads to idle during the winter months if ambient temperatures are expected to drop below 40^{o}F
- Idling is required to maintain locomotive battery charge or voltage at a level sufficient to start the locomotive, as determined by the manufacturer.

In situations where a locomotive is being used in an emergency, the proposed rule exempts the railroad from the 30 minute idling requirement. The other two exemptions are to ensure that shutting down a locomotive would not interfere with railroad operations. The District staff understands that the locomotive must be in a state where it can restart. Thus, to ensure that the locomotive that is shutdown can restart, the proposed rule exempts the railroad from idling requirements if the ambient temperature is predicted to fall below 40^{o}F or of the battery voltage drops below a level where the engine could be restarted. Provisions under Proposed Rule 3502 allow for the lead locomotive to idle if the locomotive is occupied to provide comfort heat and cooling to the crew and air pressure for the railcar brakes.

Severability

If any provision of this rule is held by judicial order to be invalid, or invalid or inapplicable to any person or circumstance, such order shall not affect the validity of the remainder of this rule, or the validity or applicability of such provision to other persons or circumstances. In the event any of the exceptions to this rule are held by judicial order to be invalid, the persons or circumstances covered by the exception shall instead be required to comply with the remainder of this rule.

CHAPTER 3: IMPACT ASSESSMENT

SUMMARY OF DISTRICT RAIL OPERATIONS

Railroads and Locomotive Populations

Railroads are used to move more than 40 percent of the freight moved in the United States, on a ton-miles basis[17]. In 2002, there were 554 railroads in the United States, operating on approximately 142,000 miles of track.[18] During this same period, 30 freight railroads operated over approximately 5,900 miles of track in California.[19] Two railroads with operations in California, BNSF and UP, are categorized as Class I railroads by the U.S. Department of Transportation, Surface Transportation Board. Class I railroads are those with operating revenues of at least $277 million (49 CFR Part 1201 Subpart A). The remainder of the railroads operating in California are classified as regional railroads (non-Class I line-haul railroads operating 350 or more miles of road and/or with revenues of at least $40 million), local railroads (railroads which are neither Class I nor a regional railroads and engaged primarily in line-haul service), or switching and terminal railroads (non-Class I railroads engaged primarily in switching and /or terminal services for other railroads). There are currently four freight railroads with operations in the District, consisting of the two Class I railroads (BNSF and UP) and two switching and terminal railroads, Los Angeles Junction Railway (LAJ) and Pacific Harbor Line, Inc. (PHL). LAJ is wholly owned by BNSF. CARB estimates that BNSF and UP operate approximately 240 locomotives exclusively in the District, while LAJ and PHL operate approximately 25 locomotives exclusively in the District[20].

Railyard Site Visits

District staff visited several railyards as part of the PR 3502 rule development process. The railyards visited and date(s) of visits are as follows:

- BNSF
  - Commerce Diesel Maintenance Facility, Commerce (March 10, 2005 and August 17, 2005)
  - Commerce/Eastern Intermodal, Commerce (March 10, 2005 and August 17, 2005)
  - Los Angeles Intermodal/Hobart, Commerce (March 10, 2005 and August 17, 2005)
  - San Bernardino Yard, San Bernardino (August 25, 2005)
  - Watson Yard, Wilmington (August 18, 2005)
- PHL
  - Water Street Yard (September 30, 2005)
- UP
  - Aurant Yard, Alhambra (August 18, 2005)
  - City of Industry Yard, Rowland Heights (May 31, 2005 and August 25, 2005)

[17] Association of American Railroads, 2004, Overview of U.S. Freight Railroads.

[18] Association of American Railroads, 2004, Railroad Service in the United States – 2002

[19] Association of American Railroads, 2004, Railroad Service in California – 2002.

[20] California Environmental Protection Agency, Air Resources Board, 2004, Staff Report: Initial Statement of Reasons – Public Hearing to Consider Proposed Regulatory Amendments Extending the California Standards for Motor Vehicle Diesel Fuel to Diesel Fuel Used in Harborcraft and Intrastate Locomotives.

- Colton Yard, Colton (March 10, 2005 and August 25, 2005)
- Commerce Intermodal, Commerce (May 31, 2005 and August 17, 2005)
- Dolores Yard, Carson (August 18, 2005)
- Intermodal Container Transfer Facility (ICTF), Long Beach (August 18, 2005)
- LATC, Los Angeles (August 18, 2005)
- Mira Loma Auto Distribution, Mira Loma (May 31, 2005 and August 25, 2005)

The site visits on August 17, 18, and 25 were conducted jointly with CARB staff.

Estimated District Emissions Contribution

The 2003 Air Quality Management Plan estimates NO_x emissions of 32.98 tons per day and particulate matter less than 10 microns (PM_{10}) emissions of 0.90 tons per day from freight locomotives. VOC, CO, SO_x, and particulate matter less than 2.5 microns ($PM_{2.5}$) emissions are estimated to be 1.70, 6.04, 2.83, and 0.82 tons per day, respectively.[21] NO_x and VOC are the primary contributors to ozone formation. VOC, SO_x, and NO_x are precursors to PM_{10} and $PM_{2.5}$. In addition, NO_x and PM affect visibility.

EMISSION REDUCTIONS

District staff has conducted an analysis to determine the expected emissionsreductions due to PR 3502. Overall, PR 3502 is estimated to result in reductions in PM, NOx, HC, and CO from restricting idling from implemeting idling reduction strategies. Table 3-1 summarizes the estimated emissions benefits associated with PR 3502. The following provides a discussion of how these reductions were derived.

Table 3-1
PR 3502 Estimated Emissions Benefits

Pollutant	Reduction (tons per day)	Reduction from Freight Locomotive Baseline (percent)
PM	0.06	7
NOx	1.35	4
HC	0. 23	14
CO	0.44	7

Emissions Calculation Methodology

In the 2004 Roseville study,[22] the CARB staff, in conjunction with UP, prepared an emissions inventory and health risk assessment of the Roseville Railyard in Northern California. For the purpose of PR 3502, staff used the idling emissions profile from the Roseville Study and the

[21] South Coast Air Quality Management District, 2003 Air Quality Management Plan: Appendix III – Base and Future Year Emission Inventories.

[22] California Environmental Protection Agency Air Resources Board. Roseville Rail Yard Study. October 14, 2004.

methodology CARB staff developed for the 2005 Statewide Agreement with the Class I railroads to estimate idling emission reduction potential.[23]

The Roseville Study analyzed the specific operations at the railyard and included estimates of idling durations for each of these operations. Based on the Roseville study, idling events occurred at arrival, departure, fueling, servicing, maintenance, and hump and trim areas. Based on the provisions of Proposed Rule 3502 and consistent with methodology used by CARB staff for the 2005 Statewide MOU, District staff assumed that the idling requirements would directly apply for arrival and departure of trains only. The idling time for arrival of trains varied from 15 to 30 minutes. Thus, if the locomotive was equipped with an anti-idling device there could be a reduction in idling time from 30 to 15 minutes in some situations. For example, the idling duration in the Departure Yard was calculated to be 120 minutes. Since Rule 3502 requires that anti-idling devices be set at 15 minutes and that locomotives without anti-idling devices be shut down after 30 minutes of unnecessary idling, in the case of the Departure Yard, locomotive idling emissions under the rule would be expected to be reduced by 75 to 87.5 percent (e.g., instead of idling for 120 minutes, a locomotive would idle for 30 minutes; 30 minutes / 120 minutes = 25 percent, which is equivalent to a reduction of 100 minus 25 percent, or 75 percent).

Although it is expected that PR 3502 will reduce idling emissions in the other areas such as fueling, servicing, maintenance, and the hump and trim area, no emission reductions were assumed. It was unclear from the Roseville study the specific reason for idling in specific areas. For example, with idling associated with fueling, it is unclear if the idling is due to queuing while waiting to be fueled or while the locomotive was actually being fueled. Thus, the only areas where reductions in idling were assumed were for the arrival and departure of trains.

Estimated Emission Reductions

These percent reductions are then applied to the overall AQMP freight locomotive emissions inventory to estimate the emission reductions associated with implementing PR 3502. It should be noted that these emission reductions are conservative as they assume only the emission reductions associated with idling reductions within railyards as opposed to potential idling reductions that would occur outside of the railyard. Also, additional idling reductions are expected from other areas of the railyard that are not assumed in this analysis such as queuing for fueling, and service and maintenance that does not require operation of the engine.

Switching Locomotives

For switching locomotives without anti-idling devices meeting an idling limit of 30 minutes, District staff calculated that overall PR 3502 idling emissions reductions, if applied at the Roseville railyard, would be approximately 27 percent.

[23] California Environmental Protection Agency Air Resources Board, 2005. Public Meeting to Consider the ARB/Railroad Statewide Agreement. October 13, 2005.

Line Haul Locomotives

For line haul locomotives without anti-idling devices meeting an idling limit of 30 minutes emissions reductions would be 35 percent due to PR 3502.

Overall Emission Reductions

When using the Roseville railyard idling emission profile, the overall estimated emissions benefits due to PR 3502 are 27 to 35 percent, depending on the type of locomotive.

Emissions Calculations and Results

The estimated PR 3502 reductions, as calculated for the Roseville Railyard, were then applied to the locomotive emissions inventory from the 2003 AQMP for freight locomotives to determine the estimated emissions benefits expected from PR 3502. The baseline emissions inventory for freight locomotives is summarized in Table 3-2. Table 3-2 also shows emissions from idling, using data from a 1991 study conducted for CARB by Booz-Allen and Hamilton,[24] showing that idling produces 18, 12, 38, and 33 percent of inventories for PM, NOx, HC, and CO, respectively. Baseline idling emissions were calculated by multiplying baseline emissions by the applicable percentage. The baseline emissions assumed no existing anti-idling devices installed.

Table 3-2
District Freight Locomotive Baseline Emissions

Pollutant	Locomotive Service	Baseline Emissions (tons per day)	Baseline Idling Emissions (tons per day)	Baseline Non-Idling Emissions (tons per day)
PM	Switching	0.08	0.02	0.06
	Line Haul	0.81	0.15	0.66
NOx	Switching	3.48	0.42	3.06
	Line Haul	29.50	3.54	25.96
HC	Switching	0.18	0.07	0.11
	Line Haul	1.51	0.58	0.93
CO	Switching	0.52	0.17	0.35
	Line Haul	5.52	1.82	3.70

Next, percentage reductions calculated from the Roseville Study data were used to estimate the emissions inventory reductions under PR 3502. For switching locomotives, the multiplier was 0.73 (1 minus the 0.27 reduction due to anti-idling devices), while for line haul locomotives, the multiplier was 0.65. Table 3-3 shows the idling emissions inventory resulting from implementation of PR 3502.

[24] Booz- Allen and Hamilton, Inc., 1992. Report on Locomotive Emission Inventory: Locomotive Emissions by County. Locomotive Emissions Study, p. 4-20. August 1992.

Table 3-3
District Freight Locomotive Idling Emissions with PR 3502

Pollutant	Locomotive Service	Idling Emissions with PR 3502 (tons per day)
PM	Switching	0.01
	Line Haul	0.10
NOx	Switching	0.31
	Line Haul	2.30
HC	Switching	0.05
	Line Haul	0.37
CO	Switching	0.12
	Line Haul	1.33

Table 3-4 summarizes the estimated freight locomotive emissions with PR 3502.

Table 3-4
District Freight Locomotive Emissions with PR 3502 Based on 2003 AQMP Inventories

Pollutant	Baseline Non-Idling Emissions (tons per day)	Idling Emissions With PR 3502 (tons per day)	Emissions with PR 3502 (tons per day)
PM	0.72	0.11	0.83
NOx	29.02	2.61	31.63
HC	1.04	0.42	1.46
CO	4.05	1.55	5.60

Table 3-5 summarizes overall emissions reductions from PR 3502.

Table 3-5
District Locomotive Emissions Reductions from PR 3502 Based on 2003 AQMP Inventories

Pollutant	Baseline Emissions (tons per day)	Emissions with PR 3502 (tons per day)	PR 3502 Emissions Reductions (tons per day)	PR 3502 Emissions Reductions (percent)
PM	0.89	0.83	0.06	7
NOx	32.98	31.63	1.35	4
HC	1.69	1.46	0. 23	14
CO	6.04	5.60	0.44	7

Based on the information submitted by the Class I railroads, the number of anti-idling device installations already in place has been estimated (i.e., out of 2,145 switch and line haul locomotives in the District, of which approximately 1,005 are equipped with anti-idling devices). The emission reductions based on the 2003 AQMP inventories are further adjusted to reflect this adjustment, as shown in Table 3-6.

Table 3-6
Adjusted PR 3502 Emission Reductions

Pollutant	Emissions Reductions (tons per day)
PM	0.03
NOx	0.72
HC	0.12
CO	0.23

CALIFORNIA ENVIRONMENTAL QUALITY ACT

In accordance with CEQA, the District, as the Lead Agency, has reviewed PR 3502. Consistent with CEQA Guidelines §15168(a)(4), the District has decided to prepare a Program Environmental Assessment (PEA) for PR 3502 and PR 3501 – Recordkeeping for Locomotive Idling since the proposed project is carried out with the same authorizing statutory or regulatory authority having generally similar environmental effects which can be mitigated in similar ways. Therefore, pursuant to state CEQA Guidelines §15252, District staff has prepared a Draft PEA to analyze the potential adverse environmental impacts from the proposed project.

SOCIOECONOMIC ANALYSIS

A socioeconomic analysis will be conducted and will be released for public review and comment at least 30 days prior to the District Governing Board hearing on PR 3502.

DRAFT FINDINGS UNDER CALIFORNIA HEALTH AND SAFETY CODE SECTION 40727

Requirements to Make Findings

California Health and Safety Code Section 40727 requires that prior to adopting, amending or repealing a rule or regulation, the District Governing Board shall make findings of necessity, authority, clarity, consistency, non-duplication, and reference based on relevant information presented at the public hearing and in the staff report.

Necessity

A need exists to adopt PR 3502 to minimize emissions from locomotive idling.

Authority

The District Governing Board has authority to adopt PR 3502 pursuant to the California Health and Safety Code Sections 39002, 40000, 40001, 40702, 40716, 40725 through 40728, 41508, and 41700.

Clarity

PR 3502 is written or displayed so that its meaning can be easily understood by the persons directly affected by the rule.

Consistency

PR 3502 is in harmony with and not in conflict with or contradictory to, existing statutes, court decisions or state or federal regulations.

Non-Duplication

PR 3502 will not impose the same requirements as any existing state or federal regulations. The proposed amended rule is necessary and proper to execute the powers and duties granted to, and imposed upon, the District.

Reference

By adopting PR 3502, the District Governing Board will be implementing, interpreting or making specific the provisions of the California Health and Safety Code Sections 40702 (rules to carry out duties), 41700 (nuisance), and 40001 (rules to attain state and federal ambient air quality standards)..

Health and Safety Code Section 40727.2

Health and Safety code section 40727.2 requires a comparative analysis. This analysis is in a subsequent section of this staff report.

Rule Adoption Relative to Cost-effectiveness

PR 3502 is not a control measure in the 2003 Air Quality Management Plan (AQMP) and thus, was not ranked by cost-effectiveness relative to other AQMP control measures in the 2003 AQMP. Cost-effectiveness in terms of dollars per ton of pollutant reduced is not applicable to rules regulating TACs. PR 3502 is expected to result in both emission reductions and cost savings. As a result of the cost savings, cost effectiveness is not applicable.

AQMP and Legal Mandates

PR 3502 is not a measure in the Air Quality Management Plan (AQMP). However, the AQMP does include a large “black box” of NOx and VOC reductions for which specific measures have not been identified. Therefore, the AQMP requires all feasible measures to reduce these pollutants be implemented. Emission reductions will occur due to limits to locomotive idling.

COMPARATIVE ANALYSIS

PR 3502 establishes idling limits for locomotives used in the District. As part of the rule development process for PR 3502, District staff will seek consistency with federal and state requirements. The following comparative analysis has been completed pursuant to Health and Safety code section 40727.2.

Existing Federal Requirements

As described in Chapter 1, in April 1998, the U.S. EPA promulgated a rulemaking, entitled, "Emission Standards for Locomotives and Locomotive Engines". This rulemaking establishes emission standards and associated regulatory requirements for the control of emissions from locomotives and locomotive engines as required by the Clean Air Act section 213(a)(5). The primary focus of the emission standards, which became effective in 2000, is NO_x. In addition, standards for HC, CO, PM and smoke were also promulgated. The rulemaking also includes a variety of provisions, including certification test procedures and assembly line and in-use compliance testing requirements, to implement the emission standards and to ensure rule compliance. The rule also includes an emissions averaging, banking, and trading program to provide flexibility. The U.S. EPA rulemaking describes types of state and local requirements relating to the control of emissions from new locomotives and new locomotive engines which the U.S. EPA believes are preempted pursuant to §209(e) of the Clean Air Act.[25] The federal regulations do not address the quantification of idling emissions or risk from railyard operations. A summary of the U.S. EPA emissions standards is shown in Table 1-1.

Existing State Requirements

In November 2004, CARB approved with 15-day changes "Proposed Regulatory Amendments Extending the California Standards for Motor Vehicle Diesel Fuel to Diesel Fuel Used in Harborcraft and Intrastrate Locomotives". This rulemaking requires that beginning January 1, 2007, diesel fuel sold, supplied, or offered for sale to California intrastate locomotive operators statewide be required to meet specifications for vehicular diesel fuel, as specified in Title 13, California Code of Regulations, Sections 2281, 2282, and 2284. These specifications include maximum sulfur levels of 15 parts per million by weight and aromatics level of ten percent by volume. Current U.S. EPA requirements, finalized in June 2004, specify that 15 ppmw fuel be used in locomotives in 2012. The CARB rulemaking requires the use of low-sulfur diesel fuel six years earlier than required federally.[26]

As described previously in Chapter 1, CARB has adopted two agreements with BNSF and UP. The first, which was entered into in 1998, applies within the District and includes provisions for

[25] United States Environmental Protection Agency, 1998, 40 CFR Parts 85, 89 and 92: Emission Standards for Locomotives and Locomotive Engines; Final Rule.

[26] California Environmental Protection Agency, Air Resources Board, 2004, Staff Report: Initial Statement of Reasons – Public Hearing to Consider Proposed Regulatory Amendments Extending the California Standards for Motor Vehicle Diesel Fuel to Diesel Fuel Used in Harborcraft and Intrastate Locomotives.

early introduction of clean locomotives, with requirements for a NOx fleet average in the Basin equivalent to U.S. EPA's Tier 2 locomotive standards by 2010. In the second agreement, CARB staff developed a June 2005 statewide agreement with BNSF and UP to establish a PM emissions reduction program at California railyards. Under this agreement, the railroads committed to reduce locomotive idling by installing idling-reduction devices on their intrastate locomotive fleets. In addition, the railroads agreed to develop inventories of diesel emissions with CARB, in turn, conducting health risk assessments for most railyards statewide. This agreement is currently in effect in the District. Table 3-6 is a comparison between the 2005 CARB Agreement and PR 3502. The comparative analysis addresses only areas which are covered by both the 2005 CARB Statewide Agreement and PR 3502. Specific areas of common coverage include the applicability of idling requirements, the idling requirements themselves, exemptions from idling requirements, and penalties.

Existing District Requirements

District Rule 3503 – Emissions Inventory and Health Risk Assessment for Railyards, adopted on October 7, 2005, requires railroad operators to develop criteria pollutant and toxic emissions inventories for railyards in the District and to conduct health risk assessments to estimate the cancer and noncancer risks caused by emissions at railyards. In addition, Rule 3503 requires railroad operators to notify the public regarding such health risks. The rule is applicable to railyards operated by Class I freight railroads and switching and terminal railroads in the District.

In addition, two existing District rules address emissions from locomotives. District Rule 401 – Visible Emissions, most recently amended on November 9, 2001, prohibits the discharge into the atmosphere of any air contaminant, including any from locomotives, for a period of three minutes in one hour if it is as dark or darker in shade as that designated No. 1 on the Ringelmann Chart, or if it is of such opacity as to obscure an observer's view as much as or more than smoke designated as No. 1 on the Ringelmann Chart. District Rule 402 – Nuisance, adopted on May 7, 1976, prohibits the discharge from any source, including locomotives, of air contaminants which cause injury, detriment, nuisance, or annoyance to the public or which endangers the comfort, repose, health or safety of the public or which causes injury or damage to business or property.

Table 3-6
Applicable Key Elements of the 2005 CARB Statewide Agreement and PR 3502

General Requirements	CARB Statewide Agreement	PR 3502
Applicability	• Intrastate and interstate locomotives • BNSF and UP	• Intradistrict and interdistrict locomotives • BNSF, UP, LAJ, PHL
Anti-Idling Devices	• Installation required for 99% of intrastate locomotives	• Installation not required, but allowed as an alternative method of compliance
Idling Requirements (Operating Parameters and Work Practice Requirements)	• 15 minutes if equipped with anti-idling device • 60 minutes if not equipped with anti-idling device (See exemptions)	• Exempt if equipped with anti-idling device set at 15-minutes • No idling for more than 30 minutes for the following reasons: o Unattended consist due to crew change; o Unattended consist due to meal break; o Unattended locomotive in a railyard; o Queuing for fueling, maintenance, servicing; o Maintenance/diagnostics not requiring engine operation; o For trailing locomotives, notification of delay that will exceed 30 minutes; o For trailing locomotives, locomotive failure or breakdown will lead to a delay of more than 30 minutes.
Alternative to Idling Requirements (Monitoring, Reporting, and Recordkeeping Requirements, Including Test Methods, Format, Content, and Frequency)	• None	• Emissions Equivalency Plan to demonstrate equivalent NOx and PM benefits to what would be achieved by meeting idling requirement, consistent with the District's "Railyard Emissions Inventory Methodology" and "Health Risk Assessment Guidance for Railyards and Intermodal Facilities."
Exemptions to Idling Requirements	• Essential idling: o Ensure adequate supply of air for air brakes; o Other safety purpose; o To prevent freezing of engine coolant; o To ensure cab temperatures stay within federal guidelines o To engage in necessary maintenance activities, including but not limited to fueling, testing, tuning, servicing, and repairing; o For unoccupied locomotives not	• Locomotive being used in an emergency; • Ambient temperatures of 40^{o}F or lower occur or are expected to occur where the locomotive operates; • Idling is required to maintain battery charge or voltage at a level sufficient to start the locomotive.

General Requirements	CARB Statewide Agreement	PR 3502
	equipped with anti-idling devices when anticipated idling will be less than 60 minutes.	
Averaging Provisions, Units, and Other Provisions Associated with Emission Limits	• None	• None

ATTACHMENT A: PUBLIC COMMENTS

PUBLIC COMMENTS

An April 25, 2005 comment letter to Proposed Regulation XXXV, which included specific comments to PR 3502, was received from the Association of American Railroads. On October 12, 2005 a public workshop was held at District headquarters to solicit information and suggestions from the public regarding PR 3502**.** Approximately 10 people attended, with four individuals providing comment at the meeting. One written comment letter was received prior to the October 21, 2005 close of the public comment period for PRs 3502. Two comment letters were received after the close of the public comment period. A summary of the verbal and written comments, as well as staff responses, is given below.

Written Comments – April 25, 2005

1. Comment: The proposed rule is preempted by the Clean Air Act, the California Health and Safety Code, the ICC Termination Act, federal rail safety laws, and the Commerce Clause of the U.S. Constitution. The U.S. Congress ad the California Legislature have delegated exclusive authority over locomotive and rail emission to the federal and state agencies that can effectively and efficiently regulate in this area.

Response: The District has fully discussed its legal authority under state law to promulgate PR 3502, as well as discussed why neither rule is preempted under federal law, in our response to the railroad's written legal comments, dated November 14, 2005, included below.

2. Comment: The District is required by law to prepare and disclose its CEQA Initial Study and prepare and EIR. The CEQA analysis should include alternatives to the project and should consider the potential for increasing emissions elsewhere because of the requirements to reduce idling emissions. For example, truck traffic may be increased and congestion at the ports may be increased which would undermine the efforts of the Ports of Los Angeles and Long Beach to reduce emissions. It should consider all cumulative impacts of the project and should address all other initiatives to control railroad emissions in the SCAB.

Response: The District prepared and circulated an Initial Study for a 30-day public comment and review period from September 15, 2005 to October 14, 2005. The Initial Study identified environmental topic areas that may be adversely affected by the proposed project. The District has evaluated the environmental impacts from the proposed project and will be releasing the results in a Program Environmental Assessment in accordance with CEQA Guidelines §15252. The analysis considered potential direct and indirect impacts from the project. For example, increased congestion at the Ports is not expected because, according to the Port of Los Angeles, 50 percent of the containerized cargo received at the Port is destined for the regional or domestic market, within 350 miles and up to 950 miles. This containerized cargo is already shipped by truck. Further, the environmental analysis concluded that project-specific impacts are not significant and, therefore, are not cumulatively considerable. Since the purpose of the alternatives to the project would be to avoid or substantially lessen any significant effects of the project and the proposed project does not generate significant impacts, alternatives to the project are not required.

3. Comment: The Railroads assert that under CEQA the District must analyze the relationship between its proposed railroad rules and "all other relevant District and other plans and programs." Specifically, the railroads state that the District must look at how these proposed rules relates to: (1) the District's portion of the California SIP; (2) the District's toxic air contaminant program; (3) the 1998 ARB-Railroad MOU; and (4) current proceedings at the ports of Los Angeles and Long Beach regarding diesel vehicles.

Response: As part of the rulemaking process, the District prepared a PEA for PR3501 and PR3502. The PEA, which has been made available to the public for comment, concluded that these two rules would not result in any significant direct or indirect environmental impacts. Instead, enactment of these rules will be environmentally beneficial due to anticipated reductions in criteria pollutants such as NOx and PM, as well as in TACs. As part of the PEA, the District was required to "discuss any inconsistencies between the proposed [rules] and applicable general plans and regional plans," including any applicable air quality or regional transportation plans. CEQA Guidelines § 15125(d). The District, however, has not found any inconsistency between PR 3501 or PR 3502 and any of the plans and programs identified by the railroads.

With respect to the District's Air Quality Management Plan (AQMP) (which is incorporated into the California SIP), this plan sets forth the policies and measures to achieve compliance with the federal and state standards for all criteria pollutants, including NOx and PM10. The AQMP strategy includes measures that target stationary, mobile, and indirect sources. These measures are based on feasible methods of attaining ambient air quality standards. The proposed rule is not inconsistent with the AQMP, but instead will assist the District in its efforts to attain the state and federal PM10 air quality standards. Similarly, the District's Air Toxics Control Plan (ATCP) includes control measure AT-MBL-09 –

Control of Locomotive Idling Emissions. PR 3502 implement this control measure, which will reduce toxic risk to local residents. Thus, PR 3502 is consistent with, and will help implement, the AQMP and ATCP[27].

With respect to the 1998 ARB-Railroad MOU, that agreement achieves additional reductions in NOx emissions from locomotives by expediting the dates that the railroads must achieve EPA Tier 2 standards within the District. The 1998 MOU contains a termination clause that would allow the railroad to escape its obligation, but only under very limited circumstances. In relevant part, the agreement states that the railroad may terminate if "the State of California or any political subdivision thereof takes any action to establish (i) locomotive emission standards, (ii) any mandatory locomotive fleet average emission standards, or (iii) any requirement applicable to locomotives or locomotive engines and within the scope of the preemption established in the final EPA national locomotive rule."

PR 3502 will further the aim of reducing NOx, and are not inconsistent with the goals and objectives of the 1998 MOU. Further PR 3502 is not inconsistent with the termination clause and does not establish any type of emission standard. Moreover, for reasons fully discussed in the District's response to the railroad's written legal comments, dated November 14, 2005, neither rule is within the scope of Clean Air Section 209 preemption, as established in the final EPA locomotive rule.

Finally, with respect to the current proceedings at the ports of Los Angeles and Long Beach regarding diesel vehicles, the District is uncertain exactly what proceedings the commenter is referencing. Therefore, the District cannot analyze this issue further. If the railroads are referring to the Port of Los Angeles Draft No Net Increase Plan, these proceeding are not sufficiently developed for the District to fully analyze. Courts have stated that an agency is not required to considered proposed or draft plans (or rules) when evaluating a present project under CEQA. Chaparral Greens v. City of Chula Vista, 50 Cal. App. 4th 1134, 1145 (1996); see also Sierra Club v. City of Malibu, 205 LEXIS 8359 (Sept. 15, 2005)(unpublished). These courts have noted that nothing in CEQA suggests that an agency must "speculate as to or rely on proposed or draft regional plans in evaluating a project." Chaparral Greens, 50 Cal. App. 4th at 1145. In other words, unless the other rule or plan is already adopted, an agency need not evaluate whether its proposed project is in conflict. However, the District also believes that PR 3502 will not be inconsistent with any future

[27] The railroads also assert that PR 3501 and PR 3502 may result in an intermodal switch in freight traffic from rail to truck , which would result in localized toxic hot spots. However, as explained in the PEA, the District found no support for the railroads' position that such an intermodal switch would be likely to occur.

program by the ports to further reduce locomotive emissions. The railroads have not presented any information to the contrary.

4. Comment: The District must perform an assessment of the socioeconomic impacts of the rules including the range of probable costs, including costs to industry and the emission reduction potential of the rules.

Response: The District has conducted an assessment of the socioeconomic impacts of the proposed rules (PR 3501 and PR 3502). The assessment includes costs/savings and emission reductions. PR 3501 is a recordkeeping and reporting rule and would not result in emission reductions. Overall, PR 3502 would result in savings. As such, the cost-effectiveness analysis is not performed.

5. Comment: The cost effectiveness analysis must consider the number of reporting events per day; hours and cost to collect, consolidate, translate, and transmit reports; hours to develop training materials; hours to train railroad employees involved in collection and reporting of data; delays while crews record idling events longer than 15 minutes; delays while obtaining from the dispatcher regarding reasons holding the train; cost of idling reduction devices resulting from the rule; and emission reductions resulting from the reporting and retrofit components of the rule over time. It should address the cost of delay to shutdown and restart, including increased labor costs. It should also address increased costs to roads due to modal shift.

Response: The socioeconomic analysis of PR 3501 and 3502 has considered a gamut of cost parameters associated with the proposed rules' requirements. For example, the recordkeeping cost for PR 3501 includes the costs of system set up, data entry/weekly reporting, and annual reporting. PR 3502 is expected to result in a cost impact from training personnel and a potential savings associated with reducing unnecessary idling. Implementation of PR 3501 and 3502 would result in an overall savings. Therefore, a modal shift away from railroads is not expected.

6. Comment: The District proposal may actually increase emissions and cause safety concerns. Idling is an integral part of railroad operations and there are many reasons why idling over 15 minutes is necessary. In some cases, more emissions may be caused by stopping and starting the engine than would be caused by idling a few more minutes. It can take 15 to 30 minutes or more to shut down and start up. Pulling a large number of locomotives out of service with start/stop technology would lead to significant system delays and greater overall emissions.

Response: Proposed Rule 3502 has been modified to identify specific situations in which shutting down the locomotive would not interfere with railroad operations. In addition, the proposed rule includes exemptions for locomotives used in an emergency, ambient temperature of 40^{o}F or lower occurs or is predicted, or idling is required to maintain battery charge or voltage at a level sufficient to start the locomotive. The railroad had made a comment that increased start-ups from idling restrictions could result in a trade-off in emissions. In order to clarify this situation, the District commissioned two source testing companies, Southwest Research Institute and Engine, Fuel, and Emissions Engineering to test start-up emissions from locomotives. The results show that, based on the testing data, idle shutdown periods longer than about eight minutes, followed by a start-up-idle event, result in reduced emissions; the longer the shutdown, the more substantial the emission benefits based upon the idle emission rates.

Public Workshop Comments

7. Comment: What is the relationship between development of District railroad rules under Regulation XXXV and the 2005 CARB Statewide Agreement, particularly with regard to release clause language in the Agreement?

Response: It is District staff’s understanding that although the Agreement provides the means for the railroads to opt out of elements of the Agreement, if a local agency adopts requirements directed toward the same goal as that requirement it is ultimately up to the railroads to decide whether to do so. The District’s Governing Board has directed staff to continue development of rules under Regulation XXXV, including PRs 3501 and 3502 and Rule 3503 – Emissions Inventory and Health Risk Assessment for Railyards, which was adopted on October 7, 2005.

8. Comment: PR 3502 idling requirements that limit idling of lead locomotives equipped with anti-idling devices to 15 minutes are unnecessary, since the devices should be allowed to dictate the duration of idling based on need-based parameters such as low battery voltage and maintenance of brake pressure.

Response: District staff understands that occupied lead locomotives with anti-idling devices may need to idle, as dictated by parameters monitored by the anti-idling devices (e.g., operator comfort cooling, battery charge, brake pressure). As a result, PR 3502 does not address idling of occupied lead locomotives equipped with anti-idling devices, because it is assumed that those locomotives will idle for 15 minutes or less, or to the extent dictated by the anti-idling devices.

PR 3502 has been modified to specify that locomotives with anti-idling devices that are set at 15 minutes, engaged, and not tampered with are not subject to idling requirements. Idling requirements under PR 3502 are directed at those locomotives that are not equipped with anti-idling devices.

9. Comment: A trailing locomotive equipped with an anti-idling device that idles for longer than 15 minutes does so because the anti-idling device deems it necessary.

Response: District staff agrees with this statement. As discussed previously, PR 3502 idling requirements have been structured to not apply to locomotives equipped with anti-idling devices. However, the rule does not prohibit idling for longer than 15 minutes when parameters cause the anti-idling device to re-start the engine.

Written Comments – Received Prior to October 21, 2005

10. Comment: PR 3502 IS needed. The danger to public health from diesel engine emissions is already well-known and based on research. Particulates in emissions are hazardous to the lungs. Idling limitations are urged, as well as future regulations specifying zero emissions standards.

Response: District staff believes that Proposed Rule 3502 is needed to protect public health by limiting longer-duration idling events. The District is receptive towards advanced strategies, such as liquefied natural gas locomotives, which do not rely on diesel fuel and, as a result, do not produce diesel PM emissions.

Written Comments – Received After October 21, 2005

11. Comment: The railroads question the ultimate need for PR 3502 in light of the June 30, 2005 CARB Statewide Agreement, which provides all of the benefits of PR 3502. Therefore, duplicating the requirements of the CARB Statewide Agreement under a parallel regime as part of Regulation XXXV would not result in additional emissions reductions or any other air quality benefit.

Response: District staff believes that the CARB Statewide Agreement has several deficiencies relative to PR 3502. For example, the Statewide Agreement includes exceptions to idling limits which are much less clearly defined, and as a result significantly less stringent, than proposed in PR 3502. In addition, the District questions the enforceability of the Statewide Agreement. For these reasons, District staff is unclear whether the Statewide Agreement will result in true air quality benefit, while PR is structured to ensure enforceable benefits.

12. Comment: Although it might appear as though PR 3502 is more protective than the 2005 CARB Statewide Agreement because it would limit non-exempt idling to 30 minutes instead of 60 minutes as allowed by the Statewide Agreement, in fact the overall benefits that will be achieved under the 2005 Statewide Agreement as a whole are at least equivalent to, and likely are greater than, those that would result from implementation of PR 3502.

Response: The commenter has provided no data to validate that the 60 minute threshold in the Statewide Agreement would result in benefits which are equivalent to or greater than what would be achieved under the PR 3502 limit of 30 minutes. Under PR 3502, idling requirements are very specific. PR 3502 has been modified to identify distinct situations where idling over 30 minutes would be prohibited. As a result, the exemptions to these situations are very limited. District staff believes that this approach is very clear and enforceable and will lead to greater emission reductions than the 2005 CARB Statewide Agreement.

13. Comment: PR 3502 should not exclude passenger train operations. If the objective of PR 3502 is to reduce idling emissions from diesel-powered locomotives, reducing idling emissions from passenger locomotives furthers this objective. No explanation is provided as a basis for excluding locomotives used to transport passengers from the proposed rules.

Response: As explained in the PR 3502 staff report, passenger railyards operating in the District would be excluded from the requirements of PR 3501 based on a preliminary data analysis indicating that they contribute less than ten percent of NOx and PM emissions from rail operations. Passenger railyard operations are sufficiently different than freight yards because they are characterized by very little, if any, switching and cargo handling activities, in addition to considerably lower traffic volumes. In addition, in most cases commuter rail has priority over freight locomotives, further reducing the possibility of idling events. Also, passenger railroads operate on a more predictable schedule such that crew changes and breaks can occur at specified time periods and locations to avoid delays and idling associated with such activities. As a result, passenger railyard operations have proportionally lower idling emissions than freight railyards. If warranted, passenger operations may be considered in the future.

14. Comment: The definition of “anti-idling device” in PR 3502 should be redrawn more generally for universal application. As drafted, the proposed definition does not account for the fact that parameters vary from model to model.

Response: The intent of the comment is unclear. As currently written, the definition lists in general terms what an anti-idling device is. In this regard, the definition achieves what the commenter is requesting. Although the definition does not specifically state that parameters vary from model to model, it does provide a list of possible parameters, such as engine water temperature, ambient temperature, battery charge, and railcar brake pressure, which might be monitored as part of an anti-idling device. The list of parameters is given as an example, essentially allowing for the fact that the parameters vary from model to model. Given the context of the definition, it is difficult to determine how the addition of explicit language stating that parameters vary from model to model will improve the definition.

15. Comment: For consistency with the CARB Statewide Agreement, the definition "idling" or "idling event" should be revised to include fueling as a permitted idling event.

Response: PR 3502 has been revised to identify the specific circumstances in which a locomotive cannot idle for more than 30 minutes. Fueling of a locomotive is not one of the situations that would be subject to the idling prohibition. However, queuing for fueling, as specified under subparagraph (d)(1)(D) would be restricted from idling for more than 30 minutes.

16. Comment: The PR 3502 definition of "operator" must be reconciled with the definition of "railroad." As proposed, the definition of "railroad" could include commercial passenger carriers as well as freight. However, the definition of "operator" is understood only to mean Class I freight carriers. Because inclusion of the term "railroad" within the otherwise more limited definition of "operator" could have the unintended consequence of broadening the scope of PR 3502, the definitions should be clarified and consistent.

Response: To respond to this comment, PR 3502 definitions of "operator" and "railroad" have been revised for consistency with the same definitions in PR 3501. The definitions are now consistent in referring only to freight transport.

17. Comment: PR 3501 and 3502 define "railroad" differently. The definitions should be identical

Response: The PR 3502 definition of "railroad" has been amended for consistency with the same definition in PR 3501.

18. Comment: The PR 3502 definition of “emergency vehicle” refers to the California Vehicle Code definition of the term. This is an improper definition given that rail operations are generally beyond the constraints of the Vehicle Code.

Response: In response to this comment, the definition of “emergency vehicle” has been deleted from PR 3502. To address the use of locomotives in emergency situations, PR 3502(i)(1) has been amended to allow use of a locomotive during an emergency, with “emergency” defined in subdivision (c) as “any sudden, unexpected occurrence involving a clear and imminent danger, demanding immediate action to prevent or mitigate the loss of, or damage to, life, health, property, or essential public services.”

19. Comment: PR 3502 defines “trailing locomotive” as “any locomotive in a consist of locomotives, including consists made up of switching locomotives and locomotives not connected to railcars, that is not the controlling locomotive.”

Response: Correct.

20. Comment: PR 3501(f)(2)(D) requires a statement to be included in an Alternative Compliance Plan that each anti-idling device be set at 15 minutes or less. This requirement fails to acknowledge a number of other factors that necessarily affect a decision than an idling control device automatically should shut off the locomotive’s engine. Consistent with the CARB Statewide Agreement, PR 3501 should be revised to account for instances in which adherence to such a limit would cause premature component failure. Such a revision would be consistent with parameters listed in the PR 3501 definition of “anti-idling device.” This concern also applies to PR 3502(d), which generally requires that locomotives equipped with anti-idling devices be shut down after 15 minutes of continuous idling.

Response: The staff report includes clarification regarding the statement for setting the anti-idling device. This statement is to ensure that the anti-idling device is set at 15 minutes or less to shut the engine down provided all of the parameters, such as air pressure, voltage, water temperature, ambient temperature, etc. are met. However, if one or more of the parameters drops below a specified level the engine would automatically restart, irrespective of the anti-idling device being set at 15 minutes.

21. Comment: It is unclear whether an approved Alternative Compliance Plan submitted under PR 3501(f) constitutes compliance with idling requirements in PR 3502(d) for the same locomotives.

Response: No, unless one or more of the following conditions are met: (1) the locomotive propulsion strategies proposed under the PR 3501 Alternative Compliance Plan include anti-idling devices; or (2) the criteria for exemption from PR 3502 idling requirements, as specified in PR 3502, subdivision (j) are met; or (3) a PR 3502 Emissions Equivalency Plan has been submitted by a railroad and approved by the Executive Officer.

It is important to note that alternative technologies used within an approved PR 3501 Alternative Compliance Plan could likely also be used to meet the requirements of the PR 3502 Emissions Equivalency Plan. However, an approved PR 3501 Alternative Compliance Plan in the absence of an approved PR 3502 Emissions Equivalency Plan will not satisfy the requirements of PR 3502.

22. Comment: In lieu of compliance with idling limitations PR 3502(e) allows an operator to prepare and submit an Emissions Equivalency Plan demonstrating emission reductions greater than or equal to those that would be achieved by not continuously idling locomotives for more than 15 minutes. PR 3502 is silent on a number of relevant issues, including the methodology to be used in quantifying baseline emissions and subsequent emission reductions, procedures for making the required demonstration, and the baseline condition to be used for the comparison.

Response: Proposed Rule 3502 has been modified to provide additional clarity regarding information needed for operators that elect to submit an Emissions Equivalency Plan. The proposed rule has been modified such that quantification of emission reductions should demonstrate that the reductions are greater than or equal to the annual emission reductions that would be achieved by not idling locomotives for more than 30 minutes for all events in the same calendar year, except as exempted pursuant to subdivision (i) and there is no increase in toxicity.

The methodology to quantify emissions shall be consistent with the most recent revision to the District's Railyard Emissions Inventory Methodology. Estimates of cancer risk and acute and chronic noncancer health effects shall be consistent with the most recent revision to the District's Health Risk Assessment Guidance for Railyards and Intermodal Facilities. These documents, which were included with the October 7, 2005 Board package for Rule 3503 – Emissions Inventory and Health Risk Assessment for Railyards are included as Attachments B and C of the Draft Staff Report for Proposed Rule 3502.

23. Comment: The list of bases for exemption from PR 3502 idling requirements is incomplete. PR 3502(j) should be modified to clarify that the subdivision

is not intended to be an exclusive list, or at least to include: (1) All specified parameters fail to continuously meet the acceptable levels identified in PR 3502(c)(1) for the applicable idling duration; and (2) The locomotive that is idling is a trailing locomotive that is also in motion.

Response: Regarding the first recommendation, under Proposed Rule 3502, a locomotive that is equipped with an anti-idling device that is idling to maintain specific minimum operating parameters such as engine water temperature, railcar brake pressure, battery charge, and battery voltage is not subject to the idling requirements.

Regarding the second recommendation for the definition for "idling or idling event" states that idling is the operation of the locomotive's diesel internal combustion engine(s) used for locomotive motive power during which the engine is not used to move the locomotive. It shall not be considered idling when the engine is operating while the locomotive is being slowed or moved by gravity. In a situation where the locomotive is a trailing locomotive where the locomotive is in the idle throttle notch and the reverser handle is not centered, because the consist is working, this situation would not fit the definition of an idling event.

24. Comment: In light of the numerous, serious technical and legal flaws inherent in the promulgation of PR 3502, the railroads urge the District to terminate the rulemaking process.

Response: District staff disagrees with the assessment of inherent technical and legal flaws. Every effort has been made to address all technical issues raised and changes have been made to the proposed rules based on comments received. District staff has also designed the rules to avoid federal preemption. From the staff's perspective, the proposed rules are necessary, with PR 3502 establishing limits on idling from locomotives. For this reason, the staff believes that continuing the rulemaking process is warranted.

25. Comment: The PR 3502 definition of "maintenance or diagnostic purposes" should be clarified. As written, the railroads may interpret the exemption associated with this definition too broadly and the rule might provide an easy means for the railroads to undermine the effectiveness of the rule.

Response: Proposed Rule 3502 restricts idling to 30 minutes or less if a mechanic is idling the locomotive for maintenance or diagnostic purposes which can be conducted on the locomotive that does not require operation of the engine. An operator shall not idle a locomotive for more than 30 minutes if the locomotive is queuing prior to or following these activities and for fueling or servicing a locomotive.

26. Comment: The District should provide more clarification about where money from penalties will go. It is suggested that it would be appropriate to use the funds to improve air quality in the community where the violation occurs. In addition, the District should make sure that the penalty money does not go back to the railroads for mitigation measures.

Response: If penalties are collected from implementation of Proposed Rules 3501 and 3502, the District staff will evaluate appropriation of these funds. The District staff will take into consideration implementation costs associated with implementing and enforcing Proposed Rules 3501 and 3502. In addition, as part of its consideration, the District staff will consider use of funds to improve air quality in local communities, specifically the areas where violations occur.

27. Comment: The railroads argue that idling prohibitions constitute a "requirement" which the state or district is preempted from adopting by section 209(e)(1) of the Federal Clean Air Act.

Response: The railroads ignore the fact that their interpretation has already been rejected by the courts. In *Engine Manufacturers Association v U.S. Environmental Protection Agency* (D.C. Cir. 1996) 88 F 3d. 1075 at page 1093, the Court of Appeals held that EPA had properly interpreted the term "requirements" as used in section 209(e) to refer to only "certification, inspection, or approval" requirements of the same type preempted in section 209(a) and (c), and that section 209(d) shows that "requirement" does not include use restrictions. The Court of Appeals upheld EPA's interpretation, so that use restrictions, such as idling limits, are not preempted "requirements." While it is true that the regulation upheld in this case does not apply to locomotives, it is the exact same provision, section 209(e), that applies to locomotives as applies to the other nonroad engines that were the subject of the rule in this case. EPA could not interpret the same exact section of the statute-the word "requirements"-differently as applied to locomotives and as applied to other nonroad engines. To do so would be arbitrary and capricious, in violation of section 307 of the Clean Air Act.

28. Comment: The railroads also argue that Proposed Rule 3502 is a "transparent retrofit requirements" and therefore would be preempted under the Clean Air Act.

Response: This assertion is incorrect. PR 3502 does not require retrofits of locomotives. These proposed rules require recordkeeping of idling events and limitation of unnecessary idling. In addition, engines that use anti-idling devices or alternative technologies are either exempt from the rule's requirements or can be used as an alternative method of compliance with the rules, which is essentially the same as an exemption. The Clean Air Act does not prohibit states from exempting certain cleaner locomotives from otherwise-valid use restrictions. The railroads appear to be impliedly making an argument that the proposed rules are so burdensome that they effectively do not give the railroads any choice but to retrofit their locomotives. They supply no facts to support such an argument. Moreover, any such argument is belied by the fact that the railroads have agreed to limit unnecessary idling in their MOU with CARB, which shows that idling restrictions are not overly burdensome. The MOU sets forth types of idling which the railroads believe is necessary, which does not include the circumstances in which idling is limited by PR3502. Also, the recordkeeping requirements have been adjusted to address the railroads' concerns by only requiring reasons for idling events over two hours and by allowing a delay between the conclusion of the weekly recordkeeping period and the date the reports are due to the District.

29. Comment: The railroads argue that the proposed rules would impermissibly conflict with, interfere with, contradict or duplicate the EPA regulatory program for locomotives.

Response: Since the railroads fail to cite any provision of the federal regulations to which this argument applies, there is no basis for this claim.

30. Comment: The railroads argue that anti-idling requirements "squarely impinge upon rail operations" and thus are preempted under the ICCTA.

Response: The railroads first cite the proposition that environmental permitting or pre-clearance requirements are preempted. However, neither proposed rule imposes any permitting or pre-clearance requirements. Next, they cite *Village of Ridgefield Park v New York, Susquehanna & Western Railway*, 750 F. 2d. 57, 67 (N.J. 2000) for the proposition that a locality's action to enjoin a nuisance from a railroad facility was preempted by the ICCTA. However, this does not mean that any rule limiting idling would be preempted by the ICCTA. The court stated that to adjudicate the common-law nuisance claim would infringe on the Surface Transportation Board's exclusive jurisdiction over the location and operation of railroad facilities. Presumably, this is because idling which was necessary to further rail operations could still constitute a public nuisance, and therefore it would interfere with rail operations if such activity were enjoined. However, that case recognized that nondiscriminatory police power regulations that do not interfere with rail operations may still be enforced. The proposed rules are designed so as not to interfere with rail operations, allowing idling in all cases where it serves a legitimate operational need, and only limiting idling in cases where the idling is unnecessary. Idling limits do not discriminate against railroads because there is already a CARB rule limiting idling to five minutes for trucks and buses. Indeed, since the railroads have already agreed in the CARB MOU to limit unnecessary idling, they have acknowledged that such a requirement does not interfere with rail operations. Hence, it is not preempted. Moreover, the *Village of Ridgefield Park* decision acknowledges, as does the Surface Transportation Board, that whether a regulation interferes with rail operations is a fact-bound question. Here, the railroads have cited no facts to support an argument that either of the proposed rules interferes with rail operations. As also stated in the cited case, police power regulations are presumed valid, and it is the railroads' burden to present proof that a regulation interferes with rail operations.

31. Comment: The railroads assert that the proposed rules will have adverse impacts on the environment.

Response: The railroads cite no facts to support this claim; and the District's CEQA analysis revealed no significant environmental impacts.

32. Comment: The railroads argue that the proposed rules are unnecessary because they have entered into an MOU which limits idling and some of their members have corporate policies to limit idling, in order to reduce fuel consumption and emissions.

Response: However, the rules are still necessary because they limit unnecessary idling to 30 minutes, rather than 60 minutes as stated in the MOU, and, more importantly, because the rules are enforceable via injunctive relief and substantial penalties, whereas the CARB MOU specifically prohibits CARB from obtaining injunctive relief or specific performance, and provides only small penalties compared with the penalties available under the state law for violation of district rules.

33. Comment: As the Railroads' Rule 3503 comments explained in detail, it is improper to segregate the environmental review of PR 3501 and PR 3502 from Rule 3503 and future PR 3504. The District improperly defines PR 3501 and PR 3502, exclusive of Regulation XXXV and the accompanying rules, as the project for purposes of CEQA. The District improperly ignores the history of Regulation XXXV and the interrelationship between the rules. Because the rules in Regulation XXXV "were intended, collectively, to regulate the railroad operations and emissions in the South Coast Air Basin" and because District Staff initially proposed to bring the rules in

Regulation XXXV to the District Board for a single approval, the District must now consider the cumulative effect of Regulation XXXV as a whole in a single CEQA document.

Response: The District does not agree with the railroads that merely because a set of proposed rules relate to a similar industry, or because they may be promulgated within a relatively similar time frame, that under CEQA they must be considered cumulatively in a single document. District staff did initially propose a single CEQA assessment for all four rules contained in Regulation XXXV. However, as explained in response to the railroads' comments on Rule 3503, during rulemaking District staff determined that a single CEQA review was neither necessary nor appropriate for two primary reasons.

First, it was determined that PR 3501 and PR 3502 are sufficiently different in purpose and affect from PR3503 that it was not necessary to adopt these rules at the same time. The District found that the causal link between Rule 3503 on one hand and PR3501 and PR3502 on the other was lacking, and, therefore, all three rules were not required to be treated as a single project for purposes of CEQA. See *Kaufman & Broad-South Bay, Inc. v. Morgan Hill Unified Sch. Dist.*, 9 Cal. App. 4th 464, 474 (1992)(requiring a causal link between the creation of a community facility district and future construction of new schools before CEQA applied); *Fullerton Joint Union High School Dist. v. State Bd. of Ed.*, 32 Cal. 3d 779, 798-97 (1982)(recognizing that CEQA applies when it is shown that the government action constitutes an essential step culminating in future action which may impact the environment).

Here, PR3501 and PR3502 focus on evaluating and actually reducing emissions associated with unneeded locomotive idling in the basin. This function stands independent of Rule 3503, which is solely an information gathering rule intended to advise the District and public about the type of, amount of, and risks from, air pollution emissions associated with railyard facilities. Also, idling controls reduce *regional* air pollutants and, thus has an additional independent purpose from gathering information about *localized* health risks from railyards. Therefore, like in *Kaufman*, adoption of Rule 3503 did not create any need to adopt rules relating to locomotive idling. Nor was adoption of Rule 3503 required for the district to proceed with PR3501 and PR3502. Under such circumstances, the District properly went forward with Rule 3503 separate from PR3501 and PR3502.

Second, the District decided to forgo adoption of PR 3504 until additional information could be gathered from railroads under Rule 3503 to assist the District in best fashioning any future rule regarding railyard risk reduction plans. Based upon future information provided from the railroads, either from the Interim Railyard Emission Inventory Reports, the railyard-wide criteria pollutant and toxic air contaminant emissions inventory, or the health risk assessments, the District will further consider the scope of PR3504. Depending on the level of risk, the District may consider different applicability, requirements, or compliance schedules, or even propose an entirely different approach to limit railyard risk. Indeed, if risks are determined to be at acceptable levels and likely to be maintained at such levels, the agency may not move forward with promulgation of PR3504 at all. Accordingly, CEQA review at this time of PR3504 would be premature because no definite plan has been formulated as to when or how to proceed with the rule. See *Kaufman & Broad-South Bay, Inc. v. Morgan Hill Unified Sch. Dist.*, 9 Cal. App. 4th 464, 474-75 (1992); *Berkeley Keep Jets Over The Bay Committee v. Board of Port Commissioners of the City of Oakland*, 91 Cal. App. 4th 1344, 1362 (1991); *Lake County Energy Council v. County of Lake*, 70 Cal. App. 3d 851, 854-55 (1977).

Because any action on PR3504 remains uncertain and unspecified, the decision not to prepare a CEQA analysis of that rule is distinguishable from those court cases cited by the railroads that found improper piecemealing of a project. Those cases overwhelmingly involve government agency approvals which the court found strong evidence were part of larger construction or development projects, or that directly created the need for future action or approvals. Thus, in *Laurel Heights* the Court was able to find a “myriad of facts” revealing that at the *very time* the University of California was approving the acquisition of an office building, it already had future plans to significantly expand the use of that *very same building*. See *Sacramento Old City Ass’n. v. City Council of Sacramento*, 229 Cal. App. 3d 1011, 1026 (1991) (explaining and distinguishing the holding *Laurel Heights*). In *Bozung v.LAFCO*, 13 Cal. 3d 263 (1975) the court found that none of the parties made “any bones about the fact” that the impetus for the action – approval of a land annexation plan – was part of a larger project to allow an individual landowner to subdivide his 677 acres of agricultural land into residential lots). In *Orinda Association v. Board of Supervisors*, 182 Cal. App. 3d 1145 (1986) (the court found that the administrative record showed from the “outset” that future demolition of two buildings was considered part the larger construction project approved by the agency). Finally, in *McQueen v. Board of Dir. Mid-Peninsula Regional Open Space Dist.*, 202 Cal. App. 3d 1136 (1998) (the court found that the agency had defined its project – the purchase of two parcels of land – too narrowly by failing to mention the agency’s nearly simultaneous adoption of a land use and management plan for the newly acquired land).

34. Comment: As discussed in the railroad letter of September 7, 2005 regarding Rule 3503, the District's exemption of PR3503 from CEQA and its conclusion that the rule may be segregated from the rest of Regulation XXXV directly violates California law.

Response: To the extent that this comment again challenges the Notice of Exemption for Rule 3503, the District has previously explained in detail that Rule 3503 is categorical CEQA exemption under Guidelines Section 15306 which the project "consists of basic data collection, research, experimental management, and resource evaluation activities which do not result in a serious or major disturbance to an environmental resource." Before its adoption, the railroads failed to explain why Rule 3503 "goes far beyond information gathering." While Rule 3503 contains an information reporting requirement, that is the public noticing requirement, this provision did not remove Rule 3503 from the exemption in section 15306. See *City of Ukiah v. Mendocino,* 196 Cal. App. 3d 47 at 54-55 (1987). Moreover, Rule 3503 was exempt from CEQA pursuant to Guidelines section 15262, as Rule 3503 involves information gathering and reporting as a feasibility or planning study to evaluate possible future actions, and Guidelines section 15061(b)(3), which exempts a project if it can be seen with certainty that there is no possibility that it may have a significant effect on the environment. The railroads also failed to provide any information to support their claim that these two Guideline sections could not be applied to Rule 3503.

To the extent that the railroads are asserting that potential impacts from Rule 3503 must be considered under CEQA as part of the PR3501 and PR3502 rulemaking process, the District disagrees for two reasons. First, the railroads have yet to provide any information that Rule 3503 would have any direct or indirect impact on the environment which needs to be evaluated under CEQA. Accordingly, the District does not believe that further consideration of Rule 3503 would require a change to the scope of the CEQA document for PR3501 and PR3502. Second, as previously stated, the District does not believe there is any casual link to between these rules requiring them to be considered together under CEQA. Given this, the District is required only to consider the direct and indirect physical changes to the project associated with PR3501 and PR3502. See CEQA guidelines section 15064(d).

35. Comment: The District does not have the authority under state law to regulate locomotives. The authority relied on by the District to justify this rule does not support the District's position that it has the requisite authority under state law. Neither Health & Safety Code Section 43013, 40716, 40702, 41511 nor 41700 confer any authority to the District to regulate

locomotives, including the requirement of health risk assessments and public notice.

Response: A thorough discussion of this issue appears in the Staff Report at pages 1-5 through 1-7.

As previously stated in the District's response to comments to the Railroads September 7, 2005 letter and in the Staff Report, state law confers upon the local air districts the primary responsibility to regulate air pollution from all sources, except for motor vehicles over which the state Air Resources Board (ARB) has exclusive jurisdiction. Health & Safety Code §40000. Additionally, Health & Safety Code §40412 states that "(T)he south coast district shall be the sole and exclusive local agency within the South Coast Air Basin with the responsibility for comprehensive air pollution control…" Unless there are specific statutes which limit this broad district authority, the districts can adopt rules and regulations to control all non-motor vehicular sources of air pollution.

Locomotives are nonvehicular sources, not motor vehicles[28], thus it is the districts that have the authority to regulate locomotives, unless the state legislature restricts this authority. See Staff Report at 1-5.

<u>Health & Safety Code §43013</u>

While the commenter cites Health & Safety Code §43013 as authority for the proposition that the Air Resources Board has exclusive jurisdiction over locomotives, neither section grants such exclusive authority. The state legislature, while granting authority to the Air Resources Board to regulate "off-road or non-vehicle engine categories" (§43013(b)) such as locomotives, did not revoke or limit the existing District authority to regulate these sources. Health & Safety Code §40702 places limitations on the District's authority to regulate locomotives, but does not revoke it entirely. (See discussion below) Utility engines, which are also included under this Section 43013(b), are typically regulated by districts. The legislature took the further step under Section 41750 et. seq. (added 1995) of the code to limit the existing authority of the districts after the legislature had already given the ARB authority to regulate these sources under Section 43013 (added 1988). If the Legislature had intended that §43013 be an exclusive preemptive grant of authority, as the commenter suggests, there would have been no need for the legislature to take measures to limit District authority by adopting the portable equipment

[28] Pursuant to Health & Safety Code §39039 a motor vehicle has the same meaning as defined in Section 415 of the Vehicle Code, which is "a vehicle that is self-propelled." "A vehicle is a device by which any person or property may be propelled, moved or drawn upon a *highway*…" Vehicle Code §670. (Emphasis added.)

regulations, Section 41750, et. seq.[29] Section 43013 cannot impliedly repeal the District's pre-existing authority to regulate nonvehicular sources absent "undebatable evidence" of such intent. Western Oil & Gas Assn. v. Monterey Bay Unified APCD, 49 C.3d 408 (1989). The railroads have failed to prove such intent.

Health & Safety Code §40716

Health & Safety Code §40716 does confer authority to the District to mitigate emissions from indirect sources such as railyards. See Staff Report at 1-5. An indirect source is a source that does not necessarily emit air pollutants independently, but rather draws other sources such as trucks, yard hostlers, automobiles and a variety of other nonroad sources that pollute in and around the indirect source. The citations provided by the commenter to the Clean Air Act and the Air Resources Board definitions of these sources explain that indirect sources include those that attract any kind of mobile sources, not just vehicles. Classic examples are stadiums, office buildings and ports. While the commenter concludes that the District is defining a locomotive as an indirect source, it is the railyard that is the source. A railyard draws to it a variety of polluting sources such as locomotives, trucks, loaders and forklifts. Thus, the District has the authority to regulate pollution from railyards. The District disagrees that Section 40716 is limited to the authority to adopt rules to reduce the number or length of vehicle trips, found in §40716(a)(2). Section 40716(a)(1] provides separate statutory authority to adopt regulations to "reduce or mitigate emissions from indirect or areawide sources…"

Health & Safety Code §40702

The commenter clearly misinterprets the language of Health & Safety Code §40702. As thoroughly explained in the draft Staff Report at pages 1-5 through 1-6, this statute confers upon the District the duty to adopt rules and regulations to execute the powers and duties granted to it. Additionally, this statute places a limitation of that broad authority granted the District by narrowly restricting the District's ability to "specify the design of equipment, type of construction or particular method to be used in reducing the release of air contaminants from railroad locomotives." Here, the proposed rules neither specify the design of equipment, the type of construction, or any particular method in reducing air pollution from locomotives. The District's statutory interpretation is not absurd, but rather the most logical interpretation. If the legislature had meant to completely prohibit the districts from regulating locomotives it could have

[29] §41750(a) "Existing law authorizes each district to impose separate and sometimes inconsistent emission control requirements…"

easily said so, rather than stating specific limits on authority as it did in §40702.

Health & Safety Code §41511

The commenter's arguments that Section 41511 limits districts to determine the amount of emissions only from "stationary sources" is contradicted by the wording of the statute, which allows districts to collect such information from "any air pollution emission source . . .." Locomotives are clearly air pollution sources, and Proposed Rule 3501 is clearly a reasonable way of obtaining information to help the District to determine the amount of emissions from both locomotives and railyards. See Staff Report at page 1-6 for further analysis.

Health & Safety Code §41700

As explained in the Staff Report at pages 1-7, this section of the Health & Safety Code it directly enforceable by the District and the District may adopt rules and regulations to ensure the compliance of sources with statute. The statute does not limit the term "source" to stationary sources, as the commenter states. Rather this statute clearly states it applies to *any source*. While there is clearly the potential for health risks from smoke, toxic diesel and other air contaminant emissions from idling that could be termed an endangerment to public health as prohibited by Section 41700, an actual nuisance in this instance, as explained in the Staff Report at page 3-3, the District need not wait until an actual nuisance has occurred, rather the District may adopt rules and regulations to ensure that the likely nuisance will not occur. Here the railyards are emitting large amount of diesel particulate matter, which endanger the public's comfort health and safety.

The commenters' conclusion that Section 41700 does not support Rules 3501 and 3502 is based upon its prior incorrect argument that Section 40702 completely preempts the District's authority over locomotives. As explained above, this argument is incorrect. Thus, the District also has the authority to regulate locomotives pursuant to Section 41700.

ATTACHMENT B: ~~SOURCE TEST~~EMISSIONS TESTING RESULTS

INTRODUCTION

In developing rules to address idling by locomotive engines, the District funded two separate locomotive testing projects in support of PR 3502. The District staff received comments from the railroad industry that increased start-ups from idling restrictions could result in a trade-off in emissions. One study was conducted by Southwest Research Institute (SwRI) in which two locomotives, one owned by UP and one by BNSF, were tested using specially designed test procedures to measure start-up emissions. The second study was conducted by Engine, Fuel, and Emissions Engineering, Inc. (EF&EE) on two locomotives owned by Metrolink.

LOCOMOTIVE SELECTION

Locomotive models for testing were selected based on the prevalence of particular models and/or engine types in the locomotive fleets represented in the District, as well as achieving a representative sample of 2-stroke and 4-stroke locomotives and representative horsepower for switch and line haul locomotives. The two major manufacturers of the locomotives used in the District by BNSF, UP, and LAJ are Electro-Motive Diesels, Inc. (EMD) and General Electric Transportation (GE). For the testing conducted for PR 3502, a total of four locomotives were selected: (1) EMD SD60, a line haul locomotive; (2) GE Dash 9-44CW, a line haul locomotive; (3) EMD F40, a passenger locomotive; (4) EMD MP15DC a switch locomotive.

The EMD SD60 and GE Dash 9-44CW locomotives were selected to represent the most common line haul locomotives and/or engines used by the Class I railroads for interdistrict service. The EMD F40 utilizes the EMD 16-645E engine, which is very commonly used for both interdistrict and intradistrict service. The EMD MP 15DC locomotive was selected to represent locomotives used for switching and intradistrict service. Based on data from CARB and the railroads, only EMD locomotives are used for switching duty at both UP and BNSF.

SwRI

Two locomotives were selected for testing by SwRI. The first locomotive tested was an EMD MP15DC locomotive equipped with a 12 cylinder 645E engine rated at 1500 horsepower, provided by UP. This unit is often used as a shunter or yard switcher rather than for line haul applications, although this particular locomotive model is suitable also for road switching (e.g., local switching and hauling outside of railyards). As is common to EMD locomotives, the MP15DC locomotive is equipped with a 2-stroke diesel engine. The unit was recently rebuilt and fitted with an automatic engine start stop system manufactured by ZTR Control Systems.

The second locomotive selected was a GE Dash 9-44CW locomotive equipped with a 16 cylinder GE 7FDL16 engine rated at 4400 horsepower, provided by BNSF. This unit is a line haul locomotive, equipped with six axles for motive power, used primarily for hauling freight for long distances rather than for yard or local duty. The GE 7FDL16 engine is a 4-stroke diesel engine. The unit was fitted with an automatic engine start stop system installed at the time of manufacture by GE.

EF&EE

Testing by EF&EE was conducted using two locomotives supplied by Metrolink. The first locomotive tested was an EMD SD60 locomotive equipped with at 16-cylinder EMD 16-710E engine rated at 3800 horsepower. This unit is a typical six-axle freight locomotive of the last generation, used primarily for hauling freight for long distances. This unit was not equipped with any sort of anti-idling device.

The second locomotive was an EMD F40 passenger locomotive, equipped with a 12-cylinder EMD 16-645E engine rated at 3000 horsepower. The engine used on this locomotive is used in freight locomotives commonly used in the District, including the EMD GP40, a four-axle general purpose locomotive used for local and line haul service. This unit was not equipped with any sort of anti-idling device.

TESTING METHODOLOGY

Current U.S. EPA regulations governing emissions from locomotives do not address start-up emissions. As a result, locomotive emissions testing conducted by SwRI and EF&EE to measure start-up emissions was conducted using test procedures specifically developed by SwRI and EF&EE.

Testing at SwRI was conducted at SwRI's facilities using the Federal Test Procedure, which was developed as part of the U.S. EPA's 1998 rulemaking establishing emissions standards for locomotives. For each locomotive, testing occurred over three days, with the first two days dedicated to investigating the effects of restarting and idling of locomotives, and the third day focused on repeating certain testing to acquire PM samples for District analysis. Testing was conducted in November and December 2005.

The EF&EE testing was conducted in the field at Metrolink's Los Angeles railyard using EF&EE's Ride Along Vehicle Emission Measurement (RAVEM) system. The RAVEM system is based on proportional partial-flow constant volume sampling sampling (CVS), while conventional emission laboratory methods defined by the U.S. EPA and CARB utilize full-flow CVS, in which the entire exhaust flow is extracted and diluted. For each locomotive testing occurred over three days, consisting of a series of start-ups, shut-downs, and restarts. Testing was conducted in November 2005.

District staff conducted a follow-up analysis of the SwRI data to evaluate startup emissions. District staff subsequently discussed the data analysis with SwRi. SwRI has provided input to the District's analysis.

It is important to note that although the test methodologies used by SwRI and EF&EE were different from one another, the results from both sets of tests were fairly consistent in showing emissions trends.

Comparison of Continuous Idling and Startup Emissions

SwRI

Data collected from the SwRI tests for locomotives UPY1378 and BNSF4373 were analyzed to determine whether shutting down an idling locomotive, taking into account the emissions associated with the startup of the shutdown locomotive, provides emissions benefits compared to allowing the locomotive to idle. Specifically, the analysis evaluated NOx and PM emissions associated with the continuous idling of UPY1378 and BNSF4373 for periods of 30, 60, 120, and 240 minutes, as compared with emissions resulting from the startup of the same locomotives following a shutdown period of the same time duration. As discussed in the SwRI Report titled "Locomotive Exhaust Idle and Start-up Emissions Testing" the 15 minute shutdown period is envisioned to be a non-typical operating cycle for the AESS. If the locomotive is occupied and the engineer anticipates moving the locomotive then it is assumed the operator would override the AESS system. If the locomotive is not occupied, the pre-test data showed that the locomotive would be shutdown for 90 minutes increments based on the AESS setting. As will be discussed subsequently in greater detail, the duration of continuous idling events, and corresponding emissions estimates, were increased by 30 minutes to reflect the time duration over which startup emissions were quantified. Overall, for each time period analyzed for both locomotives, continuous idling emissions of NOx and PM were greater than startup emissions following a shutdown period. The following discussion describes emissions calculations used in this analysis.

Startup of Locomotives for the Shutdown Scenarios

Startup emission rates from testing conducted by SwRI for UPY1378 and BNSF4373 were used by District staff to estimate startup emissions from shutdown locomotives. For NOx, these rates reflect the sum of NOx emissions over the test following locomotive shutdown durations of 30, 60, 120, and 240 minutes. For purposes of this emissions analysis, NOx startup emissions for 30 minute time intervals were used to reflect a conservative emissions case. The 30 minute idling time after start up was used since the proposed rule would limit idling to 30 minutes. The 30 minute time intervals were established for startups subsequent to each locomotive shutdown period, consisting of NOx emission data for the time period from 0 to 10 minutes added to the data for the time period after 10 minutes. Since in most instances NOx data was collected for a period of only 11 to 20 minutes, data for time periods after 10 minutes were projected out to 30 minutes by extrapolating the average NOx emissions that were measured for the increment after the first 10 minutes. By projecting data to 30 minutes, District staff's estimates of startup emissions are overestimated relative to what was measured by SwRI.

PM data, which were collected over five minute intervals for as many as three samples per restart following a shutdown period (or 15 minutes worth of PM accumulation), have been adjusted to reflect the actual number of samples collected. For example, when data from two PM filters (10 minutes worth of PM accumulation) were obtained, they were first averaged and then multiplied by three to represent a 30 minute startup period. When data from three filters (15 minutes of PM accumulation) were obtained through testing, the data were averaged, with the resulting value multiplied by two to represent a 30 minute startup period. Tables 1, 2, 3 and 4 show the startup emission rates and assumed startup emissions for UPY1378 and BNSF4373, respectively.

Table 1. Startup Emission Rates for UPY1378

Shutdown Period	NOx First 10 Minutes	Projected NOx After the First 10 Minutes	Assumed Startup NOx Emissions (30 Minutes After Startup)
30 minute	102	120	342
60 minute	100	88	276
120 minute	108	112	332
240 minute	111	112	335

Table 2. Startup PM Emission Rates for UPY1378

Shutdown Period	Maximum PM Filter	Number of Filters	Assumed Startup PM Emissions (30 Minutes After Startup)
30 minute	0.9	2*	2.7
60 minute	0.9	2	2.7
120 minute	0.9	3	1.8
240 minute	1.0	3	2.0

*There was only one filter sample taken. The second filter is a projected value.

Table 3. Startup NOx Emission Rates for BNSF4373

Shutdown Period	NOx First 10 Minutes	Projected NOx After the First 10 Minutes	Assumed Startup NOx Emissions (30 Minutes After Startup)
30 minute	65	59	183
60 minute	159	80	319
120 minute	287	180	647
240 minute	228	176	580

Table 4. Startup PM Emission Rates for BNSF4373

Shutdown Period	Maximum PM Filter	Number of Filters	Assumed Startup PM Emissions (30 Minutes After Startup)
30 minute	0.9	2	2.7
60 minute	2.9	2	8.7
120 minute	4.1	3	8.2
240 minute	5.6	3	11.2

Continuous Idling of Locomotives

Stabilized idle emission factors based on SwRI test data for UPY1378 and BNSF4373 were used to calculate emissions associated with continuous idling for the 30, 60, 120, and 240 minute time periods of locomotive shut down evaluated previously. In order to provide a fair comparison with emissions associated with startup of shutdown locomotives, idling durations were increased by 30 minutes to reflect the assumption that idling locomotives would idle for the 30 minutes over which the startup emissions are aggregated, as described previously. For example, the baseline NOx idle emission rate for UPY1378 is 605 grams per hour. Thus, for a locomotive shut down for 120 minutes and subsequently restarted, the corresponding NOx emissions from a locomotive idling for 120 minutes would be calculated as follows:

Idling emissions = (120 minutes / 60 minutes) * 605 g/hr = 1210 g
Startup adjustment = (30 minutes / 60 minutes) * 605 g/hr = 303 g
Total emissions = 1210 g + 303 g = 1513 g

Tables 5 and 6 show baseline idle emission factors based on SwRI testing, as well as NOx and PM estimates, for UPY1378 and BNSF4373, respectively.

Table 5. Continuous Idling Emissions for UPY1378

Shutdown Period	Baseline NOx Idle Emission Rate (g/hr)	Idle NOx Emissions (g)[1]	Baseline PM Idle Emission Rate (g/hr)	Idle PM Emissions (g)
30 minute	605	605	6.7	6.7
60 minute	605	908	6.7	10.1
120 minute	605	1513	6.7	16.8
240 minute	605	2723	6.7	30.2

[1] Idle NOx emissions are idle emissions for the shutdown period plus 30 minutes of startup emissions.

Table 6. Continuous Idling Emissions for BNSF4373

Shutdown Period	Baseline NOx Idle Emission Rate (g/hr)	Idle NOx Emissions (g)[1]	Baseline PM Idle Emission Rate (g/hr)	Idle PM Emissions (g)
30 minute	297	297	10.6	10.6
60 minute	297	446	10.6	15.9
120 minute	297	743	10.6	26.5
240 minute	297	1337	10.6	47.7

[1] Idle NOx emissions are idle emissions for the shutdown period plus 30 minutes of startup emissions.

Comparison

Figures 1 through 4 show emissions associated with the startup of UPY1378 and BNSF4372 following shutdown periods of 30, 60, 120, and 240 minutes, as compared with emissions associated with the continuous idling of these locomotives for the same time intervals plus an additional 30 minutes to compensate for the 30 minute period over startup emissions would be aggregated under the locomotive shutdown scenario.

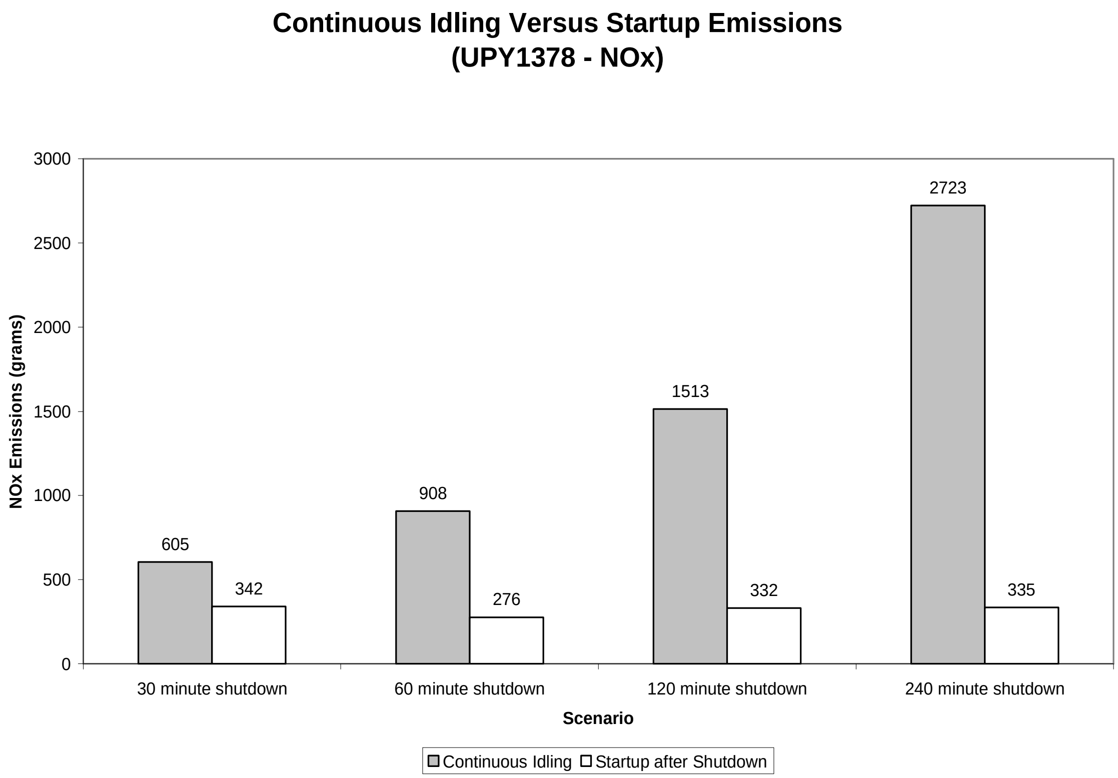

Figure 1. UPY1378 NOx Emissions

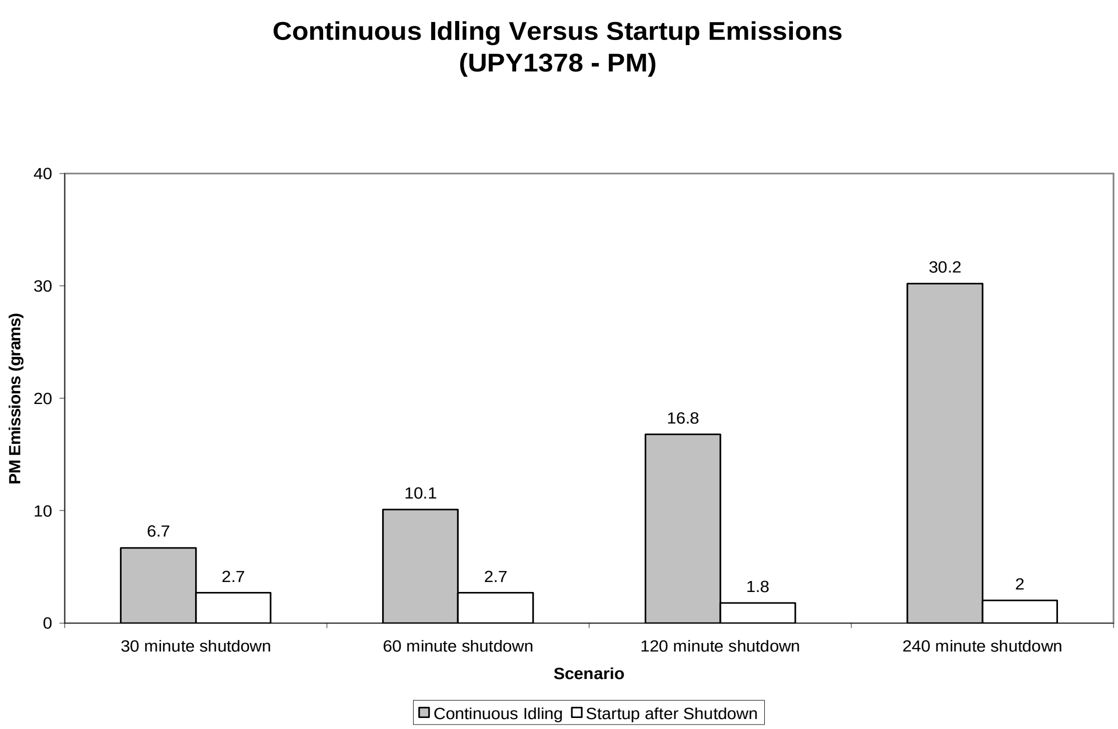

Figure 2. UPY 1378 PM Emissions

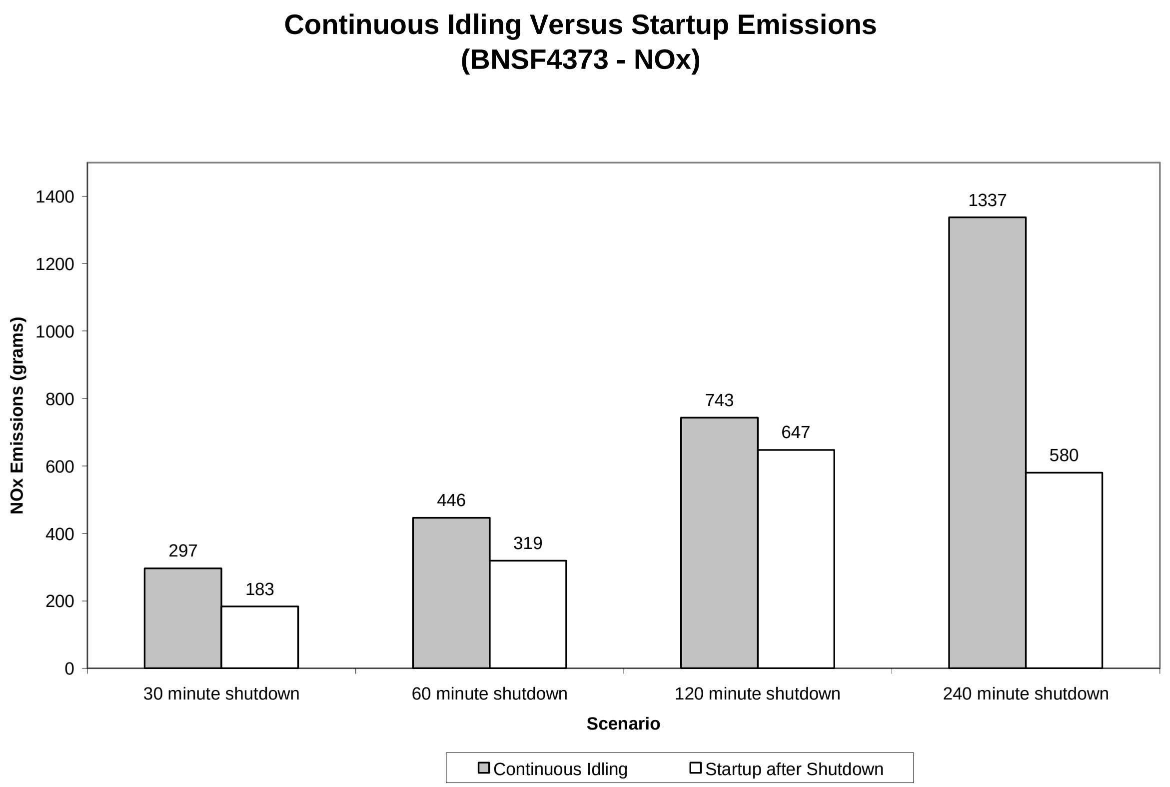

Figure 3. BNSF4373 NOx Emissions

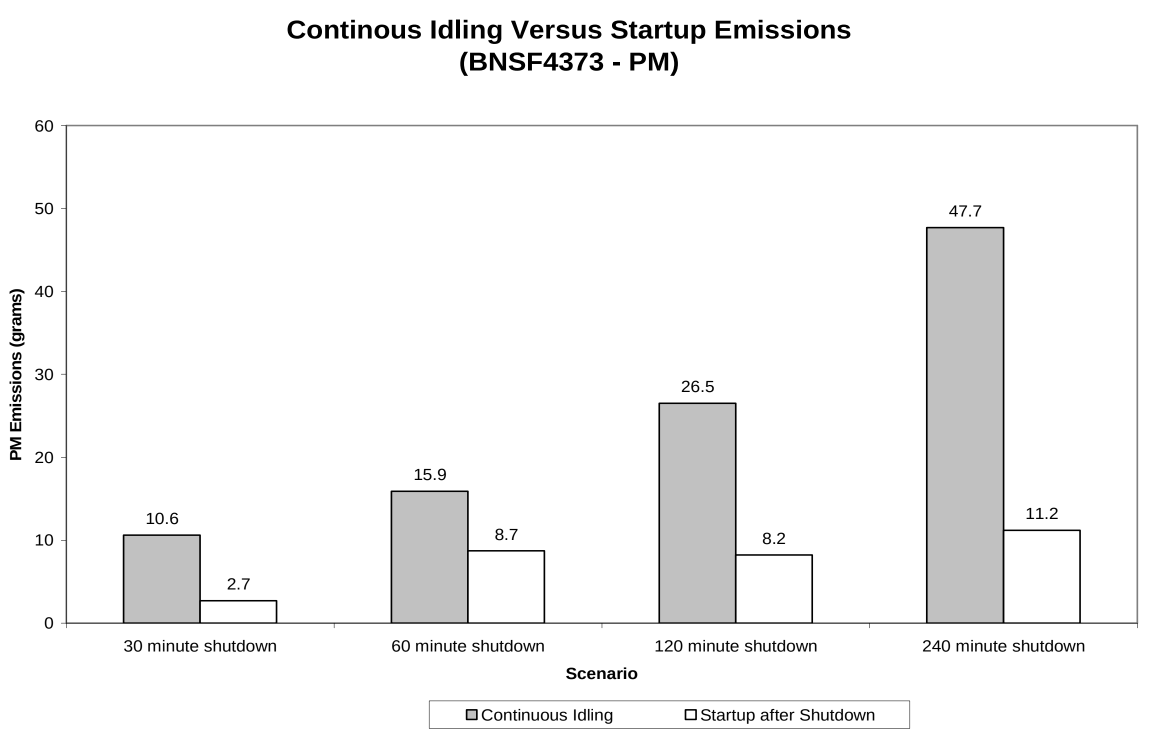

Figure 4. BNSF4373 PM Emissions

Data Analysis

The EMD locomotive and the GE locomotive both have automatic engine start stop systems (ZTR SmartStart for the EMD locomotive and GE Automatic Engine Start Stop (AESS) System for the GE locomotive) that were disengaged during the shutdown/restart emission testing. The GE locomotive had a computer control system to protect the locomotive engine and allows the engine to idle from a low speed to a higher speed if warranted by the computer control system. This system allowed the engine to operate in different programmed modes, based upon engine operating parameters to maintain engine operation, fuel consumption and protection.

During the emissions testing for the GE locomotive for the Restart Post 120- and 240-Minute Shutdown periods, there was changes of engine idle speed that ranged from 580 to 888 rpm. Representatives of General Electric (GE), the manufacturer of the locomotive, indicated that these changes are due to a software algorithm to protect the locomotive engine. This system is called the Engine Protection Algorithm (EnPA). An example of one engine protection strategy is one that requires the engine, when started to use the temperature reading of the engine oil (cold oil strategy). If the engine oil is below a pre-set temperature, the engine speed will be increased to a high speed to accelerate the heating of the oil. When the oil temperature reaches a pre-determined temperature, the engine speed will lower and will be reduced further to a lower speed when normal oil temperature is attained. The engine software will continue to measure other engine operating parameters and will adjust engine speed as indicated in the software algorithm.

This control strategy does contribute to higher mass emissions measured during the restart tests for the 120- and 240-minute shutdowns, since the speed of the engine did increase to correspond to the EnPA oil temperature and high speed parameters.

The testing sequence for both locomotives consisted of a standard FTP warm up which allows the engine to reach normal operating parameters, i.e., the engine is warmed and ready to work, followed by the baseline idle test, 15 minute shutdown and restart test, 30 minute shutdown, and restart testing, etc. Each test mode the engine operated 30 minutes before the engine was shut off for the next timed period of shutdown prior testing for restart. The shutdown periods, after standard FTP warm up, began with the shortest period of shutdown time, 15 minutes then tests were run consecutively for a 30 minute shutdown, 60 minute shutdown, a 120 minute shutdown, going out to 240 minutes. During the shutdown periods the engine oil temperature and water temperatures fell substantially in the 120 to 240 minutes shutdown periods. The engine therefore became cooler than it would have after a typical single shutdown. This situation will cause the later restart emission readings to be higher than what they may actually be over a locomotive that is operating in a warmed operating condition and then shutdown, i.e., similar to those operating after the 15, 30, and 60 minutes shutdowns, because the EnPA will require the engine to operate at higher speed upon restart to reach its programmed engine protection mode. It is fair to assume if the engine was allowed to reach specified warm temperatures prior to shutdown, the restart up emissions would have been lower because the engine would be warmer at startup with lower emissions and the EnPA that idle speed would have operated over a shorter period..

During this testing procedure with the GE locomotive the AESS was disengaged. After the testing was completed, it was learned that by disengaging the AESS, the EnPA was indirectly blocked. Based on information from GE, the AESS will auto start if one or more of the following conditions do not meet pre-set engine requirements:

- Ambient temperature
- Battery voltage
- Reservoir brake air pressure
- Pre-set time since last auto start

In addition, if the AESS is engaged, the locomotive would auto stop only if all of the following conditions meet pre-set engine requirements:

- Ambient temperature
- Lubrication oil temperature
- Battery charging
- Battery voltage
- Reservoir brake air pressure
- Number of auto stops within 24 hours

The temperature of the lubrication oil is a parameter measured by the EnPA. As shown above, the AESS restarts the engine if the auto start was not activated within a pre-set time period. During such a restart, the engine will not be auto stopped if the lubrication oil is too cool, a parameter that is associated with the EnPA. If the AESS was not disabled, the locomotive would have restarted and would not have shutdown until the lubrication oil reached a minimum temperature. The reasons for the pre-set time auto start is to ensure the engine to maintain a specified engine oil temperature for immediate engine operation and if the temperature is already within the specified temperature range, the engine will be automatically be shutdown again. As previously discussed, the high engine speeds at the 120- and 240-minute shutdowns were due to the low oil temperature and the EnPA activating at the startup to rapidly heat the engine oil.

The test data measuring idle speed during the 4-hour idle time shows this phenomenon. Under normal operating conditions where the AESS would have been engaged and the EnPA not been interrupted, the engine would invariably never reach the actual conditions during testing for the 120- and 240-minute shutdown tests, i.e., low engine oil temperature mandated the EnPA to operate at high speed and therefore, produce higher emissions.

Additionally, there is a “skip fire” idling sequence used by GE which allows the engine to disable certain fuel injectors and skip the operating fuel injectors around the engine to different cylinders. This strategy allows higher fuel flow through the operating injectors, improves combustion, and reduces idle fuel consumption. This function is separate from EnPA. Skip fire accounts for the GE locomotive operating in the low 300 rpm range for the Post 30 Minute Shutdown Restart test. The low emissions from that startup reflect both the lower skip fire idle speed and the warm engine temperature which is very close to the standard FTP conditions.

RESULTS AND CONCLUSIONS

The results from the SwRI and EF&EE locomotive tests show that there is an increase in emissions from a locomotive startup after a ½-, 1-, 2- and 4-hour shutdown periods exhibited a spike in emissions for a period of less than 3 minutes, in most cases the spike lasted less than 15 seconds, at the beginning of the test, thereafter, the emission rates moved to levels that would be exhibited by a stabilized idling situation.

Based on conclusions from EF&EE, one can ascertain that not idling a locomotive engine for greater than 8 minutes would produce an air quality benefit even considering the emissions resulting from a startup. Based on this data, idle shutdown periods longer than about eight minutes, followed by a startup-idle event, result in reduced emissions; the longer the shutdown, the more substantial the emission benefits based upon the idle emission rates. The data was evaluated to estimate the amount of time locomotives can idle before generating emissions equivalent to a startup event. In general, the test results exhibited a trend of emissions during startup increasing sharply for a short duration, and then lowering from slightly elevated levels above idle to stabilized idle levels over approximately 30 minutes.

Conservatively, the emissions data shows that emissions due to startup in relationship to stabilized idling mode are very low (i.e., startup emissions would contribute very little to the overall emission when compared with stabilized idling). Therefore, a benefit to air quality would be had with the locomotive shut down and not idling for a period exceeding 8 minutes, and combined with a startup whenever needed for operational necessities.

Using the data from the SwRI report shows in a total emissions standpoint, the same conclusion as the EF&EE report, that an air quality benefit will occur with shutdown and restart as opposed to continuously idling a locomotive.

The continuous idling emissions of NOx and PM in the SwRI Report were greater than startup emissions following each shutdown period for both locomotives, except for GE shutdown periods of about 15 minutes or less. As discussed in the SwRI Report titled “Locomotive Exhaust Idle and Start-up Emissions Testing” the 15 minute shutdown period is envisioned to be a non-typical operating cycle for the AESS. If the locomotive is occupied and the engineer anticipates moving the locomotive then it is assumed the operator would override the AESS system. If the locomotive is not occupied, the pre-test data showed that the locomotive would be shutdown for 90 minute increments based on the AESS setting. Even with disengaging the GE AESS for the BNSF4373 locomotive, the above test scenarios still show that an air quality benefit will occur with shutdown and restart as opposed to continuously idling a locomotive.

In addition, regarding the GE AESS system, when BNSF 4373 was first delivered and parked, it auto started and auto stopped approximately every 90 minutes and then had an extended idle of about 8 hours until finally shutting down again (Figure 5). It appears this extended idle reflected a conflict between the auto start and auto stop criteria. Because the auto start essentially forced a restart every 90 minutes, 8 auto stops had occurred in less than 24 hours not allowing a further auto stop until the end of the 24 hour cycle. The locomotive apparently needed to idle until enough time passed to meet the criteria of less than 8 auto stops per 24 hours, and then it shutdown. It appears that the emissions during the 7-hour extended idle were excessive and unnecessary. If the auto start were set to the optional 210-minute auto start criteria, the excessive idle condition would not have occurred and fuel consumption and emissions would have been reduced. This scenario should not occur under the proposed rules as the definition of anti-idling device is that the locomotive would "automatically restart the engine when parameters are no longer at acceptable levels." This definition does not allow restarting to check parameters. Thus, the anti-idling device should check parameters before instead of as compared to the restarting the locomotive then checking specified parameters.

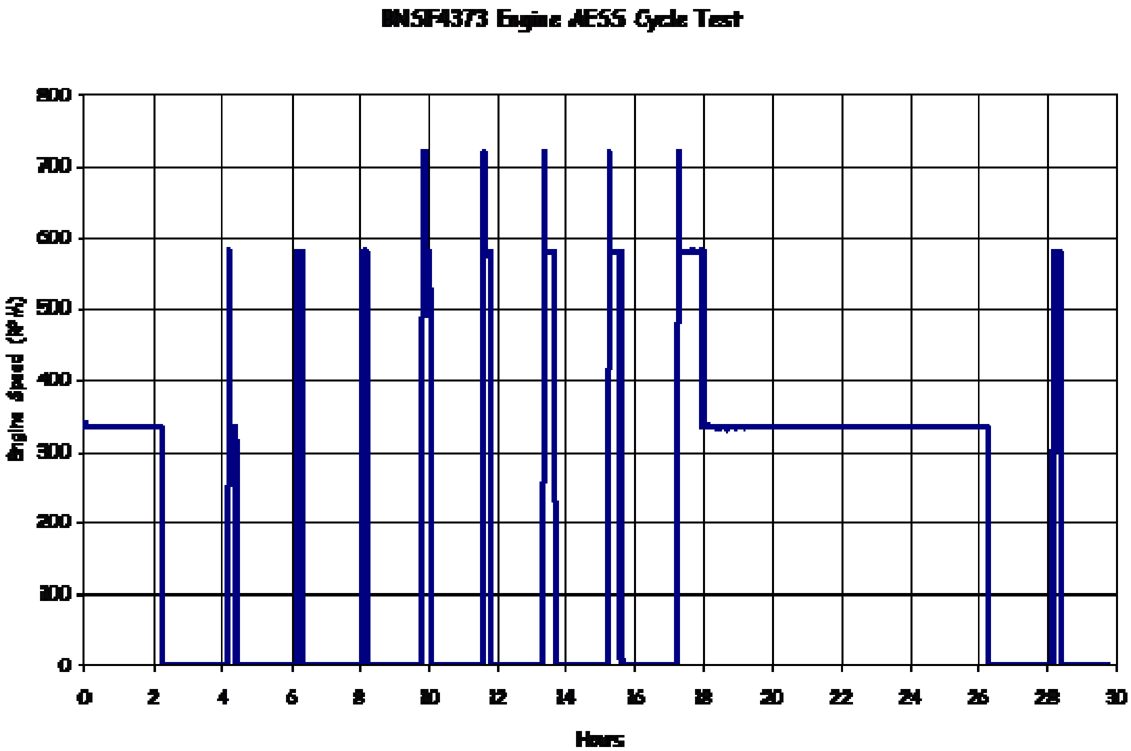

Figure 5 – Engine Speed During 29-hour Pre-test of BNSF 4373

Appendix A to this attachment consists of data from the SwRI Final Report, addressing the BNSF and UP locomotive testing. Appendix B consists of the EF&EE Final Report.

~~RESULTS~~

~~The results from the SwRI and EF&EE locomotive tests show that there is an increase in emissions from a locomotive start-up after a ½-, 1-, 2- and 4-hour shut down periods exhibited a spike in emissions for a period of less than 3 minutes, in most cases the spike lasted less than 15 seconds, at the beginning of the test, thereafter, the emission rates moved to levels that would be exhibited by a stabilized idling situation. Based on results from EF&EE, one can ascertain that not idling a locomotive engine for greater than 8 minutes would produce an air quality benefit even considering the emissions resulting from a start-up. Based on this data, idle shutdown periods longer than about eight minutes, followed by a start-up idle event, result in reduced emissions; the longer the shutdown, the more substantial the emission benefits based upon the idle emission rates. The data was evaluated to estimate the amount of time locomotives can idle~~

~~before generating emissions equivalent to a start-up event. In general, the test results exhibited a trend of emissions during start-up increasing sharply for a short duration, and then lowering from slightly elevated levels above idle to stabilized idle levels over approximately 30 minutes. Conservatively, the emissions data shows that emissions due to start-up in relationship to stabilized idling mode are very low (i.e., start-up emissions would contribute very little to the overall emission when compared with stabilized idling). Therefore, a benefit to air quality would be had with the locomotive shut down and not idling for a period exceeding 8 minutes, and combined with a start-up whenever needed for operational necessities.~~

~~Appendix A to this attachment consists of data from the SwRI interim staff report, addressing the BNSF and UP locomotive testing. Appendix B consists of the EF&EE draft final report.~~

APPENDIX A

S O U T H W E S T   R E S E A R C H   I N S T I T U T E ®
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ENGINE, EMISSIONS, AND VEHICLE RESEARCH DIVISION
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ISO 9001 CERTIFIED
ISO 14001 CERTIFIED

January 25, 2006

TO: South Coast Air Quality Management District
21865 Copley Drive
Diamond Bar, California 91765

ATTN: Mr. Michael Bogdanoff

SUBJECT: SwRI® Project No. 03-11806, titled "Locomotive Exhaust Idle and Start-Up Emissions Testing" Final Report

This final report covers Southwest Research Institute's (SwRI) "Locomotive Exhaust Idle and Start-Up Emissions Testing" for South Coast Air Quality Management District's (SCAQMD). This report documents results from the two locomotives tested under this project during November and December 2005.

The body of this report covers:

- Test locomotives
- In-bound inspection
- Test plan
- Instrumentation
- Fuel system
- Test fuel
- Results
- Conclusions

Each of these topics will be covered in the following sections.

Test Locomotives

The first locomotive tested was UPY1378, which is an EMD MP15DC locomotive, and was equipped with a 12-cylinder 645E engine rated at 1500 horsepower. This locomotive is known as a shunter or yard switcher and is not typically used for line haul applications. The locomotive was recently rebuilt and fitted with a ZTR automatic engine start stop system. A photo of the locomotive, at Southwest Research Institute's (SwRI's) Locomotive Technology Center (LTC), can be seen in Figure 1.

Figure 1. UPY1378

The second locomotive tested was BNSF4373 which was a GE Dash9-44CW. It was originally manufactured in March 1999 and was recently rebuilt into a Tier-0 configuration. This locomotive has a 16-cylinder engine, produces 4,400 horsepower and is considered a line-haul locomotive. This locomotive was equipped with a GE Automatic Engine Start Stop (AESS) System. Figure 2 shows the front view of BNSF4373.

Figure 2. BNSF4373

In-Bound Inspection

Upon receipt of the locomotive, SwRI inspected and logged the following components:

1. Document the cylinder head part and serial numbers for the EMD locomotive and the Power Assembly (PA) part number and serial numbers for the GE locomotive.

2. Document locomotive injector part and serial numbers for the EMD engine and the jerk pump part and serial numbers for the GE engine.

3. Document governor part number, UTEX number, and serial number for the EMD engine and the numbers stamped on the numbers printed on the body of the GE engine controller known as the EGU.

4. Document blower part and serial numbers on the roots blown EMD and the part and serial numbers on the GE turbocharger.

These items are provided in Appendix A for UPY1378 and in Appendix B for BNSF4373.

Test Plan/Test Sequence

Testing of both the UPY1378 and BNSF4373 was completed in three days for each locomotive. The first test day studied the affects of restarting the locomotive engine on emissions. The second day was used to investigate the affect of four hours idling, followed by a transition to Notch 3. The third day was used to repeat a number of these tests to acquire PM emission samples on a SCAQMD provided quartz filter media. These filters were then shipped to SCAQMD for EC/OC analysis.

The test sequence for the Day 1 restart portion of the testing is shown in Figure 3. The test sequence allowed for emissions sampling during the initial start and warm up of the engine, which overall resulted in a 12 hour test day. As shown in the Figure 3, the shutdown and start-up sequence for each of the scenarios was conducted consecutively. There was no warming of the locomotive between each test. For example, the engine was shutdown for 60 minutes, restarted and idled for the test, the engine was shutdown for 120 minutes and restarted and idled for testing, and the engine was shutdown for 240 minutes and restarted and idled again. The engine was never loaded after the baseline emissions test was started.

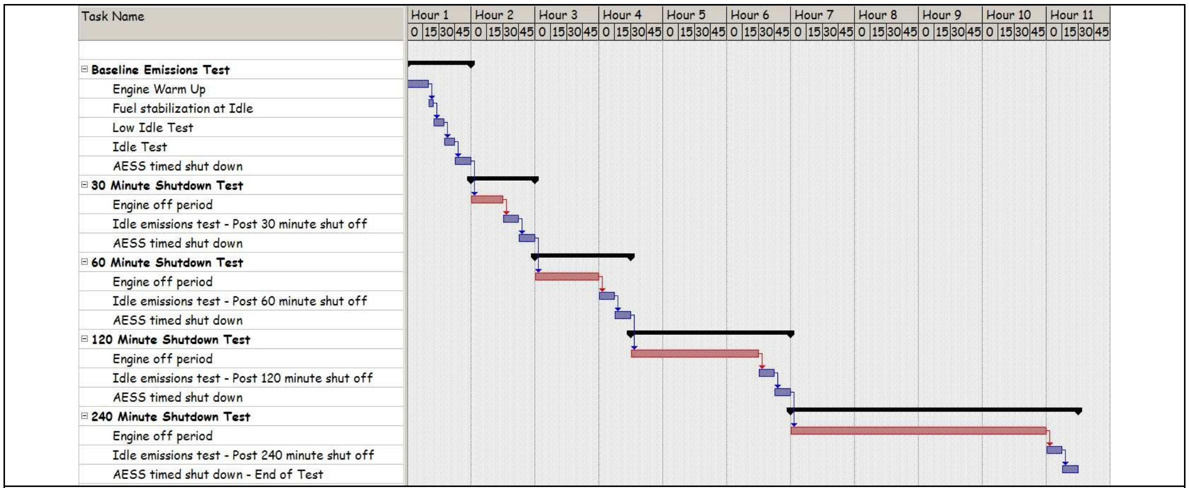

Figure 3. Day 1 Test Time Line

Day 2 of testing began with a start of the engines, after the engine had been shutoff overnight. After the engine was started (with the ZTR SmartStart system or the GE AESS System disabled), the engine was allowed to idle continuously for 4 hours. Over the four hours of idle, emissions data was acquired every 30 minutes. At the end of the 4 hours of idling, the engine was transitioned to Notch 3 (loaded) and emissions were measured during the transition. The two test days can be seen in sequence, along with test numbers used to track the emission test, in Table 1. During this testing, fuel flow rate, fuel and intake air temperature, ambient temperature, water jacket temperature and oil sump temperature were measured. In addition, hydrocarbon, NOx, CO_2 and CO concentrations were recorded to calculate emissions during testing. Details of the results are in included in Appendix C.

TABLE 1. TEST SEQUENCE FOR DAYS 1 & 2

Test Condition	UPY1378 Test Number	BNSF4373 Test Number
Test Day 1		
Initial Start	T1	T-20
Baseline test simulating FTP	T2	T-21
Restart post 15 minute shutdown	(A)	T-22
Restart post 30 minute shutdown	T3	T-23
Restart post 60 minute shutdown	T4	T-24
Restart post 120 minute shutdown	T5	T-25
Restart post 240 minute shutdown	T6	T-26

Test Day 2		
Initial start	T7	T-27
30 minute of idle	T8	T-28
60 minute of idle	T9	T-29
90 minute of idle	T10	T-30
120 minute of idle	T11	T-31
150 minute of idle	T12	T-32
180 minute of idle	T13	T-33
210 minute of idle	T14	T-34
240 minute of idle	T15	T-35
Transition to notch 3	T16	T-36

(A) Initial test plan did not call for this test point but was added for BNSF4373 test.

Instrumentation

After the inbound inspection was completed the locomotive was installed on the test track and instrumented. The low speed data that was acquired for this test included:

- Jacket water temperature
- Oil Sump temperature
- Fuel flow rate (Average over the test point)
- Engine speed
- Ambient temperature at the start of the test
- Barometer
- Relative humidity or wet bulb temperature
- Rack position (EMD)

Emissions that were acquired for each of the test points included:

- Oxides of nitrogen (NO_X) (PPM)
- Carbon monoxide (CO) (PPM)
- Carbon dioxide (CO_2) (%)
- Oxygen (O_2) (%)
- Hydrocarbons (HC) (PPMC)
- Particulate (mg)

Gaseous emissions from the multi-stack EMD locomotive were sampled within an exhaust manifold collection system installed above the roof of the locomotive, as shown in Figure 4 for the roots blown engine in UPY1378. A heated line transferred the raw exhaust sample to the emission instruments for analysis. Hydrocarbon concentrations in the raw exhaust were determined using a heated flame ionization detector (HFID), calibrated on propane. NO_X concentrations in the exhaust were measured with a chemiluminescence analyzer. NO_X correction factors for ambient air humidity are applied as specified by EPA in 40 CFR

§86.132(d). Concentrations of CO and CO_2 in the raw exhaust were determined by non-dispersive infrared (NDIR) instruments.

Figure 4. Exhaust Manifold Collection System For Emissions Sampling on UPY1378

Particulate emissions were measured at each test point using a "split then dilute" technique, in which a portion of the raw locomotive exhaust is "split" from the total flow and mixed with filtered air in a 10-inch diameter dilution tunnel. The split sample is transferred to the dilution tunnel through a 2-inch diameter stainless steel tube that is insulated and electrically heated to 375°F.

A particulate sample was extracted from the dilute exhaust stream within the dilution tunnel. Particulates were accumulated on 90 mm fluorocarbon-coated glass fiber filters (Pallflex T60A20) at a target filter face velocity of 70 cm/s. The filters were mounted in stainless steel filter holders and connected to the dilution tunnel. Particulate filters were preconditioned and weighed before and after testing, following the FTP. The particulate mass emission rate were computed using the increase of mass on the filters, the volume of dilute exhaust drawn through the filters, and dilution air and raw exhaust flow parameters.

The emissions data acquisition system for these tests was based on an Agilent Technologies HP34970A, controlled by Agilent BenchLink Data Logger software. This software allows the HP34970A to export the emissions analyzer output data in a CSV file format for post processing of the emission data. The sample rate for the emissions data acquisition system was approximately 2 Hz.

Calibration of the HP34970A and the emissions cart output voltages was completed over a 6 point curve. This allow for conversion of the acquired emissions analyzer output voltage signal to a PPM value. The PPM values were later the used to post calculate emissions mass flow rates.

Fuel system

Fuel flow measurements for the restart tests on UPY1378 utilized SwRI's standard fuel flow measurement system. The fuel system utilizes floats in the fuel system's day tank are used to modulate the flow rate, to maintain constant fuel level. Any make up fuel, needed to keep a constant level in the tank, is measured by the MicroMotion™ sensor.

The standard SwRI fuel flow system is design for an operating engine, tested over a typical FTP emissions test. However, the existing system was found to be poorly suited for these restart tests, due to the inertia of the system or lag between the engine operation and the response of the fuel flow measurement as shown in Figure 5. This lag in response also caused the fuel system to over-compensate in the measured flow rate, once the system did respond. This caused the instantaneous fuel flow measurements for the restart tests to be inaccurate.

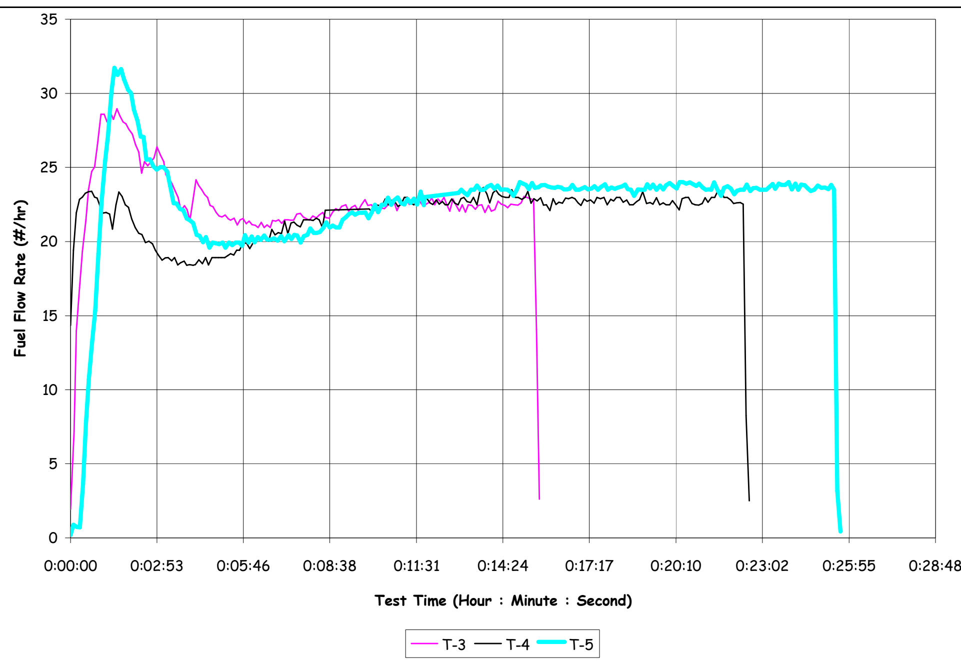

Figure 5. Fuel System Response To Engine Start-up Using a Day Tank Reservoir

To correct the instantaneous fuel flow measurements on UPY1378, the fuel flow rate was calculated by using the measured rack position. Rack position was measured during all tests at a sample rate of 1 sample per 6 seconds; a rack position measurement was available over the entire test sequence. Figure 6 was generated to define at the relationship between the rack position and fuel flow for the steady state data sets taken during the 6 tests on the first day of testing. With a correlation factor (R^2) value of 0.955, the calculated linear relationship between rack and fuel flow was used to calculate the start sequence instantaneous fuel rate shown in Figure 7.

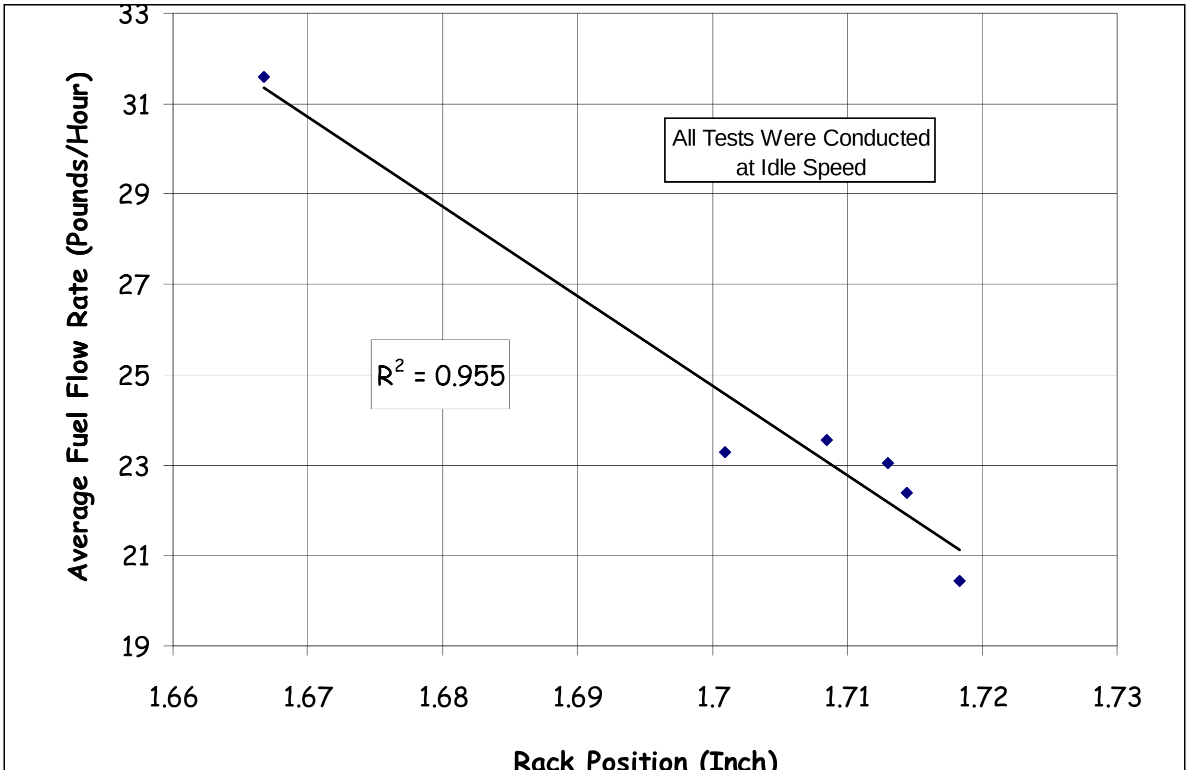

Figure 6. Correlation Between Rack Position and Fuel Flow Rate at Idle Engine Speed

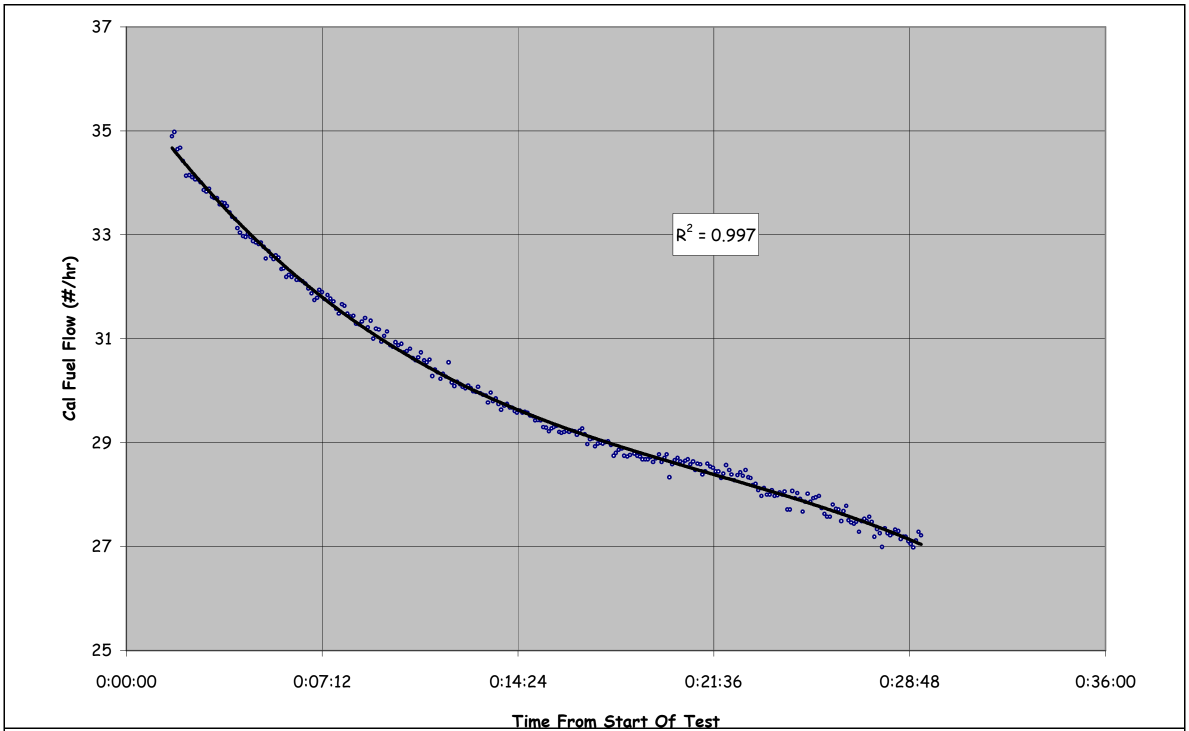

Figure 7. An Example of Calculated Fuel Flow Rate Based on Rack Position

Figure 8 shows the fuel flow rate for the first restart test after the fuel flow rate was further corrected for engine speed. These steps were repeated to calculate the fuel flow rate for all of the restart tests and applied to the emissions calculations.

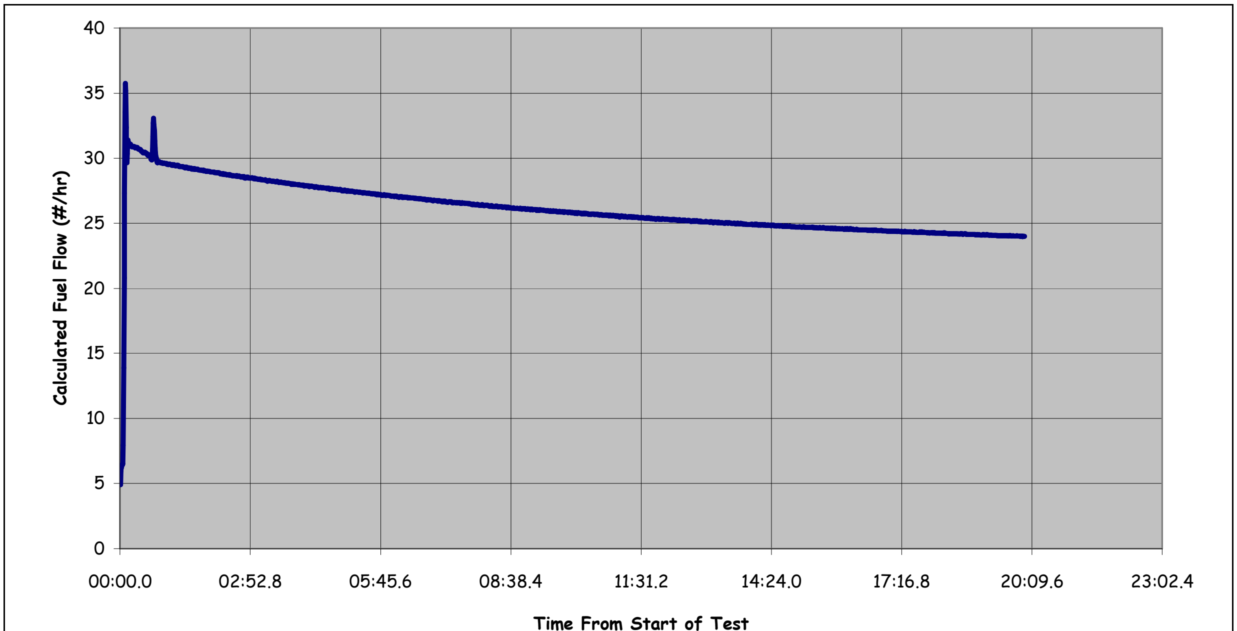

Figure 8. UPY1378 Calculated Fuel Flow Rate With Engine Speed Correction

Because of the issues of instantaneous fuel flow measurements on UPY1378, a load cell and hanging barrel system were used to measure the fuel flow on BNSF4373. This allowed for a direct mass change calculation, via the HP34970A DAQ system that was used to measure the gaseous emissions.

Test Fuel

Diesel fuel used in locomotives in the U.S. is currently not regulated by EPA or CARB. However, EPA regulations for diesel fuel used in non-road engines, including locomotives, will begin on June 1, 2007. EPA is requiring non-road diesel fuel to have less than 500 ppm sulfur, have a Cetane index greater than 40 and have an aromatic content less than 35 percent. In June, 2010, the maximum sulfur allowed for non-road engines is reduced to 15 ppm, except for fuel used locomotives. Locomotive fuel sulfur is reduced to 15 ppm in June, 2012.

In California, the Air Resources Board (CARB) recently passed regulatory amendments extending the California standards for motor vehicle diesel fuel to include diesel fuel used in harbor craft and intrastate locomotives, requiring CARB diesel for intrastate locomotives starting in Jan. 1, 2007. [30] CARB diesel fuel regulations wal1 require < 15 ppm Sulfur, < 10% aromatics, and a minimum Lubricity standard.[31] The CARB diesel fuel regulations apply to intrastate locomotives used in freight, passenger, commuter, regional, short-line, switch, industrial, terminal and port operations.

California will require the railroads to use CARB Diesel. The CARB Diesel is a high quality fuel with a high cetane number, low sulfur, and low aromatics. The high cetane number aspect of the fuel was especially important because the high cetane number fuel allows for good cold start ability of the engine. For these tests, SwRI used a Valero supplied diesel fuel called Texas Low Emissions Diesel (TxLED) that met CARB requirements for aromatic and content, and low sulfur level content requirements. Table 2 shows a typical fuel analysis for the Valero TxLED fuel, and also gives select properties for the specific batch of fuel used for testing UPY1378 and BNSF4373.

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[30] CARB Resolution 04-38 (November 18, 2004), http://www.arb.ca.gov/regact/carblohc/res0438.pdf

[31] California Code of Regulations, Title 13, §2281-§2285.

Table 2. Typical Analysis Result for the Valero TxLED Fuel

Property	Unit	ASTM	Typical	Test Fuel
SwRI Fuel Code			EM-5347-F	
Cetane Number		D613-84	55.6	
Cetane Index		D-4737		
Cetane Index		D-976		
Aromatic Content	mass %	D5186-96	1.7	6.64
Mono Aromatics	mass %	D5186-96	1.5	5.86
PNA Content	mass %	D5186-96	0.1	0.77
Sulfur Content	ppmw	D5453-93	< 5	2.3
Nitrogen	ppmw	D4629-96	3	
API Gravity [1]		D287-82	39.1	
Kinematic Viscosity @ 40°C	cSt	D445-83	3.0	
Flash Point	°F	D93-80	202	
Initial Boiling Point	°F	D86-96	429	
T10	°F	D86-96	454	
T50	°F	D86-96	507	
T90	°F	D86-96	577	
Final Boiling Point	°F	D86-96	615	
% H		D-5292	14.20	
% C		D-5292	85.50	
Calculated H/C			1.98	
specific gravity		D-4052	0.8353	
Heating Value, gross (HHV)	BTU/lb	D240	19,966	
Heating Value, net (LHV)	BTU/lb	D240	18,671	
density, lb/gal	lb/gal		6.97	
Fuel Energy Content - HHV	BTU/gal		139,184	
Fuel Energy Content - LHV	BTU/gal		130,153	

Results for Tests on UPY1378

Test "T2" utilized a standard FTP warm up and performance and emissions test at the idle condition. This test is the baseline for comparison for all of the other tests on this locomotive. The results of this test are:

- NO_X (Corrected) = 605.4 g/hr
- CO = 138.8 g/hr
- HC = 130.8 g/hr
- PM = 6.7 g/hr

For the restart tests (tests T3 through T6), the measured exhaust emission were post processed to calculate mass emissions flow rates. The results can be seen in Figures 10 through 13, for tests 3 through 6 respectfully. The NO_X emissions shown in these graphs have are corrected for atmospheric humidity per 40 CFR Part 92 requirements.

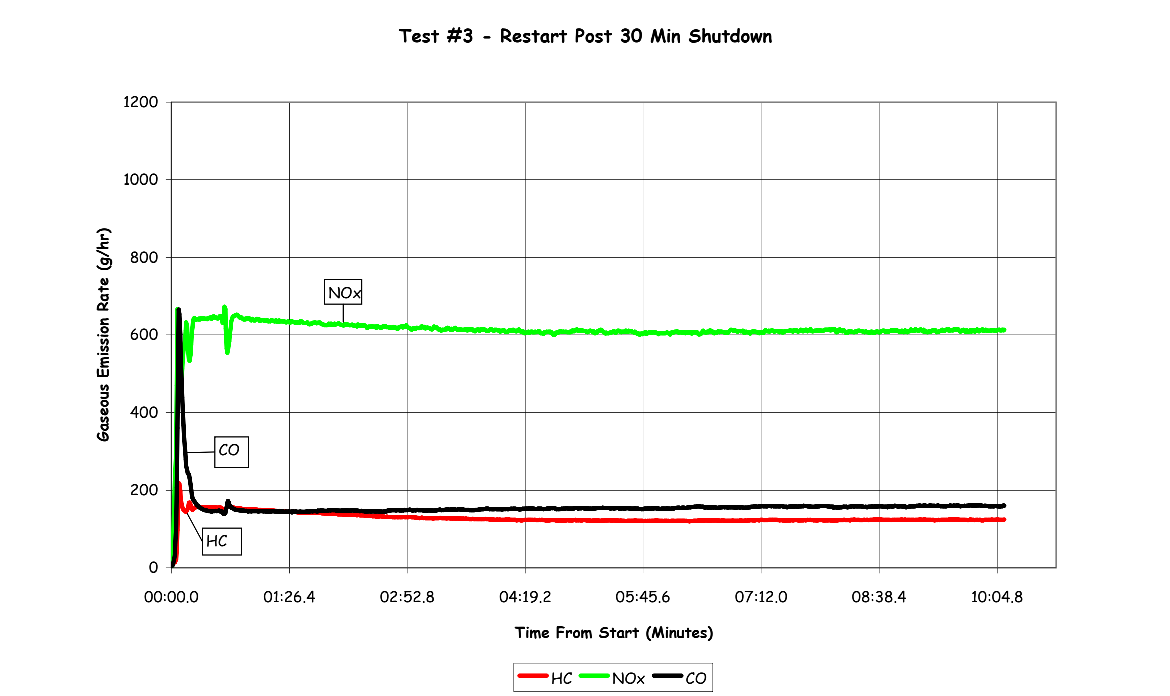

Figure 10. Test 3 Emissions Mass Flow Rates for UPY1378

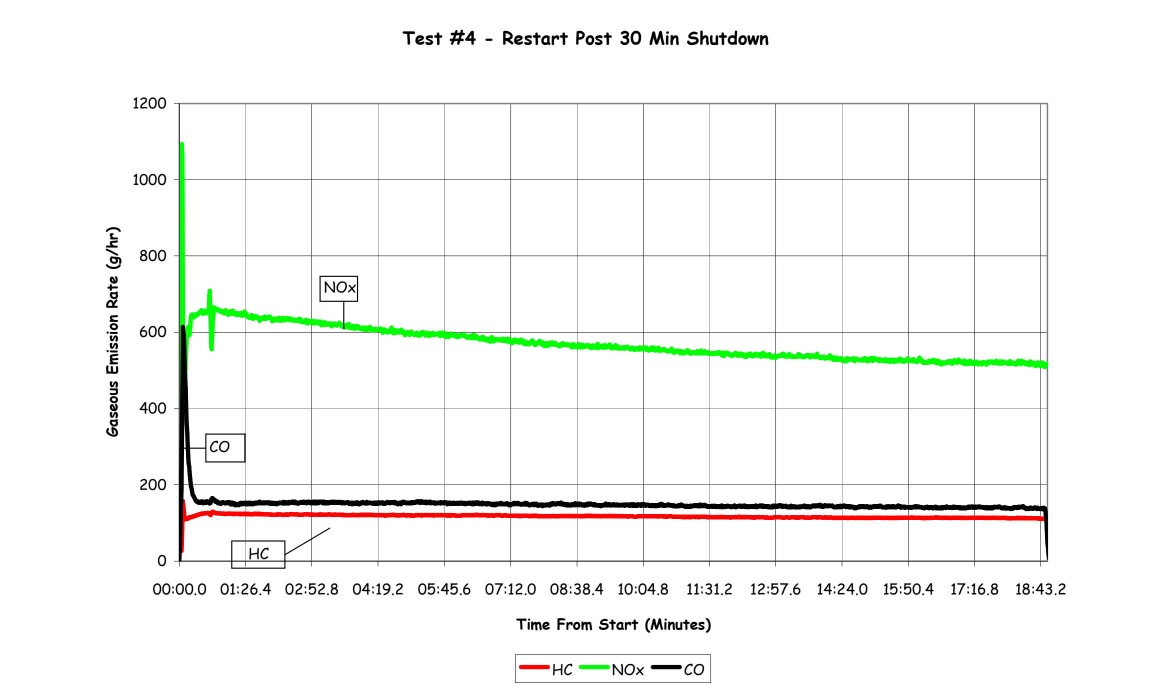

Figure 11. Test 4 Emissions Mass Flow Rates for UPY1378

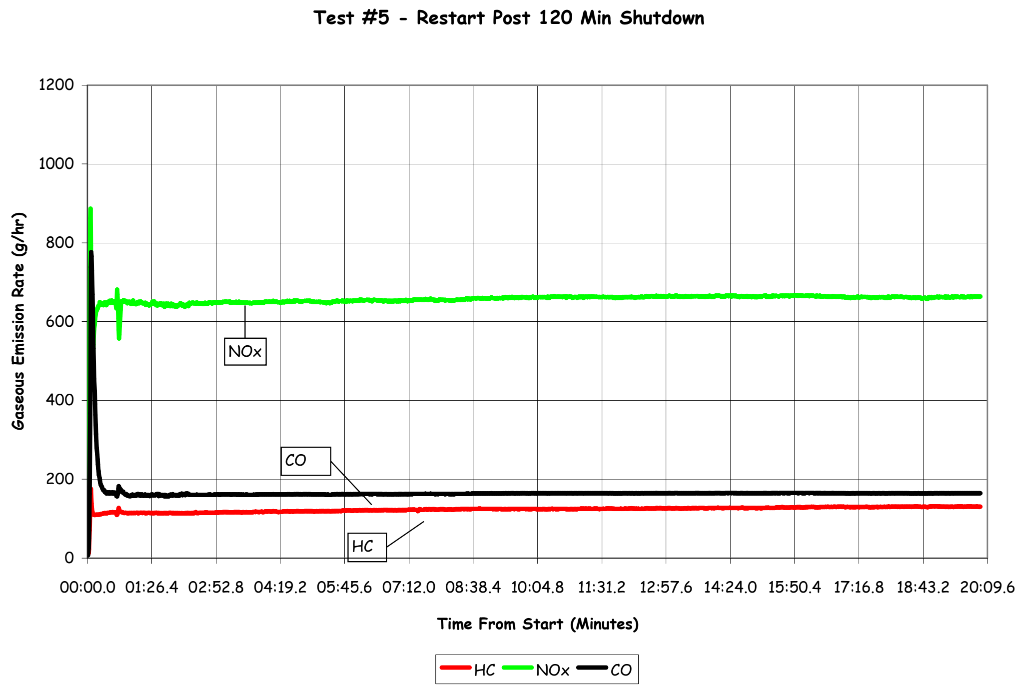

Figure 12. Test 5 Emissions Mass Flow Rates for UPY1378

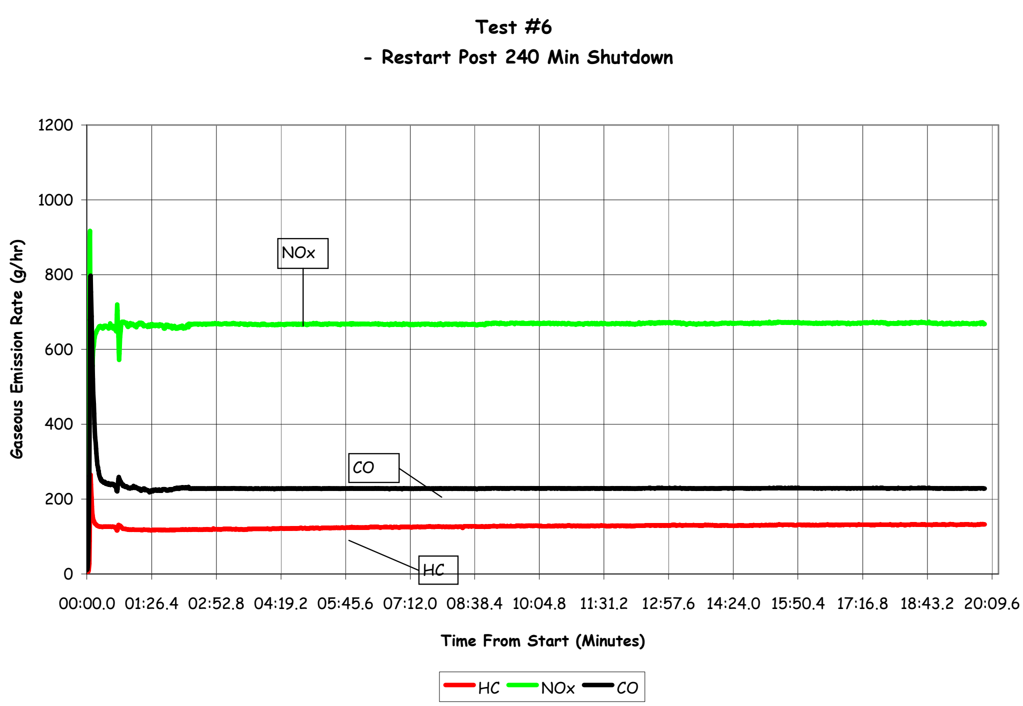

Figure 13. Test 6 Emissions Mass Flow Rates for UPY1378

The instantaneous emissions mass flow rates, from tests 3 through 6, were then integrated over the test cycle. The outcomes of these results were compared to the baseline emissions test, assuming that baseline emissions rate would be constant while the engine was idling. The results of this work for NO_X emissions are shown in Figure 14. In general, the affect of restarting the engine is not an issue for the NO_X emissions from the engine. Figures 15 and 16 shows the trends for HC and CO emissions are the same as the NO_X emissions.

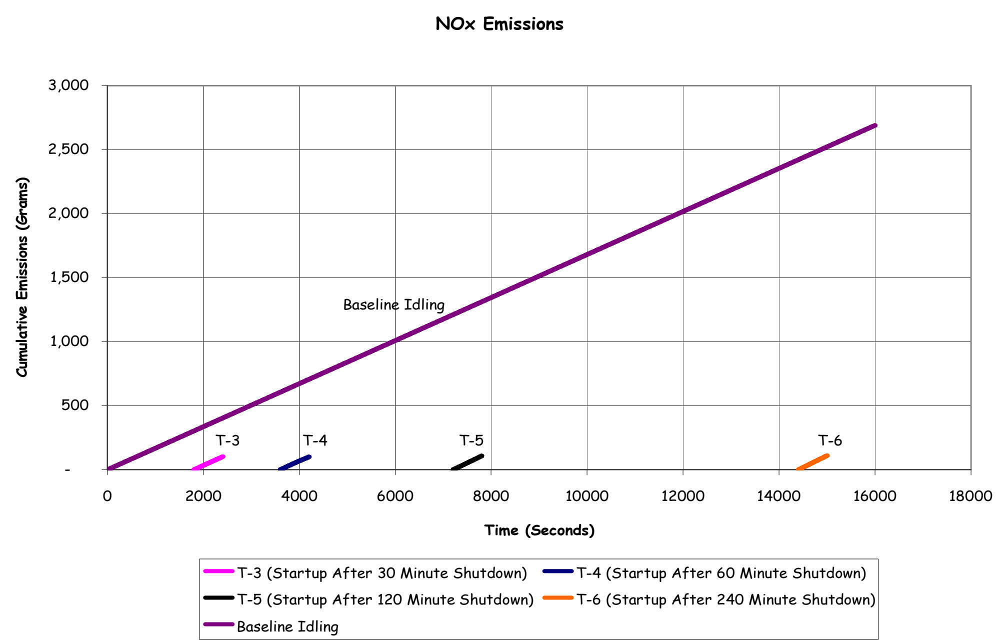

Figure 14. UPY1378 Cumulative NO_x Emission for UPY1378

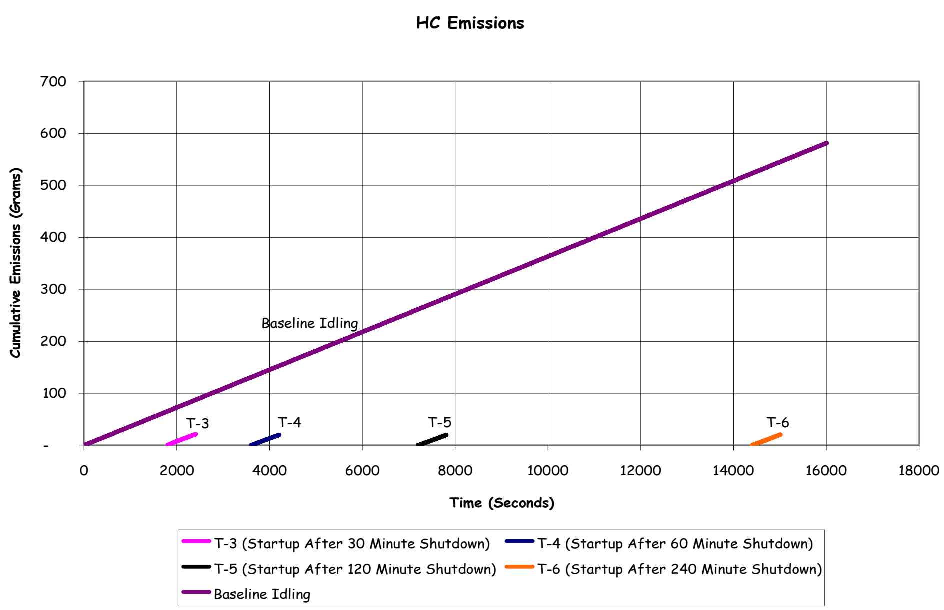

Figure 15. UPY1378 Cumulative HC Emission for UPY1378

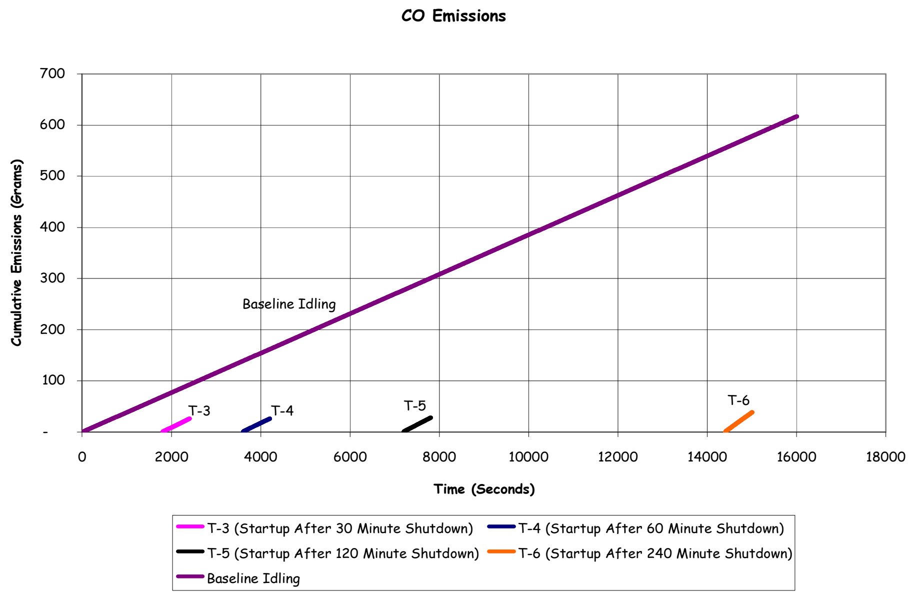

Figure 16. UPY1378 Cumulative CO Emission for UPY1378

PM emissions were also measured for each of the restarts. Some of the tests had multiple PM samples taken and were labeled Filters A, B and C. Each PM emissions sample was taken for 300 seconds, so the filter weights are an average over the 300 second sample period. The test description, test code, PM filter weight gain, and the PM emissions rate are all shown in Table 3.

Table 3. PM Emissions Results for Restart Tests on UPY1378

Condition of Test	Test Code	PM Emissions Filter A (g/hr)	PM Emissions Filter B (g/hr)	PM Emissions Filter C (g/hr)
Baseline = FTP conditions	T-2	6.7	(A)	(A)
Start-up post 30 minute shutdown	T-3	13.1	(A)	(A)
Start-up post 60 minute shutdown	T-4	13.2	7.8	(A)
Start-up post 120 minute shutdown	T-5	17.6	7.8	7.2
Start-up post 240 minute shutdown	T-6	19.3	7.1	8.0

(A) PM emissions not measured

These tests show that the PM emissions rate increased during the start-up of the engine compared to the standard idle PM emissions rate. However, the additional filters taken on Test 4 and Test 5 shows that the PM emissions rates returns to a level close to the baseline PM emissions rates after the initial filter is completed. This suggests that the start-up event PM emissions are somewhat higher, from the engine at a restart of the engine were somewhat higher than baseline, but quickly drops to a lower level shortly after the restart of the engine.

The test sequence and emissions results for the extended idle tests are given in Table 4. This table shows that the emissions rate over the 4 hours of idle after the start of the engine was relatively steady. However, the emissions rate during the transient from idle to Notch 3 at the end of the 4 hours of idle produced an extremely high PM emissions level, which decreased with time, but did not stabilize, over the three PM samples taken over a 15-minute period after the transient.

Table 4. Steady State Emissions Results from 4 Hour Idle Study on UPY1378

Test	Notch	Time (Minutes)	NOx (g/hr)	HC (g/hr)	CO (g/hr)	PM (g/hr)
7A	Idle	0				20
7B	Idle	5	554	132	294	9
7C	Idle	10				9
8	Idle	30	630	154	289	11
9	Idle	60	611	150	231	10
10	Idle	90	610	149	203	11
11	Idle	120	615	152	194	10
12	Idle	150	609	149	177	11
13	Idle	180	592	144	166	10
14	Idle	210	583	145	163	(A)
15	Idle	240	588	154	159	10
16A	3	250				433
16B	3	255	4751	705	310	209
16C	3	260				101

(A) = PM sample filter torn.

Results for Tests on BNSF4373

Test "T-21" utilized a standard FTP warm up and performance and emissions test at the idle condition. This test is the baseline for comparison for all of the other tests on BNSF4373. The results of this test are:

- NO_X (Corrected) = 296.6 g/hr
- CO = 29.1 g/hr
- HC = 30.6 g/hr
- PM = 10.6 g/hr

For the restart tests (tests T-22 through T-26), the measured exhaust emission were post processed to calculate mass emissions flow rates. The results can be seen in Figures 17 through 21, for tests 22 through 26 respectfully. The NO_X emissions shown in these graphs have are corrected for atmospheric humidity per 40 CFR Part 92 requirements. These graphs shows that the emissions out of the engine varies over the test period due to the changes in engine speed and various auxiliary loads of the locomotive are on and off. These are primarily the air compressor and various cooling fans.

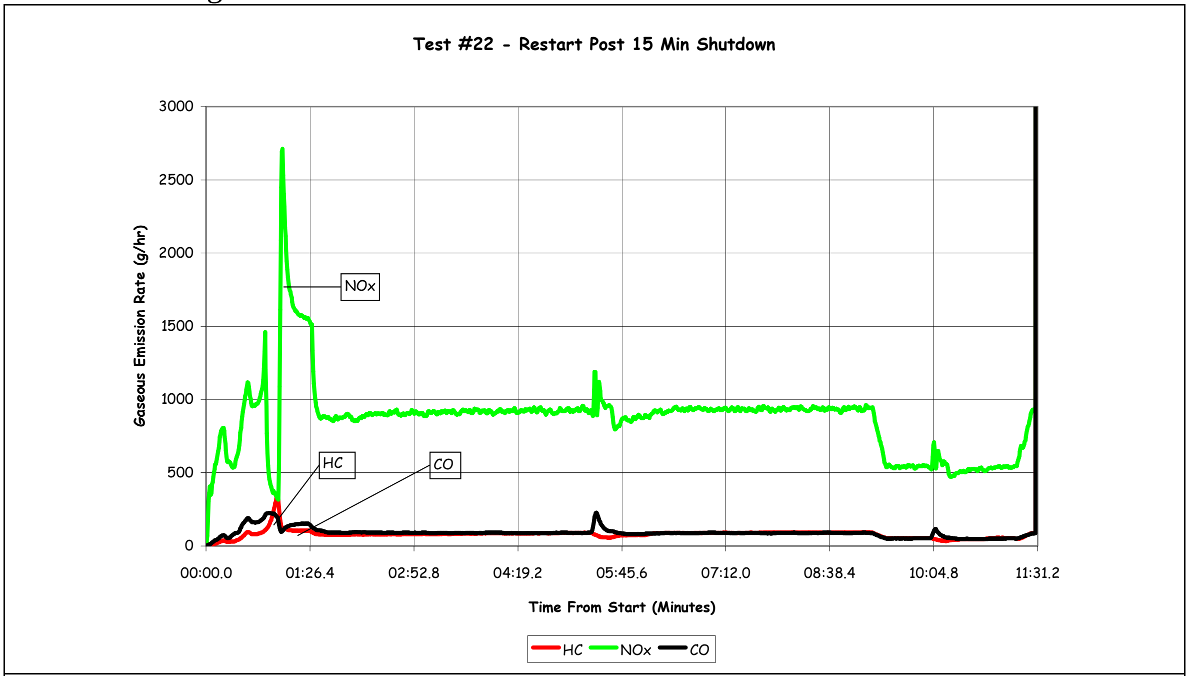

Figure 17. Test 22 Emissions Mass Flow Rates for BNSF4373

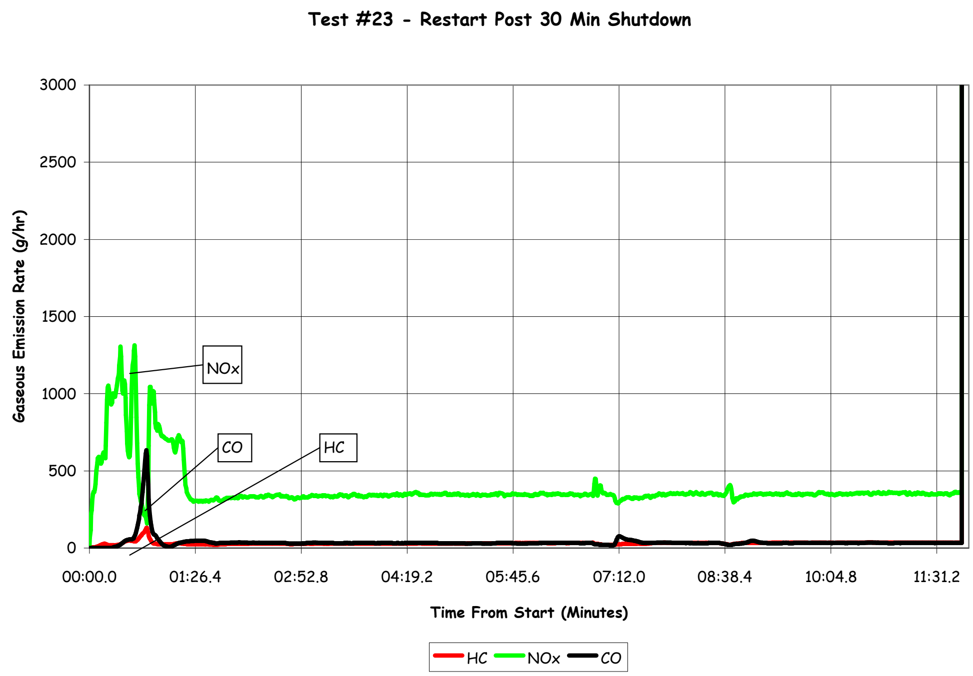

Figure 18. Test 23 Emissions Mass Flow Rates for BNSF4373

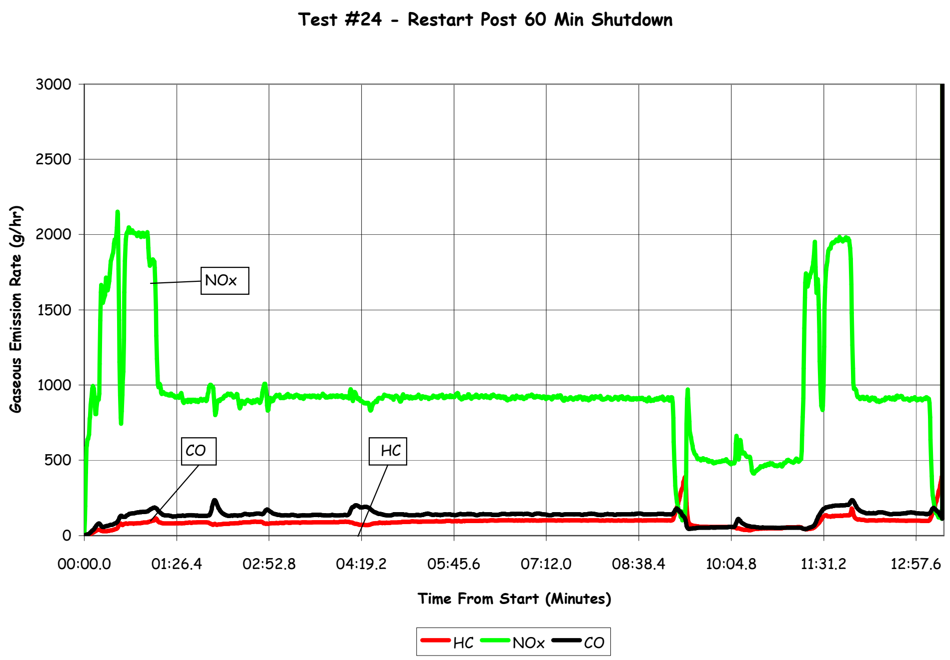

Figure 19. Test 24 Emissions Mass Flow Rates for BNSF4373

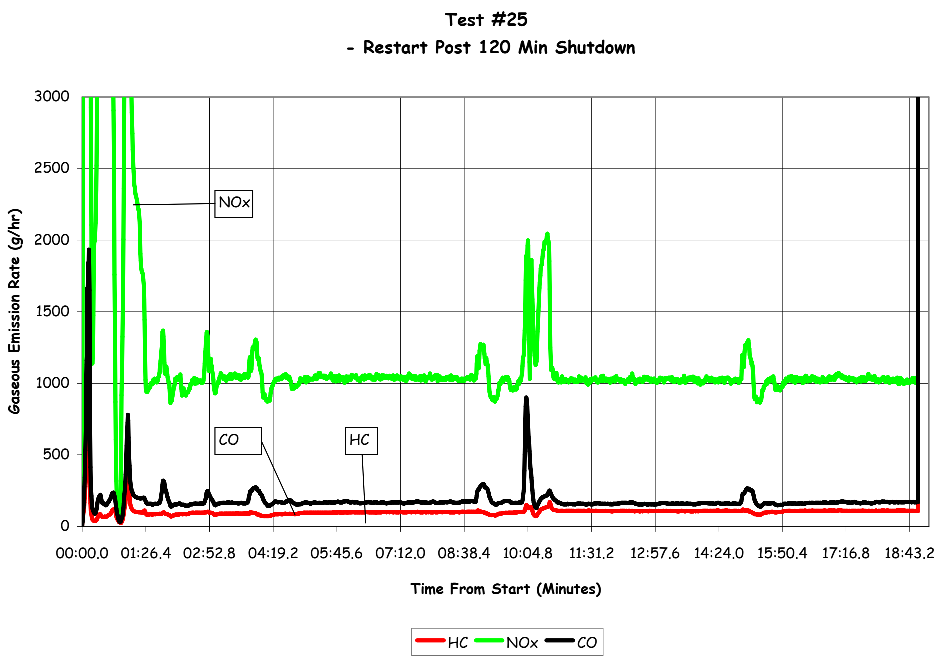

Figure 20. Test 25 Emissions Mass Flow Rates for BNSF4373

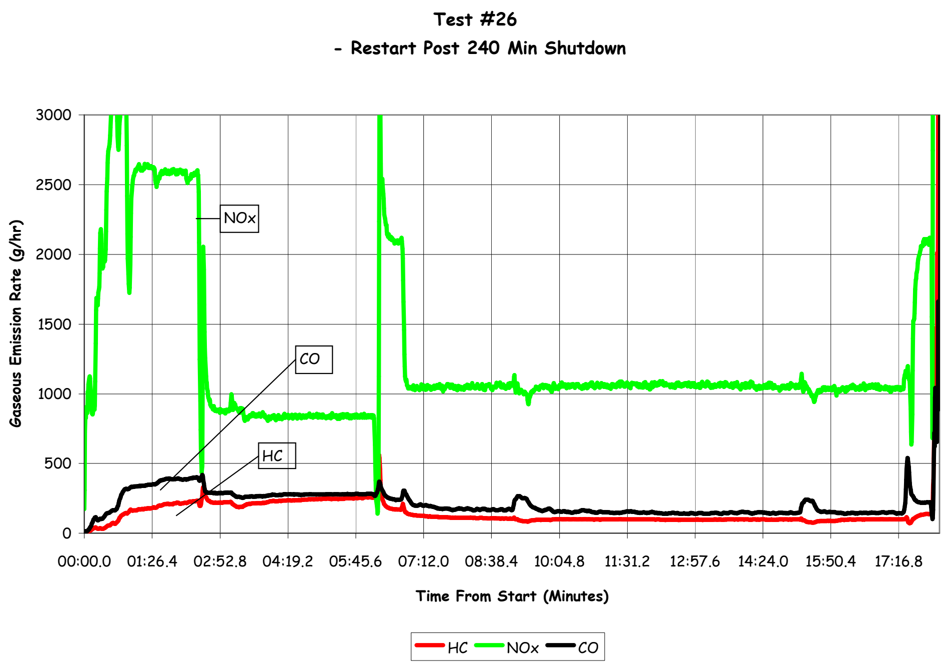

Figure 21. Test 26 Emissions Mass Flow Rates for BNSF4373

The emissions profile from the BNSF4373 locomotive was significantly different than that of the UPY1378 locomotive. These two locomotives are different in many ways. These include, but are not limited to; manufacturer, control system of the engines and the locomotive in general, engine types and power rating. The one fact that became obvious during these tests was when the UPY1378 was started, the engine speed was held constant by the mechanical governor, except for minor (and short lived) droops in engine speed as the air compressor was turned on shortly after the engine was started. BNSF4373 is computer controlled and equipped with electronic fuel injection and electronic speed governing. The GE locomotive computers manage various engine and locomotive parameters, including engine speed up for high and low jacket water and oil sump temperatures and low air pressure. These locomotive control issues, which drove the variable emissions traces seen in figures 17 through 21 can also be seen in the engine speeds of the BNSF4373 locomotive over these same tests. The engine speed over the tests can be seen in Figure 22.

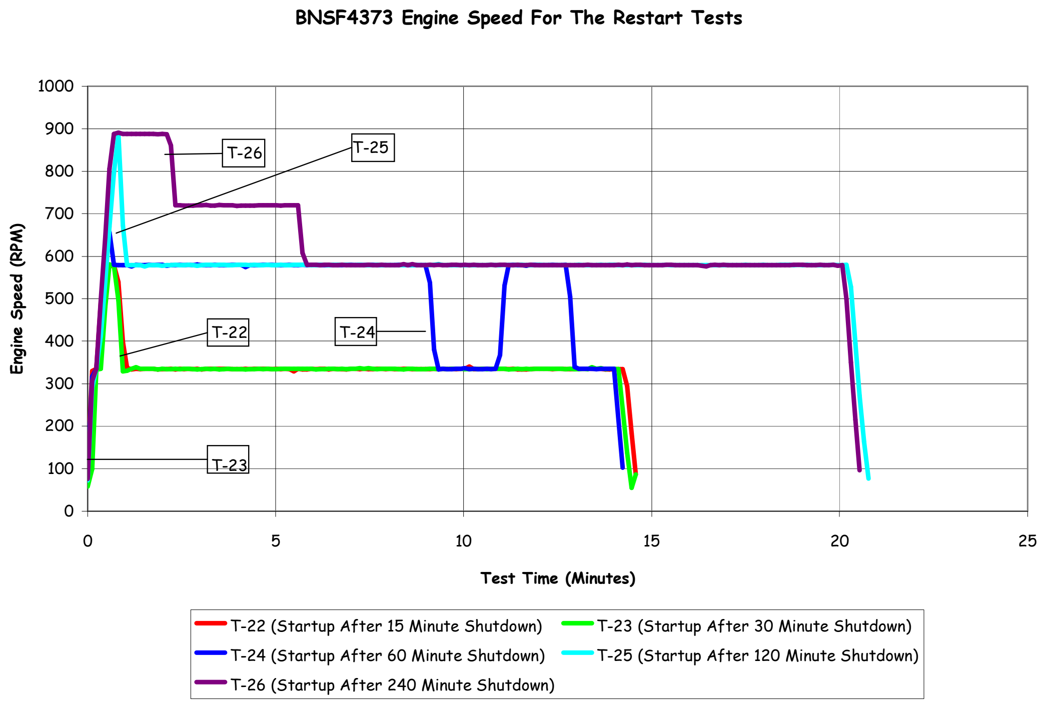

Figure 22. Engine Speeds During the Restart Tests on BNSF4373

Because of the variable emissions profile from BNSF4373, the cumulative emissions rates are also more unpredictable, as shown in Figures 23 through 25. These emissions rates shows that the higher engine speeds and auxiliary loads of the locomotive when the restart takes place causes the cumulative rate to be very steep and in T-22 actually crosses the baseline test line. One many of these tests the cumulative emissions rates are starting to drop somewhat and have less steep of a slope, after about 5 minutes of operation, depending on the test.

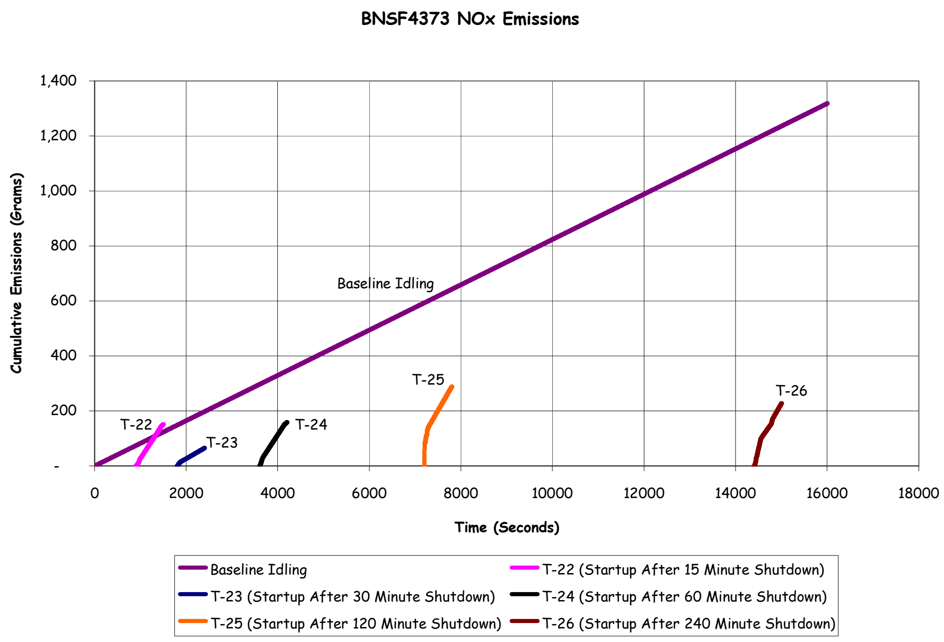

Figure 23. Cumulative NO_x Emissions From BNSF4373

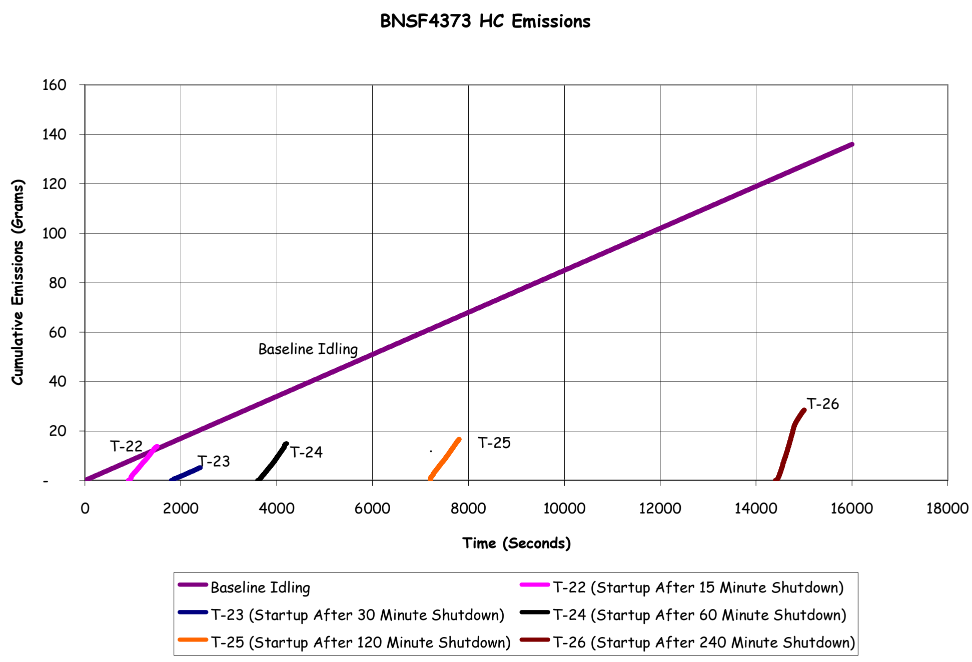

Figure 24. Cumulative HC Emissions From BNSF4373

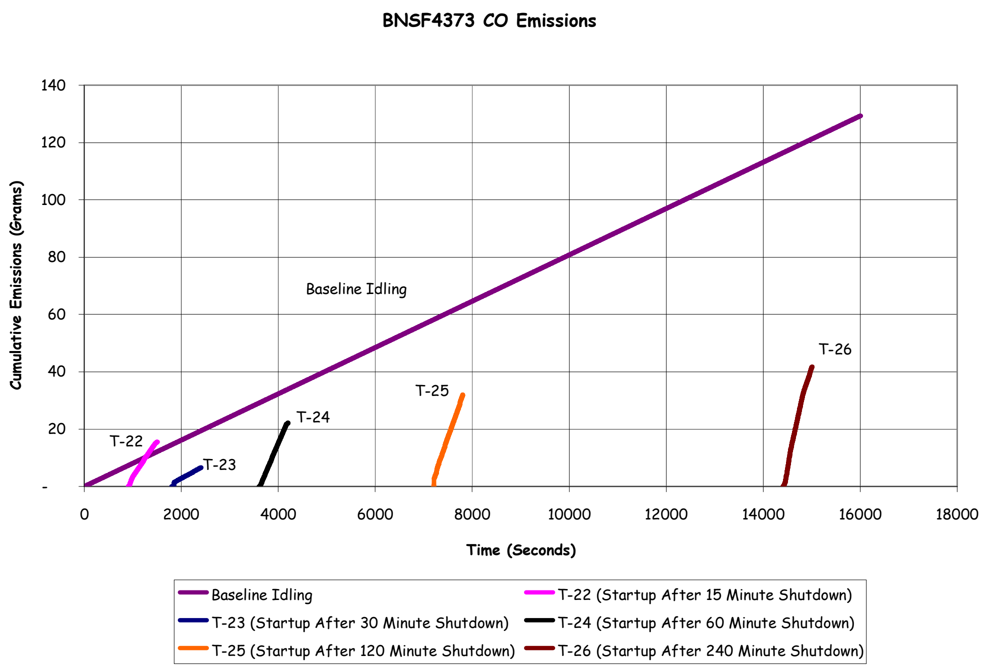

Figure 25. Cumulative CO Emissions From BNSF4373

The PM emissions from this series of restart tests are shown in Table 5. By comparing the PM results in Table 5 to the PM results of the UPY1378 in Table 3, one can see that the PM emissions from BNSF4373 are higher than that of the UPY1378. Additionally if one compares the results shown in Table 5 to the engine speeds that the engine exhibited during the restart tests, as shown in Figure 22, one can see that the engine produces higher PM emissions as the engine is allowed longer engine shutdown periods and as the locomotive drives the engine to higher speeds, for a longer duration, after the restart of the engine.

Table 5. PM Emissions Results for Restart Tests on BNSF4373

Condition of Test	Test Code	PM Emissions Filter A (g/hr)	PM Emissions Filter B (g/hr)	PM Emissions Filter C (g/hr)
Baseline = FTP conditions	T-21	10.6	(A)	(A)
Start-up post 15 minute shutdown	T-22	11.0	9.8	(A)
Start-up post 30 minute shutdown	T-23	10.7	10.1	(A)
Start-up post 60 minute shutdown	T-24	36.3	32.3	(A)
Start-up post 120 minute shutdown	T-25	46.1	51.6	48.4
Start-up post 240 minute shutdown	T-26	106.3	50.6	45.2

(A) PM emissions not measured

The test sequence and emissions results for the extended idle tests are given in Table 6. The data shows that all of the emissions were greatly reduced between Test T-30 and T-31, the point that the engine speed transited from higher idle speed of 580 RPM, apparently to assist in the warm up of the engine, and the low idle speed of 330 RPM. The emissions rate during the transient from idle to Notch 3, at the end of the 4 hours of idle, produced an extremely high PM emissions level, which decreased after the first filter (after 5 minutes). This is a different profile of emissions than what was seen on the UPY1378, in Table 4, where the PM emissions were more consistent over the 4 hour idling period, due to the one engine speed, and the PM emissions. Additionally, the UPY1378 produced much lower PM emissions at the transient from the 4 hours of idle to Notch 3 then did the BNSF4373. However, on a brake specific basis, these differences will be minimized due to the higher horsepower output of the BNSF4373 engine at notch 3.

Table 6. Steady State Emissions Results from 4 Hour Idle Study on BNSF4373

Test	Notch	Time (Minutes)	NOx (g/hr)	HC (g/hr)	CO (g/hr)	PM (g/hr)
T-27A	Idle	0	2159	144	283	37
T-27B	Idle	5				43
T-27C	Idle	10				45
T-28	Idle	30	2272	164	253	50
T-29	Idle	60	1054	96	116	33
T-30	Idle	90	1035	105	136	38
T-31	Idle	120	397	36	34	11
T-32	Idle	150	398	37	35	12
T-33	Idle	180	444	43	41	14
T-34	Idle	210	407	36	37	13
T-35	Idle	240	343	31	31	10
T-36A	3	250	16699	657	1455	1169
T-36B	3	255				263
T-36C	3	260				230

Conclusions

The first and main conclusion that can be drawn from this testing is that continuous idling emissions of NO_X and PM were greater than start-up emissions following each shut-down period for both locomotives. The only exception is the 15 minute restart test on the BNSF4373, but this is envisioned to be a non-typical operating cycle for the AESS system.

The second conclusion is that restarting the EMD 12-645E engine does not dramatically increase the emissions rate. Figure 12 shows that by shutting down the engine for 4 hours could reduce the NO_X emissions by nearly 2,450 grams or nearly 5.4 pounds. Additionally there does not appear to be a significant increase in any of the other emissions emitted by the engine at the start-up.

The third conclusion is that the GE T-0 locomotive engine in BNSF4373 operated at higher than nominal idle speed for a number of the restart tests (see Figure 22). After restart, the engine operated at engine speeds of 580 RPM and some times as high as 980 RPM to accommodate the Engine Protection Algorithm. These high engine operating speeds increase the emissions rate from the GE engine when compared to the baseline condition.

The fourth conclusion is that extended idling of the locomotive engines that were tested can cause high PM emissions to be produced when the engine is transitioned from idle to a power producing notch. This is due to the build up of unburned fuel and lubrication oil that collects in the exhaust system during the idle and is ejected from the engine exhaust with the higher exhaust temperature and the higher exhaust mass flow through the exhaust system during the transient. This simply reinforces the desirability of shutting down the engines to avoid unnecessary idling. To further understand the emissions affect of the transient at the end of an extended idle, an FTP Notch 3 data point should be run. This will allow for a better estimate for the amount of time that is required to stabilize the engine emissions after the transient.

A fifth conclusion is that during any future tests to characterize idle or restart emissions, the pre-shutdown engine conditioning should better reflect actual locomotive operation, especially for 120- and 240-minute equivalent shutdowns where a typical cold starting occurred.

The final conclusion from this project concerns the GE Automatic Engine Stop Start (AESS) system tested. When BNSF4373 was first delivered to SwRI for testing, the system only allowed the engine to be shutdown for a maximum of approximately 90 minutes at a time and had an extended idle of about 9.45 hours until finally shutting down again. These operating characteristics of the AESS system may provide excellent engine and locomotive protection; but would not be considered an optimum operating cycle for emissions or fuel consumption reductions.

Closure

If you have any questions or comments regarding this report, please feel free to contact me via e-mail at jhedrick@swri.org, by telephone at (210) 522-2336, or by fax at (210) 522-2019.

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Department of Engines and Emissions Research
Engine, Emissions & Vehicle Research Div.

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/mr

Appendix A

In-Bound Inspection Worksheet UPY1378

Date:	10/10/2005	Customer:	SCAQMD
Locomotive Type	MP-15 DC		
Engine Serial Number:	82J2-1042	Road Number:	Y1378

Head Assembly		Cylinder	Part Number	Serial Number	Diamond #
	EMD	1	9556059	05D33765	5
	EMD	2	"	05E33165	5
	EMD	3	"	05E33128	5
	EMD	4	" (?)	05E33127	5
	EMD	5	"	05E33167	5
	EMD	6	"	05D33763	5
	EMD	7	"	05E33467	5
	W	8	"	05E33114	6
	W	9	"	05E33115	6
	W	10	"	05E33159	6
	EMD	11	40021328	05E33124	6
	EMD	12	9556059	05E33456	5
		13			
		14			
		15			
		16			

Injector		Cylinder	Part Number	Serial Number
	Haynes	1	5229200	D5251107
		2	"	D525111?
		3	"	D5251109
		4	"	D5251110
		5	"	D5251111
		6	"	D5251112
		7	"	D5251113
		8	"	D5251114
		9	"	D5251121
		10	"	D5251122
		11	"	D5251123
		12	"	D5251124
		13		
		14		
		15		
		16		
Blower			Part Number	Serial Number
		Rt	8369676 RH	5113905 2-9-05
		Lt	8369677LH	51B2105-4 2-21-05
Governor			Part Number	Serial Number
		UTEX	8482413	1014146
		Customer	7326788	
		Balance Point	0.83	
		Engine Speed	900	

Appendix B

In-Bound Inspection Worksheet BNSF4373

Date:	11/26/2005	Customer:	AAR
Locomotive Type:	Dash9-44CW		
Engine Type:	7FDL16Y16	Road Number:	BNSF4373
Engine Serial Number:	040126R		

Power Assembly

Cylinder	CAT Number	Serial Number	Part Number
Right 1	121X1228	LQ00090962R	41R992519P8
Right 2	"	CG97110948R	"
Right 3	"	CG98010853R	"
Right 4	"	CG00099020R	"
Right 5	"	CG00090837R	"
Right 6	"	CG97030135R	"
Right 7	"	LG00091314R	"
Right 8	"	CG95110362R	"
Left 1	"	LG95040603R	"
Left 2	"	CG95060532SA	"
Left 3	"	LG98040455R	"
Left 4	"	CG98010307R	"
Left 5	"	CB97120757R	"
Left 6	"	CG98010357R	"
Left 7	"	CG95040703R	"
Left 8	"	LG01020212R	"

Injection Pump

Cylinder	CAT Number	Serial Number	Part Number
Right 1	132X1825-1R	39277413	41C642286P2R
Right 2	"	39277427	"
Right 3	"	39277433	"

Right 4	"	39277432	"
Right 5	132X1825-2R	584117735	84C623439P1R
Right 6	132X1825-1R	39277429	41C642286P2R
Right 7	"	39277436	"
Right 8	"	39277430	"
Left 1	132X1825-2R	584117748	84C623439P1R
Left 2	132X1825-1R	39277422	41C642286P2R
Left 3	"	39277467	"
Left 4	No Tag	No Tag	No Tag
Left 5	132X1825-1R	39277466	41C642286P2R
Left 6	"	39277436	"
Left 7	"	39277443	"
Left 8	"	39277505	"

Turbocharger

CAT Number	Serial Number
126x1886R	7S45B6R

Aftercooler

	Part Number	Serial Number
Left	??	??
Right	41E914534G1	RG03111424

Governor / EGU

Part Number	Serial Number
89954-169D4727P1	

Appendix C

Test Data Sheets

UPY1378	10/25\/2005																
Restart Test	Project # 03.11806																
Test #	Test Condition	Time	Baro	Engine RPM	Fuel flow Rate	Fuel Temp	Intake Air Temp	Ambient Dry Bulb Temp	Ambient Wet Bulb Temp	Locomotive Horsepower	Jacket Water Temp	Oil Sump Temp	HC, g/hr	CO, g/hr	Corr. NOx, g/hr	PM1, g/hr	[illegible]
T-1	Cold Start	9:32	29.50	318	20.4	50	65	53	44	16	62	73	152	373	431	22.8	
T-2	Baseline	11:34	29.47	318	22.5	110	80	51	47	16	175	214	131	139	605	6.7	
	15 Min Shut Down	--	--		--	--	--	--	--	--	--	--	--	--	--	--	
T-3	30 Min Shut Down	11:52	29.45	318	20.4	110	77	57	50	16	186	195	113	126	547	13.1	
T-4	60 Min Shut Down	14:08	29.40	318	20.9	108	81	73	52	16	168	170	107	139	530	13.2	
T-5	120 Min Shut Down	16:39	29.36	318	22.5	106	81	75	52	16	159	161	114	157	568	17.6	
T-6	240 Min Shut Down	21:11	29.39	318	23.6	98	67	63	48	16	144	147	119	219	575	19.3	
BNSF4373	10/26/2005																
Extended Idle Test	Project # 03.11806																
Test #	Test Condition	Time	Baro	Engine RPM	Fuel flow Rate	Fuel Temp	Intake Air Temp	Ambient Dry Bulb Temp	Ambient Wet Bulb Temp	Locomotive Horsepower	Jacket Water Temp	Oil Sump Temp	HC, g/hr	CO, g/hr	Corr. NOx, g/hr	PM1, g/hr	[illegible]
T-7	Start	10:39	29.36	318	27.8	62	69	68	55	16	65	72	132	294	554	20.1	
T-8	30 Min of Idle	11:22	29.35	318	26.5	78	73	68	55	16	111	109	154	289	630	10.9	
T-9	60 Min of Idle	11:55	29.35	318	25.2	90	75	71	56	16	126	126	150	231	611	10.3	
T-10	90 Min of Idle	12:21	29.34	318	24.8	101	77	72	56	16	145	145	149	203	610	10.5	
T-11	120 Min of Idle	12:48	29.34	318	24.6	105	79	74	57	16	155	156	152	194	615	10	
T-12	150 Min of Idle	13:53	29.33	318	24.0	76	80	74	57	16	162	164	149	177	609	10.6	
T-13	180 Min of Idle	14:52	29.32	318	23.4	78	81	75	57	16	174	175	144	166	592	10.4	
T-14	210 Min of Idle	15:41	29.3	318	23.4	77	84	76	57	16	180	182	145	163	583	--	
T-15	240 Min of Idle	16:29	29.31	318	23.5	72	85	77	58	16	179	195	154	159	588	9.6	
T-16	Notch 3 Transient	17:18	29.3	512	193.8	79	86	78	58	475	182	197	705	310	4751	**432.8**	2

APPENDIX B

START-UP AND IDLING EMISSIONS FROM TWO LOCOMOTIVES

FINAL REPORT

January 16, 2006

Submitted to:
Technology Advancement Office
South Coast Air Quality Management District

EF & EE
ENGINE, FUEL, AND EMISSIONS
ENGINEERING, INCORPORATED

START-UP AND IDLING EMISSIONS FROM TWO LOCOMOTIVES

Final Report

<u>Submitted to</u>
Technology Advancement Office
South Coast Air Quality Management District
21865 East Copley Drive
Diamond Bar, CA 91765

Contract No. 00112

January 16, 2006

<u>Submitted by</u>
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EXECUTIVE SUMMARY

The South Coast Air Quality Management District (SCAQMD) is developing regulations to limit idling by locomotive engines. Such regulations would necessarily result in more-frequent starting, including start-up after varying periods of being shut down. The SCAQMD staff has received comments from the railroad industry that increase in the number of start-ups due to idle restrictions could result in a tradeoff of emissions.

To clarify the relationship between start-up and idling emissions, the SCAQMD Technology Advancement Office requested Engine, Fuel, and Emissions Engineering, Inc. (EF&EE) to carry out emission measurements on two locomotives owned by the South Coast Regional Rail Authority – better known as Metrolink. Emission measurements were performed using the Ride Along Vehicle Emission Measurement (RAVEM) system developed and manufactured by EF&EE. Pollutants measured included particulate matter (PM), oxides of nitrogen (NOx), carbon dioxide (CO_2), and total hydrocarbons (HC). CO concentrations were also measured, but the results were below detection levels, and are not reported. The emission measurements were performed during the period from November 3 to 8, 2005, at Metrolink's Central Maintenance Facility (old "Taylor Yard") in Los Angeles.

The two locomotives tested were both produced by the Electromotive Division of General Motors (EMD), and were equipped with 16-cylinder, two-stroke, turbocharged and aftercooled diesel engines. The first locomotive tested, Metrolink No. 804, was an SD60 model – a typical freight locomotive of the last generation – equipped with an EMD 16-710G engine. This unit was also equipped with a computer control system that – among other functions – changed the idle speed from low idle (about 200 RPM) to higher speed in response to low coolant temperature, low battery voltage, or low pressure in the air brake reservoir. The second unit tested was Metrolink No. 800, an F40 locomotive equipped with an EMD 16-645E engine. This unit was equipped with an electromechanical control system, and included a manual switch to select between low and normal idle speeds. Consistent with normal railroad practice, low idle speed was selected during all of the idle and start-up measurements in this test program.

PM emissions at idle from the two locomotives tested were 0.66 and 0.38 grams per minute, respectively; and NOx emissions were 16.7 and 19.8 grams per minute. A significant fraction of the total PM (15% in the first case, and 49% in the second) is not emitted at the time, but retained in the exhaust system as "soup" – semivolatile hydrocarbons and lubricating oil – to be emitted subsequently when the locomotive returns to higher-load operation. The present Federal locomotive test procedure fails to measure these substantially-increased PM emissions during the transient conditions following a period of idle.

The incremental emissions due to engine start-up from these locomotives were small compared to the emissions produced under stabilized idle conditions. In none of the start-up tests conducted did these emissions exceed the equivalent of 8 minutes of idle operation. Based on these data, shutting down the engine and restarting it will result in reduced emissions compared

to allowing it to idle, as long as the idle shutdown period is longer than eight minutes. The longer the shutdown period, the greater the emission benefits.

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INTRODUCTION

In the railroad industry, it is presently a common practice for locomotive engines to be left idling when the locomotive is not in use – sometimes for very long periods. The South Coast Air Quality Management District (SCAQMD) is developing regulations to limit idling by locomotive engines. Such regulations would necessarily result in more-frequent starting, including start-up after varying periods of being shut down. There was concern, therefore, that the extra emissions due to more-frequent starts – especially starting with the engine cold – might offset the benefits of reduced pollutant emission from the shut down periods.

In order to clarify the relationship between start-up and idling emissions, the SCAQMD Technology Advanced Office requested Engine, Fuel, and Emissions Engineering, Inc. (EF&EE) to carry out emission measurements on two locomotives owned by the South Coast Regional Rail Authority – better known as Metrolink. Emission measurements were performed using the Ride Along Vehicle Emission Measurement (RAVEM) system developed and manufactured by EF&EE. Pollutants measured included particulate matter (PM), oxides of nitrogen (NOx), carbon dioxide (CO_2), and total hydrocarbons (HC). CO concentrations were also measured, but the results were below detection levels. The emissions measurements were performed during the period from November 3 to 8, 2005, at Metrolink's Central Maintenance Facility (old "Taylor Yard") in Los Angeles.

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EMISSION MEASUREMENT SYSTEM INSTALLATION AND OPERATION

Emission measurements were performed using EF&EE's "Ride Along Vehicle Emission Measurement" (RAVEM) system[i,ii]. Conventional vehicle emission measurement methods defined by the U.S. EPA[iii] and California ARB[iv] utilize *full-flow* constant volume sampling (CVS), in which the entire exhaust flow is extracted and diluted. RAVEM measurements use *partial flow* CVS. This is similar to the EPA and CARB methods, except that the sampling system extracts and dilutes only a small, constant fraction of the total exhaust flow. The RAVEM system is further described in the Appendix.

Although the RAVEM system is designed to measure emissions while "riding along" on the vehicle under test, it can also be used for stationary tests in those cases where the source being measured does not need to move. For this program, the RAVEM system unit was placed on a table next to the locomotive. Figure 1 and Figure 2 show these installations for locomotives 804 and 800, respectively.

In the RAVEM system, as in conventional CVS systems, particulate matter is normally collected on filters of Teflon-coated borosilicate glass. For the testing in this program, the SCAQMD requested that EF&EE also collect particulate matter from some tests on quartz filters, to allow the content of organic and elemental carbon to be determined. Thus, two sets of PM sample filters were collected for most of these tests. The sample filter plumbing was modified to allow two filter holders to be installed in parallel, and flow through the quartz filter was controlled by an auxiliary mass flow controller slaved to the mass flow controller for the Teflon/borosilicate glass filters.

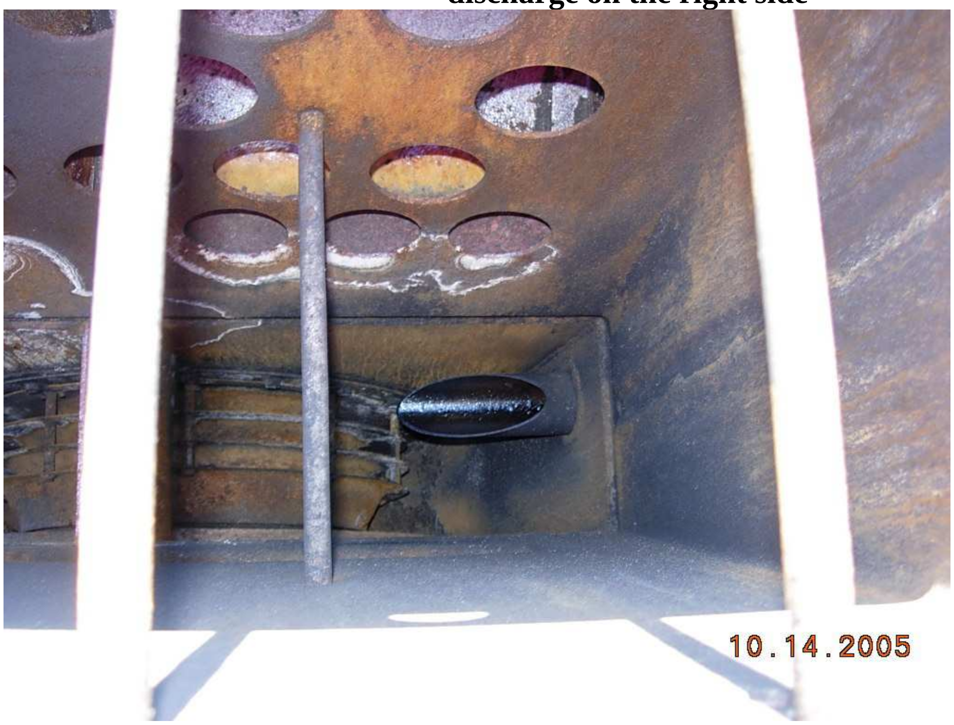
The RAVEM system normally does not measure gaseous HC emissions, as experience has shown that diesel engines emit very low quantities of HC. For these tests, it was considered possible that HC emissions would be significant, so a heated sample probe, heated line, and heated FID analyzer were added to the measurement system. Background HC concentrations cannot be determined reliably from the RAVEM's background bag samples, due to HC hangup in the bag system. Thus, background HC concentrations were measured before and/or after each test. The variability in these background measurements was comparable in magnitude to the net HC concentrations measured in the dilution tunnel, so that the HC results reported here should be considered only approximate.

Figure 1: Emission measurement system installation on Metrolink No. 804

Figure 2: Emission measurement system installation on Metrolink No. 800

Inspection of the locomotive exhausts showed that both units discharge almost directly from the turbocharger to the atmosphere via a very short, tapered exhaust stack. While the mixing due to passage of the exhaust through the turbine would have helped to provide homogeneity, there was concern that the distribution of pollutants could be affected by the crankcase vent discharging into the right side of each stack. In addition, it would have been difficult to find a single probe location in the existing stacks for which the exhaust velocity would be equal to the average velocity of the exhaust as a whole, as required by the isokinetic proportional sampling system. To increase the opportunity for mixing, and to help provide a uniform velocity profile in the exhaust, EF&EE extended each locomotive's stack by 7.5 feet, using rectangular sheet metal extensions cut to fit around the edge of the existing stack. The RAVEM probe was attached to a crossbar at the top center of the stack extension, and the insulated one-half inch sample line was led from the probe to the sample inlet on the CVS.

Figure 3: Inside of exhaust stack on Metrolink No. 804, showing the crankcase vent discharge on the right side



As a check on the accuracy of the sampling system, a system for measuring mass fuel consumption was installed on locomotive 800. This system consisted of a 55-gallon drum, a drum scale, and a pair of three-way valves inserted in the fuel supply and return lines, with supply and return tubes leading to the 55-gallon drum. By opening and closing the three-way valves, it was possible to switch the locomotive's fuel supply and return from its own tank to the drum mounted on the scale, and thus to measure the fuel consumed during a given emission test. A similar installation was planned to be made on locomotive no. 804, but this proved to be impractical. The fuel system on no. 804 had been rebuilt at some time in the past, and was assembled with non-standard fittings in such a way that the three-way valves could not be installed without damaging it.

EMISSION RESULTS

The planned emission test sequence was as follows:

1. Precondition the engine and check the accuracy of the RAVEM sampling system using carbon balance. Begin an emission test using the RAVEM system. With the RAVEM system recording data, start the engine, and allow it idle for 10 minutes. Increase the throttle to notch 2 for 10 minutes, and then to notch 4 for 10 minutes. Note the weight indicated by the drum scale at the beginning and end of each segment. End the emission test, reduce the throttle to notch 3, read the sample bags, and change the PM filters. Confirm that the fuel consumption rate calculated by carbon balance from the RAVEM measurements matches that calculated from the change in weight of the fuel drum.
2. "Soup" test baseline – This test, carried out after the exhaust system has been cleaned of "soup" (accumulated heavy HC and lube oil), establishes the baseline for the "soup" test at the end of the program. Reduce the throttle from notch 4 to idle. Start the emission test after no more than 5 minutes at idle. After 60 seconds, return the throttle to notch 3. Measure emissions for 20 minutes. End the emission test, change PM filters, and read bags while continuing to run the engine in notch 3.
3. Cooldown idle. Reduce the locomotive throttle from notch 3 to idle. After ten seconds, begin the emission test. Measure emissions and fuel consumption and monitor cooling water temperature for 30 minutes. Change filters and read bags while the engine continues to idle. If the engine coolant temperature has not stabilized by the end of the test, perform additional 30 minute tests until stability is reached. (i.e. the rate of change in cooling water temperature is less than 1 degree C per 5 minutes.)
4. Stabilized idle. Measure stabilized emissions for 30 minutes.
5. Restart ½ hour. Shut down the locomotive for 30 minutes. Begin the emission test, wait 30 seconds, and then restart the engine. Allow the engine to idle for 29 minutes before shutting it down. End the emission test 30 seconds after shutting down.
6. Restart 1 hour. Shut down the locomotive engine for 60 minutes. Begin the emission test, wait 30 seconds, and then restart the engine. Allow the engine to idle for 29 minutes before shutting it down. End the emission test 30 seconds after shutting down.
7. Cold Restart. Shut down the locomotive engine for 12 to 16 hours. Begin the emission test, wait 30 seconds, and then restart the engine. Allow the engine to continue idling while reading bags and changing filters for the next test. If the engine coolant temperature has not stabilized by the end of the test, perform additional 30 minute tests until stability is reached. (i.e. the rate of change in cooling water temperature is less than 1 degree C per 5 minutes.)
8. Stabilized idle. Measure emissions for 30 minutes.

9. Restart 2 hours. Shut down the locomotive engine for 120 minutes. Begin the emission test, wait 30 seconds, and then restart the engine. Allow the engine to idle for 29 minutes before shutting it down. End the emission test 30 seconds after shutting down.
10. Restart 4 hours. Shut down the locomotive engine for 240 minutes. Begin the emission test, wait 30 seconds, and then restart the engine. Allow the engine to idle for 29 minutes before shutting it down.
11. "Soup" Test -- Start the emission test with the engine at idle. After 60 seconds, increase the throttle to notch 3. Measure emissions for 20 minutes. During this time, the increased exhaust temperature will drive off the "soup" that has accumulated in the exhaust system during the preceding idle tests, allowing it to be measured.
12. Shut down the locomotive, remove the stack extension, probe, thermocouple, and three-way valves.

Because of scheduling issues (primarily involving the availability of the locomotives and the scheduling of the cold start), it was necessary to change the order of the emission tests somewhat. Also, system problems led to repeating some tests on locomotive 804. Table 1 shows the emission tests performed on that locomotive, in the order they were performed.

Table 1: Summary of Emission Tests on Metrolink No. 804

Test	Start	Test	Coolant °C		Run	Total Emissions (g)			
No.	Date/Time	Conditions	Start	End	Min.	PM	CO_2	NOx	HC
T0759	11/3/05 8:02	Warm-Start Idle	#N/A	#N/A	29.5	18.4	19,864	559	33
T0760	11/3/05 9:00	Idle-Notch 2-Notch 4	#N/A	#N/A	30.0	59.9	73,061	1,753	85
T0761	11/3/05 9:49	Soup Test Baseline - Notch 3	#N/A	#N/A	20.0	38.9	65,231	1,532	28
T0762	11/3/05 10:24	Cooldown Idle from Notch 3	#N/A	#N/A	30.0	9.4	14,632	473	12
T0763	11/3/05 11:31	Restart after 30 minutes	#N/A	#N/A	29.0	12.5	13,520	449	26
T0764	11/3/05 13:01	Restart after 1 hour	#N/A	#N/A	29.0	13.8	13,008	426	13
T0765	11/3/05 16:01	Restart after 2 hours	#N/A	#N/A	29.0	18.6	13,199	436	22
T0767	11/3/05 20:34	Restart after 4 hours	#N/A	#N/A	29.0	18.6	19,629	484	20
T0769	11/4/05 9:03	Restart after 12 hours	32.3	52.8	29.5	19.3	24,132	632	33
T0770	11/4/05 9:42	Warmup Idle after Cold Start	56.3	60.0	30.0	13.5	17,695	518	31
T0771	11/4/05 10:25	Semi-stabilized idle	61.2	64.1	30.0	#N/A	16,199	495	12
T0772	11/4/05 11:13	Stabilized Idle after Cold Start	65.3	67.5	30.0	16.9	15,449	484	30
T0773	11/4/05 12:00	Soup Test	68.1	81.2	20.0	70.9	70,147	1,654	88
T0774	11/4/05 12:38	Cooldown Idle after Notch 4	84.7	75.9	30.0	12.9	16,188	533	9
T0775	11/4/05 13:43	Restart after ½ h our	71.1	74.3	29.0	11.4	13,835	485	18
T0776	11/4/05 15:13	Restart after 1 hour	66.7	71.4	29.0	9.9	14,391	476	20
T0777	11/4/05 17:43	Restart after 2 hours	58.7	65.9	29.0	#N/A	15,975	506	23
Soup Test Minus Baseline					324	32.0	4,915	123	60

In addition to the summary results shown in Table 1, detailed second-by-second data and plots of gaseous pollutant concentrations, exhaust temperature, and coolant temperature are given in the Excel files produced by the RAVEM system for each test. These files also contain background pollutant concentrations and environmental data such as ambient temperature, humidity, and barometric pressure.

During the first day of testing, a software error prevented the coolant temperature data from being stored with the rest of the test data, although some limited data were recorded manually by another participant. During test 771, the primary PM sample filter stuck to the filter holder and tore, invalidating the weight results. During test 777, the sample filter holder was not pushed all the way into its receptacle, and this was not noticed until most of the way through the test.

Table 2 summarizes the emission tests performed on locomotive 800. With the increased experience of the sample team, no significant problems were experienced during this testing. In one deviation from the planned procedure, test 779 – preconditioning – was performed with the engine throttle set to notches 2 and 4, but without the self-load system in operation. This was because no-one available at the time knew how to apply the self-load system. The resulting exhaust temperatures were lower than if the self-load had been in effect, but still exceeded 100 ^oC. We believe that this adequately preconditioned the engine and exhaust system for the subsequent tests.

Table 2: Summary of Emission Tests on Metrolink No. 800

Test	Start	Test	Coolant ^oC		Run	Total Emissions (g)			
No.	Date/Time	Conditions	Start	End	Min.	PM	CO_2	NOx	HC
T0778	11/7/05 21:58	Stabilized Normal Idle	72.1	78.8	20.0	12.2	28,214	573	42
T0779	11/7/05 23:24	Idle-Notch 2-Notch 4 Prep	81.1	76.3	30.0	25.4	51,084	991	104
T0780	11/8/05 10:11	Cold Start after 10 hours	37.4	54.2	29.5	9.3	24,066	545	60
T0781	11/8/05 10:58	Warmup idle after cold start	58.1	63.4	30.0	10.0	23,721	578	53
T0782	11/8/05 11:45	Stabilized Idle	65.5	68.4	30.0	8.0	23,539	627	66
T0783	11/8/05 13:15	1 hour restart	59.0	67.0	29.0	8.5	22,315	589	32
T0784	11/8/05 14:16	30 Minute Restart	62.5	67.6	29.0	6.4	22,731	621	44
T0785	11/8/05 17:00	2.25 hour restart	51.8	63.5	29.0	7.0	21,878	565	37
T0786	11/8/05 21:30	4 hour restart	42.5	56.7	29.0	9.6	20,143	498	38
T0787	11/8/05 22:18	Soup Test	56.5	77.8	20.0	102.6	114,541	1,862	62
T0788	11/8/05 22:57	Soup test baseline	76.1	82.4	20.0	54.3	117,218	2,004	84
T0789	11/8/05 23:33	Cooldown idle after Notch 3	77.4	75.8	30.0	5.4	21,910	612	35
T0790	11/9/05 0:15	Stabilized Idle	74.8	72.7	30.0	3.8	21,314	594	38
Soup Test Minus Baseline					259	48.3	(2,677)	-142	-21

Fuel consumption measurements and carbon balance checks were conducted on all but the last two emission tests on locomotive no. 800. During the course of this testing, it was found that the locomotive fuel system is not closed, but includes air vents or leaks that allow it to "drain down" when the fuel pump is not running. This requires that the system be "primed" by running the fuel pump for about 15 seconds before attempting to start the engine. The amount of fuel entering and leaving the weighed drum during these processes amounted to about three kilograms – a substantial fraction of the 7-8 kilograms consumed during a half-hour idle. Because of these effects, carbon balance during the start-up and shutdown events was poor.

Carbon balance checks were conducted during preconditioning at notches 2 and 4 (test 779), and during the soup test baseline at notch 3 (test 788), resulting in fuel carbon recoveries of 98.3% and 101.0%, respectively. Unlike the start-up tests, the engine was not started or stopped during these tests, so that the transient effects discussed above had little effect on the results. Another carbon balance test was attempted during the "soup test" at notch 3 (test 787), but the fuel level in the drum fell below the entry to the fuel supply hose, allowing air to enter the fuel system.

A carbon balance calculation can also be conducted on the two-hour period covering tests 780 through 782. During this period, the locomotive underwent a cold start, followed by 123 minutes of idle, after which the locomotive was shut down for one hour. The 123 minutes of run time included 89.5 minutes during the three tests, as well as the roughly 15 minute periods between the tests. Allowing for these periods, total fuel consumption during the 123 minutes of idle is calculated at 30.93 kg. Fuel drum weight prior to the cold start was 92.4 kg, and it was 63.6 kg after the engine had been shut down for 55 minutes, giving total consumption of 28.8 kg over the period. Thus, calculated fuel consumption was 107% of the measured fuel consumption over the time period.

ANALYSIS AND DISCUSSION

The main purpose of this test program was to determine the tradeoff in emissions between more-frequent restarting and continuous idling of locomotive engines. Table 3 shows how the incremental emissions due engine restarting were calculated.

In calculating PM emissions at idle, the effects of exhaust system "souping" turned out to be very significant. Although this particulate matter is not emitted immediately, it accumulates until the next time the locomotive goes to a higher power setting, and is emitted then. Since the amount emitted depends on the amount accumulated, it is appropriate to attribute it to the idling period rather than the high-power operation when it actually comes out the stack. These substantial PM emissions are not measured by the Federal locomotive test procedure, since this procedure does not measure during the transition between test modes.

The first line in the table shows the stabilized exhaust emissions measured from locomotive 804, in grams per minute. Emissions from "souping" were calculated by subtracting the emissions during the soup test baseline from those during the soup test, and then dividing by the number of minutes of idle operation between the two tests. The results came to 0.10 g/minute of PM for locomotive 804 and 0.19 g/min for locomotive 800. These amounted to 15% and 49%, respectively, of the total PM emissions at idle. Incremental emissions of CO_2, NOx, and HC attributable to "souping" were very small, and probably reflect test-to-test variability rather than any actual accumulation in the exhaust.

Having calculated the emissions – including "soup" buildup – attributable to a 29-minute period of stabilized idle, we then added the same allowance for "soup" buildup to the 29-minute idle period in each of the start-up tests (29.5 minutes in the case of the cold-starts). Incremental start-up emissions were obtained by subtracting the stabilized idle emissions from those observed during each start-up.

As Table 3 shows, the incremental emissions due to start-up were relatively small, even for the ten and twelve-hour shut down periods. In the case of locomotive 804, the incremental emissions from start-up after one-half hour and one hour were negative. In no case did the incremental PM emissions due to start-up exceed the emissions produced during eight minutes of stabilized idle. The maximum incremental NOx emissions were observed in the 12-hour test for locomotive 804, and were equivalent to 10 minutes of stabilized idle.

Table 3: Calculation of Incremental Emissions Due to Locomotive Restart

	Emissions				Start-Idle Equivalence (min)	
	PM	CO_2	NOx	HC	From PM	From NOx
Locomotive #804 (SD-60)						
Stabilized Idle (g/minute)	0.56	527	16.3	0.7		
Addl Emissions from Soup Test (g/min)	0.10	15	0.4	0.2		
Total Stabilized Idle Emissions/Min	0.66	542	16.7	0.9		
Stabilized Idle (g/29 minutes)	19.2	15,725	484	25		
Emissions From Restart + Plus 29 min Idle (including "Soup")						
After 1/2 hour	14.8	14,118	478	27		
After 1 hour	14.7	14,139	462	22		
After 2 hours	21.5	15,027	482	28		
After 4 hours	21.5	20,069	495	26		
After 12 hours	22.2	24,572	643	39		
Incremental Emissions From Restart						
After 1/2 hour	-4.4	-1,608	-6	2	-6.7	-0.4
After 1 hour	-4.5	-1,586	-22	-4	-6.8	-1.3
After 2 hours	2.2	-698	-2	2	3.4	-0.1
After 4 hours	2.2	4,344	12	0	3.4	0.7
After 12 hours	3.3	9,118	168	14	5.0	10.1
Locomotive #800 (F-40)						
Stabilized Idle (g/minute)	0.20	747	20.3	1.7		
Addl Emissions from Soup Test g/min	0.19	(10)	-0.5	-0.1		
Total Stabilized Idle Emissions/Min	0.38	737	19.8	1.6		
Stabilized Idle (g/29 minutes)	11.1	21,361	574	48		
Emissions From Restart + Plus 29 min Idle (including "Soup")						
After 1/2 hour	11.8	22,431	605	42		
After 1 hour	13.9	22,015	573	30		
After 2 hours	12.4	21,578	549	34		
After 4 hours	12.4	20,583	509	43		
After 12 hours	12.1	24,506	556	65		
Incremental Emissions From Restart						
After 1/2 hour	0.6	1,069	31	-6	1.7	1.6
After 1 hour	2.8	654	-1	-18	7.2	0.0
After 2 1/4 hours	1.3	216	-25	-13	3.3	-1.3
After 4 hours	1.3	-778	-65	-5	3.4	-3.3
After 10 hours	1.2	3,513	-8	18	3.0	-0.4

SUMMARY AND CONCLUSIONS

Emission tests were performed on two locomotives equipped with engines typical of those used in older line-haul locomotives in the U.S. These tests focused on emissions produced at idle, and under start-up conditions after the engine was shut down for varying periods up to 12 hours.

PM emissions at idle from the two locomotives tested were 0.66 and 0.38 grams per minute, respectively; and NOx emissions were 16.7 and 19.8 grams per minute. A significant fraction of the total PM attributable to idle operation (15% in the first case, and 49% in the second) is not emitted at the time, but retained in the exhaust system as “soup”, to be emitted subsequently when the locomotive returns to higher-load operation. The present Federal locomotive test procedure fails to measure these substantially-increased PM emissions during the transient conditions following a period of idle.

The incremental emissions from these locomotives due to engine start-up were small compared to the emissions produced under stabilized idle conditions. In none of the start-up tests conducted did these emissions exceed the equivalent of 8 minutes of idle operation. Based on these data, shutting down the engine and restarting it will result in reduced emissions compared to allowing it to idle, as long as the idle shutdown period is longer than eight minutes. The longer the shutdown period, the greater the emission benefits.

REFERENCES

[i] C.S. Weaver and L.E. Petty “Reproducibility and Accuracy of On-Board Emission Measurements Using the RAVEM™ System “, SAE Paper No. 2004-01-0965, March, 2004.
[ii] Weaver, C.S. and M.V. Balam-Almanza, “Development of the ‘RAVEM’ Ride-Along Vehicle Emission Measurement System for Gaseous and Particulate Emissions”, SAE Paper No. 2001-01-3644.
[iii] 40 CFR 86, Subpart N “Emission Regulations for New Otto-Cycle and Diesel Heavy-Duty Engines; Gaseous and Particulate Exhaust Test Procedures”
[iv] "California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Heavy-Duty Diesel Engines and Vehicles" as amended on February 26, 1999, California Air Resources Board, available at

APPENDIX

RAVEM SYSTEM DESCRIPTION

The Ride-Along Vehicle Emissions Measurement (RAVEM) technology was developed by and patented by EF&EE. The RAVEM system was among the first portable emission measurement systems (PEMS) to be developed, and is presently the only commercially-available PEMS that can measure emissions of PM as well as NOx, CO, and CO_2. Optional capabilities – also allow the measurement and quantification of total hydrocarbons (THC), sulfur dioxide (SO_2), as well as individual species of volatile organic compounds (VOC) and carbonyls such as formaldehyde, acetaldehyde, and acrolein.

During the last four years, EF&EE has applied it's own prototype RAVEM unit to measure pollutant emissions from a wide variety of mobile sources, ranging from natural gas garbage trucks[v] to diesel ferryboats[vi]. It has also been applied to the evaluation of emission control systems including selective catalytic reduction (SCR), diesel particulate filters (DPF), diesel oxidation catalysts (DOC) and emulsion fuels.

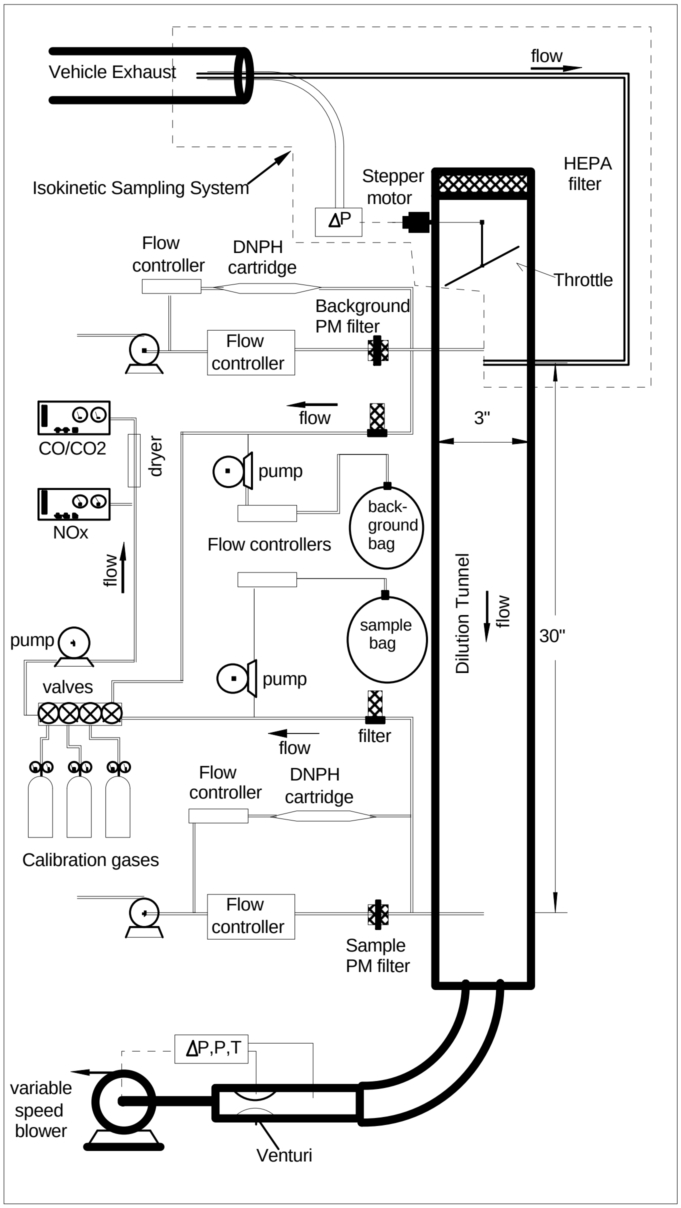
Principles of Operation

The RAVEM system is described in two published papers[vii,viii], so its operating principles are summarized only briefly here. As Reference vii explains in more detail, the RAVEM system is based on proportional *partial-flow* constant volume sampling (CVS) from the vehicle exhaust pipe. The CVS principle is widely used for vehicle emission measurements because the air dilution and total flow arrangements are such that the pollutant *concentration* in the CVS dilution tunnel is proportional to the pollutant *mass flow rate* in the vehicle exhaust. Gaseous pollutant concentrations can be measured readily, as can integrated concentrations of particulate matter. On the other hand, exhaust mass flow rates are difficult and expensive to measure accurately – especially under transient conditions.

The total pollutant mass emissions over a given driving cycle, such as the US Federal Test Procedure, European Transient Cycle, or Mexico City Bus Cycle, are equal to the integral of the pollutant mass flow rate over that cycle. In a CVS system, this integrated value can readily be determined by integrating the concentration measurement alone. The CVS flow rate enters into the calculation as a constant multiplier. The integration of pollutant concentration can be accomplished either numerically or physically. The vehicle exhaust mass flow rate does not enter into the calculation, making it unnecessary to measure.

For gases, the RAVEM system uses both numerical and physical integration. Concentrations of NOx, CO_2, and CO in the dilute exhaust gas are recorded second-by-second during each test. In addition, integrated samples of the dilute exhaust mixture and dilution air are collected in Tedlar® bags during the test, and analyzed afterward for NOx, CO_2, CO and (optionally) other pollutants.

In CVS sampling for particulate matter, sample integration is accomplished physically -- by passing dilute exhaust mixture through a pre-weighed filter at a constant, controlled flow rate. The weight gain by the filter is then divided by the volume of mixture passed through it to yield the average particulate concentration over the test cycle.



A schematic diagram of the RAVEM system is shown in Figure 1. Except for the isokinetic sampling system at the top of the figure, this diagram closely resembles a conventional single-dilution CVS emission measurement system.

Conventional emission laboratory methods defined by the U.S. EPA[ix] and California ARB[x] utilize full-flow CVS, in which the entire exhaust flow is extracted and diluted with air. However, the large amounts of dilution air required make full-flow CVS impractical for portable systems.

The principle of the RAVEM sampling system is as follows: the RAVEM's sampling system extracts and dilutes only a small, constant fraction of the total exhaust flow. The dilution air requirements and dilution tunnel size can thus be reduced to levels compatible with portable operation. As explained in Section 0, the patented isokinetic proportional sampling system[xi]. system continuously adjusts the sample flow rate so that the flow velocity in the sample probe is equal to that of the surrounding exhaust. Since the velocities are equal ("isokinetic"), the ratio of the flow rates in the exhaust pipe and the sample probe is equal to the ratio of their cross-sectional areas.

Figure 4: Schematic diagram of the RAVEM system

Pollutant concentration measurements in the RAVEM system follow the methods specified by the U.S. EPA (US CFR Vol 40 Part 86) and ISO standard 8178. The pollutants measured are as follows:

- Oxides of Nitrogen (NOx) by chemilumenescent analysis of the dilute exhaust sample,
- Carbon monoxide (CO) and carbon dioxide (CO_2) by non-dispersive infrared analysis of the dehumidified dilute exhaust sample;

- Particulate matter (PM) by collection particulate matter on pre-weighed filters of Teflon-coated borosilicate glass fiber, followed by post-conditioning and reweighing of the exposed filters.
- Volatile organic compounds (VOC) by gas-chromatographic (GC) analysis of the integrated bag samples, using flame ionization detectors in a method patterned on California Air Resources Board methods 102 and 103.
- Aldehydes and carbonyls by collection in silica-gel cartridges coated with di-nitro phenyl hydrazine (DNPH), followed by elution with acetonitrile and analysis of the eluate by high-pressure liquid chromatography, as specified in U.S. EPA method TO-11a.

Aldehyde measurements and GC analysis to characterize VOC emissions were not employed during the first part of this test program, as these optional capabilities were ordered later than the basic RAVEM system, and were not available at the time that the program began.

RAVEM Subsystems and Operation

The RAVEM system comprises the following key subsystems.

- Miniature constant volume dilution system
- Isokinetic proportional sampling system
- Bag sampling system: a) exhaust sample; b) background air sample
- Gas analyzer system: a) CO/CO_2; b) NO_x
- Particulate sampling system
- Cartridge sampling system (not used in this test program)
- Data processing and handling system
- Auxiliary inputs

MINIATURE CONSTANT-VOLUME DILUTION SYSTEM

This constitutes the heart of the RAVEM system. As diagrammed in Figure 4

Figure 4, the variable speed blower draws dilute air/exhaust gas mixture out of the dilution tunnel at a constant rate (expressed in standard liters per minute). The flow rate is controlled by a closed-loop system that measures volumetric flow rate via a venturi meter, corrects this to standard conditions of one atmosphere pressure and 20^{o} C, and then adjusts the blower speed to maintain the flow setpoint. The venturi meter is calibrated against a high-accuracy hot-wire mass flow meter (not shown) in order to compensate for any drift. High accuracy is needed, as any error in the mass flow will result in a proportional error in the final results.

Raw exhaust gas enters the dilution tunnel near the upper end, where it mixes with filtered dilution air. The relative proportions of exhaust gas and dilution air are controlled by the isokinetic sampling system, by means of the throttle in the air inlet.

ISOKINETIC PROPORTIONAL SAMPLING SYSTEM

The isokinetic sampling system comprises: a) the sampling probe in the exhaust pipe; b) an insulated sample line connecting the sampling probe to the raw gas inlet on the dilution tunnel; and c) the system for controlling the sample flow to maintain isokinetic conditions. The control system uses static pressure taps on the inside and outside surfaces of the probe, connected to a sensitive differential pressure sensor. When this sensor reads zero, the inside and outside pressures are the same. This requires that the velocities inside and outside the sample probe also be equal – i.e. isokinetic. Thus, exhaust gas entering the sampling probe is equal in velocity to that in the main engine exhaust stream ($v_1 = v_2$).

The throttle at the upstream end of the dilution tunnel is connected to a "smart" motor/controller combination. The controller responds to the signal from the differential pressure sensor by changing the throttle position to maintain isokinetic conditions. When the exhaust flow rate increases, the controller closes the throttle somewhat, increasing the pressure drop between the probe and the dilution tunnel, and thus increasing the flow velocity through the probe. When the exhaust flow decreases, the throttle opens, decreasing the pressure drop and the flow velocity in the probe. A fan upstream of the throttle (not shown) extends the possible range of dilution tunnel pressures to include slightly positive as well as negative values (compared to ambient atmospheric pressure).

Since the control system depends on equalizing the static pressures measured inside and outside the probe, leaks or other problems in the pressure taps, pressure lines, or differential pressure sensor can affect the measured pressure difference, and thus the emission results. This was a significant problem during the early part of the measurement campaign. The need to strengthen quality assurance procedures in this area was one of the key lessons drawn from the experience of this project. To aid in detecting this problem, EF&EE developed and retrofit a design change to permit *in situ* leak checks on the differential pressure lines. This modification was installed in the Mexico City RAVEM at the beginning of September, 2005.

BAG SAMPLING SYSTEM

The bag sampling system is designed to fill one pair of Tedlar bags for each test. One bag contains an integrated sample of the dilute exhaust from the dilution tunnel, and the other contains an integrated sample of the dilution air. Two choices are available with respect to the Tedlar bags: a pair of internal bags having a usable volume of about 10 liters, or a pair of 60 liter external bags fed through two quick-connect ports on the exterior of the system unit. The system is designed to allow the external bags to be exchanged quickly between tests, so that the bag samples for each test can analyzed off-board – e.g. by gas chromatograph. A pair of manually operated three-way valves selects the internal or external bags.

For each bag, gas is drawn from a sample port in the dilution tunnel, through a filter to a small pump. It then passes through a mass flow controller to the bag selector valve, and thence to the bag. The flow rate to the bags typically ranges from 0.25 to 1.5 standard liters per minute, and is kept constant during each emission test. The flow rate is normally calculated and set automatically, to capture a specified volume of gas over the length of the emission test. It can also be set manually by the RAVEM operator. The volume flowing to the sample bag is added to the total CVS flow in calculating the emission results.

Any leaks in the sample bag will directly affect the bag emission results. A leak check is therefore performed in the process of emptying the sample bags before each test.

During this test program, we found that the mass flow controllers to the sample bags would occasionally malfunction during long tests, allowing the bags to overfill and pop. The cause of this problem has not yet been identified, but software changes to monitor the backpressure in the bag feed lines have made it possible to detect and correct it.

GAS ANALYZER SYSTEM

The gas analyzer system comprises a sample pump, valve manifold, and conventional laboratory-grade heated NOx and ambient-temperature CO/CO_2 analyzers installed in a shock-mounted 19 inch rack inside a protective case. The NOx analyzer is a California Analytical Instruments HCLD 400 equipped with an NO to NO_2 converter using activated carbon. The analyzer is maintained at 60^oC, making it unnecessary to dry the sample to avoid condensation Dry, low-pressure compressed air for the ozone generator is supplied by an on-board pump by way of a filter and desiccant cartridge.

The CO/CO_2 analyzer is a California Analytical Instruments model ZRH using non-dispersive infrared (NDIR) analysis. Water vapor interferes with the NDIR measurement, especially for CO, and must be removed from the sample. This is accomplished by passing it through a Nafion™ semi-permeable membrane mass-exchanger. Dry gas for the other side of the mass exchanger is supplied by a small pump circulating air through a desiccant cartridge.

The gas analyzer system valve manifold allows the analyzer sample feed to be drawn from any one of the following sources: the dilute exhaust mixture in the dilution tunnel, the dilution air entering the tunnel (for background measurements), the integrated sample bag, the integrated background bag, zero gas, CO/CO_2 span gas, or NOx span gas. The latter three gases are used for calibration, and are supplied to quick-connect ports on the exterior of the RAVEM system unit. The gases used are certified by the manufacturer (PraxAir) and are traceable to U.S. NIST standards.

During an emission test, gas concentrations in the dilute exhaust are monitored continuously, and recorded about once per second. After the test ends, the analyzers are normally again calibrated prior to analyzing the concentrations in the sample and background bags.

Since the second-by-second pollutant readings can be affected by drift, vibration, and changes in background pollutant concentrations as the vehicle drives, the bag data are normally more accurate, and are generally the ones reported. The second-by-second data are useful for examining the variation in emissions over the driving cycle, and also provide a backup should the bag results be compromised – e.g. by bag failure during a test.

Particulate Sampling System

The particulate sampling system comprises a vacuum pump, two flow controllers, two shutoff valves, and two filter holders: one for the PM sample, and one for the background dilution air. Each filter holder contains two 37 mm filters in series. The filters are composed of Teflon-coated borosilicate glass, and meet U.S. EPA (40 CFR 86.1311-90) and ISO 8178 specifications for diesel PM measurement. At least two sets of filter holders are used, and they are designed to be quickly connected and removed from the sampling system – thus allowing one emission test to go on while the filters from the last test are being exchanged for the filters for the next.

During an emission test, the shutoff valves are opened, and the dilute exhaust gas and dilution air are drawn through their respective filter sets. The filtered gas then passes through the flow controllers to the vacuum pump, where it is exhausted. The flow controllers maintain a constant flow rate (typically 10 to 30 SLPLM, depending on the anticipated PM loading) throughout the emission test. Integrated flow volume is recorded during the emission test in order to calculate the particulate mass concentration in the dilute air/exhaust sample and in the background dilution air.

The filter set exposed to the dilution air provides a “blank” sample for each test, correcting for the effects of changing humidity, atmospheric pressures, and any ambient PM (including condensable species) present in the filtered dilution air. Experience has shown that such corrections can amount to 0.01 to 0.02 grams of PM per BHP-hr. This is important since this amount of PM is of the same order as the total measured PM emissions for the DPF-equipped vehicles in this study.

CARTRIDGE SAMPLING SYSTEM

The DNPH cartridge sampling system is similar in design to the PM sampling system described above, comprising two shutoff valves, two holders for SKC 6 mm glass sampling tubes, two flow controllers. Initially, the system included only a single pump, but later each flow controller was given its own pump. The DNPH sampling system differs from the PM sampling system in having much lower designed flow rates (i.e. 0 to 2 liters per minute, rather than 0 to 30), and in drawing from the filtered sample stream that also feeds the Tedlar bags, rather than directly from the dilution tunnel.

To measure the concentration of carbonyls such as formaldehyde, acetaldehyde, and acetone, the cartridge sampler is loaded with two 6 mm glass tubes containing DNPH-impregnated silica gel. Gas is drawn from the sample and dilution air ports, through filters, and then through the cartridges, where any carbonyls present react with the DNPH and are retained in the cartridge. The cartridges are then removed, placed in a cooler at approximately 4 ^{o}C, and transported to the laboratory, where they are kept in a freezer until analysis by high performance liquid chromatography (HPLC), as specified in EPA method TO-11a.

DATA PROCESSING AND HANDLING SYSTEM

The data processing and handling system comprises a laptop computer, connected to a National Instruments Fieldpoint system containing 24 analog-to-digital channels, 8 digital-to-analog channels, 36 digital outputs, 8 general-purpose digital inputs, and 4 counter inputs. These include a number of spare inputs and outputs beyond those required by the RAVEM system itself, making it easy to interface auxiliary sensors.

The RAVEM system measures and records numerous data on a second-by-second basis during each emission test, including the raw inputs and calculated concentrations of CO,

CO_2, and NOx, the CVS flow rate, throttle position, and differential pressure sensor reading. Calibration data relating the raw inputs and calculated concentrations are also recorded, making it possible to recalculate the second-by-second results using the calibration at the end of the test. Exhaust temperature and up to two auxiliary temperatures are recorded second-by-second; in addition, the temperature, barometric pressure, and humidity are recorded at the beginning of each test. All of these are stored in separate data file for each test, in a compact binary format.

A data file reading utility is supplied with the RAVEM system. This utility can be used to review and correct the data collected for each test, and to add data developed later such as the post-test weights of the particulate filters. This utility can also copy the data to a Microsoft Excel worksheet file. This file is formatted to be "human readable", and occupies much more space than the compact binary format. Copies of the Excel worksheets for each emission test are given in the CD ROM that accompanies this report, along with summary worksheets that combine the individual test results.

AUXILIARY INPUTS

Auxiliary inputs to the RAVEM system include a global positioning system (GPS) receiver, as well as user-specified pulse, voltage, and 4-20 ma current inputs. The GPS system provides three-dimensional location and velocity data, based on signals from the global positioning network. These are supplied and recorded at a frequency of 1 Hz.

Quality Control Measures

RAVEM operating procedures include a number of quality assurance measures. Two key QA procedures are CO_2 recovery tests and fuel consumption checks. The CO_2 recovery check injects CO_2 gas from a cylinder into the dilution tunnel, and compares the CO_2 mass measured to the change in weight of the CO_2 cylinder. This confirms the accuracy of the CVS flow measurement, as well as the gas sampling system and the CO_2 analyzer. As mentioned earlier, CO_2 recovery checks performed prior to the correlation testing with WVU showed a discrepancy of 6 to 8%. The source of this discrepancy was subsequently determined to be leakage through a setscrew hole. Once this hole was plugged, CO_2 recovery checks have shown close agreement between the CO_2 emissions as measured by the RAVEM system and by the change in weight of the gas cylinder.

Fuel consumption checks compare the mass of fuel consumed by the vehicle under test to the fuel consumption calculated from the CO_2 and CO emissions by carbon balance. In addition to the CVS and gas sampling system, this procedure also checks that the isokinetic sampling system is working properly.

References

[v] Weaver, C.S., M.V. Balam-Almanza, D. Noriega, R. Rodriguez, and L. Petty, "Medición de Emisiones a Vehículos Recolectores de Basura en la Ciudad De México" (Measurement of Emissions from Garbage Collection Vehicles in Mexico City), presented to the Interamerican Association for Sanitary Engineering, Cancún, Mexico, September 2002.

[vi] Weaver, C.S., L.M. Chan and L. Petty, Measurement of Air Pollutant Emissions From In-Service Passenger Ferries, report to the Water Transit Authority of San Francisco Bay, August, 2002.

[vii] C.S. Weaver and L.E. Petty "Reproducibility and Accuracy of On-Board Emission Measurements Using the RAVEM™ System ", SAE Paper No. 2004-01-0965, March, 2004.

[viii] Weaver, C.S. and M.V. Balam-Almanza, "Development of the 'RAVEM' Ride-Along Vehicle Emission Measurement System for Gaseous and Particulate Emissions", SAE Paper No. 2001-01-3644.

[ix] 40 CFR 86, Subpart N "Emission Regulations for New Otto-Cycle and Diesel Heavy-Duty Engines; Gaseous and Particulate Exhaust Test Procedures"

[x] "California Exhaust Emission Standards and Test Procedures for 1985 and Subsequent Model Heavy-Duty Diesel Engines and Vehicles" as amended on February 26, 1999, California Air Resources Board

[xi] U.S. Patent No. 6,062,092. "System for Extracting Samples from a Stream", May 16, 2000.

ATTACHMENT C: RAILYARD EMISSIONS INVENTORY METHODOLOGY

Railyard Emissions Inventory Methodology

Version 1.2

October 2005

Introduction

Rule 3503 – Emissions Inventory and Health Risk Assessment for Railyards requires an emissions inventory be conducted for railyards operated by all Class 1 freight railroads and switching and terminal railroads in the Basin for the purpose of conducting a Health Risk Assessment. The following methodology is intended to provide a quantification methodology to estimate the emissions of both criteria and toxic air pollutants (VOC, NOx, PM10, CO, SOx, and Toxic Air Contaminants) from all dedicated and transient mobile sources at railyards in the Basin. This methodology is applicable to locomotives (both line haul and switching), cargo handling equipment (e.g., yard tractors), on-road trucks and vehicles, and other off-road equipment such as transport refrigeration units. All mobile emissions within the railyard boundary, as defined in Proposed Rule 3503, must be quantified using this methodology. This methodology does not apply to stationary sources and the emissions inventory for stationary sources shall be conducted according to Proposed Rule 3503 (d)(2).

For the purpose of preparing Health Risk Assessment air dispersion modeling inventory input data, use of annual emissions can be desegregated into hourly emissions based upon operational profiles, for each equipment category, that can represent peak or average hourly emissions. This approach is appropriate provided the derived peak hourly emissions that are derived from annual average emissions utilize appropriate assumptions, such as seasonal variations, daily variations, etc., that would represent the peak hourly.

The following sections describe specific emissions inventory methodologies for each source category.

Locomotives

Locomotive emissions must be quantified separately for line haul and switcher locomotives. Emissions are based on number of locomotives, engine size, activity level (i.e., time spent in each power notch) and applicable emission factors from a district approved source (e.g., U.S. EPA, manufacturer's certification data) for each locomotive type. Since locomotives operate in discrete throttle settings called notches, ranging from notch position one through eight, plus an idle position, emissions for each locomotive must be calculated based on the time spent in each notch as well as the corresponding emission factor for each notch. Any locomotive activity, regardless of ownership, that occurs within the railyard should be included in the emissions inventory. The emissions inventory, however, does not include emissions outside of the railyard, such as emissions from locomotives that may travel along rail lines that are adjacent to the railyard. This means that the emissions from locomotives on main lines that pass through railyards must be quantified, while emissions from locomotives on main lines located adjacent to but outside of railyards should not be quantified.

Use of an average operating mode (AOM) for an equipment category may be used in cases where it can be shown that equipment will be operating in a pattern that is predictable and repetitive.

Sufficient verifiable data must be provided to validate the AOM of the equipment category and the use of the average operating mode must be approved by the Executive Officer. Use of an

AOM shall include only the necessary information to validate normal use of the equipment which shall, include but not be limited to, time in each engine load or notch, fuel type and amount utilized, time in idle mode, distance traveled in miles within the railyard, hours of operation in railyard, or any other information to show the predictable and repetitive nature of the equipment.

a) Line Haul Locomotives

Data Needed:

1. number of line haul locomotives
2. size (hp), make, and model of locomotive
3. emission factor (EF) per locomotive per notch (g/hp-hr)
4. time-in-notch (hours) for each locomotive within rail yard boundary

Emissions Calculation:

$$EI_{Line\ haul} = \sum_{i=1}^{n} EF_{ij} * (Time - in - Notch)_{ij} * HP_i$$

Where:

$EI_{Line\ haul}$	=	Emissions inventory for all line haul locomotives
EF_{ij}	=	Emission factor per locomotive per notch (g/bhp-hr)
$Time\text{-}in\text{-}Notch_{ij}$	=	Time spent in each notch for each locomotive (hours)
HP_i	=	Horsepower of each locomotive (hp)

b) Switcher Locomotives

Data Needed:

1. size (hp), make, and model of locomotive
2. emission factor (EF) per locomotive per notch (g/hp-hr)
3. time-in-notch (hours) for each locomotive within rail yard boundary

Emissions Calculation:

$$EI_{Switchers} = \sum_{i=1}^{n} EF_{ij} * (Time - in - Notch)_{ij} * HP_{ij}$$

Where:

$EI_{Switchers}$	=	Emissions inventory for all switcher locomotives
EF_{ij}	=	Emission factor per locomotive per notch (g/bhp-hr)
$Time\text{-}in\text{-}Notch_{ij}$	=	Time spent in each notch for each locomotive (hours)
HP_i	=	Horsepower of each locomotive (hp)

c) Maintenance and Certification Testing of Locomotives (Line Haul or Switcher)

Data Needed:

1. size (hp), make, and model locomotive
2. emission factor (EF) per locomotive per notch (g/hp-hr)

3. Time-in-notch (hours) or operating test mode time interval for each locomotive within railyard boundary

Emissions Calculation:

$$EI_{Maintenance} = \sum_{m=1}^{n} EF_m * (Time\text{-}in\text{-}notch)_m * HP_m$$

Where;

$EI_{Maintenance}$	=	Emissions inventory for all locomotives
EF_m	=	Emission factor per locomotive per notch (g/bhp-hr)
$Time\text{-}in\text{-}notch_m$	=	Time spent in each notch or operating test mode time interval for each locomotive (hours)
HP_m	=	Horsepower per locomotive per notch (hp)

Cargo Handling Equipment

Cargo handling equipment (CHE) refers to all off-road mobile equipment used to move containers or bulk goods at rail yards such as yard tractors, forklifts, cranes, side and top picks, chassis stackers, loaders, and flippers. Emissions are based on number and type of equipment, activity levels (i.e., hours of operation), and applicable emission factor from a district approved source (e.g., U.S. EPA, manufacturer's certification data) for each equipment type.

Use of an average operating mode (AOM) for an equipment category may be used in cases where it can be shown that equipment will be operating in a pattern that is predictable and repetitive.

Sufficient verifiable data must be provided to validate the AOM of the equipment category and the use of the average operating mode must be approved by the Executive Officer. Use of an AOM shall include only the necessary information to validate normal use of the equipment which shall, include but not be limited to, engine load, fuel type and amount utilized, time in idle mode, distance traveled in miles within the railyard, hours of operation in railyard, or any other information to show the predictable and repetitive nature of the equipment.

Data Needed:

1. population of cargo handling equipment
2. emission factor (EF) by size and model year (g/bhp-hr)
3. size (hp)
4. load factor (LF)
5. activity within rail yard boundary (hours)

Emission Calculation:

$$EI_{CHE} = \sum_{i=1}^{n} EF_i * HRS_i * HP_i * LF_i$$

Where:

EI_{CHE}	=	Emissions inventory for all cargo handling equipment

EF_i	=	Emission factor for each CHE by type, size, and model year (g/bhp-hr)
HRS_i	=	Operating hours within rail yard boundary (hours)
HP_i	=	Horsepower of each equipment (hp)
LF_i	=	Load factor

On-Road Trucks

The emissions from on-road trucks, either dedicated or transient visitors (e.g., delivering containers) are based on number of trucks, activity levels (i.e., vehicle average miles to designated areas traveled within rail yard boundary, idling hours), and applicable emission factors from CARB's most recently approved EMFAC model. An overall fleet average for each class of on-road trucks (i.e., heavy-heavy-duty on-road trucks, heavy-duty on-road trucks) can be used to estimate emissions.

Use of an average operating mode (AOM) for an equipment category may be used in cases where it can be shown that equipment will be operating in a pattern that is predictable and repetitive.

Sufficient verifiable data must be provided to validate the AOM of the equipment category and the use of the average operating mode must be approved by the Executive Officer. Use of an AOM shall include only the necessary information to validate normal use of the equipment which shall, include but not be limited to, time in each engine load or notch, fuel type and amount utilized, time in idle mode, distance traveled in miles within the railyard, hours of operation in railyard, or any other information to show the predictable and repetitive nature of the equipment.

Data Needed:

1. for each class of truck, the number of trucks
2. fleet average EMFAC emission factor (EF_{VMT}) for average speed within rail yard (g/mile) – for dedicated on-road trucks, use model year specific EMFAC emission factor
3. fleet average EMFAC emission factor (EF_{idling}) for idling (g/hour) – for dedicated on-road trucks, use model year specific EMFAC emission factor
4. average of miles to designated areas traveled within rail yard boundary (VMT) for each truck
5. time spent idling within rail yard boundary (hours)

Emission Calculation:

$$EI_{Trucks} = \sum_{i=1}^{n} (EF_{VMT})_i * VMT_i + (EF_{idling})_i * HRS_i$$

Where:

EI_{Trucks}	=	Emissions inventory for all trucks
EF_{VMTi}	=	fleet average (model year specific for dedicated on-road trucks) EMFAC emission factor for average speed within rail yard (g/mile)

EF_{Idling}	=	fleet average (model year specific for dedicated on-road trucks) EMFAC emission factor for idling (g/hour)
VMT_i	=	number of average miles to designated areas traveled in each truck within rail yard boundary
HRS_i	=	idling hours for each truck (hours)

Other On-Road Vehicles (e.g., Light Duty Service Trucks)

The emissions from other on-road vehicles such as light duty service trucks, either dedicated or transient visitors, are based on number of trucks, activity levels (i.e., vehicle miles traveled within rail yard boundary), and applicable emission factors from CARB's most recently approved EMFAC model. Employee passenger vehicles are to be excluded from the inventory. An overall fleet average for each class of on-road vehicles (i.e., light-duty trucks, medium-duty trucks) can be used to estimate emissions.

Use of an average operating mode (AOM) for an equipment category may be used in cases where it can be shown that equipment will be operating in a pattern that is predictable and repetitive.

Sufficient verifiable data must be provided to validate the AOM of the equipment category and the use of the average operating mode must be approved by the Executive Officer. Use of an AOM shall include only the necessary information to validate normal use of the equipment which shall, include but not be limited to, engine load, fuel type and amount utilized, time in idle mode, distance traveled in miles within the railyard, hours of operation in railyard, or any other information to show the predictable and repetitive nature of the equipment.

Data Needed:

1. for each on-road vehicle class, the number of on-road vehicles
2. fleet average EMFAC emission factor (EF) (g/mile) – for dedicated on-road trucks, use model year specific EMFAC emission factor
3. miles traveled within rail yard boundary (VMT) for each vehicle

Emission Calculation:

$$EI_{Onroad} = \sum_{i=1}^{n} EF_i * VMT_i$$

Where:

EI_{Onroad}	=	Emissions inventory for other on-road vehicles
EF_i	=	fleet average (model year specific for dedicated on-road trucks) EMFAC emission factor (g/mile)
VMT_i	=	number of miles traveled within rail yard boundary

Other Off-Road Equipment

The emissions from other off-road equipment such as transport refrigeration units (TRU) are based on activity level (i.e., number of equipment, activity levels (i.e., hours of operation), and applicable emission factor from a district approved source (e.g., U.S. EPA, manufacturer's certification data) for each equipment type.

Use of an average operating mode (AOM) for an equipment category may be used in cases where it can be shown that equipment will be operating in a pattern that is predictable and repetitive.

Sufficient verifiable data must be provided to validate the AOM of the equipment category and the use of the average operating mode must be approved by the Executive Officer. Use of an AOM shall include only the necessary information to validate normal use of the equipment which shall, include but not be limited to, engine load, fuel type and amount utilized, time in idle mode, distance traveled in miles within the railyard, hours of operation in railyard, or any other information to show the predictable and repetitive nature of the equipment.

Data Needed:

1. population of off-road equipment (non-cargo handling equipment)
2. baseline emission factor (EF) by size and model year (g/bhp-hr)
3. size (hp)
4. load factor (LF)
5. activity within rail yard boundary (hours)

Emission Calculation:

$$EI_{offroad} = \sum_{i=1}^{n} EF_i * HRS_i * HP_i * LF_i$$

Where:

$EI_{offroad}$	=	Emissions inventory for all other equipment
EF_i	=	Emission factor by type, size, and model year (g/bhp-hr)
HRS_i	=	Operating hours within rail yard boundary (hours)
HP_i	=	Horsepower of each equipment (hp)
LF_i	=	Load factor

Total Emissions from Rail Yards

The total mobile source emissions from rail yards are calculated by summing the individual totals for each source category as follows:

$$EI_{TotalMobile} = EI_{Linehaul} + EI_{Switcher} + EI_{Maintenance} + EI_{CHE} + EI_{Trucks} + EI_{Onroad} + EI_{Offroad}$$

Recordkeeping Requirement

The railyard operator must maintain records of all items described above under Data Needed for each locomotive, CHE, on-road truck, other on-road vehicle or off-road equipment. The information must be recorded in a format approved by the District and be maintained for a minimum of two years. The source for all emission factors and information used to determine emission factors shall be referenced and documented.

The emissions inventory for each source category shall be determined in accordance with Rule 3503 (d) and provided in a format that is re-producible by District staff.

ATTACHMENT D: HEALTH RISK ASSESSMENT GUIDANCE FOR RAILYARDS AND INTERMODAL FACILITIES

Health Risk Assessment Guidance for Railyards and Intermodal Facilities

South Coast Air Quality Management District

September 2005

Introduction

The purpose of this document is to provide dispersion modeling and health risk assessment guidance for railyard and intermodal facilities. The California Air Resources Board (ARB) has done significant work in this area. Much of the guidance presented here is built upon their previous work on the Diesel Risk Management Plan[1] and the Roseville Rail Yard Study.[2]

Air Dispersion Modeling

Air dispersion modeling is performed for the exposure assessment of the health risk assessment (HRA). A basic understanding of dispersion modeling is presumed. For a more detailed overview of regulatory modeling procedures, the reader is referred to the U.S. Environmental Protection Agency's "Guideline on Air Quality Models."[3]

Facility Description and Source Information

The HRA report should contain a brief description of the facility and its activities as shown in the detailed HRA report outline provided in Appendix A. Table 1 lists the information on the facility and its surroundings that must be provided in the modeling analysis. The facility location is used to determine the most representative meteorological data for the analysis. The nearby land use is needed to properly label receptors as residential, commercial, sensitive, etc.

The facility plot plan (including a length scale) is needed to determine all stationary and mobile source locations (including their elevations above sea level), building dimensions, truck and train routes, truck and train idling activities, cargo handling activities, other on- and off-road equipment activities, and the property boundary. Table 2 lists the potential sources that must be included in the HRA. The operating profile, the hourly emission rates, the annual average emission rates, and the source parameters listed in Table 1 are necessary to accurately characterize the source emissions. It is acceptable to estimate the hourly emission rate of certain equipment based on operating profiles. The reader is referred to the detailed outline provided in Appendix A for additional information and guidance.

Source Treatment

On-road and off-road mobile emission sources, such as trucks, locomotives, cargo handling equipment, etc., should be treated as point sources when stationary or idling and as volume sources when moving. Stack parameters representative of the fleets of trucks, locomotives, and cargo handling equipment for the railyard should be used. The stationary or idling mobile equipment are not typically uniformly distributed throughout the facility. Their location in the dispersion modeling should be based on a detailed study and survey of the facility activity; emissions should only be placed where activity occurs.

Emissions from the movement of trucks and trains should be simulated as a series of volume sources along their corresponding routes of travel. A typical railyard or intermodal facility can have a large number of individual sources; the ARB modeling for the Roseville Railyard Study[2] included about 20,000 individual sources. It is acceptable and even encouraged to combine sources into large volumes in order to make the modeling analysis manageable. Like or related pollutant sources with similar source parameters may be combined. The volume source footprint should remain within the confines of the activity. Spreading the emissions to areas outside the activity is not acceptable. Appropriate volume source heights for the trucks and trains can be estimated by calculating effective plume height under expected travel speeds, atmospheric stability conditions, and stack parameters representative of the truck and train fleet.

Table 1. Required Source Information.

Information on the Facility and its Surroundings

- Location (i.e., address and UTM coordinates)
- Local land use (within 20 km)
- Local topography (within 20 km)
- Facility plot plan
  - Property boundaries
  - Horizontal scale
  - Building heights (for building downwash calculations)
  - Stationary source locations including elevations
    - Maintenance and servicing areas
    - Fueling areas
    - Vehicle entrance and exit of railyard
    - Weigh and dispatch stations
    - Switching, classification, hump location, yard sidings and spurs
  - Locations of truck and train idling activity including elevations
    - Locomotive and truck crossing locations, weigh and dispatch stations
    - Truck queuing prior to loading
  - Truck and train routes within the facility
    - Including crossing locations
  - Cargo handling activities
    - Maintenance, servicing, storage, mobile fueling locations
    - Intermodal loading/unloading, chassis loaders and stackers, yard hostlers, etc.

Point Source Information (stacks, vents, etc.)

- Annual emissions
- Operating profile (e.g., seasonal, monthly, weekly, or daily operating schedule)
- Maximum and average hourly emission rates
- Stack location (in UTM coordinates) on plot plan including elevation
- Stack height
- Stack gas exit velocity
- Stack gas exit temperature
- Building dimensions, heights, and location

Mobile and Fugitive Source Information (i.e., area and volume sources)

- Maximum and average hourly emission rates
- Annual emissions
- Source location (in UTM coordinates) on plot plan including elevations
- Source height
- Area or volume dimensions

Table 2. Potential Emission Sources for Consideration in the HRA.

Source Category	Examples
Stationary	Boilers (all fuels), water heaters (all fuels), emergency generator sets and fire pumps (all fuels), fuel dispensing (LPG, gasoline, diesel, etc.), fuel storage tanks (LPG, gasoline, diesel, etc.), waste water treatment facilities
On-road mobile	heavy duty diesel trucks (idling & moving), crew vans, crew trucks (all fuels)
Off-road mobile	overhead cranes, side loaders, chassis stackers, chassis loaders, yard hostlers, rubber tire gantry cranes, utility trucks, dozers, forklifts, locomotives (switchers and line haul)

Two important modeling input parameters are initial lateral and vertical dimensions. As recommended by the ISCST3 User's Guide,[4] the initial lateral dimension is calculated by dividing the adjacent source separation distance by 2.15 and the initial vertical dimension is calculated by dividing the effective height of the plume by 2.15. The reader is referred to a couple of ARB modeling studies for additional guidance and clarification.[1],[2] Table 3 recommends the ISCST3 source treatment for typical sources expected at a railyard.

Table 3. ISCST3 source treatment for typical railyard sources.

Source Category	Specific Sources	ISCST3 Source Treatment
Stationary	Natural gas boilers & water heaters	Point
	Diesel & natural gas emergency generators	Point
	Diesel & gasoline fuel pumps	Point
	Fuel storage tanks with floating roofs	Volume or Area
	Fuel storage tanks with vent valves	Point
	Waste water treatment facilities	Point
On-road mobile	Heavy duty diesel trucks (idling)	Point
	Heavy duty diesel trucks (moving)	Volume
	Crew vans & trucks	Volume
Off-road mobile	Overhead cranes	Volume
	Side loaders	Volume
	Chassis stackers	Volume
	Chassis loaders	Volume
	Yard hostlers	Volume
	Rubber tire gantry cranes	Volume
	Utility trucks	Volume
	Dozers	Volume
	Forklifts	Volume
	Locomotives (moving)	Volume
	Locomotives (idling)	Point

Stacks with Raincaps and Area Sources

Emission release points with raincaps or which are oriented so that the exhaust is vented downward or horizontally may not use the velocity inside the stack as the vertical velocity of the point source in the model. However, as a point source must be modeled with some vertical velocity, these stacks may be modeled with a positive vertical velocity of no more than 0.1 meters per second. In general, if there is uncertainty on how to represent sources in a model, South Coast Air Quality Management District (SCAQMD) staff in the AB2588 Section should be consulted before proceeding with modeling.

According to U.S. EPA guidance for area sources in ISCST3,[4] the aspect ratio (i.e., length/width for area sources should be less than 10 to 1. If this is exceeded, then the area should be subdivided to achieve a 10 to 1 or less aspect ratio for all sub-areas.

Model Selection and Model Options

All stationary source risk assessments prepared for the SCAQMD must follow the Office of Environmental Health Hazard Assessment (OEHHA) guidance[5] and use ARB's Hotspots Analysis and Reporting Program (or HARP).[6] The U.S. Environmental Protection Agency (U.S. EPA) air quality dispersion model, called ISCST3 (Industrial Source Complex – Short Term, Version 3) is used by HARP for the exposure assessment. Given the many and varied activities at a typical railyard or intermodal facility, HARP may not be the best tool for simulating the risks from the diesel particulate sources. Such sources may be best treated directly by ISCST3 and the risks estimated using procedures outlined in Appendix B. It is suggested that HARP be used for the all the non-diesel sources and that the results from the two approaches be combined.

ISCST3 is a Gaussian plume model capable of estimating pollutant concentrations from a wide variety of sources that are typically present in an industrial source complex. The model is applicable to transport distances of 50 km or less;[3] therefore, receptors should be limited to within 50 km of the source. Emission sources are categorized into four basic types: point, area, volume, and open pit sources. ISCST3 estimates hourly concentrations for each source/receptor pair and calculates concentrations for user-specified averaging times, including an average concentration for the complete simulation period. ISCST3 includes atmospheric dispersion options for both urban and rural environments and can address flat, gently rolling, and complex terrain situations. ISCST3 documentation is available at the U.S. EPA website.[4] Table 4 summarizes the dispersion modeling assumptions required by the SCAQMD. These requirements are discussed in more detail next.

ISCST3 should be executed using the urban dispersion parameters (i.e., URBAN), which is SCAQMD policy for all air quality impact analyses in its jurisdiction. The U.S. EPA regulatory defaults options are implemented except that the calm processing option is disabled (i.e., NOCALM). The SCAQMD believes that calm processing is inappropriate for its meteorological data for the following reasons:

- Calm processing was developed by the U.S. EPA to correct problems with preprocessed data in which calm winds are given the speed of 1 m/s and the direction of the last non-calm hour. This results in artificial persistence. Wind data collected by the SCAQMD is not preprocessed.

- Wind speeds in the SCAQMD stations are always 1 m/s or greater. Thus, model problems associated with lower wind speeds are not an issue.
- Wind direction is always recorded regardless of the wind speed and the direction is randomized over a 22.5 degree sector. Thus, artificial persistence is not an issue.
- SCAQMD data is more like on-site data and calm processing is not appropriate for on-site data.
- Given the high frequency of calms at many sites in the South Coast Air Basin and their association with high pollutant concentrations, it would be inappropriate to eliminate that portion of the data.

For these reasons, the SCAQMD does not require calm processing for dispersion modeling that uses SCAQMD supplied meteorological data.

Table 4. Summary of SCAQMD Dispersion Modeling Guidance.

Parameter	**Assumption**
Model Control Options	
Use regulatory default?	No
Urban or Rural?	Urban
Gradual plume rise?	No
Stack tip downwash?	Yes
Buoyancy induced dispersion?	Yes
Calms processing?	No
Missing data processing?	No
Source Options	
Include building downwash?	Yes
Lowbound option?	No
Meteorology Options	
Meteorological data	See note #1 below

1. The data are available for download from the SCAQMD website; see reference [7].

Meteorological Data

The SCAQMD has 1981 meteorological data (i.e., hourly winds, atmospheric stability, and mixing heights) at 35 stations in the South Coast Air Basin, as shown in Figure 1 and listed in Table 5.

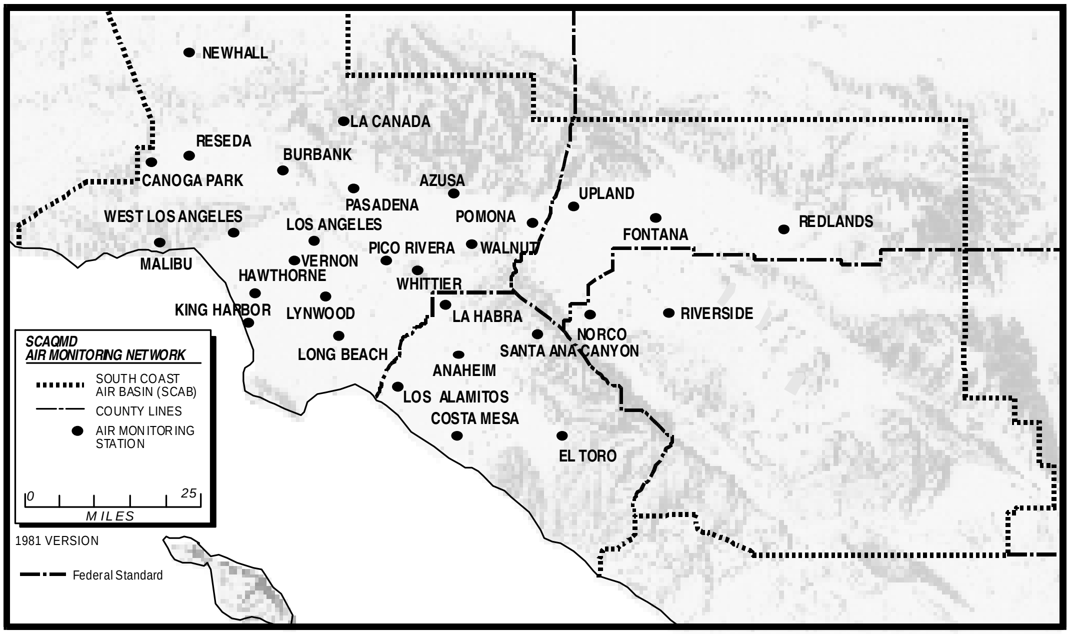


Figure 1. Locations of meteorological stations.

Table 5. Locations of Meteorological Stations

Station name	UTM Coordinates (m) E-W	UTM Coordinates (m) N-S	Lat./Long. Coordinates Latitude	Lat./Long. Coordinates Longitude
Anaheim	415.0	3742.5	33°49’16”	117°55’07”
Azusa	414.9	3777.4	34°08’09”	117°55’23”
Banning	510.5	3754.5	33°55’58”	116°53’11”
Burbank	379.5	3783.0	34°10’58”	118°18’27”
Canoga Park	352.9	3786.0	34°12’23”	118°35’48”
Compton	385.5	3750.3	33°53’19”	118°14’17”
Costa Mesa	413.8	3724.2	33°39’21”	117°55’47”
Downtown Los Angeles	386.9	3770.1	34°04’02”	118°13’31”
El Toro	436.0	3720.9	33°37’39”	117°41’25”
Fontana	455.4	3773.9	34°06’24”	117°29’01”
Indio	572.3	3731.0	33°43’06”	116°13’11”
King Harbor	371.2	3744.4	33°50’00”	118°23’30”
La Canada	388.2	3786.1	34°12’42”	118°12’49”
La Habra	412.0	3754.0	33°55’28”	117°57’07”
Lancaster	396.0	3839.5	34°41’38”	118°08’08”
Lennox	373.0	3755.0	33°55’46”	118°22’26”
Long Beach	390.0	3743.0	33°49’24”	118°11’19”
Los Alamitos	404.5	3739.8	33°47’45”	118°01’54”
Lynwood	388.0	3754.0	33°55’20”	118°12’42”
Malibu	344.0	3766.9	34°01’59”	118°41’23”
Newhall	355.5	3805.5	34°22’59”	118°31’02”

continued

Table 5. Concluded.

Station name	UTM Coordinates (m) E-W	UTM Coordinates (m) N-S	Lat./Long. Coordinates Latitude	Lat./Long. Coordinates Longitude
Norco	446.8	3749.0	33°52'54"	117°34'31"
Palm Springs	542.5	3742.5	33°49'25"	116°32'27"
Pasadena	396.0	3778.5	34°08'38"	118°07'41"
Pico Rivera	402.3	3764.1	34°00'53"	118°03'29"
Pomona	430.8	3769.6	34°03'60"	117°44'60"
Redlands	486.2	3769.4	34°04'00"	117°09'00"
Reseda	359.0	3785.0	34°11'54"	118°31'49"
Riverside	464.8	3758.6	33°58'10"	117°22'50"
Santa Ana Canyon	431.0	3748.4	33°52'32"	117°44'46"
Upland	440.0	3773.1	34°05'55"	117°39'02"
Vernon	387.4	3762.5	33°59'55"	118°13'10"
Walnut	420.0	3761.7	33°59'41"	117°51'58"
West Los Angeles	372.3	3768.6	34°03'08"	118°23'01"
Whittier	405.3	3754.0	33°55'26"	118°01'28"

This data is in a format which can be directly read by U.S. EPA's dispersion model, ISCST3 and by ARB's health risk assessment tool, HARP. The nearest representative meteorological station should be chosen for modeling. Usually this is simply the nearest station; however, an intervening terrain feature may dictate the use of an alternate station. Modelers should contact the AB2588 Section regarding the most representative meteorological station, if necessary. The data are available for download from the SCAQMD website.[7] The railyard may propose an alternative set of meteorological data subject to the Executive Officer's approval, provided that the data is representative and complete for modeling purposes.

Receptor Grid

Air dispersion modeling is required to estimate (a) annual average concentrations to calculate the Maximum Exposed Individual Resident (MEIR); the Maximum Exposed Individual Worker (MEIW); the Maximum Individual Cancer Risk (MICR), which is simply the greater of the MEIR and MEIW; the maximum chronic HI; the zones of impact; and excess cancer burden and (b) peak hourly concentrations to calculate the health impact from substances with acute non-cancer health effects. To achieve these goals, the receptor grid should begin at the facility fence line and extend to cover the zone of impact. However, the modeling domain should not extend more than 50 km in any direction from the facility due to the pollutant transport limitation of 50 km for ISCST3.[3] In addition, the receptor grid should be fine enough to identify the points of maximum impact.

To identify the maximum impacted receptors (i.e., peak cancer risk and peak hazard indices) a grid spacing of 100 meters or less must be used. All receptors should be identified in UTM coordinates. Receptor grid points outside of the facility boundary with grid spacing of 100 meters or more must be placed so that individual grid points are placed at UTM coordinates ending in "00" (e.g., grid point UTM East 572300 and UTM

North 3731000). Receptor grids with less than 100 meter spacing must include grid points at UTM coordinates ending in “00”.

Receptors on the facility boundary must be placed along the boundary following the maximum spacing requirements shown in Table 6. Sensitive receptors must be identified by exact UTM coordinates. Elevations must be provided for all receptors.

The density of the receptor network can be relaxed in downwind regions outside the peak impact area. The network must only be sufficiently dense to develop the 1, 10, 25, 100, 250, 500, 1000, 2500, 5000, etc. in a million cancer risk isopleths and the 0.5, 1, 3, 5, and 10 non-cancer hazard index isopleths.

Table 6. Maximum Receptor Spacing Requirements for Fenceline Receptors.

Area of Facility	Maximum Receptor Spacing
Area < 4 acres	20 meters
4 acres ≤ Area < 10 acres	30 meters
10 acres ≤ Area < 25 acres	50 meters
25 acres ≤ Area < 100 acres	75 meters
Area ≥ 100 acres	100 meters

Missing or Incomplete Data

Currently Rule 3503 requires the concurrent development of an air toxics inventory and health risks assessment one year after the adoption of the rule. Since annual and peak hourly emission rates are required for the preparation of the HRA, it may be necessary to estimate annual emissions from less than a complete year of activity. Given the requirements of the rule, it is acceptable to extrapolate annual emissions from less than a full year of activity. If the activity is seasonal in nature, then extrapolation to obtain the annual emissions needs to rely on operational profiles.

Risk Assessment

The SCAQMD requires that all stationary source HRAs be prepared in accordance with OEHHA and ARB guidance.[5] This guidance is implemented through the ARB computer program called, Hotspots Analysis and Reporting Program (HARP).[6] HARP is a convenient and the preferred tool to evaluate risks from multiple sources emitting multiple toxics. However, given the many and varied activities at a typical railyard or intermodal facility, HARP may not be the best tool for simulating the risks from the diesel particulate sources. Such sources may be best treated directly by ISCST3 and the risks estimated using procedures outlined in Appendix B. It is suggested that HARP be used for the all the non-diesel sources and that the results from the two approaches be combined. OEHHA guidance assumes that risks are additive.

Uncertainty in Risk Assessment

The SCAQMD recognizes that there can be uncertainty in health risk assessments. It is appropriate to include a discussion on the topic of risk assessment uncertainty in the Executive Summary and main body of the HRA. Any discussion of uncertainty must consider both the factors that contribute to risk overestimation and those that contribute to risk underestimation (see pages 1-4 and 1-5 of the OEHHA Guidelines[5]).

Toxic Pollutants Considered in the HRA

Emissions of all compounds in Appendix A-I of the OEHHA Guidelines[5] must be quantified and included in the HRA. Appendix A-I in the OEHHA Guidelines[5] provides a "degree of accuracy" for each compound, which is nothing more than a de minimis emission level for reporting. As a result, facility-wide emissions of toxics greater than one-half of their corresponding degree of accuracy must be inventoried, reported, and included in the HRA.

The degree of accuracy for diesel particulate matter given in Appendix A-I is inappropriate since it was established before OEHHA developed a cancer potency for diesel particulate. Thus, all emissions of diesel particulate matter must be reported and included in the HRA.

Although OEHHA has developed acute and chronic reference exposure levels (RELs) for many criteria pollutants, such as carbon monoxide, nitrogen dioxide, ozone, and sulfur dioxide, emissions of these pollutants should not be included in the HRA.

AQMD Risk Assessment Guidance

All HRAs prepared for the SCAQMD must include a Tier-1 evaluation, which is defined by OEHHA as a point estimate using standard assumptions. For the purpose of Proposed Rule 3503, public notification is based on OEHHA's Tier-1 risk assessment. Tier-2, Tier-3, and Tier-4 evaluations may be prepared and presented in the HRA. However, the results from any Tier-2, Tier-3, or Tier-4 evaluations must be presented in separate, clearly titled, sections, tables, figures, and text. Table 7 summarizes the risk assumptions required by the SCAQMD. These requirements are discussed in more detail next.

Residential cancer risks assume a 70-year exposure and must include, at a minimum, the following pathways: home grown produce, dermal absorption, soil ingestion, and mother's milk. A deposition velocity of 0.02 m/s should be assumed for the non-inhalation pathways. The HRA should assume the urban default value of 5.2 percent for the fraction of homegrown fruits and vegetables consumed. The other pathways of fish ingestion; dairy milk ingestion; drinking water consumption; and meat (i.e., beef, pork, chicken, and egg) ingestion should be included only if the facility impacts a local fishable body of water, grazing land, dairy, or water reservoir. The "Derived (Adjusted)" risk calculation method[8] should be used for estimating cancer risks at residential receptors. To estimate chronic non-cancer risks at residential receptors the "Derived (OEHHA)" risk calculation method[9] should be used.

Worker cancer risks assume a 40-year exposure and must include the pathways of dermal absorption and soil ingestion. A deposition velocity of 0.02 m/s should be assumed for these pathways. The "Point estimate" risk calculation method should be used for estimating cancer and non-cancer chronic risks at worker receptors.

The air concentration that the neighboring workers breathe when present at work is different than the annual average concentration calculated by the dispersion model, ISCST3. The annual average estimated by the dispersion model is a 24 hours per day, 7 days per week, 365 days per year average, regardless of the actual operating schedule of the emitting facility. Thus, the model-predicted concentrations must be adjusted by a multiplying factor to reflect the pollutant concentration that the worker breathes. For example, suppose that the off-site worker and the emitting facility have the same operating schedule, perhaps 8 hours per day, 5 days per week, and 52 weeks per year. The annual average concentrations predicted by ISCST3 must be adjusted by a factor of 4.2 (i.e., 7/5 x 24/8). The reader is referred to the OEHHA guidelines[5] on pages 8-5 and 8-6 for further detail on this issue.

Table 7. Summary of SCAQMD Guidance.

Parameter	Assumption
Pathway	
Drinking water	Site specific; see note #1 below
Fish water	Site specific; see note #1 below
Beef/dairy (pasture)	Site specific; see note #1 below
Home grown produce	Required for residential receptors
Pigs, chickens, and/or eggs	Site specific; see note #1 below
Dermal	Required for residential & worker receptors
Soil ingestion	Required for residential & worker receptors
Mother's milk	Required for residential receptors
Deposition velocity	0.02 meters per second
Fraction of homegrown fruits & vegetables consumed	5.2 percent
Cancer Risk Assumptions or Methods for Residential Receptors	
Exposure duration	70 years
Analysis method	Derived (Adjusted)
Cancer Risk Assumptions or Methods for Worker Receptors	
Exposure duration	40 years; see note #2 below
Analysis method	Point estimate
Chronic Non-cancer Risk Assumptions or Methods for Residential Receptors	
Analysis method	Derived (OEHHA)
Chronic Non-cancer Risk Assumptions or Methods for Worker Receptors	
Analysis method	Point estimate; see note #3 below

1. Required pathway only if the facility impacts a local fishable body of water, grazing land, dairy, or water reservoir.
2. See text discussion and Table 8 for required concentration adjustments.
3. The concentration adjustments provided in Table 8 are not necessary for non-cancer chronic risks.

The adjustment factors for all possible operating schedules are given in Table 8. These factors are entered into HARP by activating the worker scenario labeled "Use adjusted GLC or exposure assumptions" and entering the appropriate factor in Table 8 in the data field labeled "GLC adjustment factor." If the emitting facility operates continuously then the user should activate the worker scenario labeled "Use modeled GLC and default exposure assumptions."

Table 8. Adjustment Factors for Off-site Worker Ground-level Concentrations.*

Hours of Operation per Day	Days of Operation per Week		
	1 to 5	6	7
1 to 8	4.2	3.5	3.0
9	3.7	3.1	2.7
10	3.4	2.8	2.4
11	3.1	2.5	2.2
12	2.8	2.3	2.0
13	2.6	2.2	1.8
14	2.4	2.0	1.7
15	2.2	1.9	1.6
16	2.1	1.8	1.5
17	2.0	1.6	1.4
18	1.9	1.6	1.3
19	1.8	1.5	1.3
20	1.7	1.4	1.2
21	1.6	1.3	1.1
22	1.5	1.3	1.1
23	1.5	1.2	1.0
24	1.4	1.2	1.0

* These adjustment factors should only be used when calculating worker cancer risks. The adjustment factors should not be used when calculating chronic non-cancer risks.

Reporting Format

The reporting format for the HRA must follow the detailed outline presented in Appendix A. A completed Health Risk Assessment Summary form must be included in the executive summary of all health risk assessments submitted to the SCAQMD; a sample of the form can be downloaded from the SCAQMD's AB2588 website.[10] The detailed HRA outline provided in Appendix A lists the HARP computer files to be included in a CD with the HRA. Three (3) copies of the HRA and two (2) copies of CD(s) should be sent to the engineer or air quality specialist involved in the facility HRA. The HRA, in electronic form (i.e., pdf format), should also be included on the CD.

Cancer risk values should be reported to the nearest tenth and should be rounded up from 5 (e.g., 5.05 in a million is rounded up to 5.1 in a million). Non-cancer risk values should be reported to the nearest hundredth and should be rounded up from 5 (e.g., a hazard index of 0.105 is rounded to 0.11)

Notification Risk Levels

The SCAQMD Governing Board has adopted risk levels for purposes of public notification as shown in Table 9. Additional information regarding the SCAQMD's notification procedures are available on the web site.[11]

Table 9. Public Notification Risk Levels.

Risk Variable	**Public Notification Levels**
Cancer risk	≥ 10 in a million
Non-cancer risk	Hazard index > 1

MEIR, MEIW, and MICR

To identify the location of the Maximum Exposed Individual Resident (MEIR); the Maximum Exposed Individual Worker (MEIW); the Maximum Individual Cancer Risk (MICR), which is simply the greater of the MEIR and MEIW, it is necessary to examine current land use and allowable land use in the vicinity of the point of maximum impact (residential, commercial/industrial or mixed use). The use of block group or census tract centroids as surrogates for the maximum exposed individuals does not provide sufficient spatial resolution and will not be approved.

Cancer risk and non-carcinogenic hazard indices (HIs) must be provided for both the most exposed residential and the most exposed commercial/industrial receptors. Additionally, cancer risk and hazard index values at each sensitive receptor located within the zone of impact must be presented in a table. The zone of impact is discussed in the next section.

Zone of Impact

In any risk assessment, it is necessary to define a zone of impact or a method to set boundaries on the analysis. The SCAQMD requires that the risk assessment must encompass the area subject to an added lifetime cancer risk (all pathways) of one in a million or greater ($\geq 1.0 \times 10^{-6}$). For large railyards and intermodal facilities, one in a million cancer risks could occur more than 50 km downwind, which would exceed the 50 km pollutant transport distance limitation of ISCST3. It those instances it is acceptable to limit the receptor network to conform to the model limitation.

For non-carcinogens the analysis must bound the area subject to a hazard index of greater than or equal to one half (≥ 0.5).

Land Use Considerations

Risk estimates are sensitive to land uses (e.g. residential, commercial, vacant) since these factors can affect exposure assumptions. If residential or worker risks are not calculated at the point of maximum impact because the land is currently vacant, the location, zoning and potential future land uses must be discussed. Updated information on current land uses is requested when updated emission estimates are reported to the SCAQMD.

Maps

Maps showing the location of the source in relation to the zone of impact must be submitted. Dispersion modeling for sources should be conducted with receptors defined in terms of Universal Tranverse Mercator (UTM) coordinates. For carcinogen impacts, total risk isopleths for facilities should be plotted on the street map at cancer risk intervals of 1, 10, 25, 50, 100, 250, 500, 1000, 2500, 5000, etc. in a million. Isopleths for non-carcinogens must include levels corresponding to a HI of 0.5, 1, 3, 5, and 10.

Separate maps should be provided for each of the three risk variables: cancer risks, non-cancer acute risks, and non-cancer chronic risks. The maps must contain an accurate scale for measuring distances and a legend. The map scale that can accommodate the isopleths and show the greatest level of detail must be used. The names of streets and other locations must be presented and be legible.

The location of schools, hospitals, day-care centers, other sensitive receptors, residential areas and work-sites within the zone of impact must be identified on the map. If the area of the zone of impact is very large, then more detail should be devoted to higher concentration/risk areas versus lower risk areas. The land uses in the vicinity of the point of maximum impact (off-site) must be shown in detail. This may require a separate map. If sensitive receptors are located within the zone of impact, then risk and hazard index values must also be presented in the form of a table including all the sensitive receptors.

References

[1] Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles. Appendix VII – Risk Characterization Scenarios. ARB. October 2000. The document can be downloaded at the following link: http://www.arb.ca.gov/diesel/documents/rrpapp7.pdf

[2] ARB. 2004. Roseville Rail Yard Study. The document can be downloaded at the following link: http://www.arb.ca.gov/diesel/documents/rrstudy.htm

[3] U.S. EPA. 2003. Guideline on Air Quality Models, Appendix W of 40CFR Part 51. The document can be downloaded at the following link: http://www.epa.gov/scram001/tt25.htm#guidance

[4] U.S. EPA. 1995. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models. EPA-4504/B-95-003a & EPA-4504/B-95-003b. The program and documentation can be downloaded at the following link: http://www.epa.gov/scram001/tt22.htm#isc

[5] OEHHA. 2003. "The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments." The document can be downloaded at the following link: http://www.oehha.ca.gov/air/hot_spots/HRSguide.html

[6] ARB. 2003. HARP User Guide. The program and document can be downloaded at the following link: http://www.arb.ca.gov/toxics/harp/harp.htm

[7] Meteorological data for ISC3 and HARP can be downloaded at the following link: http://www.aqmd.gov/smog/metdata/MeteorologicalData.html

[8] An explanation of the "Derived (Adjusted)" cancer risk method is provided at the ARB web site under frequently asked questions; refer to the following link: http://www.arb.ca.gov/toxics/harp/rmpolicyfaq.htm#11

[9] An explanation of the "Derived (OEHHA)" cancer risk method is provided at the ARB web site under frequently asked questions; refer to the following link: http://www.arb.ca.gov/toxics/harp/rmpolicyfaq.htm#10

[10] Forms mentioned here can be downloaded from SCAQMD's web site at the following link: http://www.aqmd.gov/prdas/AB2588/AB2588_forms.html.

[11] AQMD's notification procedures can be downloaded at the following link: http://www.aqmd.gov/prdas/AB2588/AB2588_B4.html

[12] ARB. 2003. Recommended Interim Risk Management Policy for Inhalation-Based Residential Cancer Risk. Letter dated 10/9/2003. The document can be downloaded at the following link: http://www.arb.ca.gov/toxics/harp/docs.htm#rm

APPENDIX A

OUTLINE FOR THE HEALTH RISK ASSESSMENT REPORT

I. Table of Contents

- Section headings with page numbers indicated.
- Tables and figures with page numbers indicated.
- Definitions and abbreviations. Must include a definition of acute, chronic, and cancer health impacts.
- Appendices with page numbers indicated.

II. Executive Summary

- Name of facility and the complete address.
- Facility ID number.
- Description of facility operations and a list identifying emitted substances, including a table of maximum 1-hour and annual emissions in units of lbs/hr and lbs/yr, respectively.
- List the multipathway substances and their pathways.
- Text presenting overview of dispersion modeling and exposure assessment.
- Text defining dose-response assessment for cancer and noncancer health impacts and a table showing target organ systems by substance for noncancer impacts.
- Summary of results. Potential cancer risks for residents must be based on 70-year, Tier-1 analysis and potential cancer risks for workers must be based on 40-year, Tier-1 analysis. (The results from any Tier-2, Tier-3, or Tier-4 evaluations must be presented in separate, clearly titled, sections, tables, figures, and text).
    - Location (address or UTM coordinates) and description of the maximum exposed individual resident (MEIR), maximum exposed individual worker (MEIW), and the maximum individual cancer risk (MICR). See reference #10 for the required summary form.
    - Location (address or UTM coordinates) and description of any sensitive receptors that are above a cancer risk of ten in one million or above a noncancer health hazard index of one.
    - Text presenting an overview of the total potential multipathway cancer risk at the MEIR, MEIW, MICR, and sensitive receptors (if applicable). Provide a table of cancer risk by substance for the MEIR and MEIW. Include a statement indicating which of the substances appear to contribute to (i.e., drive) the potential health impacts. In addition, identify the exposure pathways evaluated in the HRA.
    - Provide a map of the facility and surroundings and identify the location of the MEIR, MEIW, and MICR.

- Provide a map of 70-year lifetime cancer risk zone of impact (i.e., 1 in one million risk contour), if applicable. Also show the 10, 25, 50, 100, 250, 500, 1000, 2500, 5000, etc. in one million risk contours, if applicable.
- Text presenting an overview of the acute and chronic noncancer hazard quotients or the (total) hazard indices for the MEIR, MEIW, and sensitive receptors. Include separate statements (for acute and chronic exposures) indicating which of the substances appear to drive the potential health impacts. In addition, clearly identify the primary target organ(s) that are impacted from acute and chronic exposures.
- Identify any subpopulations (e.g., subsistence fishers) of concern.
- Table and text presenting an overview of estimates of population exposure.
- Version of the Risk Assessment Guidelines and computer program(s) used to prepare the risk assessment.

III. Main Body of Report

A. Hazard Identification

- Table and text identifying all substances emitted from the facility. Include the CAS number of substance and the physical form of the substance if possible. The complete list of the substances to be considered is contained in Appendix A of *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments (August 2003)*.[5]
- Table and text identifying all substances that are evaluated for cancer risk and/or noncancer acute and chronic health impacts. In addition, identify any substances that present a potential cancer risk or chronic noncancer hazard via noninhalation routes of exposure.
- Describe the types and amounts of continuous or intermittent predictable emissions from the facility that occurred during the reporting year. As required by statute, releases from a facility include spilling, leaking, pumping, pouring, emitting, emptying, discharging, injecting, escaping (fugitive), leaching, dumping, or disposing of a substance into ambient air. Include the substance(s) released and a description of the processes that resulted in long-term and continuous releases.

B. Exposure Assessment

This section describes the information related to the air dispersion modeling process that should be reported in the risk assessment. In addition, doses calculated by pathway of exposure for each substance should be included in this section. The experienced reader should be able to reproduce the risk assessment without the need for clarification. The location of any information that is presented in appendices, on electronic media, or attached documents that supports information presented in this section, must be clearly identified by title and page number in this section’s text and in the document’s table of contents.

B.1. Facility Description

Report the following information regarding the facility and its surroundings:

- Facility name.
- Facility ID.
- Facility location (i.e., address).
- Local topography.
- Facility plot plan identifying: emission source locations, property line, horizontal scale, building heights and dimensions.
- Description of the site/route dependent exposure pathways. Provide a summary of the site-specific inputs used for each pathway (e.g., water or grazing intake assumptions). This information may be presented in the appendix with the information clearly presented and cross-referenced to the text.

B.2. Emissions Inventory

Report the following information regarding the facility's sources and emissions in table format; see Appendix K of OEHHA Guidelines (2003).[5] Depending on the number of sources and/or pollutants, this information may be placed in the main body of the report or in an appendix.

- Source identification number used by the facility.
- Source name.
- Source location using UTM coordinates (in meters); be sure to indicate the projection assumed (e.g., NAD 1927, NAD 1983, etc.).
- Source base elevation (m).
- Source height (m).
- Source dimensions (e.g., stack diameter, building dimensions, area/volume size, etc.) (m).
- Stack gas exit velocity (m/s) if applicable.
- Stack gas volumetric flow rate (ACFM) if applicable.
- Stack gas exit temperature (K).
- Number of operating hours per day and per year.
- Number of operating days per week.
- Number of operating days or weeks per year.
- Report emission control equipment and efficiency by source and by substance. The description should be brief.

- Report emission inventory methods indicating whether emissions are measured or estimated.
- Report emission rates for each toxic substance, grouped by source, in table form including the following information (see Appendix K of OEHHA Guidelines, 2003). Depending on the number of sources and/or pollutants, this information may be placed in the main body of the report or in an appendix.
  - Source name.
  - Source identification number.
  - Substance name and CAS number.
  - Annual average emissions for each substance (lbs/yr & g/s). Radionuclides are reported in Curies/yr.
  - Maximum one-hour emissions for each substance (lbs/hr & g/s). Radionuclides are reported in millicuries/yr.
- Report facility total emission rates by substance for all emittants including the following information (see Appendix K of OEHHA Guidelines, 2003). This information should be in the main body of the report.
  - Substance name and CAS number.
  - Annual average emissions for each substance (lbs/yr & g/s). Radionuclides are reported in Curies/yr.
  - Maximum one-hour emissions for each substance (lbs/hr & g/s). Radionuclides are reported in millicuries/yr.

B.3. Air Dispersion Modeling

- The HRA should indicate the source and time period of the meteorological data used. Include the meteorological data electronically with the HRA. The SCAQMD has 1981 meteorological data (i.e., hourly winds, atmospheric stability, and mixing heights) at 35 stations in the South Coast Air Basin. This data can be downloaded from the SCAQMD web site.[7]
- Include proper justification for using the meteorological data. The nearest representative meteorological station should be chosen for modeling. Usually this is simply the nearest station to the facility; however, an intervening terrain feature may dictate the use of an alternate site.
- HARP should be used for all health risk assessments prepared for the SCAQMD. Make sure that the latest version of the program is used.
- Table and text that specifies the following information:
  - Selected model options and parameters.
  - Receptor grid spacing.

- For the MEIR, MEIW, MICR, and any sensitive receptors required by the SCAQMD, include tables that summarize the annual average concentrations calculated for all substances.
- For the MEIR, MEIW, MICR, and any sensitive receptors required by the SCAQMD, include tables that summarize the maximum one-hour; maximum four-, six-, or seven-hour (for those substances with RELs based on those averaging periods); and 30-day average (lead only) concentrations.

C. Risk Characterization

HARP generates the risk characterization data needed for the outline below. Any data needed to support the risk characterization findings should be clearly presented and referenced in the text and appendices. A listing of HARP output files that meet these HRA requirements are provided in this outline under the section entitled “Appendices.” All HARP files should be included in the HRA. Ideally, the HRA report and a summary of data used in the HRA should be on paper and all data and model input and output files should be provided electronically (i.e., CD). The SCAQMD also requires the HRA in electronic form (i.e., pdf format).

The potential cancer risk for the MEIR and sensitive receptors of interest must be presented in the HRA’s text, tables, and maps using a lifetime 70-year exposure period. MEIW location should use appropriate exposure periods. A 70-year exposure duration should be used as the basis for residential public notification and risk reduction audits and plans. All HRAs must include the results of a Tier-1 exposure assessment. If persons preparing the HRA would like to present additional information (i.e., exposure duration adjustments or the inclusions of risk characterizations using Tier-2 through Tier-4 exposure data), then this information must be presented in separate, clearly titled, sections, tables, figures, and text.

The following information should be presented in this section of the HRA. If not fully presented here, then by topic, clearly identify the section(s) and pages within the HRA where this information is presented.

- Description of receptors to be quantified.
- Identify the site/route dependent exposure pathways (e.g., water ingestion) for the receptor(s), where appropriate (e.g., MEIR). Provide a summary of the site-specific inputs used for each exposure pathway (e.g., water or grazing intake assumptions). In addition, provide reference to the appendix (section and page number) that contains the modeling (i.e., HARP/dispersion modeling) files that show the same information.
- Tables and text providing the following information regarding the potential multipathway cancer risks at the MEIR, MEIW, MICR, and any sensitive receptors of concern:
  - Location in UTM coordinates
  - Contribution by substance
  - Contribution by source

  - 9- and 30-year cancer risks

- Tables and text providing the following information regarding the acute noncancer hazard quotient at the MEIR, MEIW, MICR, and any sensitive receptors of concern:
  - Location in UTM coordinates
  - Target organ(s)
  - Contribution by substance
  - Contribution by source
- Tables and text providing the following information regarding the chronic noncancer (inhalation and oral) hazard quotient at the MEIR, MEIW, and any sensitive receptors of concern:
  - Location in UTM coordinates
  - Target organ(s)
  - Contribution by substance
  - Contribution by source
- Table and text presenting estimates of population exposure. Tables should indicate the number of persons exposed to a total cancer risk greater than 10^{-6}, 10^{-5}, 10^{-4}, 10^{-3} etc. and total hazard quotient or hazard index greater than 0.5, 1.0, 3.0, 5.0, and 10.0. Total excess cancer burden should also be provided.
- Provide maps that illustrate the HRA results as noted below. The maps should be an actual street map of the area impacted by the facility with UTM coordinates and facility boundaries clearly labeled. This should be a true map (i.e., one that shows roads, structures, etc.), drawn to scale, and not just a schematic drawing. U.S. Geologic Survey 7.5 minute maps are usually the most appropriate choice. The following maps are required:
  - Locations of the MEIR, MEIW, MICR, and sensitive receptors for the cancer and noncancer acute and chronic risks. Also show the facility emission points and property boundary.
  - Total multipathway cancer risk contours for the following risk levels: 1, 10, 25, 50, 100, 250, 500, 1000, 2500, 5000, etc. in a million. Maps should be provided for the minimum exposure pathways (i.e., inhalation, soil ingestion, dermal exposure, and breast-milk consumption) and for all applicable exposure pathways (i.e., minimum exposure pathways plus additional site/route specific pathways). Include the facility location on the maps.
  - Noncancer acute and chronic hazard index contours for the following levels: 0.5, 1.0, 3.0, 5.0, and 10.0. Include the facility location.
- The risk assessor may want to include a discussion of the strengths and weaknesses of the risk analyses and associated uncertainty directly related to the facility HRA.
- If appropriate, comment on the possible alternatives for control or remedial measures.
- If possible, identify any community concerns that influence public perception of risk.

D. References

IV. Appendices

The appendices should contain all data, sample calculations, assumptions, and all modeling and risk assessment files that are needed to reproduce the HRA results. Ideally, a summary of data used in the HRA will be on paper and all data and model input and output files will be provided electronically (e.g., CD). All appendices and the information they contain should be referenced, clearly titled, and paginated. The following are potential appendix topics unless presented elsewhere in the HRA:

- List of all receptors in the zone of impact and their associated risks.
- Emissions by source.
- Census data.
- Maps and facility plot plan.
- All calculations used to determine emissions, concentrations, and potential health impacts at the MEIR, MEIW, MICR, and sensitive receptors.
- Presentation of alternate risk assessment methods (e.g., alternate exposure durations, or Tier-2 to Tier-4 evaluations with supporting information).

V. Computer Files

The list of computer files that must be submitted on CD with the HRA is as follows:

- Provide facility, device, process, emissions, and stack data in electronic transaction file, EXPORT.TRA
- ISC workbook file with all ISC parameters (filename.ISC).
- ISC input file generated by HARP when ISC is run (filename.INP).
- ISC output file generated by HARP when ISC is run (filename.OUT).
- ISC binary output files; holds χ/Q values for each hour (filename.BIN).
- List of error messages generated by ISC (filename.ERR).
- Source-receptor file; contains lists of sources and receptors for the ISC run; file generated by HARP when ISC is run (filename.SRC).
- Point estimate risk values generated by HARP; this file is updated automatically each time you perform one of the point estimate risk analysis functions (filename.RSK).
- Average and maximum χ/Q values for each source-receptor combination; values are generated by ISC (filename.XOQ).
- Plot file generated by ISC (filename.PLT).
- Representative meteorological data used for the facility air dispersion modeling (filename.MET).

- Site-specific parameters used for all receptor risk modeling (filename.SIT).
- Map file used to overlay facility and receptors (filename.DEB).

Appendix B

Calculation of Inhalation Cancer Risk for Diesel Particulate Matter

Below is a procedure for estimating the inhalation cancer risk from exposure to diesel particulate matter (DPM). Impacts to residential and worker exposures are addressed. The methods below represent a Tier-1 assessment as described by OEHHA.[5]

The inhalation cancer risk equation is as follows:

$$\textbf{Cancer risk} = \textbf{Cancer Potency (CP)} \bullet \textbf{Inhalation Dose (Dose-Inh)}$$

$$\textbf{Dose-Inh} = \mathbf{10^{-6}} \bullet \mathbf{C_{air}} \bullet \textbf{DBR} \bullet \textbf{(EF} \bullet \textbf{ED)/AT}$$

Where,

CP	=	Cancer potency; the cancer potency for DPM is 1.1 cancers/mg/kg-day;
Dose-inh	=	Dose through inhalation (mg/kg-day);
10^{-6}	=	Unit conversion factor;
C_{air}	=	Model-estimated DPM concentration ($\mu g/m^3$);
DBR	=	Daily breathing rate (L/kg-day);
EF	=	Exposure frequency (days/year);
ED	=	Exposure duration (years); and
AT	=	Averaging time period over which exposure is averaged, in days.

Assumptions for the above parameters are given in the table below:

Receptor	DBR	EF	ED	AT
Residential	302*	350	70	25,550
Worker	149	245	40	25,550

* 80^{th} percentile breathing rate per ARB's interim risk management guidance for inhalation risk at residential receptors.[12]

The inhalation cancer risk for a residential receptor simplifies to:

$$\textbf{Cancer risk} = \mathbf{318.5} \bullet \mathbf{C_{air}} \bullet \mathbf{10^{-6}}$$

The inhalation cancer risk for a worker receptor simplifies to:

$$\textbf{Cancer risk} = \mathbf{62.9} \bullet \mathbf{C_{air}} \bullet \mathbf{10^{-6}}$$

The model-predicted DPM concentration that a worker is exposed to (i.e., C_{air}) must be adjusted using the factors given in Table 8 of the main body of this document.