

California Environmental Protection Agency



**2007 Progress Report on Semiannual Public Meetings
to Evaluate Future Railroad Emission Control Measures**

A joint effort between the
California Air Resources Board (ARB)
BNSF Railway (BNSF) and
Union Pacific Railroad (UP)

**Stationary Source Division
Criteria Pollutants Branch
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I. INTRODUCTION

The Statewide Railyard Agreement (Agreement) between the California Air Resources Board (ARB), Union Pacific Railroad (UP), and BNSF Railway (BNSF) was signed on June 24, 2005 and requires both of California's Class 1 railroads to reduce diesel particulate matter emissions in and around railyards. ARB staff estimates the MOU will reduce diesel particulate matter by 20 percent over 2005 levels within three years. To achieve these emission reductions, the Agreement requires locomotive idling limitations and the installation of idle reduction devices on all intrastate locomotives, the use of low sulfur diesel fuel by all locomotives fueled in California, and a compliance rate of 99 percent for smoking locomotives each year. In addition to these three short-term measures, the railroads and ARB have developed sixteen major railyard health risk assessments (HRAs) to identify the public health risks from railyards and opportunities for future mitigation measures.

The Agreement also requires the ARB and the railroads to host two technical evaluation meetings annually to evaluate the development of future railroad emission control measures. The purpose of the technical evaluation meetings per Section 8d of the 2005 MOU, is to "evaluate other medium-term and long-term alternatives" to further reduce locomotive¹ and railyard emissions and "to ensure that the evaluation and implementation of feasible mitigation measures continues expeditiously." Section 8d also requires the parties (BNSF, UP and ARB) to "prepare a brief written progress report on these consultations and make the information available to any interested parties." This document is designed to fulfill these requirements for calendar year 2007. A summary the two meetings held in 2006 is also available on the ARB website at http://www.arb.ca.gov/railyard/ryagreement/102006rpt_rrtech.pdf.

ARB staff invited the public, community leaders, local air districts, and other interested parties, including railway companies and equipment vendors, to the technical evaluation meetings. The meetings were webcast to enable a wider group to participate. A list of the presentations delivered at these meetings is included as Attachment A of this report along with links to each presentation on the ARB website.

¹ "Locomotive means a self-propelled piece of on-track equipment designed for moving or propelling cars that are designed to carry freight, passengers or other equipment, but which itself is not designed or intended to carry freight, passengers...; and vehicles propelled by engines with rated horsepower of less than 750 kW (1006 hp) are not locomotives (see 40 CFR Parts 86 and 89 for this equipment)." Code of Federal Regulations, Title 40, Part 92.2 definitions, 40CFR92.2.

II. THIRD SEMIANNUAL TECHNICAL EVALUATION MEETING

The third semiannual technical meeting was held in Sacramento, California on June 6, 2007. Topics included presentations on U.S. EPA's proposed locomotive rulemaking, summary of locomotive aftertreatment applications, locomotive aftertreatment design concepts, and locomotive manufacturer and railroad perspectives on developing locomotive exhaust aftertreatment.

The agenda for this meeting is included as Attachment B and can be obtained at <http://www.arb.ca.gov/railyard/ryagreement/ryagreement.htm>

A. U.S. EPA's Proposed Locomotive Rulemaking

USEPA Locomotive and Marine Notice of Proposed Rule Making (NPRM)

Don Kopinski, Senior Project Manager, U.S. EPA National Vehicle and Fuel Emissions Laboratory, gave a presentation on U.S. EPA's proposed Locomotive / Marine rulemaking. These regulations are scheduled to be phased in from 2008 to 2017. Diesel locomotives are a significant component of the national mobile source inventory contributing 19 percent of the total NOx and 32 percent of the total PM. The proposed rulemaking could dramatically reduce locomotive NOx and PM emission standards (Tier 4) by up to 75 and 85 percent respectively relative to current Tier 2 Locomotive emission standards. The North American freight locomotive market is composed of two major builders (GE & EMD) and seven major customers (BNSF, UP, CSX, KC Southern, Norfolk Southern, Canadian Pacific, and Canadian National). The latest locomotives manufactured by GE and EMD meeting Tier 2 emissions standards are the GE Evolution series and the EMD 710 series. One notable difference in engine design approach between the two manufacturers is the stroke of the engines; GE Evolution is a 4-stroke and the EMD 710 is a two-stroke.

Most of the North American locomotive fleet is composed of Class 1 freight line-haul locomotives and a small portion is dedicated to Class 2 & 3 freight, passenger, and switching locomotives. Addressing emissions from new and existing locomotives will take time given the limited number of new locomotives produced each year and an average life span of 30 years. The U.S. EPA's proposed locomotive rule was published in April 2007 with hearings held in Seattle, Washington, and Chicago, Illinois in May 2007. .

Joe McDonald, Office of Transportation and Air Quality, U.S. EPA, gave a presentation on emission control technology for potential Tier 4 locomotive applications. The presentation covered line-haul locomotive PM emissions characterization, PM controls, NOx controls, ash maintenance, and lubricant formulation. Locomotive PM emissions are dominated by semi-volatile organic compounds (mostly lube oil). The next largest fraction (~25%) is sulfate (mostly sulfuric acid & water) and the smallest fraction being elemental carbon (soot). Forms of PM control include reductions in lube oil

consumption, low SAPS oil (limits on sulfated ash, phosphorous, & sulfur), improved power assemblies, improved closed crankcase ventilation (CCV), oxidation catalysts and particulate filters. Forms of NOx control involve further improvements in exhaust-out emission levels and urea selective catalytic reduction (urea-SCR) with sensor integration for closed loop operation. The proposed Tier 4 locomotive emission standard will involve the integration of both PM and NOx control approaches designed compact enough to fit within the existing locomotive body.

B. Summary of Locomotive Aftertreatment Applications

John Hedrick, Principle Engineer, with Southwest Research Institute (SwRI), gave a presentation summarizing locomotive aftertreatment applications in Europe and the United States. In Europe, exhaust aftertreatment efforts have focused primarily on diesel particulate filters (DPF). Preliminary efforts are underway to retrofit four Eurotunnel switchers with a DPF+urea-Selective Catalytic Reduction (SCR) aftertreatment within the locomotive car body. In the United States there are two locomotives retrofitted with a diesel oxidation catalyst. One is an Massachusetts Bay Transportation Authority MBTA passenger locomotive (EMD F40) and the other is a UP freight locomotive (EMD SD60M). At this time, no freight locomotives with a power rating above 1,000 hp have been equipped with SCR. Locomotive exhaust aftertreatment issues and challenges were also discussed, including temperature control, size limitations, etc.

C. Locomotive Aftertreatment Design Concepts

Steve Fritz, Manager, Medium Speed Diesel Engines, with Southwest Research Institute (SwRI) gave a detailed presentation on locomotive exhaust aftertreatment design concepts and accompanying engine exhaust projections for each approach. Other concepts such as engine blow by (closed crankcase ventilation), urea tank temperature, and exhaust gas recirculation (EGR), engine intake throttling, exhaust insulation, and exhaust flow were examined along with projected emission reductions with each approach.

Sulfur effects on particulate matter (PM) reduction efficiency using a diesel oxidation catalyst (DOC) were also examined. The DOC was retrofitted to an EMD Tier 0 (SD60) and tested over the line-haul and switch duty cycles using diesel fuel with a sulfur content of <15 and ~550 ppmw.

D. Locomotive Manufacturer Perspectives

General Electric Company – Aftertreatment Perspective

Pete Lawson, Product Line Manager, AC Locomotive, General Electric Company (GE) gave a presentation on locomotive aftertreatment and its impact on locomotives and their operations. The presentation covered unregulated locomotive exhaust emission

levels and contrasted it with the proposed Tier 4 locomotive. The technology requirements for the Tier 4 locomotive (NO_x = ~1.3 & PM = ~0.03 g/bhp-hr) will require exhaust aftertreatment devices such as diesel particulate filter (DPF) and selective catalytic reduction (SCR), and the use of ultra-low sulfur (15 ppmw) diesel fuel. Space and other constraints using exhaust aftertreatment devices within the locomotive car body will have to be addressed. Issues such as exhaust temperature, packaging, weight, and the mechanical environment (e.g., thermal stress, shock loads) will need to be incorporated into the design. Operational impacts such as a decrease in fuel efficiency and greater CO₂ emissions with the use of exhaust aftertreatment also need to be addressed. Finally the development requirements (e.g., consumables, maintenance, durability, deterioration, logistics, etc.) and timeline are crucial. GE estimates that it will take approximately seven to ten years to get a Tier 4 locomotive with DPF and SCR exhaust aftertreatment from concept development to product launch.

Electromotive Diesel, Inc. – Locomotive Experiences

Buddy Mahakul, from Electro-Motive Diesel (EMD), gave a presentation on their experience and perspective on locomotive exhaust aftertreatment. The presentation covered unregulated locomotive exhaust emission levels and contrasted it with the proposed Tier 4 locomotive. In addition the presentation discussed locomotive customer requirements (e.g., maintenance, engine life, and reliability) and the technology roadmap to achieve proposed Tier 3 and 4 emission levels. EMD's technology roadmap discusses elements such as requirements for ultra-low sulfur diesel (15 ppmw), exhaust aftertreatment devices (i.e., DOC, DPF, & SCR), product development plans, and technology transfer issues. In summary, the technology for locomotive exhaust aftertreatment will need to be developed and adapted to the specific needs unique to the freight or passenger railroad industry.

E. Railroad Perspectives

BNSF Comments On Future Locomotive Aftertreatment

Mark Stehly, Assistant Vice President, Environment and Research Development, BNSF Railway, gave a detailed presentation covering numerous items such as: air quality and the railroads contribution, truck versus rail efficiency, railroad emission reductions, current status of the BNSF fleet, fuel efficiency and greenhouse gas emissions, sources of rail yard emissions, and the railroads role in national transportation needs, and who pays for capacity improvements. Significant NO_x and PM emission reductions have been achieved with the new Tier 2 locomotives, Green-Goats, gen-sets, and LNG fueled locomotives. Research in locomotive exhaust aftertreatment continues to provide the potential to reduce emissions further in the future. The upcoming compliance dates for the 1998 CARB fleet averaging agreement and adoption of the proposed U.S. EPA Locomotive standards for new and remanufactured locomotives will bring further emission reductions.

UPRR Comments On Future Locomotive Aftertreatment

Mike Iden, General Director Car and Locomotive Engineering, Union Pacific Railroad, gave a presentation providing comments on the future U.S. EPA (Tier 4) locomotive emission aftertreatment technology. The presentation discussed the technical challenges facing locomotive exhaust aftertreatment development and provided a history of locomotive technology experiences from 1974 to the present including Green-Goats, Gen-sets and exhaust aftertreatment devices under development. The history of locomotive technology included a discussion of technology misconceptions and realities. Changes in locomotive design due to exhaust aftertreatment technology need to be compatible to the existing railroad infrastructure (e.g., manufacturing, maintenance, operational needs and practices) to be successful. The successful implementation of locomotive exhaust aftertreatment technology will require intense cooperation coordination, and commitment between the railroads, scientists, engineers, and regulators.

III FOURTH SEMIANNUAL TECHNICAL EVALUATION MEETING

The fourth semiannual technical evaluation meeting was held in El Monte, California on November 28, 2007. Topics included opening presentations to discuss the perspectives of the ARB, BNSF, and UP. The ARB discussed California's need for further emission reductions and BNSF and UP provided their perspectives regarding the successes and limitations of new technologies. Following the opening perspectives, presentations were given on updates in locomotive exhaust aftertreatment retrofit technology for freight and passenger applications. Finally, presentations on longer term technologies in development or evaluation by BNSF and GE were presented.

The agendas for each meeting are included as Attachments B and C and can be obtained at <http://www.arb.ca.gov/railyard/ryagreement/ryagreement.htm>

A. Opening Perspectives

ARB Perspective – The Need For Retrofit Technology

Harold Holmes, Manager, Engineering Evaluation Section, California Air Resources Board, gave a presentation on California's locomotive emission reduction needs. As a percent of the statewide 2005 mobile source inventory, locomotives represented about 5 percent for NOx and 3 percent for PM. Among the three main types of locomotives (e.g., line haul, switch, & passenger), line-haul locomotives contributed greater than 85 percent of California's locomotive NOx and PM emissions. Diesel PM compared to other toxic air contaminants is estimated to be responsible for 70 percent of year 2000 statewide risk from air toxic emissions. In response California has developed the Goods Movement Emission Reduction Plan (GMERP) and employed numerous rail yard strategies (e.g., 2005 MOU & CARB Diesel fuel requirement) with the ultimate goal of achieving an 85 percent reduction in diesel PM and NOx by 2020. Key locomotive elements of the GMERP include accelerated introduction of Tier 4 locomotives, upgrading Tier 2's, and replacing most switchers by 2010. The ARB submitted comments regarding the U.S. EPA's proposed 2007 locomotive and marine rulemaking. Generally, ARB's comments were supportive, but the ARB believes several portions of the rule could be expanded or strengthened. The proposed rulemaking will not achieve the NOx emission reductions in the South Coast air basin in the 2012-2014 timeframe as outlined in the State Implementation Plan (SIP).²

Railroad Perspective – From Idea to Market: Successes and Limitations of New Technology

Mark Stehly, Assistant Vice President, Environmental and Research Development, at BNSF Railway, did not provide a presentation, but talked about research and development in general. R&D for the railroads is different compared to other

² For more information on the emission reductions of locomotives required in the SIP please see <http://www.arb.ca.gov/planning/sip/2007sip/2007sip.htm>

transportation industries. In-service failures are the railroads' greatest challenge. The railroad network is not as flexible or as diverse as the United States highway or roadway system. If a failure occurs with a train or railway segment (e.g., locomotive engine failure or infrastructure – bridge fire) it must be fixed in order to resume normal freight transportation operations. Adding new technology and its potential to fail increases the burden. The railroads have historically been very good at managing their own R&D, and progress has been expedited and enhanced by working with manufacturers. Companies like General Electric (GE), Electromotive Diesel (EMD), and others are important partners in developing new locomotive products, but the lack of market size poses significant difficulties in getting commitments from vendors to perform the needed research for exhaust aftertreatment. To give some perspective, the U.S. market for locomotive production in 2007 was estimated to be ~1,350 units compared to ~320,000 units for the “big 6” class 8 truck market. Finally, the railroads must be able to jettison or eliminate an idea or technology that does not work. The Green Goat hybrid locomotive was a great idea in which a lot of money was invested, but challenges arose in malfunctions with the battery and more serious safety hazards. We should have expectations of new technology, but don't expect every avenue to be a success. The freedom to eliminate technology that doesn't work should always exist.

Mike Iden, General Director Car and Locomotive Engineering, at Union Pacific (UP) Railroad gave a presentation on technology successes and limitations. Union Pacific continues to progress towards the goals of the 1998 MOU and the 2005 MOU. There have been significant technological accomplishments since the 1998 MOU was signed. The first two locomotives in the United States retrofitted with diesel particulate filters (DPFs) have been operating for approximately one year. One DPF equipped locomotive is operating in Roseville, California and the other is in San Antonio, Texas. The first locomotive in the United States retrofitted with a diesel oxidation catalyst (DOC) has been operating for about one year. The DOC equipped locomotive has experienced periods of limited operating success along with several failures. UP now has the largest single Gen-Set fleet (61) operating in the Los Angeles basin. UP remains committed to their 11 Green Goat hybrid locomotives even with the recent battery reliability problems that occurred in the second quarter of 2007– one event resulted in a locomotive fire. All of UP's Green Goat locomotives (50 nationwide, 11 in California) are in the process of being re-commissioned and reintroduced into revenue service. UP estimates the 61 Gen-Set locomotives and 11 Green Goats have reduced total locomotive emissions in the L.A. Basin by 11 percent.

The U.S. EPA and UP recently completed testing to examine exhaust temperatures experienced with a heavily loaded train through a 10,000 foot long tunnel. Preliminary results indicate the locomotive control systems sufficiently de-rated the engines to avoid excessively high exhaust temperatures. Further information regarding this testing is expected in 2008.

Mike Iden also provided a summary of known locomotive technology paths here in the United States and the European Union. Europe has approximately 100 new locomotives

with factory equipped aftertreatment, only one of them is a road unit, the rest are switchers. Europe also has six switchers in use retrofitted with DPFs, and four commissioned switchers to be retrofitted with DPFs and urea based SCR. Comparatively, the U.S. has two switchers retrofitted with DPFs and one road unit with a DOC. Please see his presentation for further detail.

B. Updates on Locomotive Exhaust Aftertreatment Retrofit Technology

Freight Applications

Steve Fritz, Manager, Medium Speed Diesel Engines, at the Southwest Research Institute (SwRI), gave a presentation which provided an update on three freight locomotive retrofit demonstration projects. These separate retrofit projects included the installation of a diesel oxidation catalyst (DOC), two diesel particulate filters (DPFs), and selective catalytic reduction (SCR) device.

The first project update is a test program that began with Union Pacific (UP) Railroad and the U.S. EPA to demonstrate and test a diesel oxidation catalyst (DOC) with an existing line haul locomotive. The project involves an EMD SD60 locomotive (UP 2368, ~3,800 hp) that is retrofitted with the DOC device (pre turbo) and is the first such retrofit to a high horse power locomotive in the United States. Once retrofitted, UP 2368 was released into service in the Los Angeles area in October 2006. The locomotive has achieved good performance across all throttle notch settings. Emission test results using the line haul or switch duty cycles (U.S. EPA 40 CFR, Part 92) yielded emission reductions of approximately 50 percent for PM, five percent for NO_x, 35 percent for HC, and 80 percent for CO. The DOC catalyst elements had a few failures during the testing period. Currently the DOC device is undergoing failure analysis by the manufacturer Miratec and UP 2368 is back in service, but without catalyst elements.

The second project update covers the retrofit of DPFs on two switch locomotives (UPY 1378 and BNSF 3703). The UPY 1378 DPF equipped locomotive was placed into revenue service in late 2006. It started its field service in Oakland, California, and was later moved to Roseville, California. The BNSF 3703 DPF equipped locomotive is operating in San Antonio, Texas. Once BNSF 3703 completes its initial testing in San Antonio, Texas, it will be delivered to southern California for field testing. These experimental DPF aftertreatment systems are being demonstrated in switcher applications as part of California's emission reduction program to reduce diesel toxics and to enhance the railroads experience with this type of locomotive after-treatment. Demonstration of locomotive DPF technology has been ongoing for about one year. Emission testing shows PM reductions of 80 percent and HC reductions of 30 percent. Additional testing and development are ongoing to improve the efficiency of the DPFs.

The third project covers the SCR device tested by SwRI. The device is a urea-SCR catalyst technology originally developed for heavy duty truck applications in Europe

modified for use in locomotive applications. This SCR device is also being used in the SCAQMD test program to retrofit an SCR device to a Metrolink passenger locomotive. The test program objectives at SwRI include performing baseline emission testing without the SCR, studying the effects of higher exhaust back pressure on engine performance to simulate exhaust aftertreatment devices, characterizing crankcase blowby, and performing preliminary screening of the SCR device installed on an EMD 12-710G3 engine. All testing has been performed at SwRI's facility. Once the initial engine tests (e.g., baseline, backpressure, and crankcase blowby) completed, the SCR device was installed to perform preliminary SCR testing. Follow-up SCR testing is planned for 2008.

Passenger Applications

Michael Bogdanoff, Program Supervisor, Mobile Source Projects, at the South Coast Air Quality Management District, gave a presentation on three locomotive demonstration projects. The first project involves the installation of a selective catalytic reduction device (SCR) on a Metrolink passenger locomotive. The SCR will be retrofitted to an EMD F59PH locomotive. In addition to reducing NOx emissions, the SCR is also expected to function as a diesel oxidation catalyst, resulting in a reduction of total hydrocarbons and the organic portion of particulate matter emissions. The second project involves the installation of a diesel particulate filter (DPF) on a Pacific Harbor Line (PHL) switch locomotive. This project is similar to the Union Pacific Railroad DPF demonstration project (UPY 1378) except the DPF will be installed on the inside of the car body (not on the roof) and the conventional EMD two cycle engines are being replaced with DDC/MTU 12V-4000 four cycle engines. The third project involves the installation of an SCR and DPF on a Metrolink passenger locomotive head end power (HEP). The HEP is a 300-500 horsepower non-propulsion diesel engine generator set (Caterpillar 3406) in passenger locomotives that provides the power for heating, lighting, and air conditioning. All three projects are underway.

Karen Dzienkowski, Manager – Emissions Policy and Funding, at MotivePower (a Wabtec Company), gave a presentation on two new engine upgrade solutions applicable to passenger and freight locomotives. The first is a Diesel Oxidation Catalyst (DOC) module. The DOC module can be used as a stand alone device, but greater emission reductions are achieved when used in conjunction with their Tier 2 upgrade kit. The DOC module fits inside the car body replacing the existing silencer and mounts to the turbo output flange. Emissions testing at MotivePower's testing facility using an EMD 16-645F3B engine and 40 CFR, Part 92, testing procedures have yielded particulate matter (PM) reductions of 22 percent over the switch duty cycle and 25 percent over the line haul duty cycle. Higher PM reductions are anticipated using low sulfur diesel fuel compared to the diesel test fuel with 2,500 ppmw sulfur. The DOC module also achieves hydrocarbon (HC) and carbon monoxide (CO) reductions in the range of 30 to 50 percent under the switch or line haul duty cycle. The second upgrade option is a Tier 2 upgrade kit (TR2) which remanufactures locomotives to Tier 2

emission levels (NO_x – 5.5 g/bhp-hr & PM – 0.20 g/bhp-hr). The TR2 upgrade kit includes the DOC module, electronic fuel injection, enhanced cooling system, and timing adjustment. The TR2 upgrade kit has been U.S. EPA certified for an F3B engine used in passenger service locomotives. MotivePower plans to retrofit 15 Metrolink Rail passenger locomotives, a passenger rail service in southern California, with TR2 upgrade kits in the first half of 2008. In addition, MotivePower is seeking further field test opportunities for their TR2 upgrade kit in the freight locomotive sector.

C. Other technologies in Development or Evaluation

BNSF Fuel Cell Hybrid Switcher

Dr. Arnold Miller, President of Vehicle Projects LLC, gave a presentation on a “Fuel Cell Powered Hybrid Switch Locomotive.” BNSF Railway is a principle member and initiator of the project collaborating with an industry-government consortium including numerous members. The fuel cell powered hybrid switch locomotive technology is being examined for its positive environmental characteristics which include zero emissions (at locomotive), low noise, and higher overall efficiency when compared to conventional diesel-electric locomotives. The project objectives are to reduce noise and air pollution in urban areas and sea ports. It is the intention of BNSF Railway and the consortium for this technology to be demonstrated in the Los Angeles basin or one of its ports. It can also serve as mobile back up power (power to grid) for military bases and civilian disaster relief efforts. Fabrication, assembly, and testing of the fuel cell powered switch locomotive are underway at BNSF Railway’s Topeka, Kansas, rail shop.

GE Hybrid Locomotive

Pete Lawson, Product Line Manager, General Electric Company (GE), gave a presentation on GE’s “Evolution Series Hybrid Locomotive”. This locomotive technology is being evaluated by GE to reduce fuel consumption and emissions. In a conventional locomotive, energy generated by its traction motors during braking is dissipated entirely as heat through resistor grids. In contrast, in GE’s hybrid locomotive, some of that braking energy is captured and stored in a series of rechargeable batteries. With three modes of operation available the hybrid locomotive can utilize the captured braking energy as operational needs require. In “Hybrid Power” mode, the locomotive can use the stored energy in the batteries to supplement the diesel engine and allow the locomotive to conserve fuel consumption. In “Power Boost” mode the energy stored in the batteries can be used to add power to the maximum output of the diesel-electric engine. Finally, the hybrid locomotive can operate under battery power only reducing emissions and fuel consumption. GE is continuing its evaluation of this technology through this first hybrid locomotive demonstrator. Challenges such as packaging and hardening of the hybrid system are ongoing. GE has plans for a second demonstrator

and forecasts the availability of the hybrid locomotive in calendar year 2010. GE is also evaluating this hybrid technology approach in off-highway trucks and marine vessels.

Q and A Report – Evaluation of Natural Gas fueled Locomotives

Mike Iden, General Director Car and Locomotive Engineering, from Union Pacific Railroad, presented the report “An Evaluation of Natural Gas-fueled Locomotives”. The report was sponsored by BNSF Railway, Union Pacific Railway Company, and the Association of American Railroads. The report was compiled by California Environmental Associates and was prepared to help with discussions among all stakeholders regarding the use of natural gas as a fuel for locomotives. It provides information on past, current, and potential future efforts to develop and use natural gas-fueled locomotives. It also examines the economics and increased convergence of performance between the emissions natural gas-fueled locomotives and newer diesel locomotive technologies available such as the “Gen-Set” switcher, “Green Goat” battery hybrid, and Tier 2 locomotives from EMD or GE.

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ATTACHMENTS

Attachment A: Agendas 2007 Technical Evaluation Meetings

Attachment B: List of Presentations and links at ARB's website

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Attachment A: Agendas for 2007 Technical Evaluation Meetings

June 6, 2007

Revised Version (released June 5th, 2007) –

http://www.arb.ca.gov/railyard/ryagreement/060607_symposium_agenda.pdf

November 28, 2007

http://www.arb.ca.gov/railyard/ryagreement/112807loco_symposium.pdf

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Attachment B: List of Presentations and Links

June 6, 2007 Presentations

<http://www.arb.ca.gov/railyard/ryagreement/ryagreement.htm>

Presentations:

1. U.S. EPA Proposed Locomotive Rulemaking

- "EPA's Locomotive (and Marine Diesel) Proposal" by U.S. EPA ([PDF-498k](#))
- "Emissions Control Technology for Tier 4 Locomotive Applications" by U.S. EPA ([PDF-1.5mb](#))

2. Summary of Locomotive Aftertreatment Applications

- "Summary of Locomotive Aftertreatment Applications" by Southwest Research Institute ([PDF-5.8mb](#))

3. Locomotive Aftertreatment Design Concepts

- "Locomotive Aftertreatment Concepts" by Southwest Research Institute ([PDF-1.5mb](#))

4. Aftertreatment Perspective

- "Aftertreatment Perspective" by General Electric Company
Summary ([PDF-1mb](#))
Full version ([MOV-128mb](#))* recorded via webcast
*Note: This is a QuickTime file format, if you encounter difficulties viewing this file please download the [QuickTime](#) player.

5. Locomotive Experiences

- "Summary of Locomotive Aftertreatment Applications" by Electromotive Diesel, Inc ([PDF-2.1mb](#))

6. BNSF Comments On Future Locomotive Aftertreatment

- "Locomotive Aftertreatment Concepts" by BNSF Railway ([PDF-1.6mb](#))

7. UPRR Comments On Future Locomotive Aftertreatment

- "Comments on Future EPA (Tier 4) Locomotive Emissions Aftertreatment Technologies" by Union Pacific Railroad ([PDF-1.6mb](#))

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November 28, 2007 Presentations

<http://www.arb.ca.gov/railyard/ryagreement/ryagreement.htm>

Presentations:

1. ARB Perspective - The Need for Retrofit Technology

- ARB Staff Presentation ([PDF - 455k](#))

2. Railroad Perspective - From Idea to Market: Successes and Limitations of New Technologies

- BNSF Railway
- Union Pacific Railroad ([PDF - 491k](#))

3. Updates on Locomotive Exhaust Aftertreatment Retrofit Technology

Freight Applications:

- *"U.S. Locomotive Aftertreatment Retrofit Progress Report, SwRI Test Programs"* by Southwest Research Institute ([PDF - 2.8mb](#))

Passenger Applications:

- *"Three Locomotive Demonstration Projects"* by South Coast AQMD ([PDF - 700k](#))
- *"ARB Rail Technology Symposium: Diesel Oxidation Catalyst"* by MotivePower ([PDF - 3.1mb](#))

4. Other Technologies in Development

- *"Fuel Cell Locomotives for Zero-Emissions Urban Rail"* by Vehicle Projects LLC ([PDF - 2.9mb](#))
- *"Hybrid on the main line"* by General Electric Company ([PDF - 1.1mb](#))
- *"Evaluation of Natural Gas-fueled Locomotives"* ([PDF - 1.1mb](#))

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