

PROPOSED

State of California
CALIFORNIA AIR RESOURCES BOARD

BRAKE AND TIRE WEAR EMISSIONS

Resolution 18-7

March 22, 2018

Agenda Item No.: 18-2-3

WHEREAS, the California Air Resources Board (CARB or Board) has been directed to carry out an effective research program in conjunction with its efforts to combat air pollution, pursuant to Health and Safety Code sections 39700 through 39705;

WHEREAS, a research proposal, number 17RD016, titled “Brake and Tire Wear Emissions,” has been submitted by Eastern Research Group for a total amount not to exceed \$349,990;

WHEREAS, the Research Division staff has reviewed Proposal Number 17RD016 and finds that in accordance with Health and Safety Code section 39701, the results of this study will allow the Board to assess the emissions impact of brake-wear emissions and support source apportionment and health impact studies; and the results are needed because, to the best of CARB’s knowledge, brake-wear emissions comprise the largest portion of non-exhaust particulate matter (PM) emissions overall; and

WHEREAS, in accordance with Health and Safety Code section 39705, the Research Screening Committee has reviewed and recommends funding the Research Proposal.

NOW, THEREFORE BE IT RESOLVED, that CARB, pursuant to the authority granted by Health and Safety Code section 39700 through 39705, hereby accepts the recommendations of the Research Screening Committee and staff and approves the Research Proposal.

BE IT FURTHER RESOLVED, that the Executive Officer is hereby authorized to initiate administrative procedures and execute all necessary documents and contracts for the Research Proposal as further described in Attachment A, in an amount not to exceed \$349,990.

Resolution 18-7

March 22, 2018

Identification of Attachments to Board Resolution 18-7

Attachment A:

“Brake and Tire Wear Emissions” Summary and Budget Summary

ATTACHMENT A

“Brake and Tire Wear Emissions”

Background

Regulations have helped significantly reduce tailpipe emissions from on-road vehicles. However, non-exhaust emissions are currently un-regulated and are estimated to account for approximately half of all light-duty vehicle (LDV) PM emissions. With projected fleet turnover, the fraction of PM contributed by non-exhaust is likely to grow. Brake wear PM is one of the major sources of non-exhaust PM and its treatment in the emission inventory model (EMFAC) relies upon outdated information and does not consider driving behavior or newer technologies. For instance, regenerative braking is likely to reduce brake-wear PM but currently projections of brake-wear PM predict an increase from this source despite expected increases in advanced clean car numbers. In order to provide a more accurate estimation of the impact of these emissions and a better projection of their importance in the future, this project will provide updated brake-wear PM emission factors for EMFAC.

Objective

The objective of this proposed research is to measure brake-wear emissions in a controlled laboratory setting and test various brake configurations, materials, vehicle loads, and driving behaviors in order to generate speed dependent brake-wear emission factors. This project will also characterize the braking behavior and emissions of vehicles using regenerative braking.

Methods

The investigators will select a representative drive cycle to test brake-wear emissions and collect information of market share of brake materials and vehicle types. For regenerative braking they will perform a short on-road test on a test track and operate the vehicle using the chosen test cycle. The investigators will then create a method to simulate the braking activity of a regenerative braking capable system using their proposed dynamometer test. They will then develop a comprehensive test plan that varies parameters such as braking materials and vehicle loads and which includes regenerative braking. The investigators will use the facilities available at LINK Engineering to execute the test plan. For each test, they will measure brake-wear PM emissions using real-time instrumentation as well as filter sampling devices. The investigators will execute up to 140 individual tests including randomized replicates. Filters collected after each test cycle will be weighed for gravimetric analysis and mass closure and stored for future analysis by CARB. Upon the completion of the data collection, they will conduct the data analysis focused on determining brake-wear emission factors (mg/mile) by speed and driving behavior for different brake lining materials and vehicle configurations in the context of typical California light-duty vehicle driving.

Expected Results

This project will provide information on the main factors affecting brake-wear PM concentrations, composition and characteristics. Factors may include brake-wear materials, brake configurations and vehicle loads as well as braking behavior and brake

temperature. The investigators are tasked with choosing parameters carefully such that they are representative of the California on-road fleet. Thus, the results are expected to be representative of California braking materials, vehicles and driving behavior. The emission factors they derive will hence be more reliable and flexible such that they can be used for regional scale modeling which would be beneficial for SIPs, or be used for more localized PM projections, for instance to predict PM emissions from new highway projects.

Significance to the Board

The results of this study will allow the Board to assess the emissions impact of brake-wear emissions and support source apportionment and health impact studies; and the results are needed because, to the best of CARB’s knowledge, brake-wear emissions comprise the largest portion of non-exhaust PM emissions overall.

Contractor:

Eastern Research Group

Contract Period:

24 months

Principal Investigator (PI):

Sandeep Kishan, P.E.

Contract Amount:

\$349,990

Basis for Indirect Cost Rate:

Eastern Research group has listed a fully loaded rate.

Past Experience with this Principal Investigator:

Eastern Research Group has extensive experience in the development of emission factor models and collection and analysis of emissions and vehicle activity data. Their subcontractor for this project, LINK Engineering, has decades of experience manufacturing and operating brake dynamometer systems as well as experience testing brake components and collecting brake activity data. Both companies have experience with PM sampling and analysis from both tailpipe and non-tailpipe sources.

Prior Research Division Funding to Eastern Research Group:

Year	2017	2016	2015
Funding	\$ 0	\$ 0	\$ 0

B U D G E T S U M M A R Y

Contractor: Eastern Research Group

Brake and Tire Wear Emissions

DIRECT COSTS BY TASK

Description of services	Total cost for each task
Task 1: EMFAC model development and brake-wear parameter definition	
Task 1A: Analyze activity data to choose/design representative cycles	\$ 39,209
Task 1B: Analyze market share of materials and vehicle types	\$ 5,235
Task 1C: Analyze data available on regenerative braking	\$ 3,886
Task 2: Develop a test plan that describes selection of materials and vehicles	\$ 11,045
Task 3: Identify a lab grade testing facility that allows testing for PM brake-wear emissions using cycles developed/recommended under Task 1	\$ 3,873
Task 4: Collect PM brake-wear emissions using variables determined under Task 2	\$ 241,188
Task 5: Analyze collected data for use in the EMFAC model	\$ 36,809
Task 6: Recommend future testing	
Task 6a: Realistic emission factors	\$ 2,894
Task 6b: Heavy duty vehicles	\$ 2,922
Task 6c: Tire wear	\$ 2,929

TOTAL PROJECT COSTS

\$ 349,990

ATTACHMENT 1

SUBCONTRACTORS' BUDGET SUMMARY

Subcontractor:

Description of subcontractor's responsibility: To provide service in selecting braking materials and vehicle configuration parameters relevant to EMFAC model needs, running brake dynamometer experiments, and collecting brake-wear PM emissions.

DIRECT COSTS BY TASK

Description of services	Total cost for each task
Task 1: EMFAC model development and brake-wear parameter definition	
Task 1A: Analyze activity data to choose/design representative cycles	\$ 2,660
Task 1B: Analyze market share of materials and vehicle types	\$ 1,270
Task 1C: Analyze data available on regenerative braking	\$ 2,280
Task 2: Develop a test plan that describes selection of materials and vehicles	\$ 1,520
Task 3: Identify a lab grade testing facility that allows testing for PM brake-wear emissions using cycles developed/recommended under Task 1	\$ 0
Task 4: Collect PM brake-wear emissions using variables determined under Task 2	\$ 210,450
Task 5: Analyze collected data for use in the EMFAC model	\$ 7,125
Task 6: Recommend future testing	
Task 6a: Realistic emission factors	\$ 760
Task 6b: Heavy duty vehicles	\$ 760
Task 6c: Tire wear	\$ 760

TOTAL PROJECT COSTS

\$ 227,585