Report

Emission Rate Lookup Table Efficacy Report for Mobile Source Air Toxics and Criteria Pollutants

TABLE OF CONTENTS

LIST OF TABLES

1 INTRODUCTION

As part of an interagency contract with the Texas Department of Transportation (TxDOT), the Texas A&M Transportation Institute (TTI) developed a new set of emission rate look-up tables (ERLTs) for criteria pollutants, mobile source air toxics (MSATs), and greenhouse gases (GHGs) using the latest version of the United States Environmental Protection Agency's (EPA's) Motor Vehicle Emission Simulator (MOVES) emissions model. The structure of these ERLTs is similar to the previous ERLT; the emission rates for criteria pollutants, MSATs, and GHGs are concatenated and reported in a single table. This work consisted of three subtasks, as follows:

- Task 1.1 Draft & Final Work Plan
- Task 1.2 Draft & Final ERLTs
- Task 1.3 Supporting Analyses and Documentation

This document provides detailed analyses to support the efficacy (Task1.3) of the ERLT and demonstrates the effectiveness of the ERLT in each of its applications (running, idling, extended idling, and start).

2 BACKGROUND

MSATs are compounds known or suspected to cause cancer or other serious health and environmental effects. The EPA has assessed an expansive list in their rule on the Control of Hazardous Air Pollutants from Mobile Sources (Federal Register, Vol. 72, No. 37, page 8430, February 26, 2007) and identified a group of 93 compounds emitted from mobile sources that are listed in their Integrated Risk Information System (IRIS)[1,2]. The EPA identified nine compounds with significant contributions from mobile sources that are among the national and regional-scale cancer risk drivers from the 2011 National Air Toxics Assessment (NATA)[3]. These are *acetaldehyde (ACTE), acrolein (ACROL), benzene (BENZ), 1,3-butadiene (BUTA), diesel particulate matter plus diesel exhaust organic gases (DPM), ethylbenzene (ETYB), formaldehyde (FORM), naphthalene (NAPTH), and polycyclic organic matter (POM)*. While the Federal Highway Administration (FHWA) considers

[1] U.S. EPA, 2022, *Final Rule for Control of Hazardous Air Pollutants from Mobile Sources*. https://www.epa.gov/mobile-source-pollution/final-rule-control-hazardous-air-pollutants-mobile-sources

[2] U.S. EPA, 2022, *Basic Information about the Integrated Risk Information System*, https://www.epa.gov/iris/basic-information-about-integrated-risk-information-system

[3] U.S. EPA, 2022, *National Air Toxics Assessment*, https://www.epa.gov/national-air-toxics-assessment

these the priority mobile source air toxics, the list is subject to change and may be adjusted in consideration of future EPA rules.

According to FHWA rules and guidance and Texas Department of Transportation (TxDOT) guidance for addressing National Environmental Policy Act (NEPA) requirements, environmental documentation for specific categories of transportation projects that require federal action should include a qualitative or quantitative MSAT analysis[4]. The FHWA has developed updated interim guidance regarding when and how to analyze MSAT in the NEPA process for highway projects[5]. Consistent with the FHWA interim MSAT guidance as implemented by TxDOT, a quantitative MSAT analysis is required for projects located in proximity to populated areas that have an annual average daily traffic (AADT) volume greater than or equal to 140,000[6] or that create or significantly alter a major intermodal freight facility involving significant numbers of diesel vehicles. Quantitative MSAT analysis involves estimating emission factors, identifying roadway links that have changed, and calculating emissions for the roadway links identified in the process for different analysis years. FHWA recommends considering changes in the following metrics between build and no-build scenarios to define the affected transportation network for MSAT analysis:[7]

- +/- 5 percent change in annual daily traffic (AADT) on congested highway links of level of service (LOS) D or worse;
- +/- 10 percent change in AADT on uncongested highway links of LOS C or better;
- +/- 10 percent change in travel time; and
- +/- 10 percent change in delay.

The FHWA has identified in its *Technical Advisory Guidance for Preparing and Processing Environmental and Section 4(f) Documents (T 6640.8A)* that a project-level carbon monoxide traffic air quality analysis (CO TAQA) may be necessary to comply with NEPA requirements. The CO TAQA assesses whether the project would adversely affect local air quality by contributing to CO levels that exceed the 1-hour or 8-hour CO National

[4] TxDOT, *Air Quality Toolkit*, http://www.txdot.gov/inside-txdot/division/environmental/compliance-toolkits/air-quality.html [Accessed on July 8th, 2022]

[5] FHWA, 2016, *Updated Interim Guidance on Mobile Source Air Toxic Analysis in NEPA Documents*. https://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/msat/2016msat.pdf

[6] TxDOT, 2017, Useful Information: *Mobile Source Air Toxics (MSAT) Emission Rate Look-up Tables (ERLT)*. https://ftp.txdot.gov/pub/txdot-info/env/toolkit/230-01-gui.pdf

[7] FHWA, 2017, *Frequently Asked Questions (FAQ) Conducting Quantitative MSAT Analysis for FHWA NEPA Documents*. https://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/moves_msat_faq.cfm

Ambient Air Quality Standards (NAAQS). This affects all added capacity projects, where the project corridor meets the minimum traffic volume threshold.[8]

The Clean Air Act Amendments of 1990 (CAAA) requires the EPA to set NAAQS (40 Code of Federal Regulations; CFR, Part 50) for pollutants considered harmful to public health and the environment, including six principal pollutants, which are called "criteria air pollutants." These are ozone (O_3), carbon monoxide (CO), particulate matter (PM), nitrogen dioxides (NO_2), sulfur dioxide (SO_2), and lead (Pb). Emissions estimates for criteria pollutants can be used for grant applications and other various planning purposes. However, it is recommended to contact the Metropolitan Planning Organizations where the project resides to get the latest criteria pollutant emission rates, or in the case of ozone, the latest ozone precursor pollutant emission rates.

The emission rate look-up tables (ERLT) were developed for MSAT and criteria pollutants for eight Texas metropolitan geographic areas, including Austin, Beaumont, Corpus Christi, Dallas & Fort Worth, El Paso, Houston, San Antonio, and Waco. The ERLT was developed using MOVES3, the latest official release of EPA's Motor Vehicle Emission Simulator (MOVES), and the data and assumptions as documented in the ERLT development document.[9] These tables provide emission rates for MSAT, which include ACTE, ACROL, BENZ, BUTA, DPM, ETYB, FORM, NAPTH, and POM. The tables also include rates for criteria pollutants such as CO, PM_{10}, $PM_{2.5}$, SO_2, and NO_2; for the ozone precursor pollutants of oxides of nitrogen (NO_X) and volatile organic compounds (VOC); and for greenhouse gases (GHG) of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), as well as their CO_2 equivalent (CO_{2Eq}).

The ERLT deliverables include the following rates tables:

1. Annual maximum daily running exhaust emissions for MSAT and criteria pollutants (running ERLT).
2. Annual maximum daily running and idling exhaust emissions for CO (CO TAQA running and idle ERLT).
3. Annual maximum daily idling exhaust emissions for MSAT and criteria pollutants (idling ERLT).

[8] If the total predicted 1-hour CO concentration is less than the 8-hour CO standard, no separate 8-hour analysis is necessary. If the 1-hour CO concentration is greater than the 8-hour CO standard, an 8-hour analysis should be performed. Source : https://www.environment.fhwa.dot.gov/legislation/nepa/guidance_preparing_env_documents.aspx#aq

[9] TTI, 2022, *Development of MOVES3 Emission Rate Look-up Tables*.

4. Annual maximum daily extended idling[10] exhaust emissions for MSAT and criteria pollutants for long-haul 18-wheeler vehicles (MOVES vehicle type 62) (extended idling ERLT).
5. Annual maximum daily start exhaust emissions for MSAT and criteria pollutants for all vehicle types (tart ERLT).

3 APPLYING EMISSION RATES FOR PROJECTS

The following sections demonstrate the effectiveness of the ERLT by briefly describing the application of the ERLT (running, idling, extended idling, and start) described in the previous section, to estimate emissions for the following requirements.

1. Quantitative MSAT network emissions calculations
2. CO emissions for Transportation projects
   a. CO free-flow link emissions calculations
   b. CO idling link emissions calculations
3. Idling emissions for MSAT and criteria pollutants
4. Extended idling ERLT for MSAT and criteria pollutants
5. Start ERLT for MSAT and criteria pollutants

3.1 Quantitative MSAT Network Emissions Calculations

Quantitative MSAT analysis involves developing emission factors, identifying affected transportation network roadway links, and calculating emissions for the affected transportation network for different analysis years, and build/no-build scenarios. The running ERLT provides MSAT emission rates for MSAT analysis, which includes ACTE, ACROL, BENZ, BUTA, DPM, ETB, FORM, NAP, and POM. These rates can be used for estimating emissions for transportation projects that require quantitative MSAT analysis. The emission rates in the ERLT are in grams/mile.

For calculating emissions for MSAT, the formula is:

Emissions (lbs/day)** $_{\textit{Speed, roadway type}}$ **= Emission Rate** $_{\textit{Speed, Roadway Type}}$ **(grams/mile) * Vehicle Miles of Travel (miles/day) *1 lb/453.59237 grams

Where VMT on a specific link at modeled speed = Volume * Link Length.

[10] The extended idling ERLT is only applicable for combination long-haul trucks (18-wheelers).

3.1.1 Example for Estimating MSAT Emissions

For quantitative MSAT analysis, pollutant emission rates are required for each roadway link in the affected network. Table 1 shows the project description, which includes analysis year, roadway type, link length, and link-level speed and volume needed for estimating MSAT emissions for build and no-build scenarios.

Table 1. Link Input for Quantitative MSAT Emissions Calculations.

Inputs	Values	Units
District	Dallas	-
Horizon Year	2040	-
Roadway Type	Urban Restricted Access	-
Annual Average Daily Traffic (AADT) for Build and No-build Scenario	215,000	vehicles
Link Length*	0.5*	miles
Daily Vehicle Miles of Travel (DVMT)*	107,500*	vehicle-miles
Daily No-Build Average Speed	58	mph
Daily Build Average Speed	63	mph

*Link length and DVMT are independent for each link in the affected network.

Based on the information in Table 1, select the "Dallas" tab in the running ERLT excel worksheet and filter the table to only keep the MSAT pollutant values for the year 2040, roadway type of Urban Restricted Access, and the average speeds of 58 and 63 mph. The build and no-build emission rates are applied separately for each link in the MSAT analysis.

The link-level MSAT pollutant emissions can be estimated using link-specific speed and roadway-type emission rates from the MSAT ERLT in the following equation:

$$\textbf{Emissions (lbs/day)}_{\text{Speed, Roadway Type}} = \textbf{Emission Rate}_{\text{Speed, Roadway Type}} \textbf{ (grams/mile)} * (215{,}000 * 0.5) \text{ (miles/day)} * 1 \text{ lb}/453.59237 \text{ grams}$$

Table 2 shows the emission rates from the filtered running ERLT for MSAT and presents the total link emissions for each pollutant in grams/day. This process should be repeated for all links in the affected transportation network for the build and no-build scenario.

Table 2. Build and No-Build Quantitative MSAT Link Emissions Calculations.

Pollutant	No-Build Emission Rate[(a)]	Build Emission Rate[(b)]	DVMT[(c)]	No-Build Emissions [(d)]	Build Emissions[(d)]
BENZ	0.000242	0.000239	107,500	26.1	25.7
NAPTH	0.000013	0.000012	107,500	1.3	1.3
BUTA	0.000000	0.000000	107,500	0	0
FORM	0.000165	0.000164	107,500	17.7	17.6
ACROL	0.000015	0.000015	107,500	1.6	1.6
DPM	0.001294	0.001288	107,500	139.1	138.5
POM	0.000005	0.000005	107,500	0.6	0.6
ACTE	0.000165	0.000165	107,500	17.8	17.7
ETYB	0.000231	0.000222	107,500	24.9	23.9

(a) Dallas 2040 *Urban Restricted Access* roadway ERLT for MSAT emission rates (grams/mile) at 58 mph.
(b) Dallas 2040 *Urban Restricted Access* roadway ERLT for MSAT emission rates (grams/mile) at 63 mph.
(c) Based on link AADT and length. The VMT may be different for build and no-build
(d) Emissions are in grams/day

3.2 Use of ERLT for CO TAQA

A CO TAQA is developed through the use of two different models, an emissions model and a dispersion model. The EPA-approved latest emissions model is MOVES3 and the current approved EPA dispersion model for Texas is CAL3QHC. The emission rates obtained from the MOVES model will be used with the dispersion model to identify the specific concentration of CO at the applicable receptor locations.[11] The ERLT helps locate the applicable running and idling emission rates for plugging into the CAL3QHC dispersion model (inputs required are shown in Table 3).

[11] TxDOT, 2016, *Useful Information: Carbon Monoxide (CO) Traffic Air Quality Analysis (TAQA) Emission Rate Lookup Tables (ERLT)*, TxDOT Environmental Affairs Division, Effective Date: June 2016 220.01.GUI. Version 1, https://ftp.txdot.gov/pub/txdot-info/env/toolkit/220-01-gui.pdf.

Table 3. CAL3QHC Input Required (Unit) for CO TAQA.

CO TAQA Scenarios	Input Required by CAL3QHC (Units)
Freeways	Running (grams/mile)
Arterials	Running (grams/mile)
Intersection	Running (grams/mile) Idling (grams/hour)
Interchange (Freeway Section)	Running (grams/mile)
Interchange (Intersection Section)	Running (grams/mile) Idling (grams/hour)

The annual maximum CO ERLT (grams/mile or grams/hour) is used in the CO TAQA. Note that CO TAQA is a different methodology and is not captured in the subsequent sections.

3.3 Finding Total Emissions of Any Pollutants using ERLT

Running and idling link emissions for any pollutants on the ERLT can be used for estimating emissions for transportation projects that require quantitative MSAT analysis. The running emission rates in the ERLT are in grams/mile and the idling emission rates in ERLT are in grams/hour. The emission rates are calculated using the following calculation formulas:

3.3.1 Running Link Emissions Calculations

For link emissions calculations, the formula for estimating the emissions is:

Emissions (lbs/day) *Speed, Roadway Type* **=** ***Emission Rate*** *Speed, Roadway Type* ***(grams/mile) * Vehicle Miles of Travel (miles/day) * 1 pound/453.59237 grams***

Where VMT on a specific link at modeled speed = Volume * Link Length.

3.3.1.1 Example for Estimating CO Running Link Emissions

A city in Dallas plans to increase the capacity of an urban freeway (urban restricted access). The project is anticipated to have an AADT of 215,000 vehicles. The project would be finished by Fall 2023. Table 4 shows the project details needed to find the worst-case link-level CO emission rate using the ERLT for CO.

Table 4. Link Input for CO Running Emissions Calculations.

Inputs	Values	Units
District	Dallas	-
Analysis Year	2023	-
Road Description	Urban Restricted Access	-
Annual Average Daily Traffic (AADT)	215,000	vehicles
Roadway Link Length	0.5	miles
Daily Post-project Average Speed	63	mph

Based on the information in Table 3, select the "Dallas" tab in the CO running ERLT excel worksheet and filter the table to only keep the CO values for the year 2023, roadway type of Urban Restricted Access, and the average speed of 63 mph.

The link-level CO emissions can be estimated with the following equation using the link-specific speed and roadway type emission rates extracted from the CO running ERLT:

Emissions (lbs/day)**$_{63,\ Urban\ Freeway}$ **= Emission**$_{63,\ Urban\ Freeway}$ **(grams/mile) * (215,000 * 0.5) (miles/day) * 1 pound/453.59237 grams

Table 5 shows the emission rates from the filtered ERLT for CO and presents the total link CO emissions in grams and pounds/day.

Table 5. CO Running Link Emissions Calculations.

Area	Year	Road Type	Average Speed (mph)	CO Emission Rate (grams/mile)	Link Length (mile)		VMT*	Total Link CO Emissions (grams/day)	Total Link CO Emissions (lbs/day)
Dallas	2023	Urban Restricted Access	63	2.266362	0.5		107,500	243,633	597

*Based on link length in analysis.

3.3.2 Idling Link Emissions Calculations

For CO idling link emissions calculations, the formula for estimating idling emissions is:

Emissions (grams/analysis period) =
Emission Rate (grams/hour) * Idling time (hours/analysis period)

An example calculation is provided below to demonstrate the application of the idling emission rates for quantifying CO emissions.

3.3.2.1 Example for Estimating CO Idling Link Emissions

A city in Dallas plans to increase the capacity of an urban arterial roadway with a major intersection. The project is anticipated to have an AADT of 40,000 vehicles. The project would be finished by Fall 2023. Table 6 shows the project details needed to find the appropriate CO emission rates from the CO running and idling ERLT.

Table 6. Link Input for CO Idling Emissions Calculations.

Inputs	Values	Units
District	Dallas	-
Analysis Year	2023	-
Roadway Type	Urban Unrestricted Access	-
Annual Average Daily Traffic (AADT)	40,000	vehicles/day
Vehicle Idling Time at the Intersection	150	hours/day
Roadway Link Length	0.5	miles
Intersection Queue Length	0.2	miles
Daily Post-project Average Speed	63	mph

Select the "Dallas" tab in the CO running ERLT excel worksheet and filter the table to only keep the CO values for the year 2023, roadway type of Urban Unrestricted Access, and the average speeds of 63 mph. For queue length, select the "Dallas" tab in the idling ERLT excel worksheet and filter the table to only keep the CO values for the year 2023.

Table 7 shows the emission rates from the filtered ERLT for CO and presents the total link CO emissions in grams/day.

Table 7. CO Running and Idling Link Emissions Calculations.

Area	Year	Roadway Type	Average Speed (mph)	CO Emission Rate	Link Length (miles)	Activity*	Link CO Emissions (grams/day)	Total Link CO Emissions (grams/day)
Dallas	2023	Urban Unrestricted Access	63 (running)	2.443044 (grams/mile)	0.5	20,000 (miles/days)	48,861	49,244
			0 (Idling)	2.555745 (grams/hour)	0.2	150 (hours/day)	383	

*Free-flow speed activity is in vehicle miles of travel (miles/day) and idling activity is represented in hours of delay (hours/day) at the intersection.

3.4 Idling Emissions for MSAT and Criteria Pollutants

The idling ERLT provides emission rates for MSAT and criteria pollutants. The criteria pollutants can be used to estimate emissions for grant applications and other various planning purposes. However, it is recommended to contact the MPO where the project resides to get the latest emission rates. The units of idling rates are grams/hour. Idling emissions can be estimated using the following formula:

Emissions (grams/analysis period) =
Emission Rate (grams/hour) * Idling time (hours/analysis period)

An example calculation is provided below to demonstrate the application of the idling exhaust emission rates for quantifying the emissions for a project.

3.4.1 Example for Estimating Idling Emissions

Consider a project to improve operations at an isolated intersection in the Dallas district by switching the intersection from pre-timed to actuated control using advanced detectors. Table 8 presents the project information. The project would be completed in the fall of 2021. The majority of the operational benefits are experienced during the AM and PM peak periods from 6-9 am and 4-7 pm. Traffic operation analysis show pre-project AM and PM peak periods total delay is 65 vehicle hours and for post-project AM and PM peak periods total delay is 30 vehicle hours. Post-project emission reduction estimates are required for criteria pollutants and MSAT for the build year during the peak periods.

Table 8. Link Input for MSAT and Criteria Idling Emissions Calculations.

Inputs	Values	Units
District	Dallas	-
Analysis Year	2021	-
Analysis Periods	AM Peak and PM Peak	-
Analysis Period Duration	6 hours	-
Pre-project Analysis Period Delay	65	vehicle-hours
Post-project Analysis Period Delay	30	vehicle-hours
Reduction in Analysis Period Delay	35	vehicle-hours

Based on the example project input provided in Table 7, filter the Idling ERLT only to keep the Dallas district, roadway type of Urban Unrestricted Access, and year 2021 values. Emission reductions can then be obtained from the filtered ERLT using the following equations:

Emissions (grams/analysis period)$_{\textit{Pre-Project}}$ =
Emission Rate (grams/hour) * 65 (vehicle-hours/analysis period)

Emissions (grams/analysis period) $_{\textit{Post-Project}}$ **=**
Emission Rate (grams/hour) * 30 (vehicle-hours/analysis period)

Emissions (grams/analysis period) $_{\textit{Reduction}}$ **=**
Emission Rate (grams/hour) * (65 – 30) (vehicle-hours/analysis period)

Table 9 shows the emission rates from the filtered ERLT and the subsequent post-project emission reductions obtained for the analysis intersection.

Table 9. MSAT and Criteria Pollutants Idling Emissions Calculations.

Pollutant Category	Pollutant	Dallas 2021 Emission Rates (grams/hour)	Reduction in Delay (vehicle-hours)	Reduction in Emissions (grams/analysis-period)
Criteria Pollutants	CO	2.672747	35	93.55
	NO_X	1.979614	35	69.29
	SO_2	0.022753	35	0.80
	NO_2	0.530340	35	18.56
	CO_{2EQ}	3609.525768	35	126333.40
	VOC	0.250057	35	8.75
	PM_{10}	0.053790	35	1.88
	$PM_{2.5}$	0.048974	35	1.71
MSAT	BENZ	0.006013	35	0.21
	NAPTH	0.001036	35	0.04
	BUTA	0.000608	35	0.02
	FORM	0.009943	35	0.35
	ACTE	0.005666	35	0.20
	ACROL	0.000745	35	0.03
	ETYB	0.003131	35	0.11
	DPM	0.039310	35	1.38
	POM	0.000489	35	0.02

3.5 Extended Idling Emissions for MSAT and Criteria Pollutants

The extended idling ERLT provides emission rates for MSAT and criteria pollutants for combination long-haul trucks/18-wheelers (MOVES vehicle type 62). The criteria pollutants can be used to estimate emissions for grant applications and other various planning purposes. However, it is recommended to contact the MPO where the project resides to get the latest emission rates. The units are in grams/hour. The following formula may be used to estimate emissions:

Emissions (grams/day)$_{process\ type}$ =
Emission Rate (grams/hour)$_{process\ type}$ * Idling time (hours/day)

Where process type can be selected as Auxiliary Power Unit (diesel auxiliary power unit operation) or Extended Idling (extended idling using the truck engine).

An example calculation is provided below to demonstrate the application of these two hotelling process emission rates for quantifying the emissions for a project.

3.5.1 Example for Estimating Extended Idling Emissions

A city in the Dallas district is interested in assessing the daily emissions from extended idling at a truck stop near the interstate facility in the current year (2021). Field data from the truck stop shows that, on average, 50 trucks stop for rest at the truck stop—a truck rests for 10 hours on average. Twenty percent of the trucks use an auxiliary power unit during idling, while the remaining trucks use the truck engine for idling. Table 10 shows the project inputs.

Table 10. Link Input for Extended Idling Emissions Calculations.

Inputs	Value	Units
District	Dallas	-
Analysis Year	2021	-
Hotelling Hours	10	hours/ truck
Total Trucks	50	trucks
Percent of Trucks with APU	20	percent

Based on the example project input provided in Table 9, filter the Extended Idle ERLT only to keep the Dallas district and year 2021 values. Emission reductions can then be obtained from the filtered ERLT using the following equations:

Daily Hotelling hours using APU = 50 * 10 * (20/100) = 100 truck-hours

Daily Hotelling hours using truck engine = 50 * 10 * (80/100) = 400 truck-hours

Emissions (grams/day)$_{APU}$ =
Emission Rate$_{APU}$ (grams/hours) * 100 (truck-hours)

Emissions (grams/day)$_{Extnd\_Exhaust}$ =
Emission Rate$_{Extnd_Exhaust}$ (grams/hours) * 400 (truck-hours)

Table 11 shows the emission rates from the filtered ERLT and the truck stop's emissions.

Table 11. MSAT and Criteria Pollutant Extended Idling Emissions Calculations.

Pollutant Category	Pollutant	APU Emission Rate (grams/ hour)	Daily Hotelling hours—APU (truck-hours)	Extended Idling Exhaust Emission Rate (grams/ hour)	Daily Hotelling hours—truck engine (truck-hours)	APU Emissions (grams/ day)	Extended Idling Exhaust Emissions (grams/ day)	Total Emissions (grams/ day)
Criteria Pollutants	CO	9.657860	100	42.062847	400	965.8	16,825.1	17,790.9
	NO_X	16.654664	100	66.242338	400	1,665.5	26,496.9	28,162.4
	SO_2	0.012534	100	0.024869	400	1.3	9.9	11.2
	NO_2	0.949316	100	19.18987	400	94.9	7,675.9	7,770.9
	CO_{2EQ}	3,492.42	100	7,421.51	400	349,242.0	2,968,604	3,317,846
	VOC	1.474040	100	5.762831	400	147.4	2,305.1	2,452.5
	PM_{10}	0.923131	100	1.154709	400	92.3	461.9	554.2
	PM_{25}	0.849278	100	1.062329	400	84.9	424.9	509.9
MSAT	BENZ	0.011550	100	0.032436	400	1.2	13.0	14.1
	NAPTH	0.013334	100	0.039888	400	1.3	16.0	17.3
	BUTA	0.004301	100	0.008781	400	0.4	3.5	3.9
	FORM	0.115307	100	0.454148	400	11.5	181.7	193.2
	ACTE	0.052415	100	0.245949	400	5.2	98.4	103.6
	ACROL	0.009761	100	0.034429	400	1.0	13.8	14.7
	ETYB	0.003913	100	0.036722	400	0.4	14.7	15.1
	DPM	0.923131	100	1.154709	400	92.3	461.9	554.2
	POM	0.006049	100	0.011075	400	0.6	4.4	5.0

3.6 Start Emissions for MSAT and Criteria Pollutants

The extended idling ERLT provides emission rates for MSAT and criteria pollutants. The criteria pollutants can be used to estimate emissions for grant applications and other various planning purposes. However, it is recommended to contact the MPO where the project resides to get the latest emission rates. The units are in grams/start. The following formula may be used to estimate emissions:

$$\textit{Emissions (grams/day)}_{\textit{vehicle type, fuel type}} = \textit{Emission Rate (grams/start)}_{\textit{vehicle type, fuel type}} * \textit{No. of Starts (start/day)}$$

An example calculation is provided below to demonstrate the application of the start exhaust emission rates for quantifying the emissions for a project.

3.6.1 Example for Estimating Start Emissions

A city in Dallas plans to buy ten new buses to increase bus frequency (reduce bus headway) for some bus routes. This project will increase the bus number at the origin bus depot and increase the number of starts from 100 to 300 daily starts. The project would be finished by the Fall of 2021. Table 12 shows the project details. Post-project emission estimates are required for criteria pollutants and MSAT for the year 2021.

Table 12. Input for Start Emissions Calculations.

Inputs	Values	Units
District	Dallas	-
Analysis Year	2021	-
Daily Pre-project Bus-Depot Starts	100	vehicle-starts
Daily Post-project Bus-Depot Starts	300	vehicle-starts
Increase in Daily Bus-Depot Starts	200	vehicle-starts

Based on the information in Table 11, filter the Start ERLT only to keep transit bus vehicle type, diesel fuel type, Dallas district, and year 2021 values. The emissions increase can then be obtained from the filtered ERLT using the following equations:

$$\textit{Emissions (grams/day)}_{\textit{Pre-Project}} = \textit{Emission Rate (grams/start)}_{\textit{Transit Bus, Diesel}} * 100\ \textit{(vehicle-starts)}$$

$$\textit{Emissions (grams/analysis period)}_{\textit{Post-Project}} = \textit{Emission Rate (grams/start)}_{\textit{Transit Bus, Diesel}} * 300\ \textit{(vehicle-starts)}$$

$$\textit{Emissions (grams/analysis period)}_{\textit{Increase}} = \textit{Emission Rate (grams/start)}_{\textit{Transit Bus, Diesel}} * (300 - 100)\ \textit{(vehicle-starts)}$$

Table 13 shows the emission rates from the filtered ERLT and the subsequent emissions increase for the bus depot.

Table 13. MSAT and Criteria Pollutants Start Emissions Calculations.

Pollutant Category	Pollutant	2021 Dallas Diesel Transit Bus Emission Rate (grams/start)	Increase in Daily starts (vehicle-starts)	Increase in Emissions (grams/day)
Criteria Pollutants	CO	1.333535	200	266.71
	NO_X	0.777162	200	155.43
	SO_2	0.000227	200	0.05
	NO_2	0.301142	200	60.23
	CO_{2EQ}	73.572922	200	14,714.58
	VOC	0.313487	200	62.70
	PM_{10}	0.002626	200	0.53
	$PM_{2.5}$	0.002416	200	0.48
MSAT	BENZ	0.000770	200	0.15
	NAPTH	0.001064	200	0.21
	BUTA	0.000179	200	0.04
	FORM	0.016267	200	3.25
	ACTE	0.013486	200	2.70
	ACROL	0.001464	200	0.29
	ETYB	0.002918	200	0.58
	DPM	0.002626	200	0.53
	POM	0.000243	200	0.05

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