
The Usage of the U.S. Environmental Protection Agency's (USEPA) Motor Vehicle Emission Simulator (MOVES) with the Federal Aviation Administration's (FAA) Emissions and Dispersion Modeling System (EDMS)

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1 Introduction

1.1 The Federal Aviation Administration's (FAA) Emissions and Dispersion Modeling System (EDMS)

The Federal Aviation Administration's (FAA) Emissions and Dispersion Modeling System (EDMS) is a combined emissions and dispersion model for assessing air quality at civilian airports and military air bases. The model was developed by the FAA in cooperation with the United States Air Force (USAF). The model is used to produce an inventory of emissions generated by sources on and around the airport or air base, and to calculate pollutant concentrations in these environments.

In 1998, FAA revised its policy on air quality modeling procedures to identify EDMS as the required model to perform air quality analyses for aviation sources. This revised policy ensures the consistency and quality of aviation analyses performed for FAA. The FAA continues to enhance the model under the guidance of its government/industry advisory board to more effectively determine emission levels and concentrations generated by typical airport emission sources.

1.2 The U.S. Environmental Protection Agency's (USEPA) Motor Vehicle Emission Simulator (MOVES)

The Motor Vehicle Emission Simulator version 2010b (MOVES)¹ is the new emissions model developed by the U.S. Environmental Protection Agency (USEPA) to estimate emissions from mobile sources such as on-road vehicles. The previous USEPA model, MOBILE, has been replaced by MOVES as USEPA's official model for estimating emissions from cars, trucks and motorcycles. Both MOVES and EDMS cover a broad range of pollutants. USEPA plans to add the capability of modeling non-highway mobile sources in future releases.

1.3 Purpose

As of March 2013, USEPA requires the usage of MOVES as a replacement for MOBILE. This means that EDMS analysts must use MOVES with EDMS instead of MOBILE. The plan is not to modify EDMS which continues to be integrated with MOBILE6; but instead, FAA wishes to produce a best practice instructional document showing analysts how to take MOVES output and bring it into EDMS. This best practice document provides technical instruction to the EDMS end-analyst on using MOVES results in EDMS studies.

2 Instructions

To execute a MOVES run the analyst is required to develop a run specification file ("RunSpec") through the "Navigation Panel" of the MOVES Graphical User Interface (GUI). Once the RunSpec has been defined the analyst will import project specific data through the "Project Data Manager" within the MOVES GUI. This document provides the best practice in making the appropriate selections in the "Navigation Panel" and importing data utilizing the "Project Data Manager" in the MOVES GUI for use

¹ USEPA. Motor Vehicle Emissions Simulator (MOVES) User Guide for 2010b, EPA-420-B-12-001b, June 2012.

with EDMS studies. Also, provided is how the MOVES emissions rate output data is to be imported/entered into EDMS.

It is important to note that inter-agency coordination should be conducted in determining the appropriateness of the data being imported in the MOVES “Project Data Manager” for use with EDMS studies.

2.1 The Number of MOVES Runs

Using MOVES with EDMS studies requires the analyst to execute MOVES at the project level domain. Determining the number of MOVES runs is a key step in conducting a project level analysis. When run at the project level domain, each MOVES run estimates vehicular emissions for a single hour of a single month of a single year specified by the analyst. The number of MOVES runs is determined by the variation in activity (e.g., changes in traffic volume) as well as seasonal and daily meteorological variation of the project area. The number of MOVES runs will also vary depending on the EDMS use case where in some instances the analyst will only be required to conduct an emissions inventory while in other instances an air quality dispersion analysis will be required. Typically, fewer MOVES runs will be required for conducting an emissions inventory while a higher number of MOVES runs will be required for conducting an air quality dispersion analysis. However, for each use case whether it be an emissions inventory or an air quality dispersion analysis the number of MOVES runs could vary by the pollutant of concern or by the ambient air quality standard being assessed. In either case the analyst should rely on the inter-agency coordination process to determine the appropriate number of MOVES runs when conducting an EDMS study.

For this document an example of 16 MOVES runs is utilized for explanation purposes. As previously mentioned the number of MOVES runs should be determined through the inter-agency coordination process and will be dependent on the type of use case being analyzed. The example of 16 MOVES runs represents a combination of the four quarters of the calendar year (i.e., January through March, April through June, July through September, and October through December) and four levels of traffic volume (i.e., morning peak, midday, evening peak, and overnight). Tables 1 and 2 define these time periods, respectively.

Table 1. Quarters of the year for MOVES runs

Code	Name	Months
Q1	First Quarter	January - March
Q2	Second Quarter	April - June
Q3	Third Quarter	July - September
Q4	Fourth Quarter	October - December

Table 2. Traffic volume times of day for MOVES runs

Code	Name	Time of Day
AM	Morning Peak	0600 – 0900 (3 hours)
MD	Midday	0900 – 1600 (7 hours)
PM	Evening Peak	1600 – 1900 (3 hours)
ON	Overnight	1900 – 0600 (11 hours)

2.2 Running MOVES

When conducting a MOVES run the analyst needs to develop a RunSpec file through the “Navigation Panel” of the MOVES GUI. This section provides the best practice on the panel selections that should be made when using USEPA’s MOVES with FAA’s EDMS.

2.2.1 Description

A complete description of the RunSpec is to be entered to help the analyst keep track of their MOVES runs and to provide supporting documentation of any regulatory submission.

2.2.2 Scale

For conducting an airport analysis using MOVES with EDMS the analyst will choose the “Project” domain to allow MOVES to accept detailed activity input at the link level. The analyst will either select “Inventory” or “Emissions Rates” depending on if a roadway or an off-network link is being modeling.

- Roadway Links

When modeling a roadway the analyst will select “Emissions Rates” which will produce link specific emissions factors in grams/vehicle-mile. These units are currently consistent with how FAA’s EDMS accepts emissions rates.

- Modeling Parking Facility Links and Vehicle Starts

When modeling a parking facility with USEPA’s MOVES for use with FAA’s EDMS the analyst will select “Inventory” which will produce the total emissions for each link associated with a specific parking facility for the hour being modeled. MOVES models vehicle starts as a separate emissions process which is associated with parking facilities. The total emissions for each link and emissions will be divided out by the total vehicle activity for the hour being modeled. EDMS accepts emissions rates in grams/vehicle when modeling parking facilities. More information on post processing the MOVES output for parking facilities is discussed in section 2.5 *Post-Processing MOVES Output*.

2.2.3 Time Spans

When using the project domain, USEPA’s MOVES will only process one hour, of one day, of one month, of one year for each run. The analyst should enter the desired time period within the “Time Span” panel. “Time Aggregation” should be set to “hour”. The analyst will only select either “weekday” or “weekend” for the “day” selection. For the project level both options cannot be selected. The selection for “day” should correspond to the type of activity data being used.

2.2.4 Geographic Bounds

The “Geographic Bounds” panel is where the analyst specifies the county in which the airport study area is located.

2.2.5 Vehicles/Equipment

The “Vehicles/Equipment” panel is used to specify the vehicle types and fuel combinations that are to be included in the MOVES runs for use with FAA’s EDMS. The MOVES runs for airport analyses must include all the vehicle types that the analyst wants to model in the project area. The fuel type “Placeholder Fuel Type” should not be selected as it can cause errors.

2.2.6 Road Type

The “Road Type” panel is used to define the types of roads that the analyst wants to include in the airport study area. MOVES defines five different road types:

- Rural Restricted Access – a rural highway that can be accessed only by an onramp;
- Rural Unrestricted Access – all other rural roads (arterials, connectors, and local streets);
- Urban Restricted Access – an urban highway that can be accessed only by an onramp;
- Urban Unrestricted Access – all other urban roads (arterials, connectors, local streets, or parking facility links); and
- Off-Network – any location where the predominant activity is vehicle starts and idling (Used for modeling vehicle starts for airport parking facilities).

2.2.7 Pollutants and Processes

The “Pollutants and Processes” panel is used to select the types of pollutants and the emissions processes the analyst wants to include in the analysis. When using USEPA’s MOVES with FAA’s EDMS the analyst will conduct a separate set of runs for modeling roadway links and parking facility links (parking facility will include off-network links). Whether a roadway or a parking facility link is being modeled will determine the emissions processes that are to be selected.

It is at the analyst’s discretion to determine the specific pollutants that are to be analyzed for the EDMS study. In some airport analyses only a single pollutant will be of concern so the analyst may only need to model that specific pollutant. However, it is important to note that some pollutants are chained pollutants within MOVES so multiple pollutant selections need to be made in order to complete the chain and model the desired pollutant. For example, if the analyst is interested in obtaining Volatile Organic Compound (VOC) emissions then Total Gaseous Hydrocarbons needs to be selected. The MOVES GUI will prompt the analyst if there is an incomplete pollutant chain. Table 3 lists all the pollutants and required processes for which emissions rates can be represented in EDMS for analyzing roadway links. Table 4 lists all the pollutants and required processes for which emissions rates can be represented in EDMS for analyzing parking facility links (including off-network links). Although it is at the analyst’s discretion to determine which pollutant(s) will be modeled, the analyst is required to select the appropriate emissions process associated with the pollutants listed in Table 3 and Table 4.

Table 3. Pollutant and Emissions Processes for Roadway Links

Pollutant	Emissions Process
Total Gaseous Hydrocarbons	Running Exhaust and Crankcase Running Exhaust
Non-Methane Hydrocarbons	
Non-Methane Organic Gases	
Volatile Organic Compounds	
Total Organic Gases	
Carbon Monoxide (CO)	
Oxides of Nitrogen (NOX)	
Sulfur Dioxide (SO2)	
Total Energy Consumption	
Methane	
Benzene	
MTBE	
1,3, Butadiene	
Formaldehyde	
Acetaldehyde	
Acrolein	
Atmospheric CO2	
CO2 Equivalent	
Primary Exhaust PM10 - Total	
Primary Exhaust PM2.5 - Total	
Primary PM10 - Organic Carbon	
Primary PM2.5- Organic Carbon	
Primary PM10 - Elemental Carbon	
Primary PM2.5 - Elemental Carbon	
Primary PM10 - Sulfate Particulate	
Primary PM2.5 - Sulfate Particulate	
Primary PM10 - Brakewear Particulate	Running Exhaust, Crankcase Running Exhaust, and Brakewear
Primary PM2.5 - Brakewear Particulate	
Primary PM10 - Tirewear Particulate	Running Exhaust, Crankcase Running Exhaust, and Tirewear
Primary PM2.5 - Tirewear Particulate	

Table 4. Pollutant and Emissions Processes for Parking Facility Links (Includes off-network links)

Pollutant	Emissions Process
Total Gaseous Hydrocarbons	Running Exhaust, Start Exhaust, Crankcase Running Exhaust and Crankcase Start Exhaust
Non-Methane Hydrocarbons	
Non-Methane Organic Gases	
Volatile Organic Compounds	
Total Organic Gases	
Carbon Monoxide (CO)	
Oxides of Nitrogen (NOX)	
Sulfur Dioxide (SO2)	
Total Energy Consumption	
Methane	
Benzene	
MTBE	
1,3, Butadiene	
Formaldehyde	
Acetaldehyde	
Acrolein	
Atmospheric CO2	
CO2 Equivalent	
Primary Exhaust PM10 - Total	
Primary Exhaust PM2.5 - Total	
Primary PM10 - Organic Carbon	
Primary PM2.5- Organic Carbon	
Primary PM10 - Elemental Carbon	
Primary PM2.5 - Elemental Carbon	
Primary PM10 - Sulfate Particulate	
Primary PM2.5 - Sulfate Particulate	
Primary PM10 - Brakewear Particulate	Running Exhaust, Start Exhaust, Crankcase Running Exhaust, Crankcase Start Exhaust, Brakewear, Extended Idle Exhaust*, and Crankcase Extended Idle Exhaust*
Primary PM2.5 - Brakewear Particulate	
Primary PM10 - Tirewear Particulate	Running Exhaust, Start Exhaust, Crankcase Running Exhaust, Crankcase Start Exhaust, Brakewear, Extended Idle Exhaust*, and Crankcase Extended Idle Exhaust*
Primary PM2.5 - Tirewear Particulate	

* Extended Idle Exhaust and Crankcase Extended Idle Exhaust only need to be included when modeling combination long-haul truck (source type 62) within the parking facility. MOVES does not model these emissions processes for any other source type.

2.2.8 Manage Input Data Sets

Most analyses will not use the “Manage Input Data Sets” panel. One possible application is to specify analyst-supplied databases to be read by the model during execution of a run. However, for project-level analysis in MOVES, the Project Data Manager (described below) serves this same function while providing for the creation of data table templates and for the review of default data. EPA specifically developed the Project Data Manager for project analyses and recommends using it, instead of the Manage Input Databases panel, to create and specify analyst supplied database tables. Creating an analyst defined input database is discussed further in the section 2.2.12 *Project Data Manager*.

2.2.9 Strategies

The “Strategies” panel can be used to model alternative control strategies that affect the composition of the vehicle fleet. The MOVES model has two sub panels built into the Strategies panel:

- **On-Road Retrofit.** The On-Road Retrofit strategy allows the analyst to enter information about diesel trucks and buses that have been retrofitted with emission control equipment. Another application of the Strategies panel would be to apply a retrofit program to the fleet. For example, a bus terminal project might include plans to mitigate emissions by retrofitting the bus fleet that will operate at that terminal with control equipment that reduces emissions from a specific pollutant. In that case, the analyst would specify the details of the retrofit project using the On-Road Retrofit Strategy panel. Please refer to the USEPA MOVES User’s Guide when utilizing the On-Road Retrofit strategy panel.
- **Rate of Progress.** The Rate-of-Progress strategy is utilized when modeling emissions for Reasonable Further Progress State Implementation Plan (SIP) requirements. It models a “No Clean Air Act” scenario by assigning 1993 model year emissions rates to all post-1993 vehicles. Please refer to the MOVES User’s Guide when utilizing this strategy.

2.2.10 Output

The “Output” panel provides two sub-panels:

- **General Output.** The “General Output” sub-panel allows the analyst to name and create an output database. As previously mentioned, when using USEPA’s MOVES with FAA’s EDMS the analyst will create separate databases for modeling roadway links and parking facility links (including off-network links).
 - **Roadway Links.** The analyst will name and create an output database that will be used for each MOVES run that will be conducted. When modeling roadway links all output data (e.g., emissions rates) that will be used with FAA’s EDMS will be located in the “rateperdistance” table within the output database. This database table is populated with MOVES output data when the analyst chooses the “Emissions Rates” for the “Calculation Type” within the “Scale” panel. For every MOVES run that is conducted a unique identifier will be populated in the “MOVESRunID” field within the “rateperdistance” table. For example, if the analyst is conducting multiple MOVES runs to account for vehicle activity and meteorological variations the first MOVES run conducted will be assigned a “MOVESRunID” of 1. The second conducted MOVES run will be assigned a “MOVESRunID” of 2 and the “MOVESRunID” will be incremented accordingly for each subsequent MOVES run thereafter. The analyst is responsible for managing the output data in the “rateperdistance” table and confirming that the associated “MOVESRunID” values represent the intended scenario being modeled.

For the “Units” selections the analyst will select “grams” for “Mass Units”, “MillionBTU” for “Energy Units”, and “Miles” for “Distance Units”. “Distance Traveled” and “Population” will be preselected for the “Activity” selections. The analyst should verify that all these selections have been made to ensure the emissions rates in the “ratesperdistance” table are in units of grams per vehicle-mile.

- **Parking Facility Links.** The analyst will name and create an output database that will be used for each MOVES run that will be conducted. When modeling parking facility links all required output data that will be used with FAA’s EDMS will be located in the “movesoutput” and the “movesactivityoutput” tables within the output database. These database tables are populated with MOVES output data when the analyst chooses the “Inventory” for the “Calculation Type” within the “Scale” panel. For every MOVES run that is conducted a unique identifier will be populated in the “MOVESRunID” field within the “movesoutput” and “movesactivityoutput” tables. For example, if the analyst is conducting multiple MOVES runs to account for vehicle activity and meteorological variations the first MOVES run conducted will be assigned a “MOVESRunID” of 1. The second conducted MOVES run will be assigned a “MOVESRunID” of 2 and the “MOVESRunID” will be incremented accordingly for each subsequent MOVES run thereafter. The analyst is responsible for managing the output data in the “movesoutput” and “movesactivityoutput” tables and that the associated “MOVESRunID” values represent the intended scenario being modeled.

For the “Units” selections the analyst will select “grams” for “Mass Units”, “MillionBTU” for “Energy Units”, and “Miles” for “Distance Units”. “Distance Traveled”, “Population”, and “Starts” should be chosen for the “Activity” selections.

- **Output Emissions Detail.** Output Emissions Detail is used to specify the level of detail desired in the output data. Emissions by hour and link are the default selections and cannot be changed. Road type will also be checked if output by Emission Rates was selected. USEPA recommends that analysts check the box labeled “Emission Process.” No other boxes should be selected in order to produce fleet aggregate emissions factors for each link.

2.2.11 Advanced Performance Features

Most analyses will not require the use of the “Advanced Performance Features” panel. This menu item is used to invoke features of MOVES that improve run time for complex model runs by saving and reusing intermediate results. Please refer to the MOVES User’s Guide when utilizing the “Advanced Performance Features” panel.

2.2.12 Project Data Manager

After the analyst has completed all of the necessary panels to create the MOVES RunSpec, the analyst must then create an input database and provide the necessary input database tables that describe the project in detail. The input database is populated using the Project Data Manager (PDM), which can be accessed from the “Pre-Processing” menu item at the top of the MOVES GUI or by selecting “Enter/Edit Data” in the “Domain Input Database” section of the “Geographic Bounds” panel. It is recommended that the analyst create a unique input database for each MOVES run that is to be conducted. For example, if the analyst is conducting multiple MOVES runs to account for vehicle activity and meteorological variations, then individual input databases should be created for each run.

The PDM includes multiple tabs that open data importers, which are used to enter project-specific data. These tabs and data importers are:

- Meteorology
- Age Distribution
- Fuel Supply
- Fuel Formulation
- Inspection and Maintenance
- Link Source Type
- Links
- Link Drive Schedule
- Operating Mode Distribution
- Off-Network
- Fuel Type and Technologies

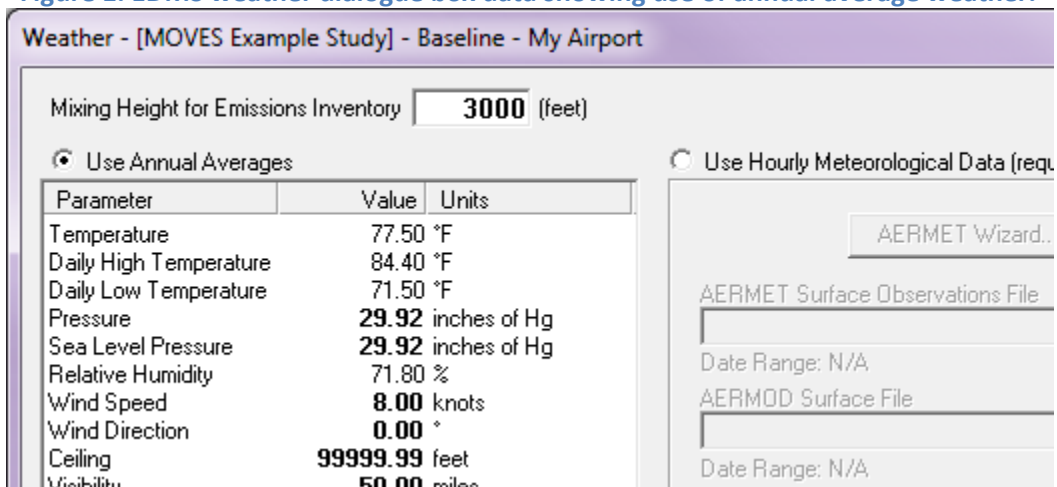
Each of the data importers allows the analyst to create a template file with the required data field names populated. The analyst then edits this template to add project specific data with a spreadsheet application or other tool and allows for the import of data files into MOVES.

This remainder of this section describes the PDM inputs and how they specifically relate to using USEPA's MOVES with FAA's EDMS. The analyst should rely on interagency coordination to determine the appropriateness of the project specific input data that is to be imported into MOVES. The analyst should also refer to the MOVES User's Guide for the mechanics of using the data importers for project level analysis.

2.2.13 Meteorology

For meteorological data, USEPA's MOVES requires ambient air temperature and relative humidity. When developing meteorological data for input into MOVES, the analyst should rely on interagency coordination to determine the appropriate meteorological data to be used. FAA and EPA do not endorse the use of the MOVES default meteorological data for project level analyses. The meteorological data being imported into MOVES directly corresponds to the number of MOVES runs that need to be executed for the airport study and will be dependent on the use case. In some instances when only an emissions inventory is being conducted the airport average annual weather value is used. Figure 1 shows an example of an annual average weather value in EDMS. In this type of case the analyst will model all associated MOVES runs using the annual average weather value.

Figure 1. EDMS weather dialogue box data showing use of annual average weather.



For other instances where multiple MOVES runs need to be conducted to better represent activity and meteorological variation for either an emissions inventory or air quality dispersion analysis, the analyst will need to rely on interagency coordination to determine the appropriate method of processing and/or obtaining representative meteorological data.

2.2.14 Age Distribution

The “Age Distribution” importer is used to enter data that provides the distribution of vehicle fractions by age for each calendar year (yearID) and vehicle type (sourceTypeID). These data are required for running USEPA’s MOVES at the project level for use with FAA’s EDMS. The distribution of ageID (the variable for vehicle age) fractions must sum to one for each vehicle type and year. This type of data should be obtained through the interagency coordination process; depending on the use case, a local agency may require the analyst to use the latest available state or local age distribution assumptions from their State Implementation Plan (SIP) or transportation conformity regional emissions analysis.

2.2.15 Fuel Supply

The analyst must define in MOVES the fuel supply and fuel formulations that are used in the study area. The “Fuel Supply” importer and “Fuel Formulation” importer are used to enter the necessary information describing fuel type and fuel mix for each respective MOVES run. The analyst should obtain this type of data through the interagency coordination process.

2.2.16 Inspection and Maintenance (I/M)

Projects within areas covered by an I/M program should define the program in the MOVES “Inspection and Maintenance” importer. The analyst should obtain this type of data through the interagency coordination process.

2.2.17 Link Source Type

The “Link Source Type” importer allows the analyst to enter the fraction of the link traffic volume (fleet mixture) that is represented by each vehicle type (source type). For each LinkID, the “SourceTypeHourFraction” must sum to one across all source types. Additionally, the analyst needs to ensure that the source types selected in the MOVES Vehicles/Equipment panel match the source types defined through the “Link Source Type” importer. Otherwise, if a vehicle is represented in the “Link Source Type” table but is excluded from the RunSpec then the vehicle will not be modeled. There are no defaults that can be exported from the “Link Source Type” importer. For any analysis at the project level, the analyst may provide source type fractions for all vehicles being modeled and for each MOVES run (as vehicle mixes may change from hour to hour and month to month).

2.2.18 Links

The “Links” importer is used to define the individual roadway links and/or parking facility links (including off-network link) for use with FAA’s EDMS. All links being modeled are required to have unique LinkIDs. The “Links” importer requires information on each link’s length (in miles), traffic volume (units of vehicles per hour), average speed (miles per hour), and road grade (percent). When using USEPA’s MOVES with FAA’ EDMS the analyst will model the roadway links and the parking facility links in separate runs. Even though MOVES will allow roadway and parking facility links to be modeled simultaneously using the same “Links” file they must be run independently because of how their output is used with EDMS. The information below describes how to setup a Links input file for use with EDMS. The analyst should refer to the interagency coordination process to determine the appropriate number of links and the lengths of specific links that are to be used for the study.

- **Roadway Links.** A unique LinkID is to be created for each roadway segment that is to be modeled in the EDMS airport study. When developing the roadway links input file the analyst will create a unique link for each roadway segment that would be set up within EDMS. The emissions rates associated with these roadway links will be in grams per vehicle-mile.
- **Parking Facility Links.** A unique Link ID is to be created for each parking facility link that is to be modeled in the EDMS airport study. When an analyst creates a parking facility in EDMS the analyst must specify a speed, distance traveled, and an idle time. This information will serve as inputs into the links input file. When modeling a parking facility in USEPA’s MOVES for use with FAA’s EDMS the analyst must create three links for each parking facility.
 1. **Parking Facility Movement Link** - The Parking Facility Movement link will model the vehicle movement within the parking facility. The analyst will enter distance traveled and the speed. These values will be entered into the EDMS GUI as the “link length” (in miles) and the “average speed” respectively when building the links input file for parking facilities. The “Urban Unrestricted Access” road type (Road Type 5) should also be selected when modeling this link.
 2. **Parking Facility Idle Link** - A unique link will be created utilizing an average speed of 0 miles-per-hour to obtain idle emissions rates for the parking facility.
 3. **Parking Facility Off-Network Link** - An off-network link for the purpose of calculating vehicle starts will need to be modeled. When modeling a parking facility for an airport analysis the analyst must consider vehicle starts. Previously with MOBILE6.2 the vehicle starts were built into the emissions rates. However, with MOVES it is modeled as a

separate emissions process. For modeling vehicle starts the analyst will use the “off-network” road type (Road Type 1). The analyst will also need to enter data into the “Off-Network” and “Operating Mode Distribution” data importers to correctly model vehicle starts by accounting for the appropriate soak time. Soak time is the amount of time the vehicle engine is off while parked and is used to differentiate a hot or cold start.

It is also important to note that MOVES can only model a single off-network link per MOVES run. If parking facilities are similar they may be able to utilize the same off-network link to obtain vehicle start emissions rates. This will depend on whether they have the same fleet mixture and operating mode distribution (soak times). In most cases off-network links associated with hourly, daily, and longer term economy parking facilities will need to be modeled using separate MOVES runs. The analyst should rely on the interagency coordination process to determine the appropriate number of off-network links that need to be modeled.

2.2.19 Link Drive Schedule

For using USEPA’s MOVES with FAA’s EDMS the FAA recommends that the analyst utilizes the average speed approach when modeling roadway and parking facility links. However, the analyst does have the option of using Link Drive Schedule through the Link Drive Schedule Importer if data is available.

The “Link Drive Schedule” importer allows the analyst to define the precise speed and grade as a function of time (seconds) on a particular roadway link. The time domain is entered in units of seconds, the speed variable is miles-per-hour and the grade variable is percent grade (vertical distance/lateral distance; 100% grade equals a 45-degree slope). MOVES builds an operating mode distribution from the link drive schedule and uses it to calculate link running emissions. Individual link drive schedules cannot be entered for separate source types. The link drive schedule therefore represents the “tracer” path of an average vehicle on each link. Link drive schedules could be based on observations using methods such as chase (floating) cars on similar types of links, or on expected vehicle activity based on an analysis of link geometry. Link drive schedules will only represent average vehicle activity, not the full range of activity that will occur on the link. Analysts can overcome this limitation by defining multiple links for the same portion of the project (links that “overlap”) with separate source distributions and drive schedules to model individual vehicle types. Please reference the MOVES User’s Guide when using a link drive schedule. The use of link drive schedules should be determined through the interagency coordination process.

2.2.20 Operating Mode Distribution

For using USEPA’s MOVES with FAA’s EDMS the FAA recommends that the analyst utilizes the average speed approach when modeling roadway links. When an off-network link is selected to model vehicle starts the analyst will be required to enter an operating mode distribution to assign appropriate soak time (this is discussed in further detail below). However, the analyst does have the option of using operating mode distributions through the “Operating Mode Distribution” importer for modeling roadway links if data is available.

- **Operating Mode Distribution for roadway links.** The Operating Mode Distribution Importer allows the analyst to directly import operating mode fraction data for source types, hour/day combinations, roadway links, and pollutant/process combinations that are included in the run specification. Operating mode distributions may be obtained from:

- Op-Mode distribution data from other locations with similar geometric and operational (traffic) characteristics. Examples of data to build an operating mode distribution include chase (or floating) cars, traffic cameras, and radar guns that have been used previously to collect some traffic data for use in intelligent transportation systems and other applications. USEPA encourages the development of validated methods for collecting verifiable vehicle operating mode distribution data at specific locations representative of different projects.
- Output from traffic microsimulation models. A traffic microsimulation model can be used to construct link drive schedules or operating mode distributions if prior validation of the model’s predictions of speed and acceleration patterns for roadway links similar to those in the project was conducted. If an analyst has a microsimulation model that has been previously demonstrated to adequately predict speed/acceleration patterns for relevant vehicle classes (e.g., heavy-duty), and has a procedure for importing data into MOVES, it may be appropriate to use the microsimulation model, subject to interagency coordination.
- **Operating Mode Distribution for off-network (parking facility) links.** In most cases an airport study will include multiple parking facilities that will need to be modeled. If the airport study does contain an off-network (parking facility) link, then both the “Off-Network” table and “Operating Mode Distribution” table should be populated and imported into the input database. The analyst will need to specify the fractions of the time spent during the hour in each operating mode. Creating an operating mode distribution for an off-network link specifically models vehicle starts and/or extended idle (if necessary) emissions. Table 5 lists the operating modes associated with calculating emissions rates for vehicle starts and extended idle emissions. The sum of the fractions of OpmodeID 101 through 108 needs to be 1. The fraction for Extended Idle Operating Mode (OpmodeID 200) should always be set to 1.

Table 5. Off-Network Operating Mode Distributions

OpmodeID Code	Operating Mode Description
101	Soak Time < 6 minutes
102	6 minutes <= Soak Time < 30 minutes
103	30 minutes <= Soak Time < 60 minutes
104	60 minutes <= Soak Time < 90 minutes
105	90 minutes <= Soak Time < 120 minutes
106	120 minutes <= Soak Time < 360 minutes
107	360 minutes <= Soak Time < 720 minutes
108	720 minutes <= Soak Time
200	Extended Idle Operating Mode

The use of operating mode distribution to define either a roadway link or parking facility link must be determined through the interagency coordination process.

2.2.21 Off-Network

The “Off-Network” importer is where the analyst provides data about vehicles start and extended idle activity within a parking facility. As previously mentioned, USEPA’s MOVES is only capable of modeling

one off-network link per run. If more than one off-network (parking facility) link is associated with the airport study, another MOVES run or set of MOVES runs will be required to characterize each additional off-network link. However, if parking facilities have similar or the same fleet mixture and operating mode distribution then the emissions rates representing the modeled parking facility can be applied to those similar or same parking facilities subject to interagency coordination. The Off-Network importer should also be used if the airport study includes an area where highway vehicles are parked, starting their engines, or in extended idling mode (such as at a truck stop, parking lot, or passenger or freight intermodal terminal).

There are no default values available for any of the off-network inputs; the analyst will need to populate the Off-Network table with information describing vehicle activity in the off-network link being modeled. The necessary fields are vehicle population, start fraction, and extended idle fraction:

- The vehicle population reflects the total number of vehicles parked, starting, or idling on the off-network area over the course of the hour covered by the MOVES run.
- The start fraction is the fraction of the total vehicle population that starts during the hour. When using MOVES with EDMS the start fraction should always be set to 1.
- The extended idle fraction specifies the fraction of time that the vehicle population spends in extended idle operation in the hour.

Extended idle operation applies only to long-haul combination trucks (source type 62) and is defined as the operation of the truck's propulsion engine when not engaged in gear for a period greater than 15 consecutive minutes, except when associated with routine stoppages due to traffic movement or congestion. Shorter periods of idling for long-haul combination trucks and all idling for other vehicles should be modeled as a roadway link with an Op-Mode distribution that consists only of idle operation (Op-Mode 1). This can be specified in the Links table by inputting the vehicle population and specifying an average speed of "0" mile-per-hour.

2.2.22 Fuel Type and Technologies

The "Fuel Type and Technologies" importer allows the analyst to modify the fraction of alternative fuel vehicles in each model year. A common use of this importer would be to change the diesel fractions of the fleet. The analyst can modify the default assumptions about diesel, gasoline, and CNG use for each source type and model year. If local information is available on these fractions, the "Fuel Type and Technologies" Importer should be used to modify the defaults. For instance, the analyst modeling an airport based transit facility may use this importer to specify that the entire fleet of buses uses CNG, or entirely diesel, rather than a default mix of both fuel types. It is important to note that if the analyst chooses only diesel transit buses in the "Vehicles and Equipment" panel then the analyst must use the "Fuel Type and Technologies" Importer to change the fraction of CNG transit buses to 0 and diesel transit buses to 1. The analyst should rely on interagency coordination to determine the appropriate adjustments that are to be made to the "Fuel Type and Technologies" input file.

2.3 Summary Steps for Running MOVES for Roadway Links

To generate MOVES output that is compatible to roadways in an EDMS study, in MOVES the analyst should use the following steps:

- (1.) Under the Scale panel, set the “Domain/Scale” to “Project.”
- (2.) Also under the Scale panel, set “Calculation Type” to “Emission Rates.”
- (3.) Under the Time Spans panel, for each run, select a time within (or equivalent to) the run’s time of year and time of day.
- (4.) Under the Geographic Bounds panel, select the geographic location (county) relevant to the EDMS study.
- (5.) Under the On-Road Vehicle Equipment panel, it is recommended that the analyst select all available vehicle and fuel types.
- (6.) Under the Road Type panel, the analyst should select all of the available road types.
- (7.) Under the Pollutants and Processes panel, analysts should select the appropriate pollutants and processes from list provided in Table 3.
- (8.) Under the General Output panel, analysts should select the same database for storing the output from all runs.
- (9.) Under the “Pre-Processing” menu, analysts should open the Project Data Manager (PDM) interface and edit its importers as well.
 - (a.) On the PDM “Database” importer, the analyst should create a unique database for each run.
 - (b.) On the PDM “Fuel” importer, the analyst should import the appropriate fuel supply and formulations.
 - (c.) On the PDM “Meteorological Data” importer, the analyst should import the appropriate meteorological data.
 - (d.) On the PDM “I/M Programs” importer, the analyst should import the appropriate inspection and maintenance (I & M) program.
 - (e.) On the PDM “Age Distribution” importer, the analyst should import the appropriate vehicle age distribution file.
 - (f.) On the PDM “Links” importer, the analyst needs to import a file describing how each link is to be modeled. Each roadway is represented by a link and assigned a unique numeric LinkID.
 - (g.) On the PDM “Link Source Types” importer, the analyst should import source type distribution file that reflects the appropriate fleet mix of each link.
 - (h.) On the PDM “Fueltype and Technologies” importer, the analyst should import a file that reflects the appropriate distribution of the kinds of fuel being used.

Once these steps are completed and green check marks are shown for each item in the “Navigation Panel” of the MOVES GUI the analyst can then execute MOVES.

2.4 Summary Steps for Running MOVES for Parking Facility and Off-Network Links

To generate MOVES output that is compatible to parking facilities in an EDMS study, in MOVES the analyst should use the following steps:

- (1.) Under the Scale panel, set the “Domain/Scale” to “Project.”
- (2.) Also under the Scale panel, set “Calculation Type” to “Inventory.”
- (3.) Under the Time Spans panel, for each run, select a time within (or equivalent to) the run’s time of year and time of day.
- (4.) Under the Geographic Bounds panel, select the geographic location (county) relevant to the EDMS study.

- (5.) Under the On-Road Vehicle Equipment panel, it is recommended that the analyst select all available vehicle and fuel types.
- (6.) Under the Road Type panel, the analyst should select all of the available road types.
- (7.) Under the Pollutants and Processes panel, analysts should select the appropriate pollutants and processes from list provided in Table 4.
- (8.) Under the General Output panel, analysts should select the same database for storing the output from all runs.
- (9.) Under the “Pre-Processing” menu, analysts should open the Project Data Manager (PDM) interface and edit its importers as well.
 - (a.) On the PDM “Database” importer, the analyst should create a unique database for each run.
 - (b.) On the PDM “Fuel” importer, the analyst should import the appropriate fuel supply and formulations.
 - (c.) On the PDM “Meteorological Data” importer, the analyst should import the appropriate meteorological data.
 - (d.) On the PDM “I/M Programs” importer, the analyst should import the appropriate inspection and maintenance (I & M) program.
 - (e.) On the PDM “Age Distribution” importer, the analyst should import the appropriate vehicle age distribution file.
 - (f.) On the PDM “Links” importer, the analyst needs to import a file describing how each link is to be modeled. Each roadway is represented by a link and assigned a unique numeric LinkID.
 - (g.) On the PDM “Link Source Types” importer, the analyst should import source type distribution file that reflects the appropriate fleet mix of each link.
 - (h.) On the PDM “Operating Mode Distribution” importer, the analyst should import an appropriate operating mode distribution file.
 - (i.) On the PDM “Off-Network” importer, the analyst should import an appropriate off-network file.
 - (j.) On the PDM “Fuel Type and Technologies” importer, the analyst should import a file that reflects the appropriate distribution of the kinds of fuel being used.

Once these steps are completed and green check marks are shown for each item in the “Navigation Panel” of the MOVES GUI the analyst can then execute MOVES.

2.5 Post-Processing MOVES Output

The analyst will need to post-process the MOVES output for the roadway links and parking facility links separately. The emissions rates for roadways in EDMS are in units of “grams per vehicle-mile,” and emission rates for parking facilities in EDMS are in units of “grams per vehicle.” In MOVES, the analyst sets the calculation type to “Emission Rates” in the “Scale” panel for modeling roadway links to obtain emissions rates in “grams per vehicle-mile” from MOVES. In order to obtain emissions that are in units of “grams per vehicle” for parking facilities the analyst needs to choose “inventory” as the calculation type in the “Scale” panel. The output for parking facility runs will be the total grams produced on the link for the hour modeled. Table 6 summarizes the emission rates units output from USEPA’s MOVES and input into FAA’s EDMS.

Table 6. EDMS source types and respective emissions rate units in EDMS and MOVES

Source Type	Units in EDMS	Units in MOVES
Roadway	grams/vehicle-mile	grams/vehicle-mile
Parking Facility	grams/vehicle	grams/hour (Total emissions produced for the link in the hour modeled.)

After all MOVES runs have been completed for both roadway links and parking facilities links the analyst will work with two sets of output data. The MOVES output for roadway links is located in the “ratepervehicle” table within the output database for which the emissions rates are in “grams per vehicle-mile”. For parking facility links, the analyst will obtain emissions output (in total grams for the link of hour modeled) from the “movesoutput” table in the output database and the link activity from the “movesactivityoutput” table in the output database.

The output database tables utilize numerical IDs to classify pollutants and emissions processes. Table 7 lists the key for decoding which MOVES Pollutant ID is associated with each pollutant that is to be used with EDMS. For PM₁₀ and PM_{2.5} Pollutant IDs 110 and 110 represent exhaust emissions, Pollutant IDs 106 and 116 represent brakewear emissions, and Pollutant IDs 107 and 117 represent tirewear emissions. The emissions output for these Pollutant ID need to be summed together to obtain the full PM₁₀ and PM_{2.5} emissions rates.

It is also important to note that emissions rates for atmospheric CO₂ (Pollutant ID 90) and CO₂ equivalent (Pollutant ID 98) cannot be imported in EDMS. However, the emissions rates for these pollutants can be used to post process their respective inventories.

Table 7. Output by MOVES utilized by EDMS roadways and parking facilities

Pollutant	MOVES Pollutant ID
CO	2
VOC	87
NMHC	79
TOG	86
NOx	3
SOx	31
PM10	(100 + 106 + 107)
PM2.5	(110 + 116 + 117)
Benzene	20
MTBE	22
1,3-Butadiene	24
Formaldehyde	25
Acetaldehyde	26
Acrolein	273
Atmospheric CO2	90**
CO2 Equivalent	98**

** These pollutants do not have a placeholder in EDMS .

Emissions output is also separated by each emissions process. The analyst will need to sum emissions processes for each pollutant for each link that was modeled to obtain the full emissions rate. Table 8 shows the key for decoding the emissions processes and the links each is associated with.

Table 8. Emissions ProcessID Decoder and Link Association

processID	Emission Process	Link Association
1	running exhaust	Roadway and Parking Facility Link
2	start exhaust	Off-Network Parking facility Link
15	crankcase running exhaust	Roadway and Parking Facility Link
16	crankcase start exhaust	Off-Network Parking facility Link
17	crankcase extended idle exhaust	Off-Network Parking facility Link (if necessary)
90	extended idle exhaust	Off-Network Parking facility Link (if necessary)

For post-processing the emissions output for roadway and parking facility links processIDs 1 and 15 need to be summed together for each pollutant and link. For post processing the emissions output for off-network parking facility links processIDs 2,16,17, and 90 need to be summed together for each pollutant and link.

As previously mentioned, the output for roadway link MOVES runs can be located in the “rateperdistance” table of the output database. The emissions rates in the “rateperdistance” table are already in units of “grams per vehicle-mile” which is compatible with FAA’s EDMS. However, there is additional post processing that is required in order to obtain emissions rates in units of “grams per vehicle” for parking facility links (including off-network links). The total emissions produced for each link of the hour modeled is located in the “emissionQuant” field of the “movesoutput” table within the output database. The values from the “emissionQuant” field will need to be divided by the vehicle population for each link which is located in the “activity” field of the “movesactivityoutput” table within the output database. The vehicle population is represented by the vehicle “ActivityTypeID” 6. The result will be emissions rates in “grams per vehicle” which is compatible with EDMS.

2.6 Using MOVES output in EDMS

Depending on the EDMS use case, the analysis may result in a single MOVES run or multiple MOVES runs. In the instance the analyst only needed to conduct a single MOVES run, the emissions rates from that run can be entered into EDMS in the same manner as if the user was entering emissions rates from an external MOBILE6 run. However, in instances where multiple MOVES runs were conducted to obtain emissions rates to account for the variation of vehicle activity and meteorological a different importation process needs to be utilized. This is due to the fact that in EDMS roadways and parking facilities accept only one set of emission rates. To enter emissions rates from multiple MOVES runs into EDMS the analyst needs to map each MOVES run to one set of roadway and parking facility copies. The analyst then enters the emission rates and traffic volumes from each MOVES run to the corresponding set of roadway and parking facility copies in EDMS where the appropriate operational profiles are also assigned.

2.6.1 Example

As a hypothetical example, suppose an analyst models one roadway by running MOVES sixteen times, one run for each combination of the four times per day and the four quarters of the year as defined earlier in Table 1 and Table 2. The results from the 16 runs are tabulated in Table 9. The traffic volumes and emission rates in the following table are notional.

Table 9. Example notional results from MOVES runs for a roadway

Run	Quarter	Time of Day	Traffic Volume (veh/hr)	Emission Rate (grams/veh-mile)
1	Q1	AM	6,000	0.044152
2	Q1	MD	3,000	0.049007
3	Q1	ON	6,000	0.040609
4	Q1	PM	1,000	0.043451
5	Q2	AM	6,000	0.044593
6	Q2	MD	3,000	0.049497
7	Q2	ON	6,000	0.041015
8	Q2	PM	1,000	0.043885
9	Q3	AM	6,000	0.045039
10	Q3	MD	3,000	0.049992
11	Q3	ON	6,000	0.041425
12	Q3	PM	1,000	0.044324
13	Q4	AM	6,000	0.044156
14	Q4	MD	3,000	0.049011
15	Q4	ON	6,000	0.040612
16	Q4	PM	1,000	0.043455

In a typical study, several pollutants are modeled simultaneously, and each pollutant has its own emission rate from each MOVES run. For the purpose of this example, we assume that the rates in Table 9 are PM₁₀ emission rates, but this example applies to any pollutant (e.g., CO, hydrocarbons, NO_x, SO_x, etc.).

Figure 2 below shows what it looks like to enter a roadway in EDMS prior to applying the results from the 16 MOVES runs. The analyst has added a roadway called “Road” to the EDMS study with a total traffic volume of 24,888,000 per year and a PM₁₀ emission rate of 0.05 grams/vehicle-mile. To use the MOVES results in Table 9, the analyst must duplicate this roadway entry 16 times, adjusting the traffic volume and emission rates in each copy of the roadway appropriately.

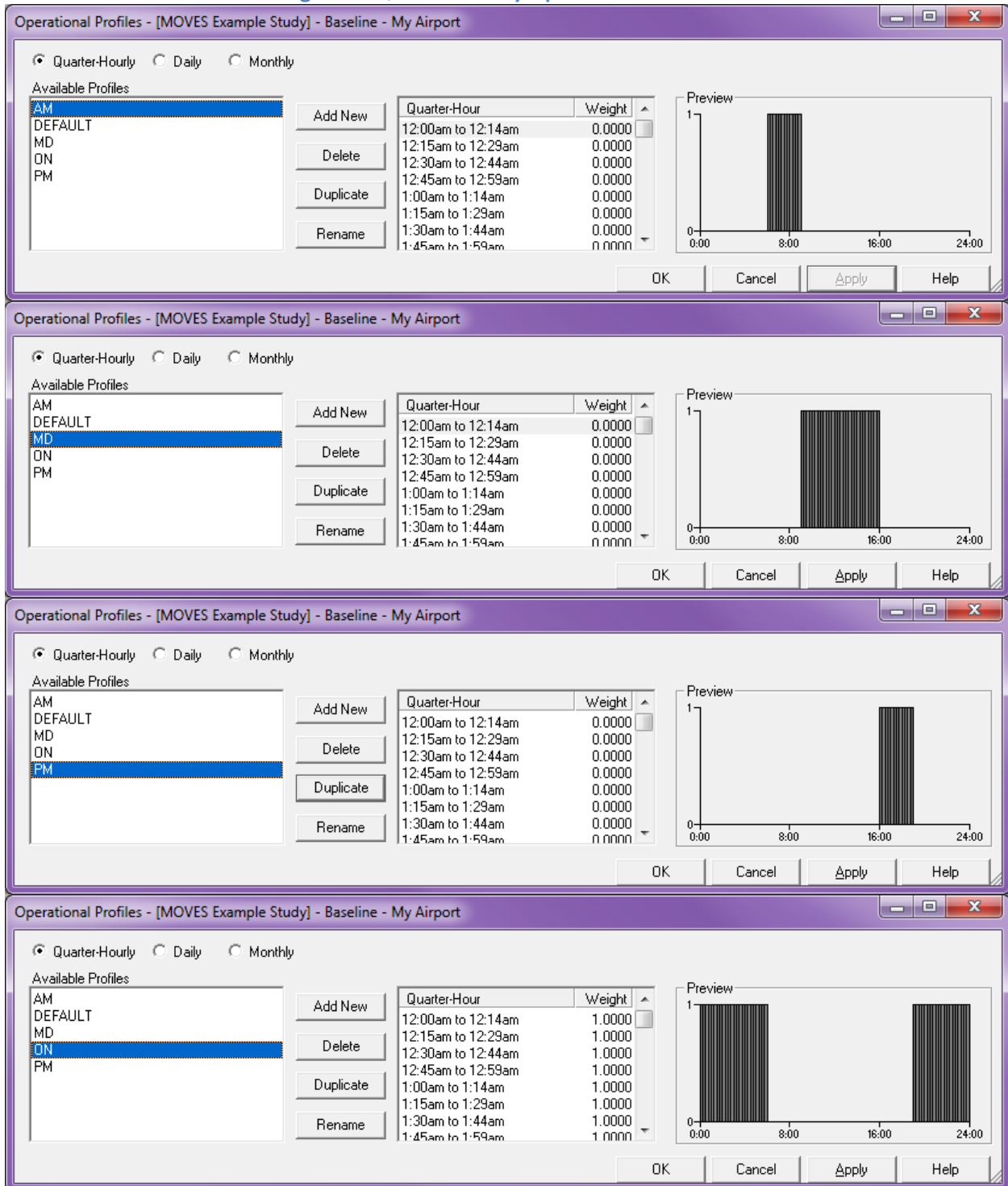
Figure 2. EDMS roadway dialogue box data entry before using MOVES results

The screenshot displays the EDMS roadway dialogue box with the following data entry:

- In Study:** Road
- Traffic Volume (Total flow regardless of direction):**
 - Yearly: 24888000
 - Peak Quarter Hour: 708
- Operational Profiles:**
 - Quarter-Hourly: DEFAULT
 - Daily: DEFAULT
 - Monthly: DEFAULT
- Vehicle Emission Parameters:**
 - Default Fleet Mix (all types, fuels & ages)
 - Fuel: [Empty]
 - Manufactured Year: [Empty]
 - Average Speed: 45 (mph)
 - Roadway Length: 10 (km)
- Emission Factors (grams/vehicle-mile):**
 - Use System Generated Values
 - CO: 8.784
 - NMHC: 0.532
 - Benzene: [Empty]
 - 1,3-Butadiene: [Empty]
 - Acetaldehyde: [Empty]
 - NO_x: 0.992
 - PM-10: 0.05
 - VOC: 0.539
 - TOG: 0.568
 - MTBE: [Empty]
 - Formaldehyde: [Empty]
 - Acrolein: [Empty]
 - SO_x: 0.0088
 - PM-2.5: 0.05

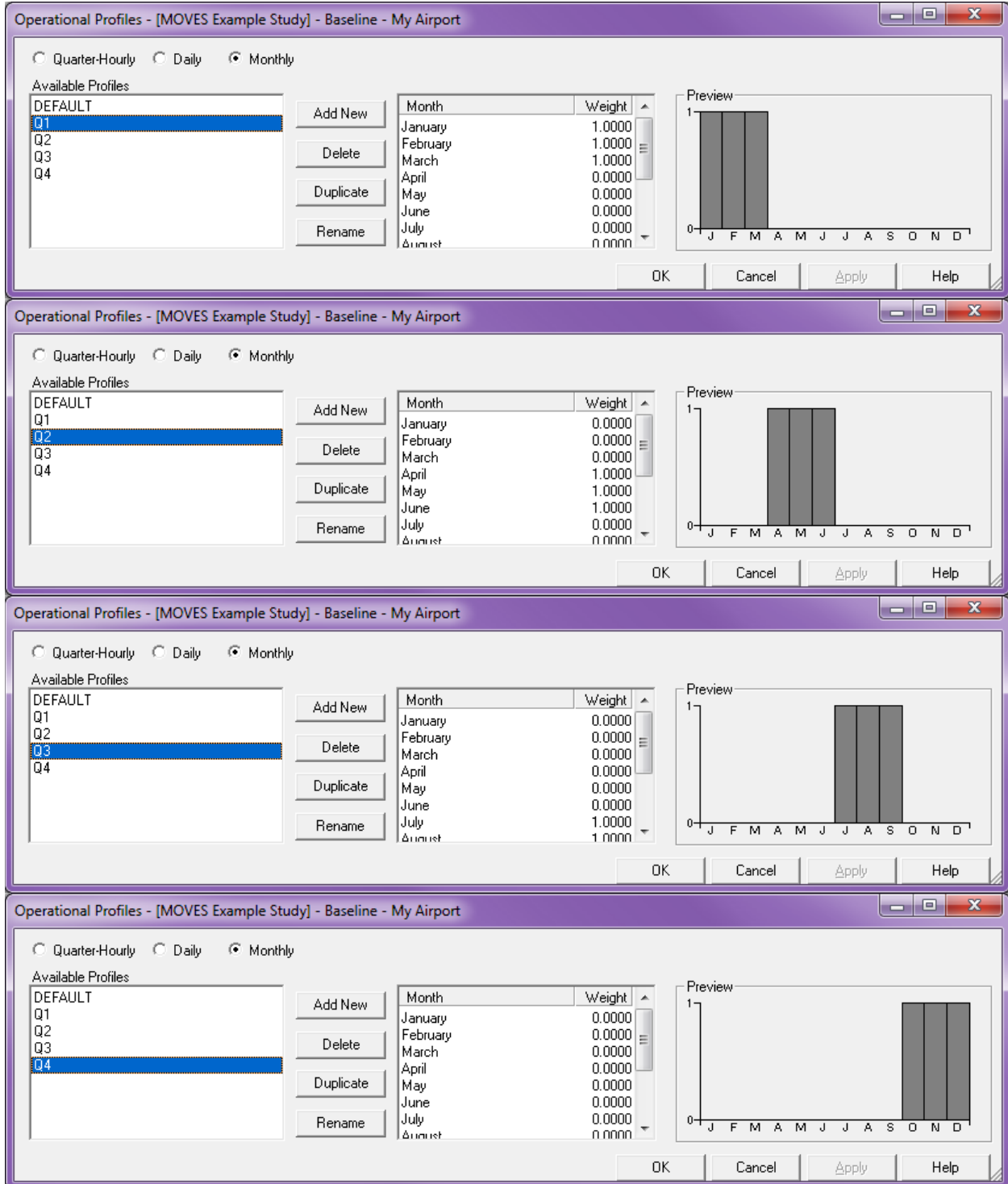
To enter the times of day of Table 1 and the quarters of the year of Table 2 in EDMS, the analyst creates operational profiles. In Figure 3, the analyst creates four quarter-hourly operational profiles (i.e., AM, MD, PM and ON) for each of the four times of the day. The analyst enters zeroes (0.0000) for quarter-hours with no associated activity, and ones (1.0000) for the quarter hours with associated activity.

Figure 3. Quarter-Hourly Operational Profiles



In Figure 4, the analyst creates four monthly operational profiles (i.e., Q1, Q2, Q3 and Q4) for each of the four quarters of the year. The analyst enters zeroes (0.0000) for months with no associated activity, and ones (1.0000) for the months with associated activity.

Figure 4. Monthly Operational Profiles



The analyst creates 16 duplicates of the roadway and renames each copy with an appropriate suffix. The analyst then assigns the appropriate operational profiles created above to each one. Because traffic volume is given in units of vehicles per hour, these values must be divided by four to get traffic volume in units of vehicles per quarter-hour. The emissions rate is entered without modification. Figure 5 shows the desired result of these actions.

Figure 5. EDMS roadway dialogue box data entry after applying the MOVES results.

The screenshot shows the EDMS roadway dialogue box with the following data entry:

- In Study:** Road AM Q1 (selected)
- Traffic Volume:** Peak Qtr-Hour: 1500
- Operational Profiles:**
 - Quarter-Hourly: AM
 - Daily: DEFAULT
 - Monthly: Q1
- Emission Factors (grams/vehicle-mile):**
 - CO: 8.784
 - VOC: 0.539
 - NMHC: 0.532
 - TOG: 0.568
 - Benzene: [empty]
 - MTBE: [empty]
 - 1,3-Butadiene: [empty]
 - Formaldehyde: [empty]
 - Acetaldehyde: [empty]
 - Acrolein: [empty]
 - NOx: 0.992
 - SOx: 0.0088
 - PM-10: 0.0442
 - PM-2.5: 0.0442

A red box highlights the Traffic Volume section with the text: "Divide the 6,000 vehicles per hour in Table 3 by 4 to get 1,500 vehicles per quarter-hour."

2.7 Importing Files

The methodology demonstrated in the preceding example with EDMS GUI data entry in dialogue boxes also applies to importing from text files. First, the analyst creates a study containing roadways and parking facilities and exports the study. The analyst modifies the exported file by duplicating the roadway and parking facilities for each MOVES run. The analyst then assigns the appropriate operational profiles and updates the emission rates and traffic volumes with values from the MOVES runs. Finally, the edited text file is imported into EDMS.