

**Memorandum**

July 20, 2010

To: MOVES Task Force

From: Sunil Kumar, Senior Environmental Engineer, COG/DEP

Subject: Development of Meteorology Inputs for Existing Conformity Analyses (Ozone & PM2.5 - 1997 Standards, CO - 1971 Standard)

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**Introduction**

This memorandum provides detailed methodologies and sources of data for the development of meteorology inputs required by the MOVES2010 model for generating onroad mobile emission for the existing conformity analyses for ozone and PM2.5 (1997 standards) and CO (1971 standard).

The Washington region currently submits conformity analyses for the 1997 ozone and PM2.5 standards and the 1971 carbon monoxide standard. The onroad mobile inventories for these conformity analyses beginning March 2012 will need to be generated using MOVES2010. For this reason, methodologies for inputs related to meteorology were developed for MOVES2010 for the above mentioned conformity analyses.

**Methodology for Meteorology Inputs**

**1. Ozone Conformity (1997 Standard)**

Meteorology used in a conformity analysis for a particular pollutant is the same as used in the SIP for that pollutant. For this reason, meteorology used in the SIP for the 1997 ozone standard for the Washington region submitted to EPA in May 2007 will also be used for the conformity analysis for the 1997 ozone standard. Since the format for the MOVES2010 meteorology data is slightly different than that of Mobile6.2, EPA’s meteorology data converter tool was used to convert the data from the Mobile6.2 format to MOVES2010 format. The original Mobile 6.2 temperature and relative humidity data and the same data converted to MOVES2010 format are provided below.

<b>Mobile 6.2 Hour ID Format</b>											
<b>Hour 1 (6:00 AM)</b>	<b>Hour 2 (7:00 AM)</b>	<b>Hour 3 (8:00 AM)</b>	<b>Hour 4 (9:00 AM)</b>	<b>Hour 5 (10:00 AM)</b>	<b>Hour 6 (11:00 AM)</b>	<b>Hour 7 (12:00 PM)</b>	<b>Hour 8 (1:00 PM)</b>	<b>Hour 9 (2:00 PM)</b>	<b>Hour 10 (3:00 PM)</b>	<b>Hour 11 (4:00 PM)</b>	<b>Hour 12 (5:00 PM)</b>
<b>Hour 13 (6:00 PM)</b>	<b>Hour 14 (7:00 PM)</b>	<b>Hour 15 (8:00 PM)</b>	<b>Hour 16 (9:00 PM)</b>	<b>Hour 17 (10:00 PM)</b>	<b>Hour 18 (11:00 PM)</b>	<b>Hour 19 (12:00 AM)</b>	<b>Hour 20 (1:00 AM)</b>	<b>Hour 21 (2:00 AM)</b>	<b>Hour 22 (3:00 AM)</b>	<b>Hour 23 (4:00 AM)</b>	<b>Hour 24 (5:00 AM)</b>

**Mobile 6.2 Temperature (°F)**

70.7	74.3	78.6	82.3	85.5	88.1	90.0	91.2	91.9	92.5	92.1	91.0
89.2	86.7	82.8	80.3	78.6	77.7	76.7	75.4	74.9	74.7	74.2	73.6

**Mobile 6.2 Relative Humidity (%)**

84.0	76.5	66.7	59.3	52.9	48.8	45.0	42.1	42.2	43.1	42.3	43.6
47.6	52.3	60.4	67.2	72.2	74.4	78.1	80.9	79.5	79.4	79.3	81.1

<b>MOVES2010 Hour ID Format</b>											
<b>Hour 1 (12:00 AM)</b>	<b>Hour 2 (1:00 AM)</b>	<b>Hour 3 (2:00 AM)</b>	<b>Hour 4 (3:00 AM)</b>	<b>Hour 5 (4:00 AM)</b>	<b>Hour 6 (5:00 AM)</b>	<b>Hour 7 (6:00 AM)</b>	<b>Hour 8 (7:00 AM)</b>	<b>Hour 9 (8:00 AM)</b>	<b>Hour 10 (9:00 AM)</b>	<b>Hour 11 (10:00 AM)</b>	<b>Hour 12 (11:00 AM)</b>
<b>Hour 13 (12:00 PM)</b>	<b>Hour 14 (1:00 PM)</b>	<b>Hour 15 (2:00 PM)</b>	<b>Hour 16 (3:00 PM)</b>	<b>Hour 17 (4:00 PM)</b>	<b>Hour 18 (5:00 PM)</b>	<b>Hour 19 (6:00 PM)</b>	<b>Hour 20 (7:00 PM)</b>	<b>Hour 21 (8:00 PM)</b>	<b>Hour 22 (9:00 PM)</b>	<b>Hour 23 (10:00 PM)</b>	<b>Hour 24 (11:00 PM)</b>

**MOVES Temperature (°F)**

76.7	75.4	74.9	74.7	74.2	73.6	70.7	74.3	78.6	82.3	85.5	88.1
90.0	91.2	91.9	92.5	92.1	91.0	89.2	86.7	82.8	80.3	78.6	77.7

**MOVES Relative Humidity (%)**

78.1	80.9	79.5	79.4	79.3	81.1	84.0	76.5	66.7	59.3	52.9	48.8
45.0	42.1	42.2	43.1	42.3	43.6	47.6	52.3	60.4	67.2	72.2	74.4

**2. PM2.5 Conformity (1997 Standard)**

Meteorology used in the SIP for the 1997 PM2.5 standard for the Washington region submitted to EPA in March 2008 will also be used for the conformity analysis for the 1997 PM2.5 standard. Since the format for the MOVES2010 meteorology data is slightly different than that of Mobile6.2, EPA’s meteorology data converter tool was used to convert the data from the Mobile6.2 format to MOVES2010 format. Data were converted for all three seasons (Winter, Summer, and Fall) as the annual onroad mobile emissions inventories for the PM2.5 conformity analyses are based on the three season approach. The original Mobile 6.2 temperature and relative humidity data and the same data converted to MOVES2010 format are provided below.

<b>Mobile 6.2 Hour ID Format</b>											
<b>Hour 1 (6:00 AM)</b>	<b>Hour 2 (7:00 AM)</b>	<b>Hour 3 (8:00 AM)</b>	<b>Hour 4 (9:00 AM)</b>	<b>Hour 5 (10:00 AM)</b>	<b>Hour 6 (11:00 AM)</b>	<b>Hour 7 (12:00 PM)</b>	<b>Hour 8 (1:00 PM)</b>	<b>Hour 9 (2:00 PM)</b>	<b>Hour 10 (3:00 PM)</b>	<b>Hour 11 (4:00 PM)</b>	<b>Hour 12 (5:00 PM)</b>
<b>Hour 13 (6:00 PM)</b>	<b>Hour 14 (7:00 PM)</b>	<b>Hour 15 (8:00 PM)</b>	<b>Hour 16 (9:00 PM)</b>	<b>Hour 17 (10:00 PM)</b>	<b>Hour 18 (11:00 PM)</b>	<b>Hour 19 (12:00 AM)</b>	<b>Hour 20 (1:00 AM)</b>	<b>Hour 21 (2:00 AM)</b>	<b>Hour 22 (3:00 AM)</b>	<b>Hour 23 (4:00 AM)</b>	<b>Hour 24 (5:00 AM)</b>

**Mobile 6.2 Temperature (°F) - Winter Season**

36.9	37.4	38.9	41.2	43.4	45.5	47.2	48.6	49.7	50.2	50.2	49.3
47.5	45.8	44.3	43.1	42.3	41.4	40.6	39.8	39.0	38.2	37.6	37.2

**Mobile 6.2 Relative Humidity (%) - Winter Season**

72.4	71.7	68.2	63.4	58.1	54.2	50.7	48.1	46.5	45.5	45.5	47.1
49.9	53.4	56.9	59.4	60.8	63.0	65.0	66.5	68.0	69.3	71.0	72.0

**Mobile 6.2 Temperature (°F) - Summer Season**

65.7	67.6	69.9	72.3	74.5	76.3	77.9	78.9	79.5	79.5	79.1	78.4
76.9	74.7	72.5	71.2	69.9	68.9	68.0	67.3	66.6	66.2	65.8	65.3

**Mobile 6.2 Relative Humidity (%) - Summer Season**

85.1	81.0	76.0	70.4	65.1	60.6	57.6	55.2	53.6	53.6	54.5	55.9
59.2	64.2	69.8	73.5	76.7	79.2	81.1	82.5	83.5	84.3	84.7	85.5

**Mobile 6.2 Temperature (°F) - Fall Season**

42.4	42.6	43.9	46.3	48.8	50.7	52.4	53.6	54.2	54.3	53.7	52.0
50.1	48.8	47.7	46.9	46.3	45.6	45.0	44.6	44.1	43.6	43.2	42.7

**Mobile 6.2 Relative Humidity (%) - Fall Season**

78.9	78.7	77.1	71.6	65.8	60.8	56.6	53.9	52.7	52.6	53.9	57.2
61.7	65.1	67.5	70.4	71.6	73.4	74.9	75.8	76.8	78.1	78.1	79.1

MOVES2010 Hour ID Format											
Hour 1 (12:00 AM)	Hour 2 (1:00 AM)	Hour 3 (2:00 AM)	Hour 4 (3:00 AM)	Hour 5 (4:00 AM)	Hour 6 (5:00 AM)	Hour 7 (6:00 AM)	Hour 8 (7:00 AM)	Hour 9 (8:00 AM)	Hour 10 (9:00 AM)	Hour 11 (10:00 AM)	Hour 12 (11:00 AM)
Hour 13 (12:00 PM)	Hour 14 (1:00 PM)	Hour 15 (2:00 PM)	Hour 16 (3:00 PM)	Hour 17 (4:00 PM)	Hour 18 (5:00 PM)	Hour 19 (6:00 PM)	Hour 20 (7:00 PM)	Hour 21 (8:00 PM)	Hour 22 (9:00 PM)	Hour 23 (10:00 PM)	Hour 24 (11:00 PM)

**MOVES Temperature (°F) - Winter Season**

40.6	39.8	39.0	38.2	37.6	37.2	36.9	37.4	38.9	41.2	43.4	45.5
47.2	48.6	49.7	50.2	50.2	49.3	47.5	45.8	44.3	43.1	42.3	41.4

**MOVES Relative Humidity (%) - Winter Season**

65.0	66.5	68.0	69.3	71.0	72.0	72.4	71.7	68.2	63.4	58.1	54.2
50.7	48.1	46.5	45.5	45.5	47.1	49.9	53.4	56.9	59.4	60.8	63.0

**MOVES Temperature (°F) - Summer Season**

68.0	67.3	66.6	66.2	65.8	65.3	65.7	67.6	69.9	72.3	74.5	76.3
77.9	78.9	79.5	79.5	79.1	78.4	76.9	74.7	72.5	71.2	69.9	68.9

**MOVES Relative Humidity (%) - Summer Season**

81.1	82.5	83.5	84.3	84.7	85.5	85.1	81.0	76.0	70.4	65.1	60.6
57.6	55.2	53.6	53.6	54.5	55.9	59.2	64.2	69.8	73.5	76.7	79.2

**MOVES Temperature (°F) - Fall Season**

45.0	44.6	44.1	43.6	43.2	42.7	42.4	42.6	43.9	46.3	48.8	50.7
52.4	53.6	54.2	54.3	53.7	52.0	50.1	48.8	47.7	46.9	46.3	45.6

**MOVES Relative Humidity (%) - Fall Season**

74.9	75.8	76.8	78.1	78.1	79.1	78.9	78.7	77.1	71.6	65.8	60.8
56.6	53.9	52.7	52.6	53.9	57.2	61.7	65.1	67.5	70.4	71.6	73.4

**3. CO Conformity (1971 Standard)**

Temperature data used in the CO maintenance plan (1971 standard) for the Washington region submitted to EPA in September 1995 will also be used for the conformity analysis for the 1971 CO standard. The maintenance plan used the Mobile 5a model to develop onroad mobile inventory and budget, which needed only minimum and maximum temperatures. Since MOVES2010 requires hourly temperature, EPA’s meteorology data converter tool was used to convert the minimum and maximum temperatures to hourly temperatures.

The above plan did not use relative humidity as an input as this was an optional input in Mobile 5a. However, MOVES2010 requires hourly relative humidity and therefore, COG/DEP staff used a three month average relative humidity dataset developed using data from December, January, and February for 1990 from the Reagan National airport (DCA) as the maintenance plan inventory and budget was based on data for these three months for 1990. For this purpose, an hourly meteorology dataset titled “Global and U.S.--Integrated Surface Hourly” available from the National Climatic Data Center’s web-site (<http://www.ncdc.noaa.gov/oa/climate/climatedata.html#hourly>) for the Reagan National airport (DCA) for the months of December, January, and February of the year 1990 was used. This weather station is closest to the Washington, DC carbon monoxide maintenance area for the 1971 standard. This data did not contain relative humidity. So the relative humidity (RH) data was developed from the available dry bulb temperature (DBT) and dew point temperature (DPT) data using the equation below.

$$RH = 100 * \frac{\exp(5423 * ((1/273.15) - (1/((DPT - 32) * 0.5555) + 273.15))))}{\exp(5423 * ((1/273.15) - (1/((DBT - 32) * 0.5555) + 273.15))))}$$

Where, RH is in percent (%) and DBT and DPT in Fahrenheit (F) units.

First, both dry bulb temperature and dew point temperature data for the months of December, January, and February for the year 1990 available in the Greenwich Mean Time (GMT) format were converted to the Eastern Standard Time (EST) format as MOVES requires data in local standard time. Then both dry bulb temperature and dew point temperature data were averaged for each of the twenty four hours of the day.

Finally, relative humidity was calculated for each of the twenty four hours of the day from these two parameters using the equation mentioned above. Mobile 5a temperature along with MOVES temperature and relative humidity developed using the procedures above are provided below.

**Mobile 5a Temperature (°F)**

Min. Temp.	33	Max. Temp.	53
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**Mobile 5a Relative Humidity** - Not used

MOVES2010 Hour ID Format											
Hour 1 (12:00 AM)	Hour 2 (1:00 AM)	Hour 3 (2:00 AM)	Hour 4 (3:00 AM)	Hour 5 (4:00 AM)	Hour 6 (5:00 AM)	Hour 7 (6:00 AM)	Hour 8 (7:00 AM)	Hour 9 (8:00 AM)	Hour 10 (9:00 AM)	Hour 11 (10:00 AM)	Hour 12 (11:00 AM)
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**MOVES Temperature (°F)**

37.3	36.2	35.3	34.6	34.1	33.5	33.0	33.4	35.9	39.9	44.0	47.5
50.6	52.3	52.8	53.0	52.6	51.4	49.4	46.8	44.3	42.0	40.4	38.8

**MOVES Relative Humidity (%)**

70.5	70.6	71.6	72.4	74.4	74.1	75.0	76.8	75.1	71.3	66.9	61.0
58.4	54.6	52.9	51.5	51.9	54.9	57.0	60.0	62.7	65.3	66.9	67.8