UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 4
ATLANTA FEDERAL CENTER
61 FORSYTH STREET
ATLANTA, GEORGIA 30303-8960

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MEMORANDUM

SUBJECT: AERMOD Buoyant Line Source Issue Resolution and Model Equivalency Demonstration Nucor Steel, Darlington, South Carolina PSD Air Quality Modeling

FROM: Christopher M. Howard, Physical Scientist
Air Data and Analysis Section
Air Analysis and Support Branch
Air, Pesticides & Toxics Management Division
US EPA Region 4

TO: George Bridgers, Director
Model Clearinghouse
Air Quality Modeling Group
Office of Air Quality Planning and Standards
US EPA

THRU: Todd Rinck, Chief
Air Data and Analysis Section
Air Analysis and Support Branch
Air, Pesticides & Toxics Management Division
US EPA Region 4

The U.S. Environmental Protection Agency Region 4 seeks concurrence from the Model Clearinghouse on the use of an approach proposed by the State of South Carolina Department of Health and Environmental Control (SCDHEC) on behalf of Nucor Steel in Darlington, South Carolina, to address two issues within AERMOD (version 16216r) related to buoyant line sources. This approach is proposed to be used to develop air quality modeling in support of a construction permit application to reconcile previously unrecognized emissions at the Darlington mill. Attached is an email from SCDHEC which describes the situation and recommends the use of this approach for the Nucor Darlington PSD modeling. EPA Region 4 staff have reviewed the proposed approach and corresponding equivalency demonstration submitted by DHEC, has determined that it is justifiable and appropriate, and is seeking concurrence by the Model Clearinghouse of our assessment on the approved use of this approach for this specific PSD permit application.

Introduction

ERM is presently developing PSD air quality modeling for the Nucor Steel Corporation Plant in Darlington, South Carolina. ERM has identified two issues related to AERMOD version 16216r and its handling of buoyant line sources. ERM has proposed methodologies to address these issues and has submitted equivalency modeling to demonstrate that their proposed approach provides predicted air concentrations equivalent to an application of AERMOD version 16216r. The purpose of this memo is to document the EPA Region 4 review of the test cases provided by ERM to support their proposed approach for addressing the issues identified and to request concurrence from the Model Clearinghouse for approval of the proposed approach.

The first issue identified by ERM is related to AERMOD's handling of multiple buoyant line sources in the same model run. The second issue relates to the handling of the conversion of NOx to NO_2 relative to buoyant line sources. ERM has proposed a "work around" or alternative approach to be used to address these two issues until such time that the issues are corrected in future EPA updates to the regulatory AERMOD model. ERM has submitted the code, user's guides, and evaluation test cases for the model utilities that they developed to address these two issues previously described. Even though the approach proposed by ERM may not generally meet the definition of an alternative model application described in Section 3.2.2 of Appendix W, an equivalency demonstration is needed to demonstrate that the approach provides predicted air concentrations equivalent to an application of AERMOD version 16216r which is the recommended regulatory model for this situation.

Problem Description

The original Buoyant Line and Point Source (BLP) model was developed to enhance the representation of sources typical of metallurgical facilities, such as smelters, pot rooms, monovents, and other sources with significant buoyancy not suitable for representation with AERMOD's POINT source option. These sources are typically housed in elongated buildings that may be misrepresented within the BPIPPRIME algorithm. Additionally, these sources have large areas of exhaust with significant thermal buoyancy associated with the emitted plumes. These types of sources are not well represented by either the POINT or VOLUME source types in AERMOD. The BLP algorithm was first introduced into AERMOD version 15181 and is now part of the regulatory model in version 16216r. However, at present there are two known, significant issues with its implementation in AERMOD:

1. **Limit of one buoyant line source configuration per model run:**

As presently implemented, the use of the buoyant line source type within AERMOD version 16216r is limited to a single group of sources that are described with identical characteristics (e.g., buoyancy parameter and vent length). If more than one buoyant line source with dissimilar characteristics or orientation is present, as is often the case at metallurgical facilities, it can be difficult to realistically simulate these sources in one run.

2. **Buoyant line source impacts are added to the model predicted impacts from other sources <u>after</u> implementation of the NO_X-to-NO_2 conversion procedures:**

According to ERM, for NO_2 model runs, the model FORTRAN code that adds the modeled impacts from the buoyant line source type to other modeled impacts is implemented after the NO_X-to-NO_2 conversion methodologies (ARM2, OLM, and PVMRM) are applied to the modeled NO_X concentrations from the other source types. As a result, 100% of the NO_X impacts from the buoyant line sources are converted to NO_2 regardless of the conversion methodology used, and thus the conversion methodologies are compared to an incorrect NO_X concentration when the conversion is calculated. For example, the ARM2 function that looks up the appropriate NO_X to NO_2 conversation ratio on the ARM2 curve uses the NO_X concentration without the contribution of the buoyant line source factored in, potentially resulting in the wrong conversion ratio being selected.

Proposed Workaround to Correct Buoyant Line Source Issues

ERM proposes the following solution to be available until such time as the implementation of buoyant line sources in AERMOD is refined by the EPA. For those scenarios where there are multiple dissimilar buoyant line sources at a facility being modeled, the following steps would be taken:

1. For each buoyant line source, a separate AERMOD run will be executed. Non-source characteristic related model inputs: pollutant, period, meteorological data set and years, receptors, etc., will be identical for each run. Non-buoyant line sources could be included in any of the separate runs.

2. For each AERMOD run, the POSTFILE keyword would be used to generate an unformatted binary file of the hourly impacts at each receptor.

3. Once the binary files for each BLP source are generated, all the binary files for a given pollutant/averaging period run would be processed with a FORTRAN utility developed by ERM called BINSUM. This utility sums and merges all the individual binary output files into a single binary file (representing source group ALL) for final processing.

4. The next step of the post-processing procedure would be executed with a utility named AERPOST developed by ERM. This FORTRAN program is based entirely on AERMOD version 16216r, and will not alter any of its internal calculation algorithms. The keyword "HRBINARY" for the control pathway was included by ERM in the AERPOST program and allows for the import of an AERMOD unformatted 1-hour binary file which can be added to any modeling run in order to perform the statistical averaging of ranked highs for all relevant averaging periods [to demonstrate compliance with various forms of the national ambient air quality standards (NAAQS)].

5. (Optional step – ARM2) If the model run is for NO_2, and the ARM2 NO_X-to-NO_2 conversion methodology is selected, the ARM2 code to look up the appropriate NO_X/NO_2 ratio and apply the ratio to the total NO_X concentration to yield the correct NO_2 concentration would be executed within AERPOST for every hour at each receptor. Note that this process could be used for any NO_2 model run that includes a buoyant line source in order to ensure that the ARM2 method is properly accounted for. The AERPOST processor will produce AERMOD results including standard AERMOD output metrics and plot file formats for review and comparison. The Tier 3 NO_x to NO_2 conversion screening methods cannot be applied within AERPOST.

ERM has developed a version of the codes described above for testing and determined that the model-predicted concentrations generated by AERPOST are identical to those generated by AERMOD for several test cases. The EPA Region 4 has reviewed the test cases submitted by ERM and agrees that the concentrations predicted by AERPOST are identical to the concentrations predicted by AERMOD version 16216r. In addition, as discussed in more detail below, the EPA Region 4 performed its own testing/modeling of most of the test cases submitted by ERM to further confirm their findings.

Summary of EPA Region 4 Review of the Model Equivalency Demonstration

To address the issue related to the limitation of the AERMOD model to only model one BLP source configuration, ERM has developed a post-processor named BINSUM that will take the AERMOD binary output files from individual AERMOD runs for point sources or buoyant line sources and merge these binary files into a single binary file. This binary file is then processed by the AERPOST post-processor to generate the standard air quality metrics for the various averaging periods and pollutants.

Test Case 1 (see Appendix A) submitted by ERM conclusively demonstrates that using AERMOD to predict 1, 3, 8, 24 -hour and annual concentrations from a buoyant line source and a point source separately, merging the binary outputs with BINSUM and generating combined impacts from the two sources with AERPOST produces results identical to modeling the two sources together in one AERMOD run. This test confirms that the ERM approach can be used to model one or more point and/or buoyant line sources in separate AERMOD runs and correctly merge the binary outputs and generate the proper model output metrics. Test Case 3 also confirms that the proposed approach can be used to model one or more point and/or buoyant line sources in separate AERMOD runs and correctly merge the binary outputs and generate the proper model output metrics for 24-hour $PM_{2.5}$.

To address the issue related to the implementation of the ARM2 NO_x to NO_2 conversion methodology for BLP sources in AERMOD, ERM proposed to use AERPOST to take a binary file generated by either BINSUM or AERMOD version 16216r and generate the standard air quality metrics for the various averaging periods and pollutants and to also optionally employ the ARM2 method for NOx emissions. Because the current regulatory version of AERMOD does not properly employ the ARM2 methodology to simulate the conversion of buoyant line source NOx emissions to ambient NO_2 concentrations when the ARM2 option is selected, there is no method available to irrefutably demonstrate that the AERPOST program developed by ERM properly handles the conversion of NOx to ambient NO_2 for one or more buoyant line sources. However, considering the results of Test Cases 2 and 4A (see Appendix A), the EPA Region 4 believes that a sufficient demonstration has been made to support the use of AERPOST for predicting NO_2 impacts from one or more buoyant line sources. Test Cases 2 and 4A confirm that AERPOST properly applies the ARM2 option to predict NO_2 impacts from point sources. Because the ARM2 curve is applied to the total predicted NOx concentration independent of the contributing source type(s), EPA Region 4 believes that AERPOST properly applies the ARM2 option in predicting NO_2 impacts from buoyant line sources as well.

Summary

ERM is developing PSD air quality modeling for the Nucor Steel Corporation Plant in Darlington, South Carolina, and has identified two issues related to AERMOD version 16216r and its handling of buoyant line sources. The first issue identified by ERM is related to AERMOD's handling of multiple buoyant line sources in the same model run. The second issue relates to the handling of the conversion of NOx to NO_2 relative to buoyant line sources. ERM has proposed methodologies to address these issues and has submitted equivalency modeling to demonstrate that their proposed approach provides predicted air concentrations equivalent to an application of AERMOD version 16216r. Even though the approach proposed by ERM may not generally meet the definition of an alternative model application described in Section 3.2.2 of Appendix W, an equivalency demonstration is needed to demonstrate that the approach provides predicted air concentrations equivalent to an application of AERMOD version 16216r which is the recommended regulatory model for this situation.

EPA Region 4 staff have confirmed the two AERMOD limitations identified by ERM. We have reviewed the proposed approach and corresponding equivalency demonstration and have identified no concerns with the application of this alternative approach. EPA Region 4 has determined that the proposed approach is justifiable and appropriate, and is seeking concurrence from the Model Clearinghouse for use of this approach for this specific PSD permit application.
Appendix A provides a detailed report of the review by the EPA Region 4 of the model equivalency test cases submitted by SCDHEC on behalf of ERM for Nucor Steel.

APPENDIX A

EPA Region 4 Review of TEST CASES SUBMITTED BY ERM

ERM submitted two sets of test cases as part of this equivalency demonstration: one set to quality test both the BINSUM and AERPOST processors and another set to quality test AERPOST. Some of the test cases also tested the application of the ARM2 model option in AERPOST.

EPA Region 4 Review of Quality Testing of the AERMOD BINSUM and AERPOST Option

This set of evaluation test cases considers the procedure proposed by ERM for use in the Nucor modeling for the purpose of addressing the AERMOD limitation of one buoyant line source configuration per model run. A separate set of evaluation cases is included in the submission from ERM that more fully evaluates the equivalency of the results using the AERPOST post-processor to results generated using the default AERMOD (version 16216r) model.

The testing of the 3-step AERMOD post-processing procedure includes 3 test cases:

1. Evaluating the 1-, 3-, 8-, 24-hour and annual average concentrations of a passive pollutant at a single receptor over a one-year modeling period. The test involves estimating the concentrations from one point source and one buoyant line source individually using the 3-step procedure (described below) and combined together in a single AERMOD run;
2. Evaluating the application of the ARM2 model option within AERPOST for 1-hour and annual average NO_2 concentrations at multiple receptors for a modeling period of five years. The test involves estimating the concentrations from two point sources individually and combined together in a single AERMOD run;
3. Evaluating the 24-hour $PM_{2.5}$ concentrations at multiple receptors for a modeling period of five years. The test involves estimating the concentrations from one point source and one buoyant line source individually and combined together in a single AERMOD run and adding monthly background values.

For each test case two sets of runs were prepared:

- **Set 1: 3-step modeling procedure including:**
  - Step 1: Running AERMOD to generate binary post files of the hourly concentrations for each individual source;
  - Step 2: Running BINSUM to combine the individual source binary files at each receptor for each hour of the modeling period into one merged hourly binary AERMOD post file;
  - Step 3: Running AERPOST using the hourly binary post file from Step 2 to calculate the standard pollutant concentration statistics for the desired averaging period.
- **Set 2: Default AERMOD application including all the sources of Set 1 in one AERMOD run.**

The results from the two sets of modeling were compared (i.e. the 3-step procedure and the default AERMOD application). In all three test cases, ERM asserted that the results from the two sets of modeling runs were found to be identical and the EPA Region 4 confirmed this finding. The EPA Region 4 performed additional testing for each of the test cases by rerunning the ERM model runs and using all of the same inputs used by ERM in each test case with the exception that a different set of meteorological data was used.

Test Case 1

The goal of Test Case 1 was to compare the 1-, 3-, 8-, 24-hour and annual average concentrations of a passive pollutant calculated using:

1.) The 3-step procedure developed by ERM involving the use of AERMOD, BINSUM and AERPOST, and
2.) The default AERMOD application.

Test Case 1 setup included a complex terrain receptor elevation, one year of meteorological data and two emission sources – one point source and one buoyant line source.

1. Sources

Source Location

Source ID	Type	X (m)	Y (m)	Z (m)
SN_01	POINT	249139.82	3976124.76	78.54
MVENT	BUOYLINE	249276.58, 249388.39	3976235.27, 3976234.39	78.54

Source Parameters

Source ID	Emission Rate (g/s)	Height (m)	Stack Temp. (K)	Exit Velocity (m/s)	Stack Diameter (m)
SN_01	15.00	40.00	380.00	13.00	4.00
Source ID	Emission Rate (g/s)	Height (m)	Buoyancy parameter (m^4/s^3)		
MVENT	5.00	36.00	1687		
	Line length = 112m	Building height = 35m	Building width = 42m	Line width = 6.2m	Line separation = 0m

PRIME building downwash was accounted for with the point source

2. Receptors

A single discrete Cartesian receptor with coordinates 249557.70 (m) E, 3975995.10 (m) N, elevation of 79.96m and hill height 84.38m was included.

3. Meteorology

The meteorology included 1 year (2012) of surface hourly data from Blytheville Regional Airport, Arkansas, (KHKA) and upper air data from Little Rock, Arkansas, (LZK) processed with AERMET v.16216. The data also included 1-minute ASOS winds from KHKA (using AERMINUTE version 15272) and surface parameters extracted for the surface station using AERSURFACE (version 13016). Finally, the low wind speed (ADJ_U*) stability option was used.

ERM submitted comparison results utilizing the MSDOS Compare utility to demonstrate that the plot files resulting from the two approaches described above produce identical results. The EPA Region 4 confirmed this finding.

Additional Testing of Test Case 1 by EPA Region 4

The testing performed by the EPA Region 4 utilized one year (2011) of surface data from Hattiesburg, Mississippi, and upper air data from Jackson, Mississippi, processed with AERMET version 16216. The data also included 1-minute ASOS winds from Hattiesburg (using AERMINUTE version 15272) and surface parameters extracted for the surface station using AERSURFACE (version 13016). Finally, the low wind speed (ADJ_U*) stability option was used. The EPA Region 4 compared the output files and concentrations predicted by the two approaches for Test Case 1 described above and confirmed that, even with a different meteorological data set, the two approaches produce identical results.

Thus, the EPA Region 4 has determined that Test Case 1 submitted by ERM conclusively demonstrates that using AERMOD to predict 1-, 3-, 8-, 24 -hour and annual concentrations from a buoyant line source and a point source separately, merging the binary outputs with BINSUM and generating combined impacts from the two sources with AERPOST produces results identical to modeling the two sources together in one AERMOD run.

Test Case 2

The goal of Test Case 2 was to compare the 1-hour and annual average NO_2 concentrations and the implementation of the ARM2 NO_X-to-NO_2 conversion option in AERPOST using:

1.) The 3-step procedure developed by ERM involving the use of AERMOD, BINSUM and AERPOST;
2.) The default AERMOD application.

Test Case 2 setup included complex terrain elevations, five years of meteorological data and 2 point sources.

1. **Sources**

Source Location

Source ID	Type	X (m)	Y (m)	Z (m)
SN_01	POINT	249139.82	3976124.76	78.54
SN_04	POINT	249575.00	3976470.00	78.54

Source Parameters

Source ID	Emission Rate (g/s)	Height (m)	Stack Temp. (K)	Exit Velocity (m/s)	Stack Diameter (m)
SN_01	15.00	40.00	380.00	13.00	4.00
SN_04	10.00	52.00	970.00	20.00	1.50

PRIME building downwash was accounted for with both point sources

2. **Receptors**

A set of nine discrete Cartesian receptors described with (X, Y) coordinates, elevations, and hill height, was included.

3. **Meteorology**

The meteorology included the 2012-2016 surface hourly data from Blytheville Regional Airport, AR (KHKA) and upper air data from Little Rock, AR (LZK) processed with AERMET v.16216. The data also included 1-minute ASOS winds from KHKA (using AERMINUTE version 15272) and surface parameters extracted for the surface station using AERSURFACE (version 13016). Finally, the low wind speed (ADJ_U*) stability option was used.

ERM submitted comparison results utilizing the MSDOS Compare utility to demonstrate that the plot files resulting from the two approaches described above produce identical results. The EPA Region 4 confirmed this finding.

Additional Testing of Test Case 2 By EPA Region 4

The testing performed by the EPA Region 4 utilized five years (2011-15) of surface data from Hattiesburg, Mississippi, and upper air data from Jackson, Mississippi, processed with AERMET version 16216. The data also included 1-minute ASOS winds from Hattiesburg (using AERMINUTE version 15272) and surface parameters extracted for the surface station using AERSURFACE (version 13016). Finally, the low wind speed (ADJ_U*) stability option was used. The EPA Region 4 compared the output files and concentrations predicted by the two approaches for Test Case 2 described above and confirmed that, even with a different meteorological data set, the two approaches produce identical results.

Thus, the EPA Region 4 has determined that Test Case 2 submitted by ERM conclusively demonstrates that using AERMOD to predict 1-hour and annual NO_2 concentrations from two point sources separately without the ARM2 option, merging the binary outputs with BINSUM and generating combined impacts from the two sources with AERPOST with the ARM2 option produces results identical to modeling the two sources together in one AERMOD run with ARM2 selected. This test confirms that AERPOST properly applies the ARM2 option in predicting NO_2 impacts from point sources.

In the PSD air quality modeling to be performed for Nucor Darlington, NOx emissions from one or more buoyant line sources will need to be simulated with the ARM2 option. Because the current regulatory version of AERMOD (version 16216r), does not properly simulate the conversion of buoyant line source NOx emissions to ambient NO_2 concentrations when the ARM2 option is selected, there is no method available to irrefutably demonstrate that the AERPOST program developed by ERM is properly handling the conversion of NOx to ambient NO_2 for buoyant line sources. However, considering the results of Test Cases 1 and 2, the EPA Region 4 believes that a sufficient demonstration has been made to support the use of AERPOST for predicting NO_2 impacts from 1 or more buoyant line sources.

Test Case 1 submitted by ERM conclusively demonstrates that using AERMOD to predict 1-, 3-, 8-, 24-hour and annual concentrations from a buoyant line source and a point source separately, merging the binary outputs with BINSUM and generating combined impacts from the two sources with AERPOST produces results identical to modeling the two sources together in one AERMOD run. This test confirms that the ERM approach can model one or more point and/or buoyant line sources in separate AERMOD runs and correctly merge the outputs.

Test Case 2 confirms that AERPOST properly applies the ARM2 option in predicting NO_2 impacts from point sources. The EPA Region 4 concludes that AERPOST properly applies the ARM2 option in predicting NO_2 impacts from buoyant line sources as well, while acknowledging that there is no way to irrefutably demonstrate this with the current AERMOD limitation related to buoyant line sources. Because the ARM2 curve is applied within AERPOST to the total predicted NOx concentrations independent of the contributing source type(s), the EPA Region 4 believes that AERPOST properly applies the ARM2 option in predicting NO_2 impacts from buoyant line sources as well.

Test Case 3

The goal of Test Case 3 was to compare the 8th high 24-hour $PM_{2.5}$ concentrations averaged over five years while adding monthly monitor background values calculated using:

1.) The 3-step procedure developed by ERM involving the use of AERMOD, BINSUM and AERPOST;
2.) The default AERMOD application.

Test Case 3 setup included complex terrain elevations, five years of meteorological data and 2 emission sources – 1 point and 1 buoyant line source

1. **Sources**

Source Location

Source ID	Type	X (m)	Y (m)	Z (m)
SN_01	POINT	249139.82	3976124.76	78.54
MVENT	BUOYLINE	249276.58, 249388.39	3976235.27, 3976234.39	78.54

Source Parameters

Source ID	Emission Rate (g/s)	Height (m)	Stack Temp. (K)	Exit Velocity (m/s)	Stack Diameter (m)
SN_01	15.00	40.00	380.00	13.00	4.00
Source ID	Emission Rate (g/s)	Height (m)	Buoyancy parameter (m^4/s^3)		
MVENT	5.00	36.00	1687		
	Line length = 112m	Building height = 35m	Building width = 42m	Line width = 6.2m	Line separation = 0m

PRIME building downwash was accounted for with the point source

2. **Receptors**

A set of nine discrete Cartesian receptors described with (X, Y) coordinates, elevations, and hill height, was included.

3. **Meteorology**

The meteorology included the 2012-2016 surface hourly data from Blytheville Regional Airport, AR (KHKA) and upper air data from Little Rock, AR (LZK) processed with AERMET v.16216. The data also included 1-minute ASOS winds from KHKA (using AERMINUTE version 15272) and surface parameters extracted for the surface station using AERSURFACE (version 13016). Finally, the low wind speed (ADJ_U*) stability option was used.

ERM submitted comparison results utilizing the MSDOS Compare utility to demonstrate that the plot files resulting from the two approaches described above produce identical results. The EPA Region 4 confirmed this finding.

Additional Testing of Test Case 3 By EPA Region 4

The testing performed by the EPA Region 4 utilized 5 years (2011-15) of surface data from Hattiesburg, Mississippi, and upper air data from Jackson, Mississippi, processed with AERMET version 16216. The additional details of the meteorological data used by EPA Region 4 for this testing is the same as for Test Case 2. The EPA Region 4 compared the output files and concentrations predicted by the two approaches for Test Case 3 described above and confirmed that, even with a different meteorological data set, the two approaches produce identical results.

Thus, the EPA Region 4 has determined that Test Case 3 submitted by ERM conclusively demonstrates that using AERMOD to predict the 8th high 24-hour $PM_{2.5}$ concentrations averaged over five years from one point source and one BLP source separately including monthly background values, merging the binary outputs with BINSUM and generating combined impacts from the two sources with AERPOST produces results identical to modeling the two sources together in one AERMOD run with monthly background values. This test also confirms that AERPOST properly applies the monthly background values.

EPA Region 4 Review of Quality Testing of the AERPOST Post Processor

The testing of the AERPOST option submitted by ERM involves control cases with 3 sources that have been modeled in flat terrain in local coordinates. Each control case is run with AERMOD only. Four control cases were performed as discussed below. Test cases corresponding to each control case are run with the binary output file(s) from AERMOD processed with AERPOST for various pollutants and averaging periods. The base sources, receptors, and meteorological data used in each of the control cases and tests are discussed below:

1. Sources

Source Location (in Local Coordinates)

Source ID	Type	X (m)	Y (m)	Z (m)
stack1	POINT	0.0	0.0	0.0
stack2	POINT	100.0	0.0	0.0
stack3	POINT	200.0	0.0	0.0

Source Parameters

Source ID	Emission Rate (g/s)	Height (m)	Stack Temp. (K)	Exit Velocity (m/s)	Stack Diameter (m)
stack1	1.0	57.91	403.15	18.66	1.626
stack2	1.0	57.91	403.15	18.66	1.626
stack3	1.0	57.91	403.15	18.66	1.626

The sources are "grouped" in the following manner:

SRCGROUP 1_2 stack1 stack2
SRCGROUP 1_2_3 stack1 stack2 stack3
SRCGROUP ALL

2. Receptors

The receptor grid is modeled on a flat terrain in Local Coordinates using the following configuration:

X Grid Origin = 0.00 Y Grid Origin = 0.00

No. of Tiers = 3
Tier 1: Segment Distance = 1000.00
Tier 1: Tier Spacing = 100.00

Tier 2: Segment Distance = 5000.00
Tier 2: Tier Spacing = 500.00

Tier 3: Segment Distance = 10000.00
Tier 3: Tier Spacing = 1000.00

3. Meteorology

The meteorology included in all the cases was from 2006-2010, using surface data from Niagara Falls, NY and upper air from Buffalo, NY processed with AERMET.

4. Output

The control cases generate both a standard AERMOD output file as well as numerous plot files that are used for the comparison benchmark testing. Also, the control cases generate UNFORMATTED 1-hour binary POSTFILES that are subsequently used by AERPOST in the corresponding test case.

The EPA Region 4 performed additional testing to confirm the results submitted by ERM for most of the following test cases by rerunning the ERM model runs and using all of the same inputs used by ERM in each test case with the exception of the meteorology data that was used.

Set 1 - Basic AERMOD Processing

Control Case 1:

(a) Run AERMOD without AERPOST file
(b) AVERAGING PERIODS: 1, 3, 8, 24, ANNUAL
(c) POLLUTID: OTHER
(d) SOURCES: Emissions on
(e) OUTPUT: 1-hr POSTFILE UNFORMATTED BINARY for source group ALL
(f) LENGTH OF RUN: 1-year (2006)

Note that in the test cases described below, entries in **BOLD** correspond to changes relative to the associated control case.

Test Case 1A:
Goal: Replicate the results for all averaging periods in Control Case 1

(a) Run AERMOD WITH AERPOST using binary file from Control Case 1
(b) AVERAGING PERIODS: 1, 3, 8, 24, ANNUAL
(c) POLLUTID: OTHER
(d) SOURCES: Emissions OFF
(e) OUTPUT: NO POSTFILE
(f) LENGTH OF RUN: 1-year (2006)

EPA Region 4 has confirmed that in the output files submitted by ERM the concentrations predicted in Test Case 1A match the concentrations predicted in Control Case 1.

Additional Testing of Test Case 1A By EPA Region 4
The testing performed by EPA Region 4 utilized 1 year (2011) of surface data from Hattiesburg, Mississippi, and upper air data from Jackson, Mississippi, processed with AERMET version 16216. The data also included 1-minute ASOS winds from Hattiesburg (using AERMINUTE version 15272) and surface parameters extracted for the surface station using AERSURFACE (version 13016). Finally, the low wind speed (ADJ_U*) stability option was used. EPA Region 4 compared the output files and concentrations predicted by Control Case 1 and Test Case 1A described above and confirmed that, even with a different meteorological data set, the two approaches produce identical results.

Thus, the EPA Region 4 has determined that Test Case 1A submitted by ERM conclusively demonstrates that using AERMOD to predict 1-, 3-, 8-, 24-hour and annual concentrations from three point sources produces results identical to modeling the three sources with AERPOST using the binary output file from Control Case 1.

Test Case 1B:
Goal: DOUBLE the results for all averaging periods in Control Case 1

(a) Run AERMOD WITH AERPOST using binary file from Control Case 1
(b) AVERAGING PERIODS: 1, 3, 8, 24, ANNUAL
(c) POLLUTID: OTHER
(d) SOURCES: Emissions on (same ones modeled in the control case)
(e) OUTPUT: NO POSTFILE
(f) LENGTH OF RUN: 1-year (2006)

The EPA Region 4 has confirmed that in the output files submitted by ERM the concentrations predicted in Test Case 1A are double the concentrations predicted in Control Case 1. The EPA Region 4 performed no additional testing for Test Case 1B.

Set 2 - Multi-year AERMOD Averaging

Control Case 2: *1-hour SO_2*

(a) Run AERMOD without AERPOST file
(b) AVERAGING PERIOD: 1
(c) POLLUTID: SO2
(d) SOURCES: Emissions on
(e) OUTPUT: 1-hr POSTFILE UNFORMATTED BINARY for source group ALL
(f) LENGTH OF RUN: Multi-year (2006 – 2010)

Test Case 2A:
Goal: Replicate SO_2 results of Control Case 2

(a) Run AERMOD WITH AERPOST using the binary from Control Case 2
(b) AVERAGING PERIOD: 1
(c) POLLUTID: SO2
(d) SOURCES: Emissions OFF
(e) OUTPUT: NO POSTFILE
(f) LENGTH OF RUN: Multi-year (2006 – 2010)

The EPA Region 4 has confirmed that in the output files submitted by ERM the concentrations predicted in Test Case 2A match the concentrations predicted in Control Case 2.

Additional Testing of Test Case 2A By EPA Region 4

The testing performed by the EPA Region 4 utilized 5 years (2011-15) of surface data from Hattiesburg, Mississippi, and upper air data from Jackson, Mississippi, processed with AERMET version 16216. The data also included 1-minute ASOS winds from Hattiesburg (using AERMINUTE version 15272) and surface parameters extracted for the surface station using AERSURFACE (version 13016). Finally, the low wind speed (ADJ_U*) stability option was used. The EPA Region 4 testing also included testing of the 5-year average of the 4^{th} high 1-hour SO_2 values since this is the metric that is used to compare model predictions to the NAAQS when 5 years of meteorological data are simulated. The EPA Region 4 compared the output files and concentrations predicted by Control Case 2 and Test Case 2A described above and confirmed that, even with a different meteorological data set, the two approaches produce identical results.

Thus, the EPA Region 4 has determined that Test Case 2A submitted by ERM conclusively demonstrates that using AERMOD to predict 1-hour SO_2 concentrations from three point sources produces results identical to modeling the three sources with AERPOST using the binary output file from the AERMOD run of Control Case 2.

Control Case 3: *24-hour $PM_{2.5}$*
(a) Run AERMOD without AERPOST file
(b) AVERAGING PERIOD: 24
(c) POLLUTID: PM25
(d) SOURCES: Emissions on
(e) OUTPUT: NO POSTFILE ***The 1-hour binary file from Control Case 2 was used*
(f) LENGTH OF RUN: Multi-year (2006 – 2010)

Test Case 3A:
Goal: Replicate $PM_{2.5}$ results of Control Case 3
(a) Run AERMOD WITH AERPOST using the binary from Control Case 2
Note: used hourly file from Control Case 2(e), even though modeled averaging period is 24-hour
(b) AVERAGING PERIOD: 24
(c) POLLUTID: PM25
(d) SOURCES: Emissions OFF
(e) OUTPUT: NO POSTFILE
(f) LENGTH OF RUN: Multi-year (2006 – 2010)

EPA Region 4 has confirmed that in the output files submitted by ERM the concentrations predicted in Test Case 3A match the concentrations predicted in Control Case 3.

Additional Testing of Test Case 3A By EPA Region 4

The testing performed by the EPA Region 4 utilized 5 years (2011-15) of surface data from Hattiesburg, Mississippi, and upper air data from Jackson, Mississippi, processed with AERMET version 16216. The data also included 1-minute ASOS winds from Hattiesburg (using AERMINUTE version 15272) and surface parameters extracted for the surface station using AERSURFACE (version 13016). Finally, the low wind speed (ADJ_U*) stability option was used. The EPA Region 4 testing also included testing of the 5-year average of the 8^{th} high 24-hour $PM_{2.5}$ values since this is the metric that is used to compare model predictions to the NAAQS when 5 years of meteorological data are simulated. The EPA Region 4 compared the output files and concentrations predicted by Control Case 3 and Test Case 3A described above and confirmed that, even with a different meteorological data set, the two approaches produce identical results.

Thus, the EPA Region 4 has determined that Test Case 3A submitted by ERM conclusively demonstrates that using AERMOD to predict 24-hour $PM_{2.5}$ concentrations from three point sources produces results identical to modeling the three sources with AERPOST using the binary output file from the AERMOD run of Control Case 3.

Control Case 4: *1-hour NO_2 with ARM2*

(a) Run AERMOD without AERPOST file
(b) AVERAGING PERIOD: 1
(c) POLLUTID: NO2
(d) SOURCES: Emissions on
(e) OUTPUT: NO POSTFILE ***The 1-hour binary file from Control Case 2(e) was used*
(f) LENGTH OF RUN: Multi-year (2006 – 2010)
(g) ARM2

Test Case 4A:

Goal: Replicate NO_2 with ARM2 results of Control Case 4

(a) Run AERMOD WITH AERPOST using the binary from control case 2(e)
(b) AVERAGING PERIOD: 1
(c) POLLUTID: NO2
(d) SOURCES: Emissions OFF
(e) OUTPUT: NO POSTFILE
(f) LENGTH OF RUN: Multi-year (2006 – 2010)
(g) ARM2

EPA Region 4 has reviewed the output files submitted by ERM and has determined that the predicted concentrations from Test Case 4A match Control Case 4.

Additional Testing of Test Case 4A by EPA Region 4

The testing performed by the EPA Region 4 utilized 5 years (2011-15) of surface data from Hattiesburg, Mississippi, and upper air data from Jackson, Mississippi, processed with AERMET version 16216. The data also included 1-minute ASOS winds from Hattiesburg (using AERMINUTE version 15272) and surface parameters extracted for the surface station using AERSURFACE (version 13016). Finally, the low wind speed (ADJ_U*) stability option was used. The EPA Region 4 testing also included testing of the 5-year average of the 8^{th} high 1-hour NO_2 values since this is the metric that is used to compare model predictions to the NAAQS when 5 years of meteorological data are simulated. The EPA Region 4 compared the output files and concentrations predicted by Control Case 4 and Test Case 4A described above and confirmed that, even with a different meteorological data set, the two approaches produce identical results.

Thus, the EPA Region 4 has determined that Test Case 4A submitted by ERM conclusively demonstrates that using AERMOD to predict 1-hour NO_2 concentrations from three point sources with the ARM2 option produces results identical to modeling the three sources with AERPOST with the ARM2 option using the binary output file from an equivalent AERMOD run without ARM2. In addition to testing the high first and high second high statistical outputs, the EPA Region 4 also tested the high eighth high statistical outputs and confirmed that the results are identical between the two techniques.

Howard, Chris

From: Glass, John <glassjp@dhec.sc.gov>
Sent: Friday, February 2, 2018 10:43 AM
To: Howard, Chris
Cc: Powell, Heather (NSSC); Bullard, Carey (NSSC); JASON.PUGH@NUCOR.COM; Milena Borissova; Richard Hamel; Jeff Twaddle; Jeffrey Barwick; Gillam, Rick; Rinck, Todd; Buckner, Katharine; Steven McCaslin; Kaiser, Heinz; Christopher Hardee
Subject: Nucor Darlington PSD Model Equivalency
Attachments: Nucor Steel - Buoyant Line Source Issues in AERMOD - Proposed Workaround - v2.0.pdf

Dear Mr. Howard,

The South Carolina Department of Health and Environmental Control (SCDHEC) has received an application for a PSD modification at the existing Nucor Steel Corporation facility located in Darlington, SC (Nucor-Darlington, SC Permit 0820-0001). Nucor-Darlington is a steel recycling mill that operates sources typical of metallurgical facilities. These sources are housed in three different elongated buildings most appropriately represented using the buoyant line (BUOYLINE) default source type option in the current regulatory version 16216r of AERMOD.

During the development of the required air quality analysis, the facility discovered a couple of issues involving the BUOYLINE source type as configured in AERMOD. Specifically, the issues involve how the buoyancy flux parameter and vent length of the BUOYLINE source is applied for multiple BUOYLINE sources as well as how the NO2 Tier 2 Ambient Ratio Method 2 (ARM2) screening technique is applied under the regulatory default option. The issues are explained in more detail in the attached memo submitted by ERM, the consultants contracted by Nucor-Darlington to develop the PSD permit application and required air quality analysis. As this memo explains, under the current regulatory default configuration, AERMOD will only allow the use of one buoyancy flux parameter and vent length at a time. In addition, the current regulatory default configuration of AERMOD will not allow the ARM2 screening technique to be applied to the BUOYLINE sources. In order to properly apply the different buoyancy flux and vent length parameters for the three different BUOYLINE sources, as well as the ARM2 screening technique, post-processing of separate model runs is required. Even though this post-processing would be applied outside the regulatory default model, the situation does not generally meet the definition of an alternative model in Section 3.2.2 of Appendix W. Nevertheless, a demonstration is needed to show that the approach proposed by ERM will produce concentration estimates equivalent to the current regulatory version of AERMOD (16216r).

ERM has developed the necessary equivalency tests as required by the alternative model approval process to demonstrate that the post-processing performed will not alter the underlying algorithms employed in the regulatory default model and that equivalent concentrations will be obtained as if the default model had properly applied the appropriate buoyancy flux and vent length parameters as well as the ARM2 screening technique within the same model. Since the size of the equivalency tests files are quite large, those files (as well as documents to fully explain the procedures used) have been made available to SCDHEC and EPA for download from an ftp site set up by ERM. Note that two sets of files were provided, one initially on 12/25/17 and then a complete set to replace that initial set of files on 1/11/18 in response to a question concerning one of the test cases (TEST Case 4a). We understand that EPA has been able to download these files, however they can still be obtained from the ftp at https://onyx.erm.com using login credentials provided in the 1/11/18 email from ERM.

We believe the documentation and files provided demonstrate that the proposed approach produces concentration estimates equivalent to the current regulatory version of AERMOD (16216r). SCDHEC requests EPA Region 4 review the submitted documentation and equivalency tests and, in consultation with the EPA Model Clearinghouse, concur with, as soon as possible, the use of these procedures for the purposes of performing the required PSD air quality analysis for the Nucor-Darlington facility.

Should you have questions concerning this request or the information and files provided, please contact me.

Respectfully,

John P. Glass, Jr.
Air Modeling Section Manager
Bureau of Air Quality
S.C. Dept. of Health & Environmental Control
Office: (803)898-4074
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