MEMORANDUM

To: David Ailor, COETF

From: Susan Barnes, Trinity Consultants

Date: April 2, 2024

RE: Intra-Mine Variability Factor for Mercury in Metallurgical Coals

On August 16, 2023, the U.S. Environmental Protection Agency (EPA) proposed revisions to the National Emission Standards for Hazardous Air Pollutants (NESHAP) for the Coke Ovens: Pushing, Quenching, and Battery Stacks (PQBS) source category, 40 CFR 63 Subpart CCCCC, and the NESHAP for the Coke Oven Batteries source category, 40 CFR 63 Subpart L. As part of the proposed Subpart CCCCC rule, EPA proposed standards for several previously unregulated hazardous air pollutants (HAPs), including new limits for mercury.

The Coke Oven Environmental Task Force (COETF), which represents all four companies that operate byproduct recovery coke plants in the U.S., previously commented to EPA that the proposed limits are not achievable and do not account for variability of HAP-related constituents in raw materials their coke plants utilize, including mercury (Hg).[1] Each coke plant has unique specifications for raw materials they use in cokemaking, including coal sources and properties. Thus, the potential variation of mercury in coal blends introduced to the batteries over the course of normal operations is high.

The COETF has requested Trinity's assistance in analyzing how this variability could be accounted for in calculating emission limitations for the industry following EPA's established methodologies in other rulemakings.

Mercury content of metallurgical coals used in this analysis ranges from 0.008 to 0.360 parts per million (ppm) as shown in Figure 1. This wide range clearly indicates the need for consideration of coal mercury variability in establishing mercury emission limitations.

[1] See Comments of the COETF on the Proposed Rule National Emission Standards for Hazardous Air Pollutants for Coke Ovens: Pushing, Quenching, and Battery Stacks, and Coke Oven Batteries; Residual Risk and Technology Review, and Periodic Technology Review (EPA-HQ-OAR-2002-0085, EPA-HQ-OAR-2003-0051), October 2, 2023; "Coke Ovens RTR Proposed Rule: White Paper on Proposed Standards" submitted by the COETF to EPA on December 29, 2023; and "Compliance Schedule Concerns 020924.pdf" submitted by the COETF to EPA on February 9, 2024.

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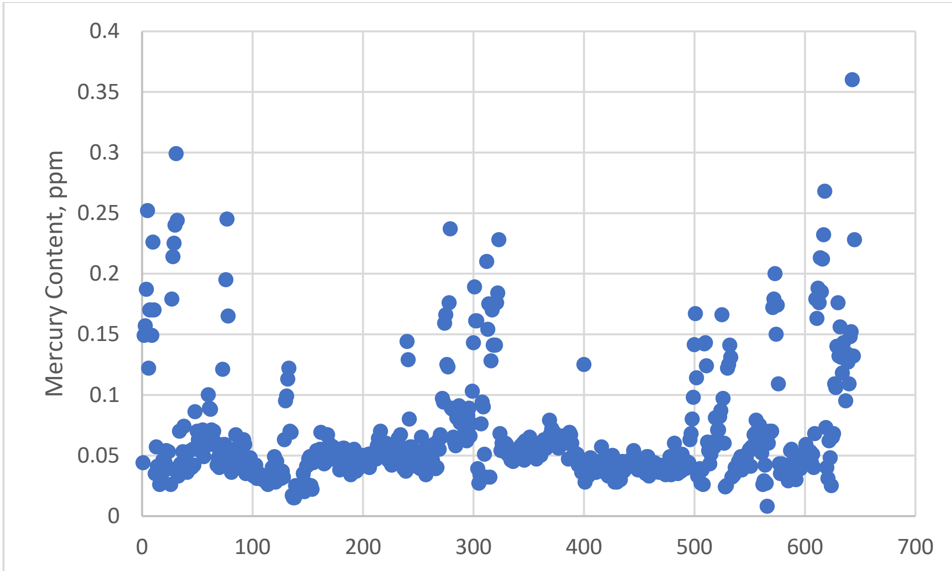
Figure 1. Mercury Content of Metallurgical Coals



EPA in several other rulemakings has properly acknowledged that an intra-quarry variability (IQV) factor should be used to set MACT limits that reflect the effects of raw material input variability.[2] In these rulemakings, EPA has applied an IQV factor to EPA's computed upper prediction limit (UPL) to reflect the MACT floor emissions rate.[3]

In this memorandum, Trinity is recommending how EPA should apply its well-established methodology for utilizing mercury content variability in raw materials, to set MACT floor emission limits for Battery Stacks and Pushing Emission Control Devices (PECs) at byproduct recovery coke plants. The variability in concentrations of Hg (and other HAP-related constituents) in emissions from these sources is directly proportional to the concentration of these constituents that naturally occur in raw materials (i.e., metallurgical coals) used in the byproduct recovery cokemaking process. Coke producers are constrained on the coal supplied to their coke batteries to ensure that the coke produced achieves the quality specifications dictated by the coking process and their customers. This means that their sources of coals to their batteries are limited by the coke quality specifications imposed on them by the process and their customers, and not by the concentrations of mercury and other HAP-related constituents in their raw materials (metallurgical coals).

MACT Floors

The existing sources EPA has chosen as the basis for the emission limits are referred to as the "best performing sources" (aka, "MACT floor sources"). For source categories with fewer than 30 sources, the MACT floor is typically the best-performing five emission units. In the proposed rule, EPA has identified the MACT floors as four Battery Stacks and five PECs. In both cases, the MACT floor includes the AKS-Middletown-OH coke battery, which has been declared permanently shutdown and is no longer operating.

[2] See the final Portland Cement NESHAP, 40 CFR 63 Subpart LLL; final Brick and Structural Clay Products Manufacturing NESHAP, 40 CFR 63 Subpart JJJJJ; and Lime NESHAP, 40 CFR 63 Subpart AAAAA as proposed on February 9, 2024.

[3] In this memorandum, we have revised the term "intra-quarry variability" (IQV) factor to "intra-mine variability" (IMV) factor. This simply acknowledges that the raw materials used in byproduct recovery coke plants (metallurgical coals) are sourced from deposits more commonly referred to as "mines," and not from "quarries." Nevertheless, the technical concept remains identical in that the requisite raw materials (metallurgical coals) from coal mines contain inherently varying and naturally occurring concentrations of Hg and other HAP-related constituents outside the control of the coke plant operator and which are used in existing MACT floor sources on a regular basis.

Therefore, Trinity recommends that the AKS-Middletown-OH facility be removed from the MACT floor sources used to set the mercury MACT floor limits.

Upper Prediction Limit

Once the best performing sources are established, EPA uses a UPL calculation to establish an emission standard. The UPL represents the value at which one can expect the average of a future specified number of observations to fall below, within a certain predicted confidence interval. For example, if the MACT floor consists of a data set of 1-hour runs from stack testing results for a specific type of source, a UPL can be used to predict the maximum average of any future three 1-hour runs for an emission unit in that specific source group (assuming it is part of the same population of data) within a specified confidence interval. The UPL takes into account the average emissions and variability in emissions within sources in the MACT floor. MACT emission limits are typically set using a 99% confidence interval.

EPA calculated the mercury limits in this proposed rule using the UPL formulas for a lognormally distributed data set.[4] However, the UPL calculation itself does not capture additional variability from naturally occurring mercury in raw materials (i.e., metallurgical coals). Below we discuss the nature and methodology Trinity used, similar to that used by EPA in prior rulemakings, and how this methodology should be incorporated into a final MACT limit for trace amounts of naturally occurring mercury constituents in metallurgical coals supplied by metallurgical coal mines to byproduct recovery coke plants.

Raw Material Variability

While the UPL calculation accounts for variability in the test run data collected (i.e., stack measurement variability, or run-to-run variability), it does not account for variability caused by differences in raw materials at a source, or between sources. EPA has accounted for variability in the mercury content in raw materials in establishing mercury standards in the cement, lime, and brick industries. Like these industries, mercury content in raw materials (i.e., metallurgical coals) being used in byproduct recovery coke plants has a direct impact on mercury emissions from Battery Stacks and PECs. Therefore, incorporating this variability into the standard UPL calculation will better predict future emissions from these emission sources, helping to ensure that the calculated MACT Floor is "achieved in practice."

In prior rulemakings, EPA accounted for an IQV factor with a "pooled" variability factor (s^2). By incorporating the IQV, the UPL equation should predict the highest average of a specified number of future runs, with the defined confidence level for a source in the specified emission category utilizing raw materials with naturally varying mercury content. EPA has calculated the IQV, as follows:

$$IQV = (RSD \times Mean)^2$$

Where:

IQV	=	Intra-Quarry Variability factor
RSD	=	Relative Standard Deviation (i.e., standard deviation divided by arithmetic mean) of raw material mercury content data
Mean	=	Arithmetic mean of emissions data in the MACT floor

[4] Refer to Equation 2 from *Use of the Upper Prediction Limit for Calculating MACT Floors*, Tina Ndoh, EPA Office of Air Quality Planning and Standards, July 30, 2014.

For the byproduct recovery cokemaking sector, it is appropriate to incorporate a variability factor to account for mercury content variability in the raw materials (metallurgical coals), to ensure that Battery Stacks and PECs, including those in the MACT floor, can comply with the MACT limits and reflect a level that is achieved in practice at the existing MACT floor sources. For these MACT floor data sets, the data are lognormally distributed. As such, Trinity has revised this IQV formula and calculated an intra-mine variability (IMV) factor for the byproduct recovery coke industry, as follows:[5]

$$IMV = (RSD \times Logmean)^2$$

Where:

IMV	=	Intra-Mine Variability factor
RSD	=	Relative Standard Deviation (i.e., standard deviation divided by arithmetic mean) of coal mercury content data
Logmean	=	Arithmetic mean of log-transformed emissions data in the MACT floor

Mercury Content Data

In this analysis, Trinity has evaluated raw material (metallurgical coal) mercury content from three byproduct recovery coke plants: Monessen, Clairton, and Burns Harbor. These plants were chosen because they are in both the Battery Stack and PEC MACT floors, and because metallurgical coal mercury content data are available. The data set consists of 645 coal samples analyzed for mercury from 2015 and 2023. This is a very robust data set, with significantly more data than were used in establishing MACT limits via an IQV for other industries. The brick industry, for example, provided 167 samples nationwide, with the final IQV being based on seven samples from four plants.[6]

Due to differences in the available precedents for setting the relative standard deviation (RSD) upon which an IQV is set, two different methods are provided in this memorandum: (1) evaluating the RSD of all available data, and (2) evaluating the RSD of the average mercury content of each mine. These are discussed in more detail below. Calculations supporting this analysis are provided in the attached spreadsheet.

Option 1: IMV Factor Based on RSD of All Available Data from MACT Floor Sources

The most recent proposed version of the Lime MACT[7] set an IQV using the mercury content of individual samples for two plants in the MACT floor. Following this precedent, under option 1, the RSD is calculated as follows:

[5] In byproduct recovery coke plants, the critical parameters of coal play a pivotal role in determining coke quality, yield, and performance. Proximate and petrographic analyses, coking properties, ash fusion temperature, size, grindability, and thermal properties are among the key factors that must be carefully evaluated and controlled. By understanding and optimizing these parameters, these plants can produce coke that will enhance the efficiency, sustainability, and competitiveness of steelmaking processes, as well as high-quality coke for diverse industrial applications.

[6] EPA-HQ-OAR-2013-0291-0660, Appendix E.

[7] EPA-HQ-OAR-2017-0015-0172.

$$RSD = \frac{SD}{Mean}$$

Where:

RSD	=	Relative standard deviation
SD	=	Standard deviation of 645 mercury content values
Mean	=	Arithmetic mean of 645 mercury content values

The RSD calculated in this manner is 0.70.

Option 2: IMV Factor Based on RSD of Mine Averages from MACT Floor Sources

Mercury limits in the Brick MACT were established based on the RSD between plant average mercury content.[8] Following this methodology for byproduct recovery coke plants is best achieved by calculating the RSD as follows:

$$RSD = \frac{SD_{AVG}}{Mean_{AVG}}$$

Where:

RSD	=	Relative standard deviation
SD_{AVG}	=	Standard deviation of average mercury content of 65 mines
$Mean_{AVG}$	=	Arithmetic mean of average mercury content of 65 mines

The RSD calculated in this manner is 0.72.

Conclusion

Mercury emissions from Battery Stacks and PECs at byproduct recovery coke plants are directly related to the mercury content of the raw materials (metallurgical coals) required to produce quality coke. EPA's established methodology for incorporating an IQV into MACT standards for other industries should be applied to the proposed mercury limits for coke Battery Stacks and PECs.

Using the specific statistical precedents set in the final Brick and proposed Lime MACT rulemakings, Trinity has presented two options above for calculating an RSD which could be added to UPL calculations to account for intra-mine variability (IMV) in mercury concentrations. Accounting for this variability is essential to ensure that the MACT floor coke plants can continuously comply with the established emission limits over time, because the mercury content varies in the raw materials (metallurgical coals) they must use to produce quality coke.

In conclusion, EPA should (1) adjust the Hg MACT floor source category data to account for the fact that the AKS-Middletown-OH facility has ceased operations; and (2) follow the precedent in the Brick MACT of choosing the higher RSD of the evaluated options (0.72) and incorporate this RSD into an IMV factor and UPL calculations to establish the final Hg MACT floor limits for Battery Stacks and PECs.

[8] EPA-HQ-OAR-2013-0291-0660, Appendix E.