MEMORANDUM

SUBJECT: Final Revised Technology Review of Acid Gas Controls for Indurating Furnaces in the Taconite Iron Ore Processing Source Category

DATE: September 27, 2023

FROM: David Putney, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina

TO: Docket ID No. EPA-HQ-OAR-2017-0664

1.0 INTRODUCTION

On May 15, 2023, the U.S. Environmental Protection Agency (EPA) proposed amendments to the National Emission Standards for Hazardous Air Pollutants (NESHAP) for Taconite Iron Ore Processing that would revise the existing standards for hydrogen chloride (HCl) and hydrogen fluoride (HF) emissions from indurating furnaces (88 FR 30917). The EPA received several comments during the public comment period that resulted in changes to the proposed HCl emission limit and the estimated costs. This memorandum provides the results of the final technology review.

2.0 BACKGROUND

The EPA promulgated the NESHAP for the Taconite Iron Ore Processing source category on October 30, 2003 (see 68 FR 61868). The NESHAP included Maximum Achievable Control Technology (MACT) standards for emissions of filterable particulate matter (PM) as surrogates for hazardous air pollutant (HAP) metals, as well as HCl and HF, that are in particulate form. The NESHAP also set work practice standards for controlling fugitive dust emissions and organic HAP emissions. The regulated emission sources are ore crushing and handling operations, ore dryers, pellet indurating furnaces, and finished pellet handling operations at a taconite iron ore processing plant that is, or is part of, a major source of HAP emissions.[1]

In 2020, the EPA completed the first technology review required under Clean Air Act (CAA) section 112(d)(6) and published a decision on the technology review in July 2020.[2] CAA section 112(d)(6) requires the EPA to review NESHAP standards once every 8 years and to "…review and revise as necessary (taking into account developments in practices, processes, and control technologies) …" those standards. The EPA considers a "development" to include:

- Add-on control technology that was not identified during the development of the current NESHAP for the source category,
- Improvement to an existing add-on control technology that could result in significant additional HAP emissions reductions,
- Work practice or operational procedure that was not identified during development of the current NESHAP for the source category, or

[1] Major sources of hazardous air pollutants (HAPs) are facilities that emit at least 10 tons per year of any single HAP or 25 tons per year of a combination of HAPs.
[2] 85 FR 45476, July 28, 2020.

- Applicable process change or pollution prevention alternative that was not identified and considered during the development of the current NESHAP for the source category.

For the 2020 technology review, the EPA researched practices, processes, and control technologies to identify any new developments for indurating furnaces and the other emissions sources at taconite iron ore processing plants. The EPA conducted literature reviews, visited taconite iron ore processing plants, and held meetings with industry representatives. To identify developments in air pollution control technologies, the EPA reviewed construction and operating permits and state regulations such as Air Quality Implementation Plans for Minnesota and Michigan, the Regional Haze State Implementation Plan (78 FR 59825, 09/30/13), and the Federal Implementation Plan for Regional Haze (78 FR 8705, 02/06/13). The sources reviewed and results are described in more detail in the memorandum *Final Technology Review for the Taconite Iron Ore Processing Source Category*.[3]

3.0 TECHNOLOGY REVIEW FOR HCL AND HF

In the 2020 technology review, the EPA found no new developments in practices, processes, or control technologies for HCl and HF emissions from indurating furnaces based on the information available at the time the review was conducted. However, the EPA collected new data in 2022 that suggest further reductions in HCl and HF emissions can be achieved.

As part of the 2022 CAA section 114 information request (2022 IR), the EPA collected new HCl and HF emissions data for 7 indurating furnaces. EPA Method 26A was used to measure emissions with three test runs completed for each stack test. The only exception was UTAC, where two sets of three stack test runs were conducted: emissions in runs 1 through 3 were measured when the furnace was burning a mixture of natural gas and coal and runs 4 through 6 were measured when the furnace was burning only natural gas. During the public comment period, the EPA received comments from industry stating that the units of measure reported for the emission factors in the stack test report submitted by the Tilden plant were incorrectly reported as "pounds per ton of taconite pellets produced," whereas the correct units of measure were "pounds per long ton of taconite pellets produced." In addition to correcting the emissions data for Tilden, the EPA reviewed the HCl and HF emissions data for the other facilities and identified and corrected one error in the HCl emissions for stack test run 3 at the Hibbing Line 1 indurating furnace, where the HCl emissions were incorrectly calculated to be 4.89×10^{-3} pounds per long ton of pellets produced (lb/LT) rather than the correct emissions rate of 6.73×10^{-3} lb/LT. Table 3-1 shows the corrected emissions data for each test run in pounds per long ton of pellets produced.

As noted above, the NESHAP for taconite iron ore processing currently includes PM limits used as a surrogate for HCl and HF emissions that are in particulate form. All indurating furnaces were in compliance with the existing PM emission standards during the stack tests. Six of the indurating furnaces tested were equipped with wet venturi scrubbers, whereas one indurating furnace tested (i.e., EUKILN1 located at the Tilden plant in Michigan) was equipped with dry electrostatic precipitators (ESP). The new emissions data indicate that the indurating furnaces using wet scrubbers to meet the PM NESHAP standards achieved lower acid gas emissions than the indurating furnace using dry ESP. Under CAA section 112(d)(6), new developments that can further reduce HAP emissions must be reviewed to determine whether revisions to the existing standards are warranted. The EPA is finalizing as proposed the determination that the new emissions data represent a "development" under CAA section 112(d)(6) because the data show further reductions in acid gas emissions is achievable. After considering the costs, we are finalizing revised emission standards for HCl and HF. In Section 4.0, we describe how we

[3] Putney, D., *Final Technology Review for the Taconite Iron Ore Processing Source Category*, January 3, 2020 (Docket ID. EPA-HQ-OAR-2017-0664-0164).

developed numerical HCl and HF limits for new and existing indurating furnaces. Section 5.0 evaluates the capital and annual costs required to meet the final standards.

Table 3-1 – HCl and HF Emissions Data

		HAP Emissions (lb/LT)						
Facility Name		**Hibbing**	**Minorca**	**Tilden**	**UTAC**	**Keetac**	**Minntac**	
Furnace ID		**Line 1**	**EU026**	**EUKILN1**	**Line 2**	**EU030**	**Line 5**	**Line 7**
HCl	1	5.39E-03	7.01E-03	1.71E-01	4.80E-03	1.33E-04	1.47E-03	1.49E-03
	2	6.63E-03	1.62E-02	1.98E-01	5.53E-03	1.05E-04	1.60E-03	1.69E-03
	3	6.73E-03	2.40E-02	1.99E-01	7.06E-03	1.26E-04	1.16E-03	1.17E-03
	4				1.37E-03			
	5				1.70E-03			
	6				2.01E-03			
	Average	**6.25E-03**	**1.57E-02**	**1.89E-01**	**3.75E-03**	**1.21E-04**	**1.41E-03**	**1.45E-03**
HF	1	1.08E-02	3.32E-03	7.27E-03	1.16E-04	4.90E-05	4.76E-05	5.03E-03
	2	1.27E-02	4.95E-03	1.05E-02	2.59E-04	5.36E-05	4.73E-05	4.71E-03
	3	1.23E-02	6.26E-03	1.25E-02	3.12E-04	5.10E-05	4.79E-05	2.91E-03
	4				5.63E-05			
	5				5.51E-05			
	6				5.57E-05			
	Average	**1.19E-02**	**4.84E-03**	**1.01E-02**	**1.42E-04**	**5.12E-05**	**4.76E-05**	**4.22E-03**

4.0 DEVELOPMENT OF REVISED EMISSION STANADARDS

This section provides a detailed description of how we developed the final revised standards for new and existing indurating furnaces. We used the HCl and HF emissions and production data from the 2022 IR stack testing discussed in Section 3.0 to develop the limits in units of pounds per long ton of pellets produced (lb/LT). The final revised limits are summarized in Section 4.3.

4.1 DEVELOPMENT OF FINAL REVISED STANDARDS FOR EXISTING INDURATING FURNACES

To develop the final limits for existing indurating furnaces, we used the emissions data from the six indurating furnaces currently using wet scrubbers to calculate an upper prediction limit (UPL). We used the UPL approach because it accounts for the variability of the performance during testing conditions. The UPL represents the value which one can expect the mean of a specified number of future observations (e.g., 3-run average) to fall below at a specified level of confidence based upon the results of an independent sample from the same population. We used a 99 percent level of confidence to calculate the UPL, which means that a facility that uses the same or similar type of air pollution control device(s) has one chance in 100 of exceeding the emission limit. A prediction interval for a single future observation (or an average of several test observations) is an interval that will, with a specified degree of confidence, contain the next (or the average of some other pre-specified number of) randomly selected observation(s) from a population. In other words, the UPL estimates what the upper bound of future values will be based upon present or past background samples taken. The UPL approach encompasses all the data point-to-data point variability. The predictions derive from the dataset to which it is applied, and, thus, can be applied to any type of data.

To calculate the UPL, we must first determine the type of distribution for the dataset because there are different equations for calculating the UPL based on the distribution of the dataset. Data can be normally distributed, lognormally distributed, or neither and thus have a skewed distribution. The skewness and kurtosis statistics were used to determine the distribution of the dataset.

The *skewness statistic* (S) characterizes the degree of asymmetry of a given data distribution. Normally distributed data have an S value of zero. An S value that is greater than zero indicates that the data are asymmetrically distributed with a right tail extending towards positive values; similarly, an S value that is less than zero indicates that the data are asymmetrically distributed with a left tail extending towards negative values. The value of S can be approximated using the following equation (which is implemented in Microsoft Excel® using the "SKEW" function):

$$\boldsymbol{S = \frac{n}{(n-1)(n-2)} \sum_{i=1}^{n} \left(\frac{x_i - \bar{x}}{stdev}\right)^3}$$

Where: n = sample size
$\bar{x}$ = mean of MACT floor pool
x_i = individual source mean

stdev = $\sqrt{\sum \frac{(x_i - \bar{x})^2}{(n-1)}}$

As part of determining whether a data distribution can be considered normal, the S value must be compared to the *standard error of the skewness statistic* (SES). The SES value can be approximated using the following equation:

$$SES = \sqrt{\frac{(6 \times n)(n-1)}{(n-2)(n+1)(n+3)}}$$

According to the skewness hypothesis test, if the absolute value of S is less than two times the absolute value of SES, the skewness of the data can be considered normal.

The *kurtosis statistic* (K) characterizes the degree of peakedness or flatness of a given data distribution in comparison to a normal distribution. Normally distributed data have a K value of zero. A K value that is greater than zero indicates a relatively peaked distribution. A K value that is less than zero indicates a relatively flat distribution. The estimate of K can be calculated one of two ways. For datasets with more than three run values, kurtosis can be estimated using the following equation (which is implemented in Microsoft Excel® using the "KURT" function):

$$Kurtosis = \left\{ \frac{n(n+1)}{(n-1)(n-2)(n-3)} \sum \left(\frac{x - \bar{x}}{stdev}\right)^4 \right\} - \frac{3(n-1)^2}{(n-2)(n-3)}$$

As part of determining whether a data distribution can be considered normal, the K value must be compared to the *standard error of the kurtosis statistic* (SEK). The SEK value can be approximated using the following equation:

$$SEK = \sqrt{\frac{(24n(n^2-1))}{(n-2)(n+3)(n-3)(n+5)}}$$ for datasets with more than three runs (n > 3)

$$SEK = \sqrt{\frac{24}{n}}$$ for datasets with three runs (n = 3)

According to the kurtosis hypothesis test, if the absolute value of K is less than two times the absolute value of SEK, the kurtosis of the data can be considered normal. If the results from both the skewness and kurtosis hypothesis tests indicate a dataset is normally distributed, the dataset is treated as normally distributed in subsequent UPL calculations. If either of these tests indicates a dataset is not normally distributed, the dataset is log-transformed, and the log-transformed dataset is evaluated for kurtosis and skewness. If both tests of the log-transformed data indicate a log-transformed dataset is normally distributed, then the dataset is treated as lognormally distributed in subsequent UPL calculations. If either of these tests indicate the raw data is normally distributed and the log-transformed dataset is normally distributed, the skewness/SES values from the raw data are compared to the skewness/SES values from log-transformed data. The smaller skewness/SES value is selected as an indication of a larger likelihood of the data to come from the corresponding distribution. If either of these tests indicate the log-transformed dataset was not normally distributed, the dataset is treated as skewed distribution in subsequent UPL calculations. The HCl emissions data have a log-normal distribution, while the HF emissions data have skewed distribution.

The UPL for HCl was calculated using the UPL equation for log-normal datasets:

$$UPL = e^{\hat{\mu}+\frac{\hat{\sigma}^2}{2}} + \frac{z_{0.99}}{m}\sqrt{me^{2\hat{\mu}+\hat{\sigma}^2}\left(e^{\hat{\sigma}^2}-1\right)+m^2e^{2\hat{\mu}+\hat{\sigma}^2}\left(\frac{\hat{\sigma}^2}{n}+\frac{\hat{\sigma}^4}{2(n-1)}\right)}$$

Where: $\hat{\mu}$ = $\frac{\sum_{i=1}^{n} log(y_i)}{n}$ = the average of the log transformed data from the dataset

$\hat{\sigma}^2$ = $\frac{\sum_{i=1}^{n}(log(y_i)-\hat{\mu})^2}{n-1}$ = variance estimate of the log transformed data

m = number of future test runs in the compliance average

e = base of the natural logarithm (i.e., 2.71828)

$Z_{0.99}$ = the 99th-percentile of the log-normal distribution estimated using the trapezoidal rule approach from the following equation:

$$\int_0^{z_{0.99}}\left(1-\frac{\sqrt{\beta_{1z}}}{6}\left(3z-z^3\right)+\frac{(\beta_{2z}-3)(3-6z^2+z^4)}{24}\right)\phi(z) = 0.99$$

The UPL for HF was calculated using the equation for skewed datasets:

$$UPL = \bar{x} + t_{df,p}\sqrt{s^2\left(\frac{1}{n}+\frac{1}{m}\right)}$$

Where: $\bar{x}$ = mean of the data calculated as $\bar{x} = \frac{1}{n}\sum_{i=1}^{N}\sum_{j=1}^{n_i} x_{ij}$

n = number of test runs = $\sum_{i=1}^{N} n_i$

m = number of future test runs in the compliance average

N = number of sources

s^2 = pooled variance calculated as $s^2 = \frac{1}{n}\sum_{i=1}^{n}\left(x_i - \bar{x}\right)^2$

$t_{df,p}$ = recalculated quantile of t-distribution based on specified level of confidence (i.e., 99 percent)

df = degrees of freedom calculated as $df = \left(\sum_{i=1}^{N} n_i\right) - 1$

The average emissions, variance, and UPLs for HCl and HF for existing furnaces are summarized in Table 4-1. The average emissions, variance, and UPL changed from those in the proposal due to the corrections to the HCl emissions data discussed in Section 3.0. The corrections resulted in a corrected UPL for HCl of 4.6 x 10^{-2} lbs/LT, which is slightly higher than the UPL for HCl calculated at proposed (i.e., 4.4 x 10^{-2} lbs/LT).

Table 4-1. Dataset Characteristics and UPLs for HCl and HF for Existing Indurating Furnaces

HAP	No. of Sources Using Wet Scrubbers	No. Data Points in Data Set (n)	Average of Top Sources	Variance of Top Sources	UPL (lb/LT)	Data Set Distribution
HCl	6	21	4.62E-03	3.39E-05	4.6E-02	Log-normal
HF	6	21	3.05E-03	1.82E-05	1.2E-02	Skewed

The results of the UPL calculation were compared to 3 times the representative detection limit (3xRDL). At very low emissions levels, the inherent imprecision in the pollutant measurement method has a large influence on the reliability of the data underlying emission limit. Method detection limits normally vary from test to test due to matrix effects, laboratory techniques, sample volume, and other factors. For datasets with test results below the method detection limit (reported as method detection limit values), the data distribution becomes truncated on the lower end, leading to an artificial overabundance of values occurring at the method detection limit. Limits based on a truncated dataset (i.e., calculated using values at or near the method detection limit) may not account adequately for data measurement variability, because the measurement error associated with those values provides a large degree of uncertainty. The expected measurement imprecision for an emissions value occurring at or near the detection limit is about 40 to 50 percent. Relative pollutant measurement imprecision decreases to a consistent 10 to 15 percent for values measured at a level about three times the method detection limit. For this reason, the EPA accounts for measurement variability by defining a detection limit that is representative of the data used to calculate the limit and minimizes the influence of outliers.

The EPA developed RDL values from the available HCl and HF method detection levels. The pollutant specific RDL values were then multiplied by three to decrease measurement imprecision to around 10 to 15 percent. Each resultant 3xRDL value was compared to the corresponding UPL. If the UPL is greater than 3xRDL, then the UPL represents an acceptable limit. If the UPL is less than 3xRDL, then the 3xRDL is selected as the limit. The 3xRDL values for HCl are provided in the memorandum *Data and Procedure for Handling Below Detection Level Data in Analyzing Various Pollutant Emissions*

Databases for MACT and RTR Emissions Limits.[4] For HF, the 3xRDL values are provided in the memorandum *Representative Detection Limit (RDL) for Hydrogen Fluoride for Taconite Iron Ore*.[5] Table 4-2 shows the 3xRDL concentration values for HCl and HF for typical sample volumes. The sample volume for the HCl and HF emissions data collected in 2022 was 2 dscm.

Table 4-2. 3xRDL for HCl and HF

HAP	3xRDL Mass (µg)	3xRDL Concentrations by Various Sample Volume				Units of 3xRDL
		1 dscm	2 dscm	3 dscm	4 dscm	
HCl	1.8E+02	1.8E+02	9.0E+01	6.0E+01	4.5E+01	µg/dscm
HF	1.5E-01	1.5E-01	7.3E-02	4.9E-02	--	µg/dscm

µg = micrograms
dscm = dry standard cubic meter

To compare the calculated UPL to the 3xRDL, the 3xRDL for a 2 dscm sample volume was converted to the same units as the UPL using a ratio of the emission data in lb/LT of pellets produced to the emission data in µg/dscm. Table 4-3 shows the converted 3xRDL values for HCl and HF after making the corrections to underlying emissions data for HCl and HF discussed in Section 3.0.

Table 4-3. 3xRDL for HCl and HF in Units of µg/dscm and lb/LT for a Sample Volume of 2 dscm

HAP	Average Ratio $\left[\frac{\left(\frac{lb\ HAP}{LT}\right)}{\left(\frac{\mu g\ HAP}{dscm}\right)}\right]$	3xRDL at 2 dscm Sample Volume (µg/dscm)	Converted 3xRDL Value (lb HAP/LT)
HCl	4.85E-03	9.0E+01	4.4E-04
HF	4.55E-03	7.3E-02	3.3E-04

We compared the converted 3xRDL values to the calculated UPLs and found the calculated UPL values were greater than the 3xRDL values for HCl and HF. The calculated UPL values were selected as the final revised emission limits for HCl and HF. Table 4-4 summarizes the results of the comparison of the UPL and 3xRDL values to determine the final revised MACT standards for HCl and HF emissions from existing indurating furnaces.

Table 4-4. Final Revised HCl and HF Limits for Existing Indurating Furnaces

HAP	Converted 3xRDL Value	Revised UPL	Final Limit	MACT Limit Based On	Units of Measure
HCl	4.4E-04	4.6E-02	4.6E-02	UPL	lb/LT
HF	3.3E-04	1.2E-02	1.2E-02	UPL	lb/LT

[4] Westlin, P., and R. Merrill. *Data and Procedure for Handling Below Detection Level Data in Analyzing Various Pollutant Emissions Databases for MACT and RTR Emissions Limits,* Environmental Protection Agency, Office of Air Quality Planning and Standards, Research Triangle Park, North Carolina, 2011 (available in Docket No. EPA-HQ-OAR-2017-0664).
[5] Bivens, R., *Representative Detection Limit (RDL) for Hydrogen Fluoride for Taconite Iron Ore,* February 16, 2023 (available in the Docket ID. EPA-HQ-OAR-2017-0664).

4.2 DEVELOPMENT OF FINAL REVISED STANDARDS FOR NEW INDURATING FURNACES

The EPA used the same general approach as the one utilized for existing indurating furnaces to develop final revised emission standards for new indurating furnaces. However, for new furnaces the EPA used only the emissions data for the best performing indurating furnace. Based on the average emissions, furnace EU030 at the Keetac plant in Keewatin, MN is the best performing furnace for HCl emissions and is equipped with two wet venturi scrubbers. This furnace has average HCl emissions of 1.21 x 10^{-4} lb/LT. For HF, the Line 5 furnace at Minntac in Mountain Iron, MN is the best performing furnace with average HF emissions of 4.76 x 10^{-5} lb/LT.

The EPA evaluated the distribution of the HCl and HF datasets for the best performing furnaces using the methods outlined in Section 4.1 and determined that both datasets have normal distributions. The UPLs for HCl and HF were calculated using the following UPL equation for datasets that have normal distribution:

$$UPL = \bar{x} + t_{df,0.99}\sqrt{s^2\left(\frac{1}{n}+\frac{1}{m}\right)}$$

Where: $\bar{x}$ = mean of the data calculated as $\bar{x} = \frac{1}{n}\sum_{i=1}^{N}\sum_{j=1}^{n_i} x_{ij}$

n = number of test runs = $\sum_{i=1}^{N} n_i$

m = number of future test runs in the compliance average

N = number of sources

s^2 = pooled variance calculated as $s^2 = \frac{1}{n}\sum_{i=1}^{n}(x_i - \bar{x})^2$

$t_{df,0.99}$ = quantile of t-distribution at the 99 percent level of confidence with degrees of freedom (df); this value can be calculated with the Student's t-test statistical method, using the "TINV" function in Microsoft Excel® software

df = degrees of freedom calculated as $df = \left(\sum_{i=1}^{N} n_i\right) - 1$

The UPLs for HCl and HF for new indurating furnaces are summarized in Table 4-5.

Table 4-5. Dataset Characteristics and UPLs for HCl and HF for New Indurating Furnaces

HAP	No. of Sources Using Wet Scrubbers	No. Data Points in Data Set (n)	Average Emissions	Variance	UPL (lb/LT)	Data Set Distribution
HCl	1	3	1.21E-04	2.12E-10	2.04E-04	Normal
HF	1	3	4.76E-05	9.00E-14	4.93E-05	Normal

The results of the UPL calculations for new furnaces were compared to the corresponding 3xRDL value provided in Table 4-3. We found the 3xRDL values were greater than the calculated UPLs. Since limited datasets (i.e., datasets with less than 7 data points) were used to develop the UPLs for HCl and HF for new furnaces, the EPA followed the steps outlined in the memorandum *Approach for Applying the*

Upper Prediction Limit to Limited Datasets[6] to determine whether the selected data distribution best represented the dataset and whether the individual runs in the limited dataset reasonably represented the performance of the furnaces. We determined that the 3xRDL values for HCl and HF are representative and that no changes to the calculation procedures were warranted. Therefore, the 3xRDL values for HCl and HF were selected as the final revised limits for new indurating furnaces. Table 4-6 summarizes the results of the comparison of the UPL and 3xRDL values for new indurating furnaces.

Table 4-6. Final Revised HCl and HF Limits for New Indurating Furnaces

HAP	Converted 3xRDL Value	UPL	Final Limit	MACT Limit Based On	Units of Measure
HCl	4.4E-04	2.04E-04	4.4E-04	3xRDL	lb/LT
HF	3.3E-04	4.93E-05	3.3E-04	3xRDL	lb/LT

4.3 SUMMARY OF FINAL REVISED STANDARDS

Using the methodology described in Sections 4.1 and 4.2, the final revised HCl and HF emission standards for new and existing indurating furnaces are summarized in Table 4-7.

Table 4-7. Final HCl and HF Standards for New and Existing Indurating Furnaces

Source	HAP	Final Emission Standard (lb/LT)	Final Limit Based On
Existing Indurating Furnaces	HCl	4.6E-02	UPL
	HF	1.2E-02	UPL
New Indurating Furnaces	HCl	4.4E-04	3xRDL
	HF	3.3E-04	3xRDL

5.0 ESTIMATED COMPLIANCE COSTS

Based on the HCl and HF emissions data collected in 2022, we expect that the two indurating furnaces located at the Tilden facility will need to add controls to meet the final revised standard for HCl. However, we expect that all existing indurating furnaces are able to comply with the final revised standard for HF without adding new air pollution controls.

5.1 ESTIMATED CAPITAL AND ANNUAL COSTS

Based on the emissions data for Tilden's EUKILN1, we determined that a 76 percent control efficiency is required to meet the final HCl emission standard. We have emissions data for only one of Tilden's two indurating furnaces. However, both furnaces are grate kilns with the same maximum production capacity and the same number of stacks, both furnaces currently use dry ESPs to meet the PM emission standards, and operating data indicate that the hourly taconite pellet production is approximately the same for both furnaces. Based on this information, the HCl and HF emissions rates are likely similar. Therefore, we expect both furnaces will need to achieve 76 percent reduction in HCl emissions to meet the final revised emission standard for HCl.

[6] Putney, D., *Approach for Applying the Upper Prediction Limit to Limited Datasets,* Memorandum from David Putney, EPA/OAQPS/SPPD to the docket, February 2023 (available in Docket No. EPA-HQ-OAR-2017-0664).

We next evaluated air pollution control devices to determine what types of controls could achieve this level of reduction. We estimated that the Tilden facility could achieve a 76 percent reduction in HCl emissions by either (1) replacing the dry ESPs with wet scrubbers, or (2) adding dry sorbent injection (DSI) to the existing dry ESP controls. We used the emissions data and stack parameters for Tilden’s EUKILN1 furnace to calculate capital and annual costs for adding these two types of controls to the existing control devices. Based on the capital and total annual costs, we determined that DSI with the existing dry ESP provided the lowest cost option. Table 5-1 provides a summary of the estimated costs, emissions reductions, and cost effectiveness of using DSI with the existing dry ESP. The estimated capital costs for installing the add-on controls necessary to meet the final HCl limit is $1,070,207, and the annual costs are estimated to be $1,393,226. We estimate that HCl emissions will be reduced by 683 tons per year. The estimated cost effectiveness is $2,040 per ton of HCl reduced. The results of the cost analyses indicate that the estimated cost effectiveness is within the range the EPA has previously considered to be a cost-effective level of control for many HAP.

In addition to reducing HCl emissions, we estimate HF and SO_2 emissions will be reduced by 36 tons per year and 32 tons per year, respectively. The detailed calculations of the DSI costs are provided in Appendix A.

Table 5-1. Estimated Emissions Reductions and Control Costs to Comply with Final Revised HCl Emission Standard

HAP	Emissions Reductions (tons/year)	Total Capital Investment ($)	Total Annual Costs ($/year)	Cost Effectiveness ($/ton)
HCl	683	1,070,207	1,393,226	2,040

APPENDIX A
Final Cost Calculations for Dry Sorbent Injection

Total Capital and Annual Costs for Indurating Furnaces EUKILN1 and EUKILN2

Total Capital Investment, 2023$ (TCI)	$1,070,207
Total Annual Cost	$1,393,226

Costs Per Furnace (2023$)*	North Stack	South Stack	Totals
Total Capital Investment (TCI)	$217,573	$317,530	$535,104
Total Annual Cost	$248,761	$447,852	$696,613

*Assumes natural gas is used as fuel and that no finishing baghouses would be needed as furnaces currently use dry ESP.

Both indurating furnaces are grate kilns having a maximum operating capacity of 600 Long tons of finished pellets per hour. The kilns process hematite ore and produce flux pellets. The furnaces burn natural gas as primary fuel. Both furnaces can burn coal, natural gas and fuel oil. However, in their 2022 IR, Tilden indicated that they have not used oil for several years.

Operating and Emissions data from 2022 Stack Test Report.

South Stack

Run	Actual Flow Rate (acfm)	% Moisture	Temperature (deg. F)	Flow (dscfm)	HCl Emission Rate (lb/hour)	HF Emission Rate (lb/hour)
1	792,364	13.74	277	462,342	69.3	3.29
2	784,191	13.99	275	457,857	73.5	4.75
3	814,926	14.32	273	475,024	76.7	5.65
Average	797,160	14.02	275	465,074	73.2	4.56

North Stack

Run	Actual Flow Rate (acfm)	% Moisture	Temperature (deg. F)	Flow (dscfm)	HCl Emission Rate (lb/hour)	HF Emission Rate (lb/hour)
1	426,939	9.7	310.08	249,652	27.3	0.817
2	425,837	10.2	306.54	248,689	39.9	1.28
3	418,966	10.4	305.42	244,679	35.6	1.4
Average	423,914	10.1	307	247,673	34.3	1.17

Estimated Total Capital Cost and Total Annual Cost per Furnace

Parameter	North Stack	South Stack	Source/Reference
Annual Operating Hours, hr/yr (H)	8,400	8,400	Assumed operating hours
Exhaust Gas Flow Rate, acfm (Qa)	423,914	797,160	From Tilden - 2022 stack test report
Exhaust Gas Flow Rate, scfm (Q)	266,651	500,698	From Tilden - 2022 stack test report
HCl Emissions at Inlet (lbs/hour)	34	73	From Tilden - 2022 stack test report
HF Emissions at Inlet (lbs/hour)	1.2	4.6	From Tilden - 2022 stack test report
Operating Labor Rate, $/hr (LR)	$31.53	$31.53	Mean hourly wage, from Bureau of Labor Statistics, May 2023, Goods-producing Industries (https://www.bls.gov/news.release/ecec.t05.htm)
Sorbent Cost, $/lb	$0.08	$0.08	Cost of hydrated lime is $145/ton (2021$) from USGS data published January 2023, see https://www.usgs.gov/centers/national-minerals-information-center/lime-statistics-and-information). Scaled to 2023$ using GDP Cost Escalation Factors published by Bureau of Economic Analysis.
Dust Disposal Cost, $/Ton	$35	$35	Disposal cost for waste collected by the ESP. Source: *Best Available Mercury Reduction Technology Analysis and Proposed Alternative Mercury Emission Reduction Plan* for Keetac $29/ton (in 2018$). Scaled to 2022$ using GDP Cost Escalation Factors published by Bureau of Economic Analysis.
Electricity Cost, $/kWh	$0.0775	$0.0775	Average electricity price for industrial customer is $0.0775/kWh. See EIA average price of electricity to industrial customers in May 2023. Available at https://www.eia.gov/electricity/data/browser/.
Capital Recovery Factor (CRF)	0.1057	0.1057	CRF calculated assuming 20-year equipment life and 8.5% interest. Current bank prime rate as of July 2023.
Sorbent Adjustment Factor (AF)	75.7%	75.7%	Estimated required control efficiency

Parameter	North Stack	South Stack	Source/Reference
Sorbent (S) (lb/hr)	91	215	NSR x [(1.015lb. sorbent/lb HCl x HCL Emissions) + (1.85lb. sorbent/lb HF x HF Emissions)] x (AF/0.80), where NSR = 2.6 (see "Effective Removal of HCl and SO2 with Dry Injection of Sodium Bicarbonate or Trona" by Young Kong and Jean-Pascal Balland in Proceedings of the 19th Annual North American Waste-to-Energy Conference, Lancaster, PA, May 16-18, 2011.
Annual sorbent usage assuming 8760 hours/year(lb/year)	763,347	1,806,306	8400 x S
Total Capital Investment, $ (TCI)	**$217,573**	**$317,530**	Calculated using algorithm 4,500 x (Q/1,976)^0.6 x (1.2 retrofit factor) x CEPCI Adj. x (1.1 contingency factor). Taken from https://www.regulations.gov/document/EPA-HQ-OAR-2002-0083-1095. Appendix E page E-3; pdf page 66
Direct Annual Cost, $/yr (DAC)	$185,247	$350,064	
Operating Labor	$8,277	$8,277	Calculated using (0.25 hr/8-hr shift) x H x LR
Supervisory Labor	$1,241	$1,241	Calculated using 0.15 x Operating Labor
Maintenance	$43,515	$63,506	Calculated using 0.2 x TCI
Sorbent	$61,188	$144,789	
Dust Disposal	$13,187	$31,203	Calculated using sorbent injection rate, capture efficiency, and disposal cost
Electricity	$57,840	$108,766	Estimated using fan cost equation 2.10 from EPA Air Pollution Control Cost Manual, Section 1, Chapter 2, Cost Estimation: Concepts and Methodology. Assumed flow rate injection is 25% of stack flow. Pressure drop assumed to be 5 inches of water. Fan efficiency assumed 70%. Specific gravity = 1.
Indirect Annual Cost, $/yr (IAC)			
Overhead	$31,820	$43,815	Calculated using 0.6 x (Labor + Maintenance)
Property Tax, Insurance, & Admin	$8,703	$12,701	Calculated using 0.04 x TCI
Capital Recovery	$22,991	$33,554	Calculated using CRF x TCI
Total Annual Cost	**$248,761**	**$447,852**	Sum of DAC + IAC

Cost Escalation Factors

Year	GDP	Esc factor 2021/Year X
2018	110.339	1.191355731
2021	118.895	1.105622608
2022	127.224	1.033240584
2023	131.453	1

Source: Bureau of Economic Analysis, Table 1.1.9. Implicit Price Deflators for Gross Domestic Product, accessed at BEA Interactive Data Application, August 2023.