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ESTABLISHING AVERAGING TIMES FOR METAL EMISSIONS FROM HAZARDOUS WASTE COMBUSTION FACILITIES

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ESTABLISHING AVERAGING TIMES FOR METAL EMISSIONS FROM HAZARDOUS WASTE COMBUSTION FACILITIES

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EXECUTIVE SUMMARY

EPA is developing standards for metal emissions from hazardous waste combustion facilities as part of the Maximum Achievable Control Technology (MACT) standard setting process under the Clean Air Act (CAA). EPA may offer continuous monitoring of metals as an alternative to metals feed analysis to ensure ongoing compliance with metals emissions limits. To be successful, a metals monitoring and compliance strategy must have the following attributes: 1) be protective of public health and the environment, 2) be readily enforceable, 3) be technologically feasible, and 4) be cost effective. To ensure compliance with emission limits, permits will specify sampling frequency and will also need to specify the time interval over which metal emissions or metals feed analyses are averaged and reported ("averaging time"). There is a need to determine the scientific basis for selecting averaging times, so the most useful data will be collected using the most appropriate technology. There are no statutory or regulatory prescriptions for establishing sampling frequencies or averaging times; historically, a variety of averaging times up to one year have been used to enforce MACT-based standards for other processes.

This paper develops a scientific rationale for selecting averaging times for monitoring metal emissions from hazardous waste combustion facilities that are protective of federal health criteria. The potential for adverse health effects from chronic exposures, the main concern for metal emissions, are being addressed by EPA regardless of what averaging time is used. This is done through the standard setting process and through requirements for multipathway health risk assessments that are based on a long-term average exposure. Therefore, this paper will be limited to developing the appropriate averaging times to protect against acute exposures, which might result in adverse health effects. The paper answers the question: " Over what time interval should continuous emissions data be averaged and reported to ensure that no adverse health effects will result from unusually high spikes that might occur during the averaging period.

To determine the appropriate averaging time, emissions data from three operating combustion units are analyzed -- one hazardous waste incinerator and two cement kilns -- relating their modeled maximum ground-level concentrations of specific metals to acceptable acute exposure criteria. Acute Scaling Factors (ASFs) for several metals are developed for each facility; the ASFs represent the multiple of the trial burn emission rate necessary to reach acute exposure concentrations at the point of highest off-site concentration with the potential for adverse health effects. The ASFs calculated for these facilities indicate that emissions would have to be 100,000 to 100 million times higher than measured emission rates to create acute exposures with the potential for adverse health effects. Depending on the metal and the type of facility, it would take between 10 and 10,000 years' of emissions, emitting at the trial burn emission rate, in a 30-minute period to create ground-level concentrations that have the potential for adverse health effects. Based on these ASFs, it is not likely that a hazardous waste combustion facility could generate a short-term peak high enough to cause acute exposures with consequent adverse effects. This is consistent with the fact that acute exposures to metal emissions are not normally considered a significant concern.

Long averaging times, on the order of months rather than days or hours, are recommended for metal emission standards for facilities combusting hazardous waste. It is believed that these example facilities are not particularly unique or unusual, and are generally representative of other combustion facilities burning hazardous waste, but it is recommended that facility-specific risks be considered when setting averaging times. It is concluded that longer averaging times contribute to a successful monitoring strategy, because they are generally protective of public health, technologically achievable, cost effective, consistent with the enabling statutes, and readily enforceable.

INTRODUCTION

The U.S. Environmental Protection Agency (EPA) is developing standards for metal emissions from hazardous waste combustion facilities using the Maximum Achievable Control Technology (MACT) approach under Section 112 of the Clean Air Act (CAA). These standards must also meet the Resource Conservation and Recovery Act (RCRA) requirements to protect human health and the environment.

One of the ways the EPA can enforce emission standards is by requiring periodic monitoring of emissions, tied to waste feed and operating controls. Another way is through continuous monitoring of emissions,[1] with less stringent or no requirements for analysis of metals in the waste feed. Continuous emissions monitoring (CEM) is the most sophisticated and complete way to verify compliance with emissions limits. A continuous sampling device with periodic analysis for metals in the laboratory has been used successfully by 3M Corporation on a hazardous waste incinerator in St. Paul, Minnesota. The technology for real-time analysis of metals is still under development and is not yet commercially available. With either the real time or continuous emissions sampling approach, both the sampling frequency and the time interval used to average metal emissions to verify compliance must be specified. These time intervals are referred to as "averaging times." [2] For cost effectiveness and simplicity, averaging times should be set at the maximum time interval that provides the information required to protect against adverse acute exposures.

Participants at the 1993 Workshop on Continuous Performance Assurance for Metals Emissions from Hazardous Waste Combustion Systems, sponsored by EPA and the American Society of Mechanical Engineers (ASME), concluded that it was critical for EPA to reevaluate the need for short-term averaging time relative to metal CEMs (Bastian et al., 1994). The consensus of the workshop participants was that continuous (not necessarily real time) metal emissions sampling was valuable for a variety of reasons. Advantages include the ability to offer facilities information about the total mass of metal emissions over time, and an enhancement of overall public perception of facility operations. Although debated at length, the workshop did not resolve whether there were any advantages to having real-time data from continuous analysis, or whether continuous sampling with periodic analysis offers the same results at lower cost. One of the key

[1] Continuous emissions monitoring is the measurement of compounds in the stack gas emissions, based on continuous or semi-continuous sampling followed by continuous or periodic analysis. Periodic analysis of composite samples from continuously sampled emissions is technologically feasible, and considered continuous emissions monitoring, but not real-time monitoring. The technology does not currently exist to continuously analyze most metal species of greatest toxicological concern (real-time monitoring), although development work is proceeding.

[2] "Averaging time" means the time period over which emissions are collected from one or more samples before determining an average rate of emissions. The total measured amount of emissions is divided by the time over which the data were taken to determine an average rate of emission. Specific averaging times for reporting can be set by regulatory authorities to ensure compliance with emissions standards.

issues was whether acute exposures could be adequately addressed by long-term averaging times. This debate led to the creation of this paper**.**

The choice of the proper monitoring technology is driven by data requirements. The main difference in outcome between real-time analysis and continuous sampling with periodic analysis is the frequency of analysis and hence the time interval over which the data can be averaged. This creates the need to answer the primary question posed by this paper: "**What averaging time will protect against adverse effects from acute exposures to a variety of metals emitted from facilities combusting hazardous waste?**" Since EPA requires multipathway risk assessments to protect against adverse health effects based on an average chronic lifetime exposure (70-year average), continually meeting the emissions limits for any averaging time will protect against chronic exposures that could result in adverse health effects. Therefore, this paper will be limited to acute exposures and the scientific rationale for selecting averaging times. Although a literature review did not reveal any unequivocal evidence of adverse effects to nearby residents due to acute exposures from metal emissions (Pleus et al., 1994), this paper develops the theory for averaging time selection that will help ensure adverse effects do not occur because of acute exposures to metal emissions.

This theory is developed by analyzing data and modeling results from three operating units -- one hazardous waste incinerator (HWI) and two cement kilns. Acute scaling factors (ASF) are developed for several metals for each type of facility. The ASFs represent the multiple of the trial burn emission rate that is required to reach acute exposure concentrations at the point of highest off-site concentration with the potential to create adverse health effects.

Statutory and regulatory limitations on metal emissions and averaging times in the Clean Air Act and the Resource Conservation and Recovery Act are discussed to illuminate the options regulators have when specifying averaging times. Examples of averaging times in other MACT rules are cited as precedents. A glossary of some of the key terms used in this paper may be found at the end of the document.

ESTABLISHING APPROPRIATE AVERAGING TIMES

Assumptions

This paper's calculations are based on some appropriately conservative assumptions. For example, there are several important toxicological parameters for metals emissions that are beyond the scope of this paper. These include the following parameters:

- A key factor is the correct identification of the specific metal compound emitted from the hazardous waste combustion facility. There is frequently a discrepancy between the form of metal being emitted from the facility, its fate in the environment, and the form of metal for which the corresponding health criterion is developed. Absent the

ability to prove otherwise through direct measurement, the EPA has generally required that 100% of the total measured metal be assumed to be present in its most toxic form, whether or not this is physically or chemically possible, generally leading to overestimates of risk. This paper assumes that only the most toxic form is present.

- Environmental fate and transport characteristics, such as persistence and degradation and other ways the compounds behave in the environment, are also key variables. This paper assumes that no degradation to a less toxic form will occur.

If these two factors had been incorporated into the calculations, they would increase the magnitude of the calculated ASFs, reducing the potential for adverse health effects due to acute exposures. Other conservative considerations were incorporated into the calculations and are discussed in later sections.

- The Immediately Dangerous to Life and Health (IDLH) values were used to determine adverse effects from acute exposures. There are no federal regulatory criteria for allowable levels of acute metals exposure for the general public. IDLH values or IDLH with a safety factor are commonly used criteria to assess acute public health exposures, such as the need to evacuate in an emergency situation.[3] In other than emergency situations, acute exposures to metals are nearly always an occupational issue, and are rarely a problem to local residents.[4] As acute exposures are the focus of this paper, the IDLH appears to be the most relevant and accepted criterion for assessing public health effects caused by acute exposures to metal emissions. Since IDLH values are a toxicity-based acute exposure limit for a population of workers, the application of these values to public acute exposures theoretically requires some allowance for the average health of the working population, which tends to be better than the general population that includes children, the elderly, and other more sensitive sub-populations. Although a safety factor is frequently introduced when extrapolating from chronic worker exposure limits to chronic public exposure limits because of differences in exposure time, cumulative body burdens, biological half-life and periodic systemic elimination, this is not generally done in practice with acute exposures. Since the calculations are designed to protect against an unlikely occurrence, it is reasonable to use IDLHs without modification. However, if the reader wants to introduce a safety factor to make the calculations more conservative, the authors do not think this will significantly change the conclusions of this paper.

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[3] Suggested Federal Emergency Management Agency (FEMA) guidance for exposures (1-hour based) includes the suggestion of using the highest value among the following:

- IDLH value divided by 10 (with 10 being a safety factor)
- TLV-STEL
- TLV-TWA multiplied by 3 (if a TLV-STEL does not exist)
- TLV-C

"Handbook of Chemical Hazard Analysis Procedures", FEMA, USDOT, USEPA, 1988

[4] A NAS/NCR Emergency Exposure Guidance Level (EEGL) exists for mercury at 200 ug/m^3 (24 hr).

The Role of Acute Scaling Factors

The key to establishing an appropriate averaging time is comparing the modeled one-hour ground level metals concentrations to safe acute exposure levels.[5] This is done with the acute scaling factor (ASF), the multiple of a particular metal's emission rate required to achieve a ground level IDLH concentration. The ASF is a measure of how much metals emissions would have to change before modeled acute exposures have the potential to cause adverse health effects. ASFs can also be used to determine the number of years of emissions, at the trial burn rate, that would have to be released in a single 30-minute period to create IDLH. concentrations. This duration can be used to determine an averaging time that would positively ensure that short-term emissions do not exceed the acute exposure criteria as long as the average emissions does not exceed the chronic exposure limit. The two methods used to calculate the ASFs is given in Appendix A.

There are four major technical parameters used to model the metals emissions data and calculate the ASFs:

1. Individual Metal Compounds - Acute Exposure Concentrations
2. Facility Type
3. Trial Burn Conditions
4. Site-Specific Air Dispersion Modeling

These four parameters are presented in the following sections, followed by a discussion of the acute scaling factor calculation.

1. Individual Metal Compounds - Acute Exposure Concentrations

Table 1 presents the acute exposure levels relevant to each metal compound of interest. The criterion used is the IDLH, which is the concentration considered by the National Institute for Occupational Safety and Health (NIOSH) to be Immediately Dangerous to Life and Health (IDLH) under the following condition: if a worker was using a respirator and the respirator failed, the IDLH is the maximum concentration that a worker could be exposed to without respirator protection for up to 30 minutes without experiencing irreversible adverse health effects. (NIOSH, 1994). As such it is something of a misnomer: it is not immediately or spontaneously acutely dangerous, but longer than 30 minutes of exposure at this concentration may result in adverse effects. The reason for choosing the IDLH was discussed in the preceding section, "Assumptions."

[5] The choice of using 1-hour converted or modeled ground-level concentration data was due to its availability for most facilities. In the event 30-minute data are available, their use will provide slightly more precise values due to the fact there is difference of 16% (increase) between the 30-minute and 1-hour modeled data for ISCST2.

Table 1
Acute Exposure Limits

Metal	Acute (NIOSH IDLH ug/m^3)
Silver	10000
Arsenic, (carcin.)	5000
Arsenic, (other)	5000
Barium	50000
Beryllium	4000
Cadmium	9000
Chromium $^{+3}$	25000
Chromium $^{+6}$	15000
Mercury	10000
Lead	100000
Antimony	50000
Thallium	15000

2. Facility Type

Although there are only three facilities evaluated in this review, the facility types represented are different. The data set includes two cement kilns burning hazardous waste and one large HWI, burning liquid and solid hazardous wastes.

The cement kilns fire wastes as supplemental fuel at different substitution rates in combination with coal. Cement kilns represent large-volume, stationary sources; there is little variance in their operational conditions, an artifact of complying with American Society of Testing and Materials (ASTM) standards in producing the final cement product. Compared to HWIs, the operational conditions of the cement kiln experiences a narrower range of variation due to its larger size, the continuous nature of the feed loading, and the need for operational consistency to ensure a uniform commercial product.

The two kilns chosen are both dry-process design with an estimated fuel consumption of approximately 4.4 million Btu per ton of clinker produced. The production capacity of these facilities are representative of large (1,200,000 tons/year) and small (380,000 tons/year) annual production. Capacities of cement kilns burning hazardous waste in the U. S. vary from 90,000 to 1,500,000 tons/year.

The rotary kiln HWI burns both liquid and solid hazardous waste. Its maximum capacity is 132 million Btu's per hour, fairly typical for a large HWI. The unit is fueled directly by high-Btu wastes, supplemented with auxiliary fuels as needed.

3. Trial Burn Conditions

In order to maintain conservative assumptions throughout the calculation of acute scaling factors, annual emission rates were based on data from trial burn stack testing designed to be representative of worst-case operating conditions.[6] The use of data from such tests would tend to bias subsequent calculations towards overestimating actual emissions and underestimating the multiple of any acute scaling factors derived from them.

Overestimating emissions and underestimating the scaling factor is a result of combining a trial burn's emission data with the use of worst-case meteorological data in the air dispersion modeling. Trial burns are designed to push a combustion process towards maximum generation rates of the analytes of interest, while the worst-case meteorological conditions, found within a one to five year data set, are used to define the highest ground-level concentration. If actual emissions data and average meteorological conditions were used to model a maximum ground-level concentration, the resulting scaling factors would be larger than those discussed in this paper.

4. Site-Specific Air Dispersion Modeling

It is appropriate to identify a few aspects of the air dispersion modeling done at these facilities since they are integral to calculating acute scaling factors from the dilution coefficients modeled.[7] Various models and methodologies were used to identify each facility's "MEI", which is the location of the hypothetically Maximum Exposed Individual, and the associated dilution coefficient. While all modeling met the objectives and approvals of the governing agencies at the time, the dilution coefficients for one-hour maximum ground-level concentrations were identified by both direct and indirect methods.

The one-hour maximum ground-level concentration can exceed the same receptor's maximum annual average ground-level concentration by more than one order of magnitude, depending on process, site, and meteorological conditions. Using the one-hour maximum reduces the magnitude of the ASF correspondingly, incorporating additional conservatism into the final results.

One of the cement kilns was modeled with a combination of the Industrial Source Complex Long Term Version 2 (ISCLT2) and Complex Terrain Screen (CTSCREEN) air dispersion models. The use of CTSCREEN for the modeling of a one-hour value is inherently conservative as CTSCREEN is a worst-case screening model, not a refined

[6] "Worst-case operating conditions" are those conditions required by EPA because they result in maximum risk attributable to the facility. Metal emission rates for the HWI are the average of the trial burn results described by Cowley et al, 1994. The cement kiln trial burn data are unpublished.

[7] Air dispersion modeling calculates an array of ground-level concentrations at designated receptor locations. The models provide output for these locations in concentration units of ug/m^3 based on some unit mass emission rate at the source, generally in g/s or 100 lb/hr of emitted compound. The modeled unit ground-level concentration, called the dilution coefficient, is then scaled by the actual measured emission rate of the compound of interest to derive a ground-level concentration specific to a given metal.

model for complex terrain. The maximum annual average for this facility was obtained through the model's application of a conversion factor of 0.03 to the one-hour value, as described in the user's manual for CTSCREEN (EPA, 1990).

Due to the lack of complex terrain features within the model grid, the other cement kiln used only ISCLT. One-hour maximums were derived by applying a factor of 1/0.053 to the modeled maximum annual average value. The basis of this conversion factor is detailed in the EPA's Methods Manual for Compliance with the BIF Regulations (EPA, 1991).

The two air dispersion models used to estimate off-site concentrations of the HWI were Industrial Source Complex Short Term Version 2 (ISCST2)[8] and a proprietary program based on the ISCST2.

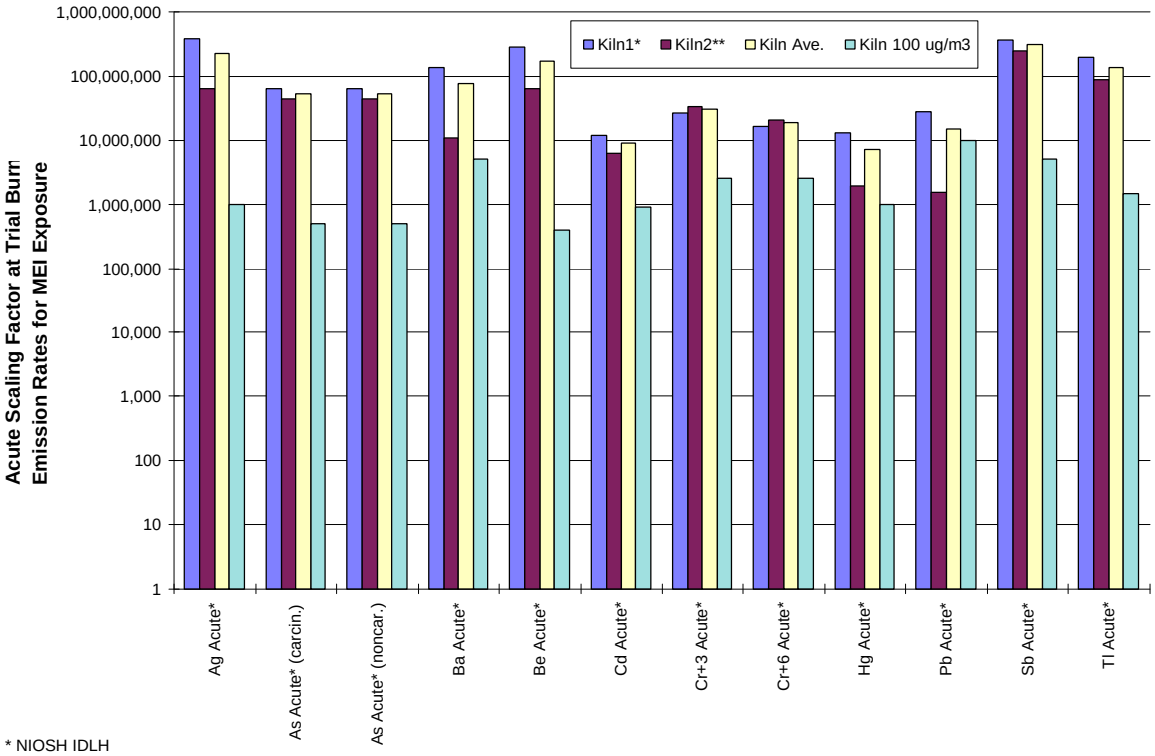
Calculating Acute Scaling Factors

The ASFs calculated for various metal emissions from the described facilities are shown in Figures 1 and 2. These figures represent the multiple of the trial burn metal emission rate that would create IDLH concentrations at the modeled MEI, the point of maximum hypothetical exposure. Higher scaling factors would result from lesser exposures that occur further from the MEI.

ASFs are also calculated assuming a generic metal emission concentration of 100 ug/m^3 for each metal. Based on conversations with EPA personnel, the authors believe this concentration is in the range that EPA will propose as technology-based limits for the metals that will be regulated from hazardous waste combustion facilities (ASME, 1995). The equations used to calculate the data displayed in these graphs are provided in Appendix A.

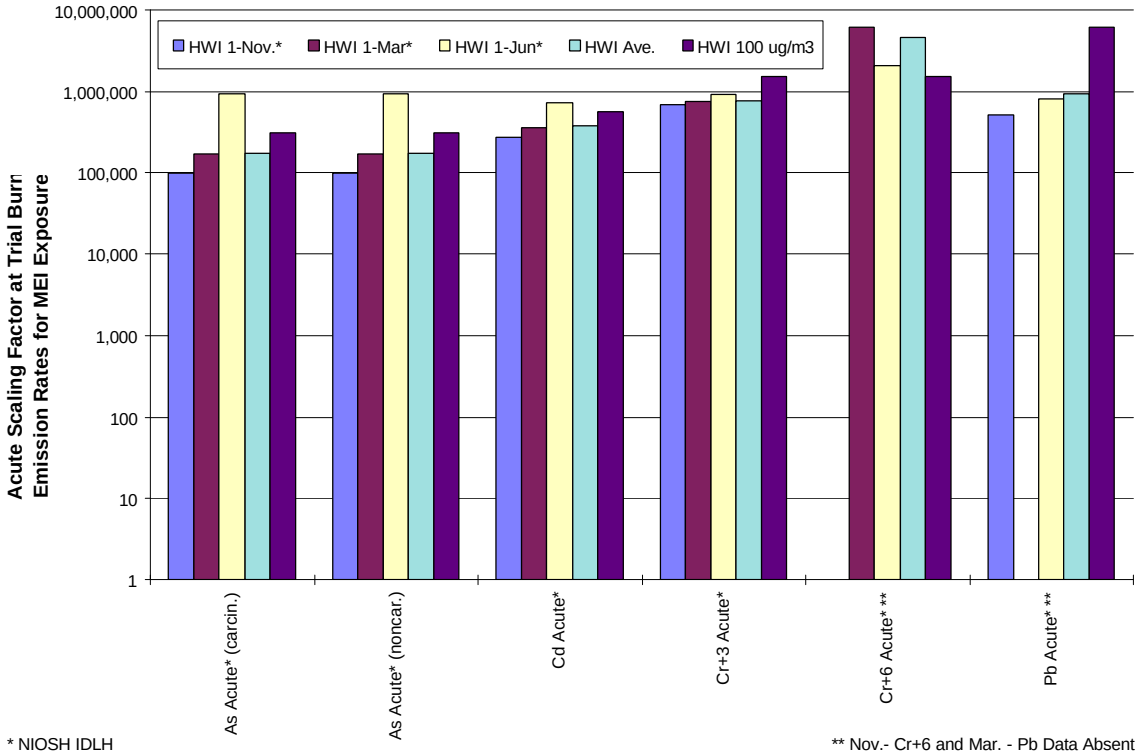
[8]Version 93101, as provided by Trinity Consultants.

Figure 1
Cement Kilns - Acute Scaling Factors



* NIOSH IDLH

Figure 2
HWI Acute Scaling Factors

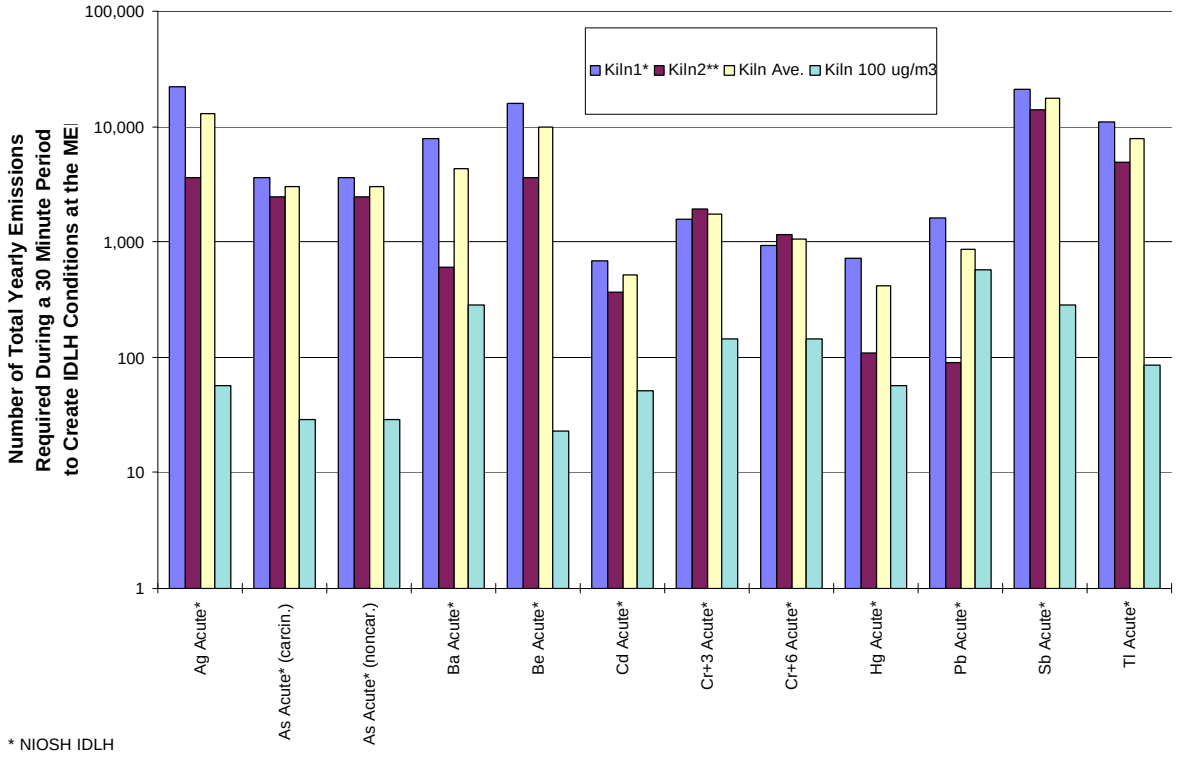


* NIOSH IDLH

** Nov.- Cr+6 and Mar. - Pb Data Absent

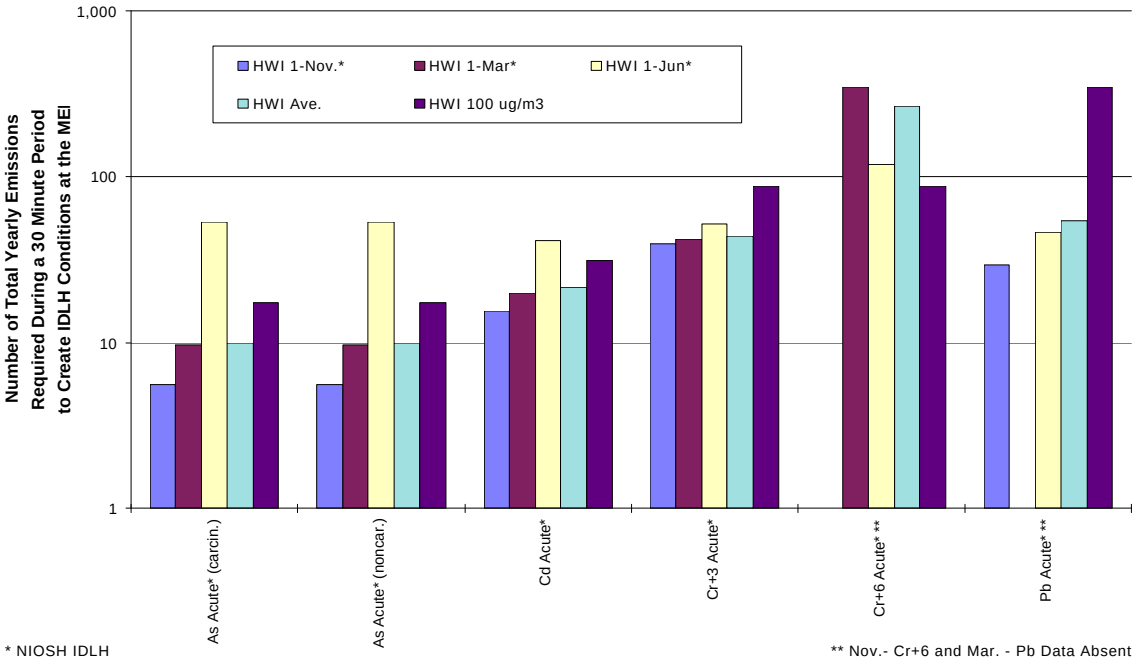
Figures 3 and 4 show the number of years' of emissions that would need to be released during a 30-minute period in order to reach IDLH acute exposure levels. They show that these facilities would have to emit 10 to 10,000 years' of emissions (depending on the metal and facility type) in a 30-minute period to reach the IDLH acute exposure concentrations at the MEI. Hence if a 100 ug/m^3 standard is not exceeded based on a 10-year average, the IDLH could not be exceeded for any 30-minute period, even if all the emissions contributing to this average occurred in a single 30-minute period. This is consistent with the literature survey that found no clear evidence of adverse effects from acute exposures to metal emissions.

Figure 3
Number of Years of Emissions That Would Need to be Released in 30 Minutes to Create IDLH Conditions



This means that a one-year averaging time provides a large margin of safety to ensure IDLH concentrations are not exceeded and nearby populations are not subjected to acute exposures with the potential for adverse health effects. It is not likely that a hazardous waste combustion facility could generate a sustained transient peak high enough to cause adverse acute exposures, so it can be argued that risks from acute exposures are negligible, and the only use for continuous monitoring data is to ensure that chronic standards are met.

Figure 4
Number of Years of Emissions That Would Need to be Released in 30 Minutes to Create IDLH Conditions (HWI)



Although it is not appropriate to extrapolate from three facilities, it can be seen that in these cases, even significantly higher emission rates will still result in averaging times of months or years, not days or hours, while still being protective of acute exposure criteria. Should the three facilities in this review prove to be representative of the larger universe of facilities, the case for long averaging times would be substantiated.

CONTINUOUS EMISSIONS MONITORING: ADVANTAGES AND DISADVANTAGES

There are advantages and disadvantages to continuous monitoring of metals in stack emissions. The advantages are:

- Continuous monitoring eliminates the need for waste feed permit limits.
- Continuous monitoring might increase internal vigilance over emissions.
- Continuous monitoring appears to enhance public perception of facility operations. However, it is not clear whether both continuous sampling and continuous analysis is required to enhance public confidence, or whether continuous or semi-continuous sampling alone is sufficient. The costs and benefits of continuous analysis should be evaluated relative to the quality and usefulness of information generated by this effort. (It appears from this paper that the same information with regard to off-site impacts can be obtained with continuous or semi-continuous sampling and periodic analysis.)

Some of the difficulties with continuous monitoring are:

- Lack of proven or commercially available technology. No real-time monitor is currently commercially available, although several are currently under development. Continuous metals sampling with periodic analysis has been used for operations monitoring on a limited basis.
- The limitations of analytical measurements, including problems of determining appropriate sample size and detection limits. The technology does not exist to measure the concentration of most metal species of greatest toxicological interest; most often the total metal concentration is determined, and the most toxic form is assumed to be present whether or not this is physically or chemically possible. Further, some metal species can be orders of magnitude more toxic than others. The combined effect of these assumptions is an overestimate of risk, perhaps by a significant margin.
- Although it might appear that real-time monitoring of emissions gives more accurate data because there are more data points, this is not necessarily true. Detection limits that exceed the low concentration in the emissions can produce less accurate data with high standard deviations and noise. Sampling for a longer time before analysis, produces a greater mass for analysis that may increase the accuracy of the data.
- Creation of false public perceptions. If an unnecessarily short averaging time is used to set a permit limit, a short term emission excursion creates the impression of a health hazard, even when one does not exist.

REGULATORY REQUIREMENTS FOR AVERAGING TIMES

While the calculations of the ASFs establish the scientific basis for setting averaging times, regulators must also consider the statutory and regulatory requirements summarized in this section.

Hazardous waste incinerators (HWI) are regulated under Resource Conservation and Recovery Act (RCRA) requirements in 40 CFR Parts 264 and 265. There are no specific standards for metal emissions under RCRA, but EPA has limited metal emissions relying on the Omnibus Authority. This statute allows permit writers to use individual discretion to limit metal emissions when the permit writer believes further emissions limits are necessary to protect human health and the environment. In 1989, EPA also published a draft guidance document entitled "Guidance on Metals and HCl Controls For Hazardous Waste Incinerators" discussing regulation and control of metal emissions (EPA, 1989).

Other hazardous waste combustion facilities, such as cement kilns and other boilers and industrial furnaces (BIF), are regulated under the BIF Rule contained in 40 CFR Part 266. These BIF standards include risk-based emissions limits for ten metals, and compliance is based on compliance certifications, trial burns and feed control.

EPA has stated it will regulate emissions of hazardous waste combustion facilities jointly under RCRA and Section 112 of the Clean Air Act (CAA), and is expected to issue new proposed regulations for hazardous waste combustion facilities in early 1996. EPA is evaluating the use of continuous emissions monitoring (CEM) to show compliance with these new standards.

There are no enhanced monitoring[9] requirements in RCRA in 40 CFR Part 264, but there is an enhanced monitoring requirement in the CAA. "*The administrator shall in the case of any person which is the owner or operator of a major stationary source, and may, in the case of any other person, require enhanced monitoring and submission of compliance certification. Compliance certifications shall include . . . whether compliance is continuous or intermittent.*" (CAA Section 114(a)(3)).

EPA's strategy for implementation of these CAA requirements has been to include emissions monitoring requirements for each MACT source category in the rule for that source category. The specific monitoring methods and averaging times for MACT sources are not stipulated in the CAA, but are left to the discretion of EPA. Generally, the frequency of sampling and the averaging time are based on the technical requirements to control each process and to prevent acute and chronic effects from emissions of

[9]Enhanced monitoring is defined by EPA as "the methodology used by an owner or operator to detect deviations with sufficient representativeness, accuracy, precision, reliability, frequency, and timeliness in order to determine if compliance is continuous during a reporting period. Such monitoring shall be conducted through an enhanced monitoring protocol established in accordance with §64.4." (58 FR 54685, October 22, 1993, proposed rule)

Hazardous Air Pollutants (HAP). The following are examples of averaging times that have been used to enforce MACT standards:

- The National Emission Standards for Halogenated Solvent Cleaning specify that halogenated solvent cleaning machines must comply with a 3-month rolling average emission limit based on solvent addition calculations. "*Each owner or operator of a batch vapor or in-line solvent cleaning machine complying with Part 63.464(a) shall demonstrate compliance with the 3-month rolling average monthly emission limit on a monthly basis . . .*" (40 CFR Part 63.464(b)).

- The proposed National Emission Standards for the Printing and Publishing Industry require emissions compliance on a monthly average basis using a material balance or a continuous emissions monitor. "*To demonstrate compliance, each owner or operator using a solvent recovery device to control emissions shall show the overall HAP limitation achieved by one of the following two procedures, either: (i)Perform a liquid-liquid material balance for each and every month as follows . . . (ii)(A) Install continuous emission monitors to determine the total organic volatile matter mass flow rate . . . such that the percent control efficiency of the control device can be calculated for each month . . .*" (60 FR 13669, March 14, 1995)

- National Emission Standards for the Synthetic Organic Chemical Manufacturing Industry (SOCMI) are applicable to emissions of any organic HAPs from the manufacture of synthetic organic chemicals. These standards provide flexibility by averaging across various forms of emissions and types of HAPs in addition to averaging on an annual basis. The Preamble of the National Emission Standards for Organic HAPs from the SOCMI states, "*Averaging is allowed across these four kinds of emission points in order to provide as much flexibility as possible while maintaining an enforceable standard.*" (59 FR 19426, April 22, 1994). "*The emissions averaging provisions in the proposed rule allowed averaging across all HAP's covered by the HON [Hazardous Organic National Emission Standards for HAPs]. . . . EPA has decided . . . compliance through averaging would not result in greater hazard or risk than compliance without averaging."* (59 FR 19427, April 22, 1994) *"EPA has decided to establish an annual compliance period for emissions averaging.*" (59 FR 19431, April 22, 1994)

It is clear from the above precedents that longer averaging times of a month to a year are consistent with existing MACT rules, and that these longer averaging times can fulfill the requirements of the CAA. These precedents of longer averaging times suggest the EPA has the statutory authority and the ability to select longer averaging times when scientifically justified.

CONCLUSIONS

The information in this paper leads to the following conclusions:

1. Consideration of actual risks when establishing monitoring frequencies and averaging times for compliance with technology-based standards, provides regulators with simpler and more efficient compliance and monitoring schemes. The methodology presented in this paper can be used to set general standards or applied to individual waste combustion units to establish scientifically appropriate averaging times.
2. A hazardous waste combustion facility is not likely to emit a sufficient quantity of metals to cause adverse health effects from acute exposures.
3. Averaging times on the order of months or years, and emission permit limits in mass units per month or year, will usually be sufficient to ensure compliance with acute exposure criteria with an appropriately conservative margin of safety.
4. Since chronic risks are controlled by meeting the EPA emissions criteria over any averaging time, averaging times that protect against acute risks will be protective of human health.
5. It can be argued that no continuous monitoring is necessary to be protective of acute exposures at these hazardous waste combustion facilities, because there is negligible potential for adverse health effects from acute exposures.
6. There is precedent for long averaging times in other MACT standards (one week to one year).
7. These conclusions are valid regardless of whether compliance is demonstrated by emissions limits or by metal feed rates. Therefore, metal feed rate limits should have the same averaging times as emissions limits.

RESEARCH RECOMMENDATIONS

1. Research is needed to identify the metals species of potential health concern that are being emitted from waste combustion stacks. Determination of the environmental fate, transport, and persistence of these species is also needed, rather than assuming 100% of total measured metal concentrations are in the most toxic form (i.e., 100% of total chromium should not be assumed to be in hexavalent form because the science indicates this is not correct).
2. Research is needed to develop sampling and analytical methodologies to identify and measure those metal species of particular health concern.
3. Health effects criteria should be developed that are based on substantive data for the compounds likely to be emitted from the facility, particularly those of potential health concern.

Although it is not prudent to extrapolate from three facilities, it can be seen that even significantly higher emission rates will still result in averaging times of months, not days or hours, that are protective of acute exposure health criteria. These conclusions are believed to hold true despite the lack of formally developed criteria for acute public

exposure to air borne metals, due to the very conservative nature of the assumptions underlying these calculations.

In summary, the authors recommend that long averaging times be chosen to control metal emissions from hazardous waste combustion facilities, on the grounds that longer averaging times can be demonstrated to be technologically achievable, protective of public health, cost effective, consistent with the enabling statutes, and readily enforceable.

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GLOSSARY

The **Acute Scaling Factor** (ASF) is a gross measurement of how much more a facility would have to emit before it could cause adverse acute exposures to off-site populations. The ASF represents what multiple of the measured emission rate of a given compound would create ground-level concentrations that could be acutely toxic if sustained for 30 minutes.

Air dispersion modeling calculates an array of **ground-level concentrations** at designated receptor locations. The models provide output for these locations in concentration units of ug/m^3 based on some unit mass emission rate at the source, generally in g/s or 100 lb/hr of emitted compound. The modeled unit ground-level concentration, called the **dilution coefficient**, is then scaled by the actual measured emission rate of the compound of interest to derive a ground-level concentration specific to a given metal. The Maximum Exposed Individual, or **MEI**, is the estimated point of maximum hypothetical off-site exposure to facility emissions.

The term "**averaging time**" as used in this paper means the time period over which emissions data are collected and averaged from one or more samples to determine a rate of emissions. The total measured emissions is then divided by the time over which the data were taken to determine an average rate of emission. Specific averaging times can be set by regulatory authorities to ensure compliance with emissions standards.

Continuous emissions monitoring is the measurement of compounds in the stack gas emissions, based on continuous or semi-continuous sampling followed by continuous or periodic analysis. Periodic analysis of composite samples from continuously sampled emissions is technologically feasible, and considered continuous emissions monitoring, but not real-time monitoring. The technology does not currently exist to continuously analyze most metal species of greatest toxicological concern (real-time monitoring), although development work is proceeding.

Enhanced monitoring is defined by EPA as "the methodology used by an owner or operator to detect deviations with sufficient representativeness, accuracy, precision, reliability, frequency, and timeliness in order to determine if compliance is continuous during a reporting period. Such monitoring shall be conducted through an enhanced monitoring protocol established in accordance with §64.4." (EPA, 1993)

The **IDLH** is the concentration considered by the National Institute for Occupational Safety and Health to be Immediately Dangerous to Life and Health (IDLH) under the following condition: if a worker was using a respirator and the respirator failed, the IDLH is the maximum concentration that a worker could be exposed to without respirator protection for up to 30 minutes without experiencing irreversible adverse health effects. As such it is something of a misnomer: it is not immediately or spontaneously acutely dangerous, but longer than 30 minutes of exposure at this concentration may result in adverse effects.

APPENDIX A

CALCULATION OF ACUTE SCALING FACTORS

The Acute Scaling Factor (ASF) is a measurement of how much more a facility would have to emit before it could cause acute exposures to off-site populations. The ASF represents what multiple of the measured emission rate of a given compound is required to create a ground-level concentration that could be acutely toxic if sustained for 30 minutes. The ASF is derived for an individual compound of concern by dividing its IDLH by a calculated one-hour maximum ground-level concentration; this concentration is obtained through combining site-specific modeling results with those of a facility's stack test or trial burn data. Alternatively, the degree of protection afforded by a proposed emission limit can be calculated, as in Figures 3 and 4 in the text, where a proposed emission limit of 100 ug/m^3 was evaluated.

The calculations used to derive an ASF are given below. The equation uses CTSCREEN's 0.03 factor for the conversion between one-hour maximums and annual maximums (EPA, 1990). For non-complex terrains, substitute the appropriate factor for the screening model or calculate one by dividing the annual maximum ground-level unit emission-based value by the one-hour ground-level maximum modeled at the same unit emission rate.

Two example calculations follow the equations.

Equation Components

ER_{actual} = Emission Rate (derived from stack test data)
AMDC = Annual Maximum Dilution Coefficient
1HMDC = One-Hour Maximum Dilution Coefficient
IDLH = NIOSH value for compound of concern
ASF = Acute Scaling Factor

Converting from a facility's annual maximum using CTSCREEN:

$$\mathbf{ASF = IDLH / [(AMDC/0.03) * (ER_{actual})]}$$

Or, if one-hour screening or refined modeling data is available:

$$\mathbf{ASF = IDLH / [(1HMDC) * (ER_{actual})]}$$

Example 1

For an incinerator with the following data:

$$Stack\_flowrate = 20.96\frac{m^3}{s}$$

$ER_{actual} = 0.00368\frac{g}{s}$ (As emission rate based on trial burn data)

Based on site specific dispersion modeling for this facility:

$$1HMDC = \frac{7.74\,{ug}/{m^3}}{{g}/{s}}$$

The NIOSH IDLH value for As-acute is:

$$\cdot IDLH = 5000\frac{ug}{m^3}$$

Therefore:

$$ASF = \frac{5000\,{ug}/{m^3}}{\left(\frac{7.74\,{ug}/{m^3}}{{g}/{s}}\right) x\left(0.0037\frac{g}{s}\right)}$$

$$ASF = 175{,}000$$

Example 2

To determine the number of years of emissions that would need to be released in thirty minutes to create IDLH conditions for the same incinerator as in example 1.

If IDLH conditions existed at groundlevel, the arsenic ground level concentration would be

$$5000\frac{ug}{m^3}$$

Using the same dispersion modeling coefficient as in example 1, the emission rate of Arsenic required to create the above ground level concentration of Arsenic would be:

$$ER_{arsenic} = \frac{5000\frac{ug}{m^3}}{\frac{7.74\frac{ug}{m^3}}{\frac{g}{s}}}$$

$$ER_{arsenic} = 646\frac{g}{s}$$

The mass amount of arsenic that would exit the stack in thirty minutes at the above theoretical emission rate would be:

$$Mass_{arsenic} = \left(646\frac{g}{s}\right)\left(60\frac{s}{\min}\right)(30\min)$$

$$Mass_{arsenic} = 1{,}163{,}000g$$

Therefore, the number of years of emissions at trial burn emission rates that would need to be released in 30 minutes to create IDLH conditions:

$$Emission_{yrs} = \frac{(1{,}163{,}000g)}{\left(\frac{0.00368g}{s}\right)\left(\frac{3600s}{hr}\right)\left(\frac{8760hr}{yr}\right)}$$

$$Emission_{yrs} = 10yrs$$