UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

EPA-SAB-EEC-89-035

September 20, 1989

OFFICE OF
THE ADMINISTRATOR

Honorable William K. Reilly
Administrator
U.S. Environmental Protection Agency
401 M Street, S.W. 20460

Subject: Science Advisory Board's Review of the Office of Water's Proposed Sludge Use And Disposal Regulation (40 CFR Parts 257 and 503)

Dear Mr. Reilly:

This report presents the EPA Science Advisory Board's (SAB) review of the Office of Water's (OW) proposed Municipal Sewage Sludge Incineration regulations, dated February 6, 1989. This SAB review was requested by the OW to fulfill partially the EPA's agreement with the Court in which the Natural Resources Defense Council (NRDC) challenged the timing of the proposed regulations (other aspects of the regulation involving land disposal and land application were reviewed by the W170 Committee of the Department of Agriculture).

The Subcommittee review consisted of a meeting in Washington, D.C. on April 26-27, 1989, a teleconference on July 28, and extensive evaluation of written and oral briefing materials provided by the EPA staff. Our examination focused on five major issues raised by the OW, as well as an evaluation of the need for long-term research by which some of the generic issues identified can be addressed to improve the scientific and technical basis for future regulations.

The Subcommittee believes that incineration is a viable and appropriate technology for the treatment of sewage sludge. In reviewing the proposed regulation however, the Subcommittee found that the OW made a good effort to develop a risk-based regulation for sewage sludge incinerators, but concluded that deficiencies in the risk and emissions data bases and, particularly, the analytical methodologies used did not permit the development of a sound, technically based regulation. Many safety factors are built into the various analyses; although each individual safety factor appears reasonable, the multiplicative use of a series of such factors (as with the definition of the Most Exposed Individual) makes the final number overly conservative and subject to misinterpretation.

Statistical analyses of the limited data base for emissions are flawed due to the practice of indiscriminate averaging over a range of different types of combustors, operating conditions, and types of air pollution control devices.

We endorse the concept of using a stack gas measure of total hydrocarbons emissions for monitoring sludge incineration and air pollution control devices as a general performance indicator. However, the proposed use of total hydrocarbons as a direct indicator of risk is not supportable due to the lack of a direct link between total hydrocarbons and the total spectrum of organics which might be emitted from sewage sludge incinerators, as well as the major risk assumptions made in developing the standard.

The air transport dispersion models used in developing the proposed regulations are approved EPA models with defined guidelines for their use. However, the OW has discounted Agency technical requirements in seeking to offer simplified ways of using results from selected model calculations.

The enclosed report provides detailed discussion of all the above issues, as well as recommendations for strengthening future efforts. We are pleased to have had the opportunity to be of service to the Agency, and look forward to your response on this report.

Sincerely,

Raymond C. Loehr

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Science Advisory Board

Richard A. Conway

Mr. Richard A. Conway, Chairman
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Dr. Francis McMichael, Chairman
Municipal Sludge Incineration Subcommittee

cc H. Habicht
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Office of the Administrator
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Washington, DC 20460

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September, 1989

Report of the Municipal Sludge Incineration Subcommittee

Review of Proposed Sewage Sludge Incineration Rules (40 CFR Parts 257 And 503)

U. S. ENVIRONMENTAL PROTECTION AGENCY

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1. EXECUTIVE SUMMARY

This report presents the EPA Science Advisory Board's (SAB) review of the Office of Water's (OW) proposed Municipal Sewage Sludge Incineration regulations, dated February 6, 1989. This SAB review was requested by the OW to fulfill partially the EPA's agreement with the Court in which the Natural Resources Defense Council (NRDC) challenged the proposed regulations. The SAB Subcommittee has reviewed five major points pertaining to the Sludge Incineration part of the regulations. The Subcommittee also looked at the need for long-term research by which some of the generic issues can be addressed to improve the scientific and technical basis for future regulations. Another aspect of the regulations (land disposal, land application) is being reviewed by the W170 Committee of the Department of Agriculture.

The Subcommittee review consisted of a meeting in Washington, D.C. on April 26-27, 1989 and extensive evaluation of written and oral briefing materials provided by the EPA staff. The Subcommittee also relied heavily on the recent draft Products of Incomplete Combustion (PIC) Subcommittee report (Proposed Controls for Hazardous Waste Incinerators: Products of Incomplete Combustion, reference 5), along with the SAB's recent resolution on the use of mathematical models (reference 6), and an earlier (1985) SAB report reviewing incineration (reference 9).

The Subcommittee believes that incineration is a viable and appropriate technology for the treatment of sewage sludge. In reviewing the proposed regulation however, the Subcommittee finds that the OW made a good effort to develop risk-based regulation for sewage sludge incinerators, but concludes that the deficiencies in the risk and emissions data bases and methodologies used do not permit the development of a technically based regulation. Major findings are summarized below.

1.1 Air Dispersion Model Selection and Use

The OW selected three EPA approved air dispersion/transport models which are well documented in Agency publications. The EPA manuals for these models identify the scientific problems associated with their misuse. Yet the Agency, in the proposed regulations, ignores its own technical requirements for the use of these models in order to simplify their application to the risk-based approach to incineration regulation. The Subcommittee found no scientific/technical evidence that dealing with emissions from sewage sludge incinerators requires the use of specifically designed models, and concludes that no new simplified model is justified for these specific regulations.

1.2 MEI Definition and Implications

The Agency defines the MEI (Most Exposed Individual--a hypothetical construct) as one who lives at the point of maximum ground level concentration, is exposed 24 hours per day, breathes 20 cubic meters of air per day, weighs 70 kg and is exposed for a 70 year lifetime. The Subcommittee finds that this definition is not developed through scientific reasoning or facts. It is highly unlikely that any such scenario is representative for any sludge incineration site. The only justification for this definition can be traced to seeking simplicity for the purpose of calculating risks. As indicated in the body of this SAB review, the MEI assumptions are extremely conservative and consequently unrealistic. Not withstanding this observation, the definition of the MEI, the simplified method of deriving air dispersion factors, the assumption of q* values (the cancer potency value, expressed as the slope of the dose-response curve in the low-dose range--see reference 3), and the assumption of the detection level concentrations for chemicals never measured, when combined, yield large uncertainties and bias the Agency risk calculations. The uncertainties and multiplicative factors are so large that it makes interpretation of the calculated risks unreasonable and misleading. Nevertheless, the Agency uses the MEI exclusively for estimation of cancer risks without addressing any other type of adverse health effects.

1.3 Assumptions on Efficiency of Air Pollution Control Devices

Most of the data regarding facilities used in the development of the proposed regulations are based on old tests employing analytical methods that were called into question by the Subcommittee. More recent comprehensive EPA studies are also of limited value because they represent old incinerators with old air pollution control devices not representative of the current state-of-the-art systems. The key issue is whether or not the Agency's generalizations of control efficiencies made from the available data base are suitable for the entire universe of combustion systems and air pollution control devices. The Subcommittee finds that flawed statistical analyses of these data vitiate many of the conclusions reached by the Agency.

The Subcommittee concludes that the average control efficiencies as specified in the proposed regulations are not appropriate due to indiscriminate averaging over a range of different types of combustion devices, different operating conditions, and different types of air pollution control devices. In particular, the metals emissions will be dictated by the design and operating conditions of the combustion system and air

pollution control device.

1.4 Total Hydrocarbon Emissions Monitoring

The Subcommittee reviewed the issue of using total hydrocarbons (THC) monitoring as an appropriate surrogate for total organics emissions and whether or not there is a scientific basis to estimate risk from exposure to organic emissions using measured THC values. For the following technical reasons, the Subcommittee concludes that the proposed THC monitoring device, the proposed limits on THC emissions level, and the basis chosen for estimating the weighted potency of the organic emissions are flawed and cannot be supported scientifically. The Subcommittee further finds that the use of a stack gas total hydrocarbon monitor is a sound approach to measuring organics destruction efficiency (this same conclusion was reached by the PIC Subcommittee), but it is necessary to differentiate between the monitoring of unconditioned flue gas samples with a hot THC analyzer equipped with a flame ionization detector (FID) and the monitoring of pre-conditioned flue gas samples with a cold THC analyzer. The hot FID device has not yet been demonstrated to be successful or reliable for monitoring in a continuous operation mode.

The Agency has proposed that total hydrocarbons can be related to risk for exposure to all organics. The Agency performed a statistical correlation analysis to relate total hydrocarbon measurements to measurements of selected volatile and semi-volatile organics. The data indicated that 90% of the organics were unaccounted for; other work indicated that THC measurements cannot be reliably correlated with specific or total organics emissions (see the PIC Subcommittee draft report noted earlier). The Subcommittee concludes that the current data and correlation analyses do not support the use of THC as a direct measure of risk at sludge incinerators.

1.5 Requirements for Incinerator Operations

The Subcommittee considered many questions in evaluating the technical basis for the regulations proposed for controlling operations of the combustion and air pollution control device that together constitute a sewage sludge incineration system.

The Agency made, in the proposed incineration regulations, an effort to reduce costs by proposing to establish minimally acceptable operating conditions, that if satisfied, will prevent the need for performance compliance testing of sewage sludge incineration facilities. The Subcommittee finds that there is

neither an adequate database nor adequate understanding of the relationship between operating parameters and emissions to support prescribing minimally acceptable conditions in lieu of performance testing.

1.6 Recommendations

As a result of the findings described above, the Subcommittee developed the following two groups of recommendations for future work:

Group I--specific recommendations for incinerator systems:

1. Develop air dispersion factors with the defined technical bounds of existing air models.

2. Carry out "multiple" simulations, reflecting "real world" incinerator sites, to develop a data base sufficiently large to yield valid statistical summaries of air dispersion factors.

3. Develop a probabilistic approach to replace "constant value" definitions of the MEI.

4. Approach metals control removals issues separately for combustion and pollution control devices.

5. Collect the needed key data on emissions and control device performance and apply the appropriate statistical analysis techniques necessary to develop sound, scientifically defensible bases for this regulation.

6. Emphasize the need for better training of POTW operators.

7. Emphasize the need to develop performance-based regulations which provide incentives for improving incineration technology and pollution control equipment.

Group II--recommendations for long-term research and development:

1. Conduct additional model validation research, in support of both the OW regulatory effort, and the many other Agency programs utilizing such data.

2. Support epidemiological research to determine the incidence of adverse health effects in populations residing near existing incineration facilities.

3. Emphasize the need for source reduction of toxic metals in the municipal waste stream to prevent such agents from reaching the incineration feedstock.

2. BACKGROUND

2.1 Process

The EPA Office of Water, on February 6, 1989, proposed a new regulation on sewage sludge use and disposal (40 CFR Parts 257 and 503). Shortly thereafter, the Natural Resources Defense Council (NRDC) challenged the proposed regulation and filed a suit in court raising a variety of issues. In some preliminary discussions with the NRDC and the Judge hearing the case, the Office of Water agreed to provide to the Court external peer reviews of a number of technical issues raised in the litigation. In late February, Water Program Officials asked the SAB to provide an ad hoc review of five major issues pertaining to the sludge incineration portion of the sewage sludge regulation (Another aspect of the proposed regulation, land application/land disposal, is being reviewed by the W170 Committee of the Department of Agriculture).

The Subcommittee met in Washington, D.C. on April 26-27, 1989. Members had been supplied with extensive documentation prior to the meeting, and received detailed briefings from EPA staff at the meeting. In addition, the Subcommittee relied heavily on the draft PIC Subcommittee report, Proposed Controls for Hazardous Waste Incinerators: Products of Incomplete Combustion, the SAB's recent resolution on mathematical models (EPA-SAB-EEC 89-012, January 1989), and an earlier SAB review of incineration (Report on the Incineration of Liquid Hazardous Wastes, April 1985).

2.2 Charge to The Subcommittee

In a memorandum dated February 28, 1989, the Office of Water identified five specific issues for SAB review:

1. Are appropriate and correct air dispersion models used to relate stack emissions to ground level concentrations for the most exposed individual (MEI) ?

2. Is the MEI defined properly ?

3. Are the assumptions concerning the efficiency of air pollution control devices correct and appropriate ?

4. Is it appropriate to use total hydrocarbon emissions as a monitoring surrogate for total organics emitted ?

5. Are the requirements for good incinerator operations properly stated ?

3. DETAILED DISCUSSION

3.1 ISSUE 1: Air Dispersion Models

Use of air dispersion models is a long-standing practice. Numerous simple-to-complex models are used routinely by the Agency and the regulated industries to assess compliance with air emissions and air quality standards. Accuracy and precision of predictions from these models depend heavily on data concerning meteorological conditions, source composition, emission rates, velocity at the emission point, and physical configuration inputs.

Dispersion values and ground level concentrations calculated by these air dispersion models change as the inputs for the meteorological conditions, emission rates, emission velocities, and stack heights are changed. Topography surrounding a source plays an important role in estimating expected concentrations at ground level.

The EPA chose three approved air dispersion models. The ISCLT model is constructed to determine air concentrations for urban and rural situations where terrain elevations do not exceed stack height. The LONGZ and COMPLEX-1 models are designed for use in complex terrain situations. These models were recently

evaluated by the PIC Subcommittee of the SAB and were found to be scientifically sound to calculate ground level concentrations within the half an order-of-magnitude precision range. The models are scientifically supportable, but require reliable input data, which are not easy to obtain. Many potential users may not be familiar with the assumptions and uncertainties involved with the models, and indiscriminate use of the models and annual average values can be misleading.

This Subcommittee chose not to conduct another in-depth review of these models; because several members of the Subcommittee also served on the PIC Subcommittee and were familiar with its conclusions, the majority of the Incineration Subcommittee accepted the findings of the PIC Subcommittee on air models as reported in the PIC draft report referenced earlier (see page v, and also reference 5).

The Agency chose to use the three models to calculate initially the maximum ground-level concentrations for ten existing sewage sludge incinerators. EPA then conducted a sensitivity analysis of the ISCLT model to determine the feasibility of developing a simplified model for obtaining dispersion factors. The analyses were designed to evaluate the sensitivity of the following parameters: incinerator stack design, including stack height and emission temperatures; meteorological conditions; and location of the MEI.

After these limited sensitivity analyses were completed, the Agency developed the regression coefficient for the relationship between dispersion factors and stack height for the reasonable worst case facility. The meteorology and building dimensions were held constant while stack height was varied.

The Agency thus used one model (i.e., ISCLT) with only one meteorological input datum and then developed a simplified model which used stack height as the only variable to derive dispersion factors. This new simplified model was subsequently used in an additional conservative mode to arrive at the dispersion values for the incineration regulations. The Subcommittee observes that emission rates , emission velocities, and transformation processes (wet and dry deposition and chemical transformation), all important variables, were not considered in obtaining air dispersion factors. The Subcommittee has the following additional comments and suggestions concerning the use of these models in the proposed regulations:

1. The three models noted above are all EPA approved models. Each was formulated for use under its own specific set of topographic conditions. The Agency publications on these models specifically recognize the inaccuracies and imprecisions that result when a model

designed for flat terrain is used to predict ground level concentrations for hilly terrain. Although the EPA manuals for model use identify these scientific problems associated with misuse, the Agency, in developing the proposed regulations, ignores its own technical requirements and chooses to use "maximum" predicted values from any of the three models, regardless of their applicability. The Subcommittee recommends that the Agency use these models to arrive at "dispersion factors" within the bounds defined in their technical reports. There is insufficient scientific evidence that dealing with emissions from sewage sludge incinerators requires specifically designed models, and the Subcommittee concludes that no new simplified air transport model is needed for these specific regulations.

2. Initially, the Agency selected three approved models to estimate air dispersion factors; but in the final regulation development, the Agency used "stack height" as the only variable to calculate these factors. This approach is misleading in that it gives the impression that EPA approved air dispersion models were used appropriately, when in fact, "dispersion factors" were calculated for only one meteorological and site condition with only the stack height varied for the purpose of dispersion calculations. No matter how scientifically sound the construct of a mathematical model may be, the output or the prediction will be no more accurate than the input information. This aspect has not been given enough attention by the Agency. We also comment on the unscientific and poor practice of reporting calculated values to many more significant figures than can be technically justified.

Since these models provide a crucial numerical input for further regulatory calculations, the Subcommittee recommends that "multiple" simulations be done where data from several different sites are used as input to represent the many locations of incinerators in the country. These simulations would represent a scientifically sound, "realistically large" number of outcomes that can be statistically summarized to give estimated "most probable," "x-th percentile level," "mean," and "median" values for the dispersion factors.

3. The Subcommittee observes that validation of a given model's ability to predict ground level concentrations of organic compounds, or the back-calculated permissible stack emission levels that would be protective of the MEI has not yet been achieved by the Agency. In a recent SAB resolution on modeling

(referenced above), it was pointed that the accuracy and precision of many models remains largely unknown. The Subcommittee believes that, in the long run, the Agency would be well served to support research on "model validation" (a generic issue) in order to reduce the prediction uncertainties which may be unnecessarily costing our society large sums of money.

3.2 ISSUE 2: Definition of The MEI

The Agency defines the MEI as a hypothetical construct who lives at the point of maximum ground level concentration, is exposed 24 hours per day, breathes 20 cubic meters of air per day, weighs 70 kg, and is exposed for a 70 year lifetime. These assumptions are best described as a policy choice rather than one that is developed by scientific reasoning or facts.

For example, we know of no evidence to show that such an MEI exists at any current or future sewage incineration site or come close to living outdoors continuously 24 hours a day for 70 years at the point of maximum ground level concentration. If one looks at the census information, it can be easily seen that at least 10 hours per day are spent elsewhere by any individual living in any geographical area. Similarly if we use human life cycle data, it is obvious that human body weight is a function of time with childhood mass increasing from 3 kg at birth to 35 kg in the first 10 years of growth. Additionally, because of shifts in meteorological conditions, the maximum ground level concentration can not coincide with the MEI for 24-hours per day for 70 years. The only justification for choosing a "constant value" for all the factors used to define the MEI could be traced to seeking simplicity in calculating risks.

The Agency has taken an overly conservative approach in the definition of the MEI. The selected scenario is not representative of sludge incinerator sites. The previously mentioned SAB Subcommittee which reviewed PICs also addressed the MEI issue. Again, because some members of our Subcommittee participated in that review, we did not initiate any new investigations to cover the same work. With the exception of one member, the Subcommittee supports the comments and conclusions presented in the PIC Subcommittee report.

Finally, the 1985 report noted above (reference 9) summarized the issue of determining exposure to incinerator emissions with a statement which, unfortunately, is still largely applicable: "The efforts of the Agency to assess such exposures have been inadequate because they resulted from either individual judgments or computer models without adequate laboratory or field validation."

The definition of the MEI, the simplified method of deriving air transport dispersion factors, the assumptions of q^* values, and the assumption of detection level concentrations for chemicals never measured, when combined, yield large uncertainties and bias in the calculations of cancer risks. In order to achieve a "reasonable worst case" for these calculations the Subcommittee suggests that it is scientifically more appropriate to use a "probability distribution approach" to represent variations of ground level concentrations as a function of time and the definition of the MEI with appropriate functions of time, space, and exposure durations. We recognize that developing more scientifically defensible risk calculations will require more support of long-term, sustained research within the Agency.

3.3 ISSUE 3: Assumptions RE Air Pollution Control Devices

Most of the data used in the development of the proposed regulations regarding incinerator facilities are based on old tests employing analytical methods with questionable quality control; these were called into question by the Subcommittee. More recent comprehensive EPA sampling studies are also limited in value because they represent old incinerators with old air pollution control devices--not representative of the state-of-the-art. Also, the statistical methods employed did not separate the effect of differences in emissions from the incinerator from the effects of differences in the efficiency of the control device. Thus, the quality of the data base hampers the Agency's ability to establish regulations.

To the extent that EPA's good efforts were able to obtain any data at all, which were necessarily from technologically substandard facilities, the Agency focused most heavily on metals control. While metals emission control for certain volatile elements is most efficient at lower temperatures (1200^0-1600^0 F to avoid volatilization), the destruction of organics can require higher temperatures (>1600^0 F). In principle, it is possible to maintain a low solids temperature to minimize metals vaporization and a high gas temperature to ensure high burnout efficiency of the volatiles. To maximize simultaneously control efficiencies through a single temperature limit for both metals and organics is difficult.

The key issue is whether or not the Agency's generalizations on control efficiencies made from the available data base is suitable to represent the entire universe of combustion systems and air pollution control devices. The Subcommittee concludes that the generalization is flawed due to the practice of indiscriminate averaging over a range of different types of

combustion devices, different operating conditions, and different types of air pollution control devices. In particular, the metals emissions will be dictated by the design and operating parameters of the combustion system and air pollution control device, and it is not appropriate to average control efficiencies across the entire system without consideration of the individual design and operating practices of the incinerators.

The mechanisms by which metals escape from the incinerator are correctly recognized in the proposed regulation development. However, the ultimate emissions of metals from the incinerator system, including the air pollution control device, will be dictated by a wide variety of other parameters that were not correctly evaluated and considered in the proposed regulations.

Specifically, the ultimate size of metal particulates and the partitioning of the metals as a function of size will be dictated not only by the sewage sludge characteristics, but also by the subsequent quench rate that occurs downstream of the incinerator device. Volatile metals will condense and form different types of particles depending on the metal species formed in combustion and on the rate of quench. The resulting size distribution will determine the capture of metals that will occur within the particulate removal device. The temperature within the air pollution control device will dictate the species formed of the highly volatile metals; for example, mercury and lead can have forms that are highly volatile even at air pollution control device temperatures. The temperature of the air pollution control device will normally result in the condensation of these metals on particulates and the subsequent ability to remove material from the flue gas.

At a minimum, the Subcommittee recommends that the combustion device be considered separately from the air pollution control device. The averaging of metals control efficiencies over a wide variety of parameters as was done is clearly misleading and can lead to misleading conclusions.

The development of control efficiencies for different metals is a critical need and the date base must be broadened if such generalizations to the universe of combustion devices and air pollution control devices is to be accomplished. In addition, the regulations must be accompanied by appropriate guidance to permit writers to allow them to implement the regulations.

The parameters specified in the regulations fall into several areas. One set of parameters are dictated when testing will not be required for incinerators; a second set is dictated when an incinerator is tested for metals emissions. The second set is generally more flexible and based on operating conditions during the test burn.

If the average control efficiencies as specified in the proposed regulations are not appropriate due to flaws in the averaging process, then it becomes necessary for permit writers to specify the appropriate operating conditions. The establishment, within the regulations, of operating conditions may not be the most appropriate means to construct the regulations. Having requirements that dictate the design and operating conditions of incinerators removes the incentive for the development of new combustion devices and can tie the hands of permit writers who are dealing with special problems that were not foreseen in the regulations.

The design of an air pollution control device is important for emissions control. A venturi scrubber can remove some submicron-sized particles (depending on the pressure drop), but a spray impinger can not. If one does not discriminate removal efficiency data with respect to equipment type, one can encounter the types of misinformation in the regulations that relates control efficiency to excess air levels.

A more generalized regulation which specifies an emission standard and suggests guidelines for the development of appropriate permit conditions would provide the flexibility both for innovative process and permit development. Again, the permit writer must be provided with very good guidance about the impacts of design and operating conditions on the partitioning of metals throughout the system.

With regard to the performance of air pollution control devices, the proposed excess air limitation (12% oxygen limitation for multiple hearth incinerators and 7% oxygen limitation for fluidized bed incinerators) is unjustified. The important factor is the air pollution control device design and operation. For a venturi scrubber, a reduction in excess air may result in lower pressure drop and lower scrubbing efficiency. Total air flow through the air pollution control device is more important than excess oxygen level in terms of air pollution control device performance.

3.4 ISSUE 4: Total Hydrocarbons As A Monitoring Surrogate

The Subcommittee reviewed the issue of using total hydrocarbons (THC) monitoring as an appropriate surrogate for total organics emissions and whether or not there is a scientific basis to estimate risk from exposure to organic emissions using measure THC values.

For a number of technical reasons, the Subcommittee concludes that the proposed THC monitoring device, the proposed limits on THC emissions levels, and the basis chosen for

estimating the weighted potency of the organic emissions are flawed and can not be supported scientifically. We support the Agency's efforts to find a direct or indirect surrogate for organics concentration in stack flue gas as a means of regulating emissions, but find that additional work will be needed before this goal can be put into practice.

The Subcommittee offers these specific observations about using the THC level as a surrogate for organic emissions, the monitoring device, and the role that they may play in sewage incinerator emission control:

1. THC monitoring plays an important role in the proposed regulations, as a means of judging the adequacy of the operation of a sewage sludge incinerator. The draft PIC Committee report recommends the use of THC monitoring "as a measure of good combustion practice." The Agency proposes to use a FID (flame ionization detector) to measure, on a continuous basis, THC as a surrogate for assessing total organic emissions. The Subcommittee endorses this concept for monitoring; but because the accuracy and reliability of such instruments have not been ascertained under actual continuous operating conditions, we conclude that the THC as a surrogate is not technologically supportable at the present time.

The key issue of the use of the total hydrocarbon monitors for incineration systems is the long-term operability. There is indeed instrumentation available, based on the flame ionization detector system, for continuously monitoring total hydrocarbons. However, it has not been demonstrated that systems using unconditioned hot stack gas samples can operate continuously in the sewage sludge incinerator stack gas environment. The Agency Office of Solid Waste has recently recommended to permit writers that they consider the use of pre-conditioned stack gas sampling with a cold THC analyzer equipped with an FID for Tier II hazardous waste incinerator stack gas (EPA Memorandum, April 7, 1989, Guidance on PIC Controls for Hazardous Waste Incinerators). A cold sampling train FID eliminates many of the operating problems associated with using hot systems for continuous monitoring (reference 2). Given the state-of the-art of continuous THC hot stack gas monitoring, we believe that it is not appropriate to propose regulations prior to a demonstration of feasibility.

2. The underlying assumption for the development of

the proposed regulation for THC is that total hydrocarbons, as measured, can be related with total organic carbon, and that total organic carbon can be related to risk. The approach to develop this relationship is based on the available data on total hydrocarbon emissions and measurement of target organics by sampling and gas chromatograph/mass spectrometer (GC/MS) analysis.

The Agency performed a statistical correlation analysis to relate FID total hydrocarbon measurements with samples collected for GC/MS analysis of selected volatile and semi-volatile organics. The correlation coefficient determined was only for those species selected for GC/MS measurement and does not include all organics. In fact, the data indicated that 90% of the organics were unaccounted for by this analysis. Other work in the Office of Air Quality Planning and Standards, as well as work reported by Environment Canada, have indicated that, at this time, total hydrocarbon measurements by FID can not be reliably correlated with specific or total organics emissions, and additionally, that correlations between total hydrocarbons and polychlorinated dioxins and furans, compounds of concern, are poor (reference 1).

3. The Subcommittee concluded that the use of THC measurements as indicators of incineration system performance extends current technical practice. It is clearly poor combustion practice to have high levels of THC emissions. The state-of-the-art of waste combustion should allow total hydrocarbon emissions to be minimized. The data base from alternative types of waste combustion systems generally reflects a total hydrocarbon emissions level of less than 10 ppm (corrected to 7% oxygen).

Most waste combustion systems have total hydrocarbon emissions that are near the detection limit of traditional FID systems. Nonetheless, the regulation, as proposed, would allow hydrocarbon emissions well in excess of the state-of-the-art of other waste combustion devices. Allowable THC emissions would be from 20, to well over 100, ppm for sewage sludge incinerators, depending on stack height and other operating variables. The data base currently available for sewage sludge incinerators indicates that the operating range is typically between zero and 30 ppm.

The standards proposed for THC would not additionally restrict the performance of sewage sludge incinerators and they would not force an improvement of technology,

but would, in fact, allow a relaxation of the appropriate operating conditions.

4. The THC measurements at best may indicate the combined performance of combustion and air quality control devices. How these measured concentrations at the stack relate to environmental concentrations of carcinogens remains unknown at this time. Because of a few very large values of risk calculated by the Agency for incinerator emissions, the Subcommittee looked carefully at the several steps and assumptions in these calculations and concluded that the accuracy and precision of the Agency analysis is questionable.

The Agency used "detection limit" concentrations for carcinogens to calculate the weighted q^* values (the cancer potency value, expressed as the slope of the dose-response curve in the low-dose range--see reference 3). There is no scientific basis for choosing these values. In fact, a weighted q^* value of 8.7×10^{-4} $[mg/kg/day]^{-1}$ and 3.5×10^{-4} $[mg/kg/day]^{-1}$ for diethylstilbestrol and 2-nitropropane respectively are introduced by this arbitrary choice. The total potency-sum of these two non-detected compounds is nearly 10% of the calculated total potency for carcinogens. The very limited data base from sludge incineration also does not indicate the presence of these compounds.

On the other hand, the 95% emission concentrations for benzene, benzo(a)pyrene, chloroform, and formaldehyde are found to be in "measurable" amounts giving rise to weighted q^* values of 1.6×10^{-4}, 3.6×10^{-3}, 3.1×10^{-4}, and 6.0×10^{-4} $[mg/kg/day]^{-1}$, respectively. The total potency, that is the sum of the q^* values, from these four compounds, is 4.67×10^{-3} $[mg/kg/day]^{-1}$, which is about the same as from the assumption of the "detection limit" values for the two undetected compounds cited above. It is our recommendation that the scientific foundations for the measurements of individual chemical carcinogens be better defined.

The apparently flawed risk estimation methodology used by the Agency to develop these regulations leads to forecasts of very high cancer risks associated with sewage sludge incinerator technology. As indicated earlier in this SAB review, the MEI assumptions, simplified air dispersion factors, assumptions on q^* values, and the assumption of detection level concentrations for chemicals never measured, inherent in these regulations, are extremely conservative and consequently unrealistic. The risk estimates are

suspect. The Agency should either re-evaluate and improve the basis for producing estimates of risk or alternatively, if shown to be feasible, initiate epidemiological studies to determine the incidence of carcinomas or other adverse health effects in persons residing around existing incinerator facilities. This would be a direct test of the validity of the risk estimates and hence the appropriateness of the data and assumptions used in the calculations. This information will not be obtainable in the short run.

5. Monitoring of emissions at the stack will at best provide data on how well the incineration and air pollution control devices are working. To provide surveillance of how the MEI is protected, periodic monitoring should be done at ground level where maximum concentrations must not be exceeded. Contributions by other sources should also be considered.

3.5 ISSUE 5: Requirements for Good Incinerator Operations

The Subcommittee considered many questions in evaluating the regulations proposed for controlling operations of the combustion device and the air pollution control device that together constitute the incinerator system. The Agency's approach seeks to establish minimally acceptable operation conditions, that if satisfied, will prevent the need to perform compliance testing. This approach potentially could reduce the cost of compliance for municipalities and operators of sewage sludge incinerators. However, at the present time, we do not find that there is an adequate data base nor an adequate understanding of the relationship between operating parameters and emissions to support such a non-testing rationale.

An important factor in the proposed regulations is the means by which they will be implemented. The establishment of operating parameters and specific values for operating parameters in the regulation could be a road block to the successful implementation of these regulations. The Agency correctly recognized the general relationship between metals volatility and the operating temperature of the combustion device. However, it was not recognized that the one temperature to be specified is the temperature that the metals actually experience within the burning bed of sludge. That particular temperature is difficult to measure and is not appropriate to be considered in a regulatory strategy. A possible alternative use of temperature as a control parameter would be one in which it is characteristic of the operating incinerator system. If a compliance test is run and metals' limits are established to be acceptable, then the

operating temperature can be monitored as a single temperature for the entire combustion system device. It is not appropriate to use a temperature that is generalizable to all combustion systems without specifying exactly how it would be determined.

To achieve the maximum environmental benefits, it is important to have regulations that impel society to take actions that result in a reduction in any harmful emissions. The Subcommittee suggests three major areas for emphasis: training and education of incineration plant operators; at-source reduction of toxic metals that presently enter the municipal wastewater system; and performance-based regulations that provide incentives for better pollution control equipment with lower life cycle costs.

The most important operational parameter is the training level of the operator of the sewage sludge incinerator system. A high level of operator training should be required in order to ensure that the system is continuously operated in a safe manner. The regulations could require a minimum level of training as well as a training certificate. Economic costs and benefits associated with the use of highly trained personnel should be considered.

It is important in the proposed regulations to establish those parameters that influence the emissions of metals and organics. However, because of the inter-dependence of the many operating parameters, it is difficult to define a single set of parameters that will ensure that all systems of different designs and operating conditions are functioning in a safe manner. The implementation of the regulations by permit writers must allow the establishment, on a case-by-case basis, the emissions and relationships to operating conditions. A compliance test could be conducted and the operating conditions established at the same values for which compliance was assured.

The Subcommittee finds that the Agency has correctly identified metals emissions from sewage sludge incinerators as requiring high priority for regulation. However, due to faulty statistical analysis of the incinerator emissions data base, the proposed control of incinerator operating conditions is incorrect and unsupported. Our review of the test data indicates that the control efficiency for metals removal is mainly a function of the air pollution control equipment, for the operating range typically seen in sewage sludge incineration.

We also recognize the advance in regulatory strategy that the Agency shows in proposing to limit the THC in the stack flue gas and thus make it unnecessary to regulate other parameters such as excess air and minimum operating temperatures which influence organics destruction. This is an improvement over current regulatory practices for hazardous waste incinerators

which reach an impasse when a multitude of dependent operating parameters are limited as though they are independent and can be regulated separately.

Problems with the level of emissions of the PIC from sewage sludge incinerators can be exacerbated if operating temperatures of 1200^0-1600^0 F exist, as below 1500^0 F, reaction rates start to decrease. At higher temperatures, the reaction rates for organics destruction are fast and mixing or mass transfer rates need to be considered. As most sewage sludge incinerators operate in the range where time and temperature history have an impact on destruction and removal efficiencies (DRE) for organics, low levels of THC should be a good indicator of operations desirable for the protection of human health and the environment.

A maximum operating temperature limitation appears rational, as data indicate that for combustion of organic compounds. little improvement in destruction efficiency is realized if the temperature is higher than about 1600^0 F and the incinerator is properly designed. Hazardous waste incinerators are operated at 1800^0 F to provide some safety margin. Sewage sludge incinerators frequently process waste streams characterized by elevated metals content. Consequently, higher operating temperatures can volatilize certain toxic metal salts and produce submicron particles which may require special and costly air pollution control devices to capture. In view of these observations, and concerns regarding data quality, the proposed limitation of 1650^0 F is not justified. More research is needed to support setting a specific maximum temperature limit . In addition, a maximum temperature limit which excludes sludge vitrification and other high temperature technologies is unwarranted as alternatively designed systems, e.g., for vitrification, may accommodate higher operating temperatures.

The Subcommittee recommends that additional attention be given to the composition of the sludge and that appropriate issues of source reduction and pre-treatment merit further study. It is generally agreed that a superior option for control is to limit the amount of metals entering the incinerator.

For good operating management of an incinerator, it is important for the operator to have continuous monitoring of oxygen, temperature, and sludge feed rate. We think that such monitoring should be required. However, except to relate these operating variables to certain control options, and to relate them to site specific conditions of successful compliance testing, we find it unwise to set universally applied operating numbers.

5. REFERENCES

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6. GLOSSARY

ADF.....Air dispersion factor, major parameter generated by air models and used to determine ground-level concentrations of contaminants from source mass emissions; stated in ug/m^3 $(g/sec)^{-1}$

CFR.....Code of Federal Regulations

COMPLEX-1.....USEPA air model for use in rural areas with complex terrain

EEC.....Environmental Engineering Committee, SAB

FID.....Flame Ionization Detector; so called "hot" FIDs utilize un-conditioned, high temperature stack gas, while "cold" FIDs work with pre-conditioned (via traps, filters, etc) lower temperature stack gas.

GC/MS.....Gas Chromatograph/Mass Spectrometer

ISCLT.....USEPA long-term air model for industrial source complexes

LONGZ.....USEPA air model for use in urban areas with complex terrain

MEI.....Most Exposed Individual; a hypothetical person living at the point of maximum ground-level concentration of the pollutant of concern, who is exposed 24 hours/day, breathes 20 m^3 of air/day, weighs 70 kg, and is exposed for a 70 year span

NRDC.....Natural Resources Defense Council

OW.....Office of Water, USEPA

PIC.....Products of Incomplete Combustion

POTW.....Publicly Owned Treatment Works

q^*.....Cancer potency value, expressed as the upper-bound estimate of the dose-response curve in the low-dose range in $[mg/kg/day]^{-1}$

SAB.....Science Advisory Board of the EPA

THC.....Total Hydrocarbons

W170.....A Committee of experts, assembled by the U.S. Dept. of Agriculture, on the land disposal/land application aspects of sewage sludge treatment

4. CONCLUSIONS

The Office of Water has made a strong effort to use a limited data base on emissions and the associated health risk of toxicants to develop a risk-based regulation for sewage sludge incinerators. These regulations focus on the control of metals and organics emissions from incinerators. The Subcommittee believes that incineration is an important and viable technology for sewage sludge disposal; we conclude however, that there are a number of technical flaws with the currently proposed regulations which are likely to preclude the effective regulation of sewage sludge treatment by incineration.

These risk-based regulations do not have a strong enough technical basis to allow actual standards to be developed directly, due to a wide range of uncertainties associated with the risk-based analysis. Many safety factors are built into the analysis. Each individual safety factor appears reasonable, but the multiplicative use of a series of such factors makes the final number unreasonable. The methodology as presented does not explicitly assign measures of uncertainty or confidence to the calculations. A false and misleading impression of confidence is conveyed by the final expression of risk as a single number.

Even though the Agency tried to simplify the regulatory process, the proposed regulations will be difficult to implement because the simplified compliance requirements are based on faulty statistical analysis. They will put a heavy burden on permit writers.

Statistical analysis of the limited data base for emissions are flawed due to the practice of indiscriminate averaging over a range of different types of operating devices, different operating conditions, and different types of air pollution control devices.

We endorse the concept of using a stack gas measure of total hydrocarbons emissions for monitoring sludge incineration and air pollution control device performance. However, the use of total hydrocarbons as a direct indicator of risk is not possible due to the uncertainties associated with the field implementation of hot FID systems and the lack of a direct link between total hydrocarbons, as measured by the FID, and the total spectrum of organics which might be emitted from sewage sludge incinerators. Also, since it has not been demonstrated that the proposed hot FID systems can operate continuously in the stack gas environment of sewage sludge incinerators, it is not appropriate to propose regulations that will demand such operation in order to be in compliance. Recent information provided by the Office of Water (reference 2), based on a survey of facilities using cold FID monitoring systems, suggests that this approach may well be a

feasible alternative method to monitoring THC. Adopting cold FID monitoring would thus appear to obviate the problems noted above.

Although we can understand the saving of resources that would follow if there were a technical basis to exempt operators of sewage sludge incinerators from required compliance testing, it is insupportable at this time to establish regulations in which individual incinerators would not have to be tested for compliance.

The air transport dispersion models used in developing the proposed regulations are approved EPA models with defined guidelines for their use. However, the Agency has ignored its own technical requirements in seeking to offer simplified ways of using results from selected model calculations. There is no scientific evidence that sewage sludge incinerators require specifically designed models to deal with their emissions. No new simplified air transport model is needed for these specific regulations.

This Subcommittee did not undertake a full review of the air transport models because it was aware of the findings of a draft report in preparation by the SAB PIC Review Subcommittee which dealt in detail with this issue (several of the Incineration Subcommittee's members participated in that review). The majority of the Subcommittee accepts the comments and conclusions of that report.

The Agency has taken an overly conservative approach in the selection of the most exposed individual. It is highly unlikely that any such exposure and physiology will actually exist. Again, since this topic was also addressed in the previously mentioned PIC report, we support the conclusions of that report.