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U. S. Environmental Protection Agency  
1200 Pennsylvania Avenue, NW  
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The Coalition for Responsible Waste Incineration (CRWI) appreciates the opportunity to submit comments on the *Interim PFAS Destruction and Disposal Guidance*; Notice of Availability for Public Comment. 89 FR 26,879 (April 16, 2024). CRWI is a trade association comprised of 30 members representing companies that own and operate hazardous waste combustors and companies that provide equipment and services to the combustion industry.

CRWI's specific comments are attached.

Thank you for the opportunity to submit these comments. If you have any questions, please contact me at (703-431-7343 or [mel@crwi.org](mailto:mel@crwi.org)).

Sincerely yours,

Melvin E. Keener, Ph.D.  
Executive Director

cc: C. Frickle, EPA

## Specific comments

First, CRWI would like to point out that no one disposal or destruction method is the best for all PFAS containing materials. The generator should be the entity that is responsible for choosing that method.

### Priorities on potential to release

The guidance sets up the following options from lowest to highest based on their potential to release per- and polyfluoroalkyl substances (PFAS) into the environment:

- Interim storage with controls;
- Underground injection;
- Hazardous waste landfills;
- Disposal in all landfill types for stable polymeric PFASs;
- Granular activated carbon reactivation units with thermal oxidizers operating under certain conditions;
- Thermal treatment under certain operating conditions;
- Solid waste landfills with composite liners and leachate and gas collection and treatment systems;
- Thermal treatment at lower temperatures (i.e., municipal solid waste incinerators, sewage sludge incinerators); and
- Construction and demolition landfills.

CRWI is concerned that the Agency believes that interim storage poses the least risk for release of these compounds into the environment. History suggests otherwise and there are measurable risks associated with interim storage. The Agency should not require holding all per- and polyfluoroalkyl substances (PFAS) containing waste in storage while waiting for a technology that will completely mineralize all PFAS compounds. In some ways, this is analogous to the chemical warfare agent storage that later created a far more difficult destruction process. The only way to minimize releases to the environment is to develop the criteria for destruction that requires all destruction methods to meet the same requirements as related to destruction and removal efficiency and resulting concentrations of products of incomplete destruction (PID).

However, CRWI agrees that some interim storage will be required and that raises several questions that are not currently addressed in the guidance. Some are as follows.

1. What does the Agency mean by interim storage?
2. Does the Agency have a storage method in mind?
3. What would be the requirements for this storage facility?

4. Will there be secondary containment requirements?
5. Will there be financial assurance requirements?
6. Will there be monitoring and reporting requirements?

Unfortunately, these questions cannot be answered through guidance. Since none of these compounds are listed as hazardous waste, the only regulations that currently apply are the same as apply to solid waste. Does the Agency plan to promulgate storage requirements for these compounds under 40 CFR 243?

### Thermal treatment

The Agency is correct that thermal treatment offers the potential to permanently destroy PFAS containing materials and to minimize PID emissions. Deep well injection and landfills can dispose of certain types of these wastes but do not offer a permanent solution. EPA research<sup>1</sup> has shown that 1100° C with a two second residence time results in no detectable PFAS compounds. The two studies (Clean Harbors and Chemours) cited in the 2024 revision show greater than 99.99% destruction and removal efficiency (DRE) of the tested compounds. More recent research has shown that the key to eliminating PIDs is to drive the reactions to form hydrogen fluoride. This can be done by ensuring there is excess hydrogen in the combustion process along with adequate temperature, residence time, and mixing.

Agency research has concentrated on destruction efficiency. In the real world, there is always some removal. This should be included in the evaluation.

The Agency states that short chain fluorocarbons such as CF<sub>4</sub>, CHF<sub>3</sub>, C<sub>2</sub>F<sub>6</sub>, and C<sub>3</sub>F<sub>8</sub> may be good indicators of mineralization. All can be measured using FTIR or OTM-50 and are potential low-risk candidates for surrogates for destruction. CRWI would like to remind the Agency that this is the same issue that it faced in the early days of setting emission limits for hazardous waste combustors. At that time, the Agency concluded that the best indicator of maximum destruction was good combustion conditions as defined by temperature, residence time, and adequate mixing. This is shown during testing and continuously monitored during operations using either carbon monoxide or total hydrocarbon as indicators. This concept is supported by the data produced at the Rainbow Furnace (Shields, et., al. 2023).

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<sup>1</sup> Shields, E., J. D. Krug, W. R. Roberson, S. R. Jackson, M. G. Smeltz, M. R. Allen, R. P. Burnette, J. T. Nash, L. Virtaranta, W. Preston, H. K. Liberatore, M. A. G. Wallace, J. V. Ryan, P. H. Kariher, P. M. Lemieux, and W. P. Linak. 2023. Pilot-Scale Thermal Destruction of Per- and Polyfluoroalkyl Substances in a Legacy Aqueous Film Forming Foam, *ACS ES&T Engineering*.  
<https://doi.org/10.1021/acsestengg.3c00098>

One of the stated concerns of the Agency is that at lower temperatures, the combustion process will result in CF fragments that will recombine post-combustion to create fluorinated PIDs. It is well known that destruction in a hazardous waste combustor is determined by a combination of temperature, residence time, and mixing in the combustion zone. This is why the Agency requires a hazardous waste combustor to conduct a test to show greater than 99.99% DRE. That test is also used to develop the operating parameters to show continuous compliance with the DRE requirements. A facility is not currently required to have 100% DRE. That is impossible to achieve. Just like it is not possible to achieve 100% mineralization of fluorine when destroying PFAS compounds. This is true for all destruction technologies. What the Agency needs to decide is what is the adequate level of destruction, develop the methods to measure the compounds of interest, and let the industry figure out how to accomplish this.

CRWI believes that showing greater than 99.99% DRE for the longer-chain PFAS compounds that are fed is relatively easy. We think the Agency agrees with us on this. The primary concern for any destruction technology is the potential generation of fluorinated PIDs. Thermal treatment is no exception. EPA has pilot test data showing that fluorinated PIDs are virtually non-existent at conditions above 1100° C with a two second residence time (Shields, et., al. 2023). Additional field test data will be generated in the upcoming Clean Harbors/EPA/Department of Defense test at the Aragonite facility. Once this data is available, CRWI encourages the Agency to update the guidance to include this information. There is no need to wait the full three years to incorporate this information into the guidance. Generators, treatment facilities, and the public need this information as soon as it is available.

The Agency should be concerned about fluorinated PIDs generated during combustion. CRWI would like to point out that this concern should be based on the risk to human health and the environments from these compounds. Toxicity information on shorter chain PFAS compounds is lacking. Without this information, it is impossible to determine what level of risk, if any, there is to human health and the environment from these compounds.

While complete destruction is never achievable, the use of a surrogate to indicate adequate destruction has been successfully used for years. The Agency has suggested using CH<sub>4</sub> or C<sub>2</sub>F<sub>6</sub> as potential surrogate for destruction of PFAS compounds. The Agency uses these two because they believe both are difficult to destroy. CRWI believes that this approach is incorrect. The choice of surrogates in this case should be what are the most prevalent measured fluorocarbon compounds in the flue gas stream. At this time, the only data on this is from the Shields, et. al., 2023, paper. If one were to look at Table 3 of the that paper, you find that the only two compounds that are consistently found above the detection limits at all temperatures in the flue gas were pentafluoroethane and trichlorofluoromethane. CF<sub>4</sub> was not found at any temperature and C<sub>2</sub>F<sub>6</sub> was only found at 970° C and lower. This would indicate that CF<sub>4</sub> and C<sub>2</sub>F<sub>6</sub> are not typical products of incomplete combustion. However, this data is limited to what is found in the laboratory. Upcoming field tests may give a different perspective.

### POHC selection

In the guidance, the Agency states “EPA’s preferred approach is to introduce a known concentration of a hard-to-destroy fluorocarbon and evaluate the behavior of this compound when exposed to specific thermal environments in order to characterize a more diverse set of possible PFAS PICs.”

This approach is similar to what was developed by the Agency in the late 1980’s when trying to determine how to show destruction of the primary organic pollutants and to minimize the amount of PIDs emitted. At that time, fluorinated hydrocarbons were not considered. However, the process for fluorocarbons should be the same as it is for non-fluorinated hydrocarbons. A facility chooses a principal organic hazardous constituent (POHC) based on where it lies in the incinerability index developed by University of Dayton. It then conducts a test that demonstrated either a 99.99% or 99.9999% destruction removal efficiency (DRE) depending on whether the units is regulated under RCRA or TSCA. The operating parameters developed during that testing are used to show continuous compliance with those requirements. This system has worked since the 1980’s. CRWI submitted detailed comments on this process in response to the 2020 version of the guidance document. The current incinerability index does not include any longer chain PFAS compounds. It is our understanding that the University of Dayton is currently generating these data. CRWI encourages the Agency to incorporate that research into the guidance as soon as it is available.

However, this does not answer the question of which fluorinated PIDs are released during thermal destruction. Based on EPA research, under certain conditions there are no detectible fluorinated PIDs using current measurement methods. Data on fluorinated PIDs from commercial hazardous waste incinerators do not exist primarily because a method to measure those compounds did not exist until the release of OTM-50. This method will be used in the upcoming Clean Harbors/Department of Defense test to be conducted in 2025. CRWI would urge the Agency to incorporate this into the guidance as soon as the results are available.

### PFAS deposition near thermal treatment devices.

The guidance suggest that additional research should be conducted on the deposition of PFAS compounds around thermal treatment facilities where fluorocarbons have been destroyed. Some of that work has already been completed and should be included in the next revision. One example is the work around the Norlite lightweight kiln in Cohoes, NY. This was initiated by a Bennington College report<sup>2</sup> showing increased PFAS contamination around the Norlite lightweight aggregate kiln. The Norlite unit had

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<sup>2</sup><https://www.bennington.edu/sites/default/files/sources/docs/Norlite%20News%20Release%20%5Bdb%20final%20updated%5D.pdf>

been treating Department of Defense generated PFAS containing waste. The Bennington study claimed soil and water testing showed the Norlite kiln was not properly treating PFAS wastes. Most who reviewed the study concluded that the sampling procedure was flawed but it prompted the New York Department of Environmental Conservation (NYDEC) to follow up with a more robust sampling around the facility.<sup>3</sup> The conclusions from the NYDEC report pertaining to deposition around the facility were:

- Analysis of soil concentrations does not show clear evidence of an increase in downwind PFAS concentrations;
- Analysis of soil concentrations does not show evidence of a significant increase in downwind metals concentrations;
- Analysis of stream water concentrations at high flow and low flow indicates possible influence from soils and precipitation in areas of low surface water PFAS concentrations, but not in locations with higher surface water concentrations, such as those found in the Patroon Creek and in the Salt Kill downstream from Norlite; and
- Analysis of surface water samples in areas of ponded water on or near Norlite property indicate that there are likely sources of PFAS compounds not associated with Norlite kiln emissions.

Finally, in the conclusion of the report, NYDEC states

As described in this report, sampling results were analyzed using a variety of basic statistical methods. These analyses did not indicate a clearly discernible upwind/ downwind gradient as is commonly found when soil samples are analyzed upwind and downwind from known emission sources of PFAS and metals. Given the absence of a deposition pattern attributable to this point source, the concentrations of PFAS observed in this study are consistent with background levels documented in the literature and more likely the result of 70 years of widespread releases to the environment since PFAS were introduced into commerce.

Another study on deposition around a thermal treatment facility was published by Martin, et., al. (2023).<sup>4</sup> The sampling procedure in this study was much better than in the Bennington College study. The following three quotes sum up the conclusions from this study.

While quantifiable levels of PFAS were detected in every soil sample in our pilot study, we are unable to pinpoint the direct source of contamination.

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<sup>3</sup> [https://extapps.dec.ny.gov/docs/materials\\_minerals\\_pdf/norlitesamplingfull0321.pdf](https://extapps.dec.ny.gov/docs/materials_minerals_pdf/norlitesamplingfull0321.pdf)

<sup>4</sup> Martin, K. V., T. J. Hilbert, M. Reilly, W. J. Christian, A. Hoover, K. G. Pennell, Q. Ding, and E. N. Hayes. 2023. PFAS soil concentrations surrounding a hazardous waste incinerator in East Liverpool, Ohio, an environmental justice community. *Environ Sci Pollut Res Int.* July. 30(33): 80643–80654.

All 35 soil samples had measurable amounts of PFAS (Table 2); however, due to the study design, we cannot directly link the observed PFAS levels in our study to the hazardous waste incinerator.

Site C had the highest PFAS concentration (8,300 ng/kg). Interestingly, site C is located over one kilometer upwind of the incinerator.

This study was unable to show that the source of soil and water PFAS contamination was due to the nearby hazard waste combustor.

#### Potential sources of release

The guidance discusses various sources of potential releases to the environment. This includes stack gases, bottom ash, and liquids from acid gas scrubbers and states that information on partitioning is lacking. The two previous Clean Harbors Aragonite tests performed PFAS material balances around the facility that include all media except for solid feeds. The media include liquid and sludge feeds, all input chemical reagents, ash/slag, baghouse dust, spray dryer solids, and stack emissions. That data has already been shared with the Agency. If this has not already incorporated into the guidance, it should be included in the next revision.

In addition, bottom and fly ash from a hazardous waste incinerator is considered as hazardous waste unless it has been delisted. As such, this material must be disposed of in a hazardous waste landfill. These landfills have been designed to prevent migration. Disposal to a hazardous waste landfill is one of the currently “approved” methods of disposal, will minimize releases, and is protective of human health and the environment. Some hazardous waste incinerators have zero waste water discharges. Others do not.

Recently, Region 5 took fly ash, bottom ash, slag, and water samples at the hazardous waste incinerator at East Liverpool, Ohio. The next revision to the guidance should include those results when they become available.

#### FTIR as a real-time technique for monitoring CF<sub>4</sub> and C<sub>2</sub>F<sub>6</sub>.

The guidance states that FTIR may be a viable option for detecting CF<sub>4</sub> and C<sub>2</sub>F<sub>6</sub> in real time depending upon its use. The current estimated detection limit for C<sub>2</sub>F<sub>6</sub> by FTIR is in the range of 10-25 ppb. The estimated detection limit by OTM-50 is in the range of 0.01-0.5 ppb. FTIR is not a viable technique for demonstrating greater than 99.99% DRE simply because the cost of the C<sub>2</sub>F<sub>6</sub> spiking gas would be approximately \$600,000 for a three-run test at a detection limit of 25 ppb. In contrast, the spiking costs when using OTM-50 to demonstrate greater than 99.99% DRE at a detection limit of 0.5 ppb will be about \$21,000.

### Future field work

CRWI agrees that future field work is needed/desired. However, that work should be oriented towards further refining the process needed for a combustion facility to show compliance through testing and setting operational parameters. Some of the objectives listed in Appendix A are more attuned to research projects than designed to show that a treatment method accomplishes its task. The Agency needs to determine the toxicity of the various PIDs and hone in on developing measurement methods for those compounds. This may become a moving target given the large number of potential compounds. While it will be impossible to determine the toxicity of all PFAS compounds, it is important to identify the most probable emissions and characterize their toxicity. These are the same issues that were faced in the early days of hazardous waste combustion of organic chemicals and resolved by using the current systems.

Right now, the Agency only has two measurement methods published. These cover approximately 110 PFAS compounds. They are currently working on another method which will expand this list of analytes. However, that effort will not come close to being able to characterize all the potential PFAS compounds. EPA should focus on deciding which PFAS compounds are important to human health and the environment, develop methods to measure them, and then decide what levels of emissions are protective. One cannot get to zero.

### Full scale testing data

One of the issues identified in the 2024 revisions to the PFAS disposal and destruction guidance is the absence of data on PIDs from a full-scale destruction unit. CRWI agrees that data is lacking but questions how relevant these data are without knowing the associated risks from these compounds. One of our members, Clean Harbors, is working with the Agency and the Department of Defense to continue their testing program at the hazardous waste combustor in Aragonite, Utah. This project is partially funded by a SERDP project being led by Sanborn, Head and Associates.<sup>5</sup>

### Appendix A

The experimental protocol in Appendix A has some good approaches and some that are technically or economically impracticable. Additional information will be gathered during upcoming tests. CRWI would be willing to work with the Agency to refine this protocol based on lessons learned during these tests. CRWI encourages the Agency to revise this protocol as often as needed.

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<sup>5</sup> <https://serdp-estcp.mil/projects/details/1df8ea8d-5722-47ee-8d17-51610397c8fc/demonstrating-cost-effective-pfas-destruction-through-high-temperature-incineration>



### Research needs for thermal treatment with priorities.

CRWI does not have any issues with the current priorities for thermal treatment as listed in the document. However, we believe that determining the toxicity of the compounds in question should be added as a priority. In fact, we believe that this should be one of the the highest priority. Without knowing the toxicity of these compounds, it is impossible to have an honest conversation about relative risk. Without knowing the risk, it is impossible to determine safe levels of emissions. To require testing on any destruction units without understanding the risk posed by its releases to the environment is just creating meaningless data.

### Future regulations

The current guidance does not establish concentrations of PFAS in wastes, spent products, or other materials that would require certain handling. This will be left to future regulations. CRWI agrees. The only current emission limits pertaining to PFAS compounds are the maximum contaminant levels for six PFAS compounds under the Safe Drinking Water Act. EPA has added perfluorooctanoic acid (PFOA) and perfluorooctane sulfonic acid (PFOS) as hazardous substances under CERCLA. There are no PFAS compounds listed as hazardous waste or as hazardous air pollutants (HAPs). Until those two determinations are made, the Agency does not have the authority to set emission limits for any of these compounds. Listing of a compound as hazardous waste is a complicated process that requires the development of treatment standards among other requirements. Any attempt to list a PFAS compound as a hazardous waste when discarded will take several years to complete. The same is true for listing PFAS compounds as hazardous air pollutants. Until they are listed as HAPs, the Agency does not have the authority to set emission limits under 40 CFR Part 63. The toxicology of each PFAS compound is needed before the Agency can add them to the list and that toxicology data is currently missing for all but a few PFAS compounds. While we are not telling the Agency anything they do not already know, CRWI suggests that the Agency take the time to complete these listings properly. The rush to list PFOA and PFOS as hazardous substances under CERCLA has created numerous unanticipated issues that now must be resolved. The Agency should carefully consider the consequences of each action before completing the process.

### Emerging technologies

In the 2024 revision of the guidance, the Agency discusses mechanochemical degradation, electrochemical oxidation, gasification and pyrolysis, and supercritical waste oxidation as emerging technologies. The guidance goes on to say that while current results show promise, additional studies are needed and that those studies need to more fully characterize the outputs of these processes. CRWI agrees. CRWI encourages additional research on emerging technologies from the simple belief that no one destruction method is best for all PFAS containing wastes. CRWI believes the Agency should keep all options open for generators to select the treatment option that is

best suited to their waste. One point we would like to make is that all destruction technologies should be held to the same criteria. For example, all should have the same destruction requirements, the same emission levels for the primary pollutant, and the same level of PIDs generated during the destruction process. No technology will be 100% effective. Hazardous waste combustors have shown the ability to destroy greater than 99.99% of the original PFAS compounds. Laboratory destruction experiments run by the Agency have demonstrated conditions where no PIDs have been detected (Shields et., al. 2023). Both studies are already discussed in the current revision. Additional data on destruction and PID emissions from a full-scale hazardous waste incinerator should be available in 2025.