Coalition for Responsible Waste Incineration

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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. 91 FR 22,825 (April 28, 2026). CRWI is a trade association comprised of 26 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).

Sincerely yours,

Melvin E. Keener, Ph.D.
Executive Director

cc: J. Tso, EPA
C. Villa-Santos, EPA
C. Davis, EPA

Specific comments

The research phase for using hazardous waste incinerators to destroy PFAS materials has been completed.

On numerous occasions in the report, EPA states that available performance and testing data are generally limited and that additional data are needed to support more specific guidance. In addition, the guidance states that data are lacking about the effectiveness of the operating conditions in different thermal destruction technologies and facilities. The guidance also states that additional studies are necessary to more fully measure and evaluate the ability to approach complete mineralization and eliminate potential formation of products of incomplete combustion.

CRWI contends that the important parts of the research phase on the destruction and removal efficiency (DRE) of PFAS compounds are now complete. Multiple tests from Clean Harbors and Veolia have shown that the original PFAS compounds can be destroyed with minimal products of incomplete destruction released to the atmosphere. Both of these units operated at afterburner temperatures near 1100 ºC. Arcwood, in conjunction with EPA, also undertook a commercial scale test program at its East Liverpool, Ohio facility, beginning in August 2025 and concluding in May 2026. Data from the Arcwood test is still undergoing review by Arcwood and EPA.

EPA should modify Appendix B to include a detailed summary of the test results from Clean Harbors, Veolia, and Arcwood.

While the text of the body of the 2026 guidance mentions the 2024 Clean Harbors Aragonite test and the 2024 Veolia Port Arthur test, Appendix B has not been updated to include the results of these tests. While it is not necessary to give a detailed description of each test, a more detailed summary of the results should be included in Appendix B. In addition, the references for the Clean Harbors test should include the report released by the Strategic Environmental Research and Development Program (SERDP) of the Department of Defense. Both reports (Troxler and the SERDP report) cover the similar ground, but each may have different perspective. Both should be included for completeness. The reference for the SERDP report is below.

Zemba, S., M. Duffy, M. Estabrooks, R. Iery, W. Fritz, F. Osman, R. Badireddy. 2026. Demonstrating Cost-Effective PFAS Destruction Through High Temperature Incineration. Final report. February 2026. SERDP Project ER22-3211

EPA already has a model for showing destruction and the minimization of PIDs.

CRWI agrees with the Agency that the DRE model used under 40 CFR Part Subpart O and 40 CFR Part 63 Subpart EEE is adequate to show destruction of the original compounds fed. Once EPA includes the thermal stability rankings for the PFAS compounds as suggested in another part of the CRWI's comments, the Agency will have all the tools it needs to use this model. As shown below C_2F_6 and CF_4 are the only two PFAS compounds that are in Class 1 of the thermal stability index. All of the other PFAS compounds are in Classes 2-5. This means that if a facility has already completed a DRE test using a Class 1 principal organic hazardous constituent (POHC), they have already established the ability to show 99.99% DRE for any PFAS compound currently in the thermal stability index. As such, there is no need for further DRE testing specifically for PFAS compounds, especially those measured by OTM-45. Previous DRE tests at that facility have developed the operating conditions necessary to show continuous compliance with the DRE requirement.

In addition, Table 3 of the Shields, et. al., 2023 paper that is referenced many times in the guidance shows a clear correlation between temperature, carbon monoxide, and products of incomplete destruction (PID). However, it should be noted that this is only one study using a pilot facility. Additional research on this possible correlation could be helpful.

<u>Appendix A should be revised as follows</u>

On Page A-2, EPA makes the following statement.

> To achieve these goals, it is necessary to determine the specific conditions (i.e., temperature, residence time, and turbulence) required to maximize DRE, minimize PICs/PIDs, and produce products appropriate for beneficial reuse.

CRWI agrees that turbulence is an important parameter in showing DRE but it cannot be directly measured. It can be calculated from gas flow rates and properties and equipment geometry. However, it is not possible to measure gas flow rates inside of the unit operations of interest (e.g., primary combustion chamber, afterburner, etc.). The best a facility can do is to model turbulence using a mass and energy balance model and a turbulence equation. In addition, turbulence is not an operating parameter used to show continuous compliance with a DRE standard. We suggest the guidance clarify that turbulence is not an operating parameter.

In addition, the Agency uses PICs/PIDs on many occasions in the guidance. PICs have been used for many years to cover a broad group of products of incomplete combustion. While this nomenclature is adequate for destruction using combustion, it is not appropriate for use by non-combustion destruction technologies. CRWI suggests that it is more appropriate to use the term PIDs (products of incomplete destruction) which encompasses all destruction technologies. This gives a consistent term that applies to all destruction technologies.

In the second bullet of the Sampling Details, the guidance states the following.

- All gas, liquid, and solid inlet, intermediate, and outlet streams would be collected and analyzed. This includes:

As the Agency already knows, getting a representative sample for solid inputs for a hazardous waste combustor is virtually impossible. Even if it were possible, safety concerns would prohibit sampling of certain types of containerized waste (e.g., lab packs, reactive wastes, pressurized drums, etc.). Also, it is not necessary to sample inlet streams such as natural gas streams or fuel oil. Sampling all intermediate streams would be a technical challenge, very expensive, and may not produce useful data. One way to address this is to add "applicable" after "all" and remove "intermediate" from the requirement. The revised bullet would be as follows

- All applicable gas, liquid, and solid inlet, ~~intermediate,~~ and outlet streams would be collected and analyzed. This includes:

The initial sub-bullet suggests sampling to include "all air pollution control devices..." It is not clear what EPA means by this phrase. Sampling before and between air pollution devices is generally not practical or possible because of the absence of sampling ports, adequate duct lengths to perform isokinetic sampling, and safety and access limitations. CRWI suggests removing this part of the bullet as shown below.

  - At the stack ~~and including all air pollution control devices (APCDs)~~.

In addition, EPA should consider adding the following to the sub-bullet points below.

  - All process materials (e.g., water used for spray dryers and/or scrubbers, powdered or granular activated carbon, high pH solution for scrubbers, dry alkali reagents) as they may contain PFAS and affect the results, if unknown.
  - All residual streams (e.g., bottom ash, spray dryer solids, baghouse and/or electrostatic precipitator [ESP] solids, scrubber effluent, spent carbon).

The third major bullet point lists what a comprehensive air emission source characterization would include. The second sub-bullet suggests using SW-846 Methods 0010/3542/8270 (soon to be OTM-55) with the inclusion of the Method 8270 procedure. CRWI suggests that the Agency has not identified why this method should be used. Trifluralin (2,6-Dinitro-N,N-dipropyl-4-(trifluoromethyl)aniline) is the only target analyte of EPA 8270 that contains fluorine (out of 105 target analytes). EPA's stated goal is to look for fluorinated PIDs. Based on preliminary data from one of our members, no significance levels of these 105 compounds have been found using this method. CRWI believes that this test will be a waste of resources for high temperature incineration. While it may be useful when testing facilities using lower temperatures or other destruction technologies, it should not be recommended for hazardous waste incinerators.

In the third sub-bullet, EPA suggests injecting carbon hexafluoride (C_2F_6) and carbon tetrafluoride (CF_4) at multiple injection locations, as a surrogate measure of destruction efficiency if appropriate and permitted. Based on experience gained during the three hazardous waste incinerator tests detailed in the most recent guidance, we suggest that this be modified. If both are injected simultaneously, an accurate determination of the destruction is difficult to make because the PIDs produced may distort the actual destruction. If both compounds are to be tested as surrogates, they should be injected during separate runs.

The fourth sub-bullet should be deleted because it is a duplicate of the second sub-bullet.

In the fifth sub-bullet, EPA suggests that C_2F_6 could be injected at multiple locations. CRWI is not sure of why this is recommended. We can see doing this (for example, in the rotary kiln and then in the afterburner) to determine the DRE if PFAS containing wastes were introduced in each location. However, these would need to be done during separate runs in order to properly interpret the data. As written, this could be interpreted as multiple simultaneous injections which would not allow a reasonable interpretation of the data. CRWI suggests this be clarified so that injections at multiple locations do not take place during the same test runs.

The fourth major bullet talks about a single, representative condition. CRWI would like to point out that if DRE is to be calculated, it should be determined before the test if the feed material contains a sufficient PFAS concentration to demonstrate the desired level of DRE or if additional PFAS compounds should be spiked to make the DRE determination.

In the "Supplemental Information" section, the term "DE" is not defined. EPA should provide a definition.

In the section on research questions on DRE, the guidance suggests sampling across multiple APCDs. As stated earlier, this is generally not feasible because there are no sampling ports upstream and down steam of most APC devices. If ports are installed, they must be located so that isokinetic sampling can be conducted (i.e., following requirements for number of duct diameters upstream and downstream of disturbances from EPA Method 1). The same point applies to the question on PICs/PIDs.

Where do C_2F_6 and/or CF_4 fit into the process

Both C_2F_6 and CF_4 are Class1 compounds (in the thermal stability index) and could be used for making a PFAS DRE determination. From the experience gained in the lab and the field, C_2F_6 appears to be a reasonable choice as a principle organic hazardous constituent (POHC). It is easy to accurately measure injection rates and will not likely be confounded by a presence in other feeds, making the DRE calculation less complicated. As will be shown later in our comments, the known thermal stability for other PFAS compounds puts them in classes that are less difficult to destroy. Even though C_2F_6 is a reasonable POHC, CRWI believes that there is no need for an additional DRE determination for PFAS compounds once the facility has shown 99.99% on a Class 1 POHC simply because the PFAS compounds of interest are Classes 2-5. Destruction of any Class 1 POHC will prove destruction for any Class 2-7 compounds. No additional DRE demonstration is needed.

CRWI does not believe that CF_4 is a good choice for making a DRE determination. However, it could be used to estimate the residence time for the entire system (front of the combustor to the end of the stack).

<u>EPA should update the thermal stability index in Appendix D of the 1989 trial burn guidance to include PFAS compounds</u>.

EPA initially released a thermal stability index in 1989 (Guidance on Setting Permit Conditions and Reporting Trial Burn Results. Volume II of the Hazardous Waste Incineration Guidance Series. January 1989, EPA/625/6-89/019. Appendix D. page 105, PDF 126 of 224). Table D-1 lists organic compounds based on their difficulty to thermally destroy and divides them into classes with Class 1 being the most difficult to destroy and Class 7 being the easiest to destroy. The data to generate this index were developed by the University of Dayton Research Institute (UDRI) under an EPA contract. UDRI researchers designed a system in their laboratory to determine at what temperature (in Celsius) 99% of certain compound would be destroyed under starved air conditions with a two second gas-phase residence time. They labeled this number as a $T_{99}(2)$. This number was then used to rank the compounds from the one with the highest $T_{99}(2)$ to the lowest. The seven classes were set up based on $T_{99}(2)$ values listed in Table D-3 (reproduced below).

Class	Compound ranking	$T_{99}(2)$ (ºC) range
1	1-34	1,590-900
2	35-77	895-800
3	78-199	790-705
4	120-193	695-604
5	194-252	600-425
6	253-271	415-360
7	272-320	320-100

A complete description of the process and results are in Appendix D. Unfortunately, Tables D-1 and D-2 only list compounds, ranking, and class. It does not contain $T_{99}(2)$ values for each compound.

$T_{99}(2)$ data were developed based on starved air conditions. Since most hazardous waste combustors are operated under excess air conditions, the absolute $T_{99}(2)$ value is not relevant. The only thing that is important is the ranking of each compound.

This index has been used since 1989 by hazardous waste combustors and others to select which organic compounds to use to meet the destruction and removal efficiency

(DRE) requirements under 40 CFR 264.343(a) and 40 CFR 63.1219(c) (for hazardous waste burning incinerators). While the index contains organic compounds that contain fluorine, it does not have any PFAS compounds. EPA recognized this deficiency and funded a study at UDRI to correct this. The resulting report was delivered to EPA in 2022 (URDI 2022). In addition, several peer reviewed publications have measured or calculated $T_{99}(2)$ values that could be added to the index. CRWI strongly urges EPA to update the 1989 thermal stability index to include new data on where various PFAS compounds fit into that index. Below is a table developed from the currently known references showing where various PFAS compounds fit into the thermal stability index. CRWI encourages the Agency to use the references cited below to verify the values in the table.

Compound	Carbon #	$T_{99}(2)$ (ºC)	Class	Reference
CF4	1	1450	1	Blotevogel, et al.,2023
		1380	1	Tsang et al., 1998
		1470	1	Tschuikow-Roux, 1965
C2F6	2	907	1	Blotevogel, et al.,2023
		912	1	Tsang et al., 1998
		919	1	Tschuikow-Roux, 1965
PFBS	4	750	3	Altarawneh, 2021
PFHxS	6	850	2	UDRI, 2022
PFOS	8	700	3	Weber et al., 2021
		750	3	Kahn et al., 2020
		850	2	UDRI, 2022
PFOSA	8	850	2	UDRI, 2022
PFBA	4	650	4	Altarawneh, 2012
PFPeA	5	800	2	Altarawneh, 2022
PFHxA	6	850	2	UDRI, 2022
PFHpA	7	850	2	UDRI, 2022
PFOA	8	850	2	UDRI, 2022
n-PFOA	8	700	3	Blotevogel, et al.,2023
br-PFOA	8	650	4	Blotevogel, et al.,2023
PFNA	9	850	2	UDRI, 2022
PFDA	10	850	2	UDRI, 2022
PFUnA	11	850	2	UDRI, 2022
PFDoA	12	850	2	UDRI, 2022
HPFO-DA	5	480	5	Blotevogel, et al.,2023

It should be noted that different sources report different $T_{99}(2)$ values for the same compound and they may disagree by as much as 200 ºC (e.g., PFOA). CRWI does not take a position on which values are most representative but would leave that to the Agency to determine. Some of these variations could be explained by the method used to either calculate or experimentally determine the values. In general, for $T_{99}(2)$ values to be comparable, they should be generated using the same procedure. The data in the table above contains $T_{99}(2)$ determined by both experimentation and various theoretical models.

It should also be noted that all of the $T_{99}(2)$ values generated by UDRI were 850 ºC. This is likely because the carbon-oxygen or the carbon-sulfur bond is weaker than the carbon-fluorine bonds. The length of the carbon-fluorine backbone does not seem to a determining factor on the $T_{99}(2)$.

The information presented above gives the Agency sufficient information to determine the class for each PFAS compound listed using Table D-3. That should be adequate for most circumstances because most hazardous waste combustors select a Class 1 principal organic hazardous constituent (POHC) when demonstrating DRE. All PFAS compounds (except CF_4 and C_2F_6 which the agency is considering as marker compounds) are ranked Classes 2 through 5. Thus, when a combustor meets the DRE requirements using a Class 1 POHC, it is also demonstrating that it can destroy the PFAS compounds of interest. Should the Agency want to take the next step and rank each PFAS compound in the index, they would need the $T_{99}(2)$ values for all of the compounds in Table D-1. Dr. Phillip Taylor (personal communications) has that information. That data are not CRWI's to share but we will encourage Dr. Taylor to provide that data to the Agency.

References that have developed $T_{99}(2)$ and/or thermal stability index rankings for PFAS compounds.

Altarawneh, M. 2012. A theoretical study on the pyrolysis of perfluorobutanoic acid as a model compound for perfluoroalkyl acids. Tetrahedron Letters, Volume 53, Issue 32, Pages 4070-4073. https://doi.org/10.1016/j.tetlet.2012.05.109.

Altarawneh, M. 2021. A chemical kinetic model for the decomposition of perfluorinated sulfonic acids. Chemosphere, Volume 263, Page 128256, https://doi.org/10.1016/j.chemosphere.2020.128256.

Altarawneh, M., M. H. Almatarneh, and B. Z. Dlugogorski. 2022. Thermal decomposition of perfluorinated carboxylic acids: Kinetic model and theoretical requirements for PFAS incineration. Chemosphere, Volume 286, Part 2, Page 131685, https://doi.org/10.1016/j.chemosphere.2021.131685.

Blotevogel, J., R.J. Giraud, and A.K. Rappé. 2023. Incinerability of PFOA and HFPO-DA: Mechanisms, kinetics, and thermal stability ranking. Chemical Engineering Journal 457(141235). February. https://doi.org/10.1016/j.cej.2022.141235.

Khan, M. Y., S. So, and G. da Silva. 2020. Decomposition kinetics of perfluorinated sulfonic acids. Chemosphere, Volume 238, page 124615. https://doi.org/10.1016/j.chemosphere.2019.124615.

Tsang, W., D.R. Burgess Jr., V. Babushok, On the incinerability of highly fluorinated organic compounds, Combust. Sci. and Tech. 139 (1998) 385–402.

Tschuikow-Roux, E. Kinetics of the thermal decomposition of C2F6 in the presence of H2 at 1300◦-1600◦K, J. Chem. Phys. 43 (1965) 2251–2256.

Weber, N. H., S. P. Stockenhuber, C. S. Delva, A. A. Fara, C. C. Grimison, J. A. Lucas, J. C. Mackie, M. Stockenhuber, E. M. Kennedy. 2021. Kinetics of decomposition of PFOS relevant to thermal desorption remediation of soils. Industrial & Engineering Chemistry Research, Volume 60, Issue 25, Pages 9080-9087.

UDRI. 2022. Thermal Destruction and Transformation of PFAS in Wastewater Treatment Residuals; Final Report. Contract No. 68HERC19D0009, Task Order No. 68HERC20F0142, APTIM Document Number: 501450-QA-PL-000469. Submitted to Task Order COR: Dr. Endalkachew Sahle-Demessie, October 18, 2022.

<u>Other issues</u>

1. On page 44, the Agency makes the statement that “Hazardous waste combustion technologies ... may not operate at those conditions at all times.”

   CRWI believes the last part of this statement is incorrect or at least misleading. Hazardous waste combustors are required to stay within the operating envelope developed during their last comprehensive performance test except when no longer burning hazardous waste or when following their startup, shutdown, or malfunction plan. At any other time, hazardous waste facilities are not allowed to feed waste. These requirements are codified in 40 CFR 63.1206(b). Facilities that destroy hazardous waste are simply not allowed to operate outside of their proven window of operations. CRWI suggests that the next version of the guidance correct that statement.

2. On page 46, EPA says there are 10 commercial incinerators. There are 11 commercial incinerator locations, some with multiple incineration units. We believe EPA is not counting Arcwood’s energetics incinerator in Joplin, MO in the 10.

3. On page 48, EPA mistakenly identified the location of Veolia test as Deer Park. That location is Port Arthur, TX. EPA should correct this error in the next version.