Clean Harbors Total PFAS Solution
EPAZ

AnnieLu DeWitt – Senior Director Total PFAS Solution, Clean Harbors

Our Total PFAS Solution

- PFAS Sampling
- PFAS Analysis
- Drinking Water Solutions
- Industrial Water Solutions
- Soil Remediation
- AFFF Management
- Transportation
- Disposal and Destruction

PFAS@cleanharbors.com

Presentation Outline

Defining SCID (Separation, Concentration, Isolation, Disposal/Destruction)

SCID by the Numbers

Creating PFAS Treatment and Disposal Narrative

Evaluation Criteria for PFAS Destruction Technologies

Mass in and Mass Out

OTM-45, OTM-50 and Draft OTM-55

PICs and PIDs (Products of Incomplete Combustion and Destruction)

3 Ts (Time, Temperature and Turbulence)

Stages of Thermal Treatment and Control Technologies

Permitting and Oversight

Scalability and Cost

Definition of **SCID** for Clean Harbors

- **S**eparate- Separate PFAS compounds from large volumes of water onto small quantities of media (adsorption and ion exchange)
- **C**oncentrate- PFAS is concentrated onto media (millions of gallons reduced to pounds of media)
- **I**solate- The PFAS compounds are isolated onto media where they can be disposed of or destroyed based on customer choice
- **D**isposal or Destruction- This is where different approaches come into play. Our policy is to treat PFAS is the most conservative manner. It is treated as hazardous in every aspect except for transportation costs. The Clean Harbors internal PFAS policy is not to third party any PFAS impacted material. It remains in our custody from “cradle to grave”. It is either directed to our “closed loop” subtilte C hazardous landfills or sent to our MACT compliant hazardous incineration facilities.

SCID by the Numbers

Separate, **C**oncentrate, **I**solate, **D**ispose or **D**estroy

minimizes transformation and liberation potential
Reliable and tested method that meets the strictest of discharge criteria
Over **12 billion gallons of PFAS impacted water** treated and discharged

Potable applications **10ppt-500 ppt** total PFAS concentrations. Carbon and Resin adsorption and ion exchange

Non potable applications **100 ppt-12 ppm** options grow for absorption and ion exchange
We can start using modified clays and zeolites for pre-treatment and PFAS removal. They will do bulk removal and protect the carbon and resin

Enhanced SCID*- **5ppm-50 ppm-** ARFF clean outs, landfill leachate, RO reject water.
Patent pending micelle introduction and removal system as a pre-treatment step to treat the most difficult PFAS impacted water sources.

CleanHarbors

Gathering Information for Creating a Defensible Treatment/Disposal Narrative

Treatment /Disposal Option	Viability	Acceptance	Permitting Oversight Level	Scalability	Cost	Speed of Deployment	Results Record	Waste Generated

Once you narrow down treatment and disposal options compare facilities and suppliers and what they offer for certificates of disposal or destruction. Are they hazardous or non-hazardous permitted. Distance of facility from site. Transportation costs. What other types of materials are disposed of at these sites.

CleanHarbors

Evaluation Criteria for Destructive Technologies
*The D in SCI**D***

Thermal destruction is by far the most studied and evaluated technology. Clean Harbors has kept up with the most updated and approved methods for evaluation.

-OTM-45 studies- achieved 99.9999% DREs

What's next: Publishing results for OTM-45, OTM-50 and (modified OTM-55) later this year.

Q. What does that mean?

A. It means that not only will it demonstrate removal efficiencies for the intact PFAS compounds but will also answer lingering questions about possible production of PIDs. (Products of Incomplete Destruction)

Not all studies are created equal. Mass **in** has to be high enough to evaluate Mass **out**

CleanHarbors

Viability Tools and Terms

-What is your criteria for evaluating viability? (ex. compound list)
-What tools can you use to measure viability for a destructive technology for PFAS?(ex. OTM-45)

DRE- Destructive Removal Efficiency

Concentration of a contaminant in → Concentration of a contaminant out

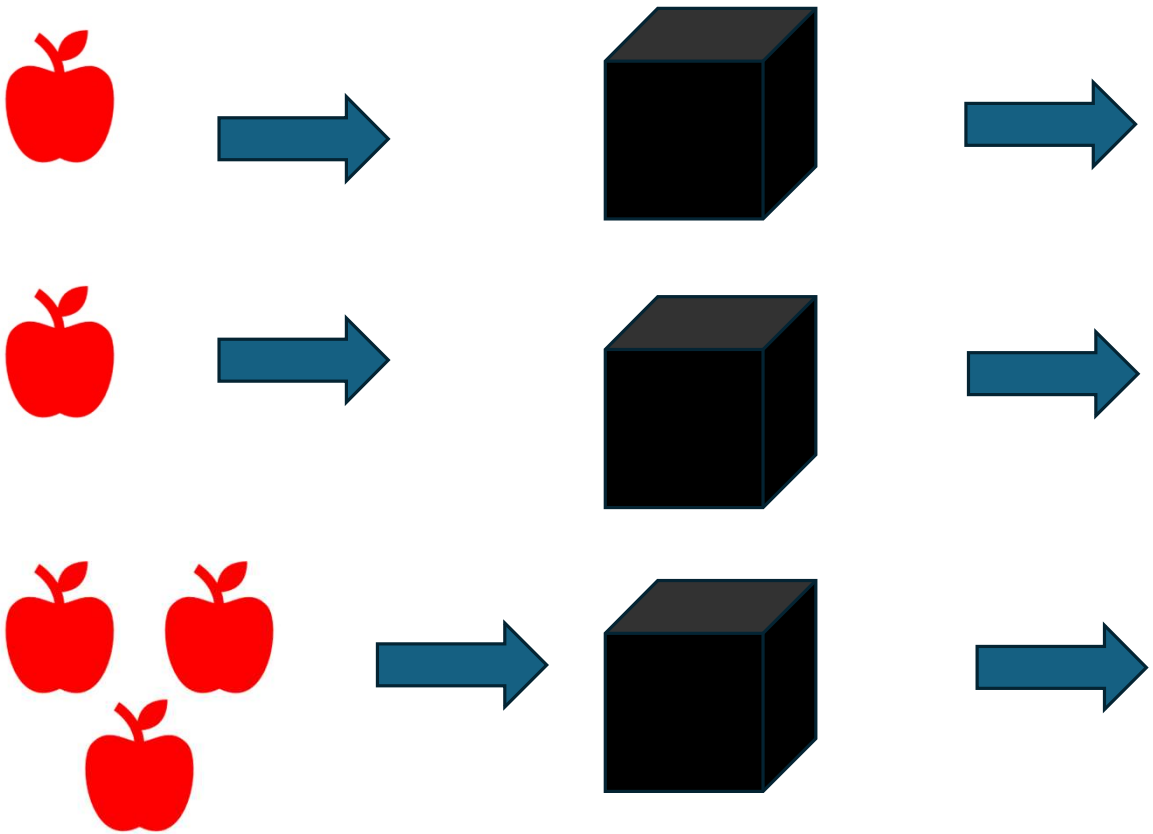
You can express this a percentage:
10ppm as a reference concentration of contaminant in →

Concentration out
99% DRE 2 nines=100,000 ppt (100ppb)
99.9% DRE 3 nines=10,000 ppt (10ppb)
99.99% DRE 4 nines=1,000 ppt (1 ppb)
99.999% DRE 5 nines=100 ppt (0.1 ppb)
99.9999%DRE 6 nines= 10 ppt (0.01 ppb)

So 6 nine 99.9999%DRE is 100 times more efficient than 4 nine 99.99% DRE

CleanHarbors

Destructive Technology Evaluation Test Methods



OTM-45 If successful it just shows that you can't see the whole intact apple.
1st step of evaluation

OTM-50 and OTM-55 Can you see any pits or stems? PIDs (products of incomplete destruction)

DREs Destruction removal efficiencies. To get more nines you need more apples. 99.9999% is 100 times more efficient than 99.99%.

CleanHarbors

PICs and PIDs
Products of Incomplete Combustion and Destruction

LC/MS/MS methods that are used for low level detection of PFAS compounds such as:

EPA 537.1, EPA 533, EPA 1633 can only see intact PFAS compounds. They do not have **TIC** reports like GC/MS methods **and** are also not meant for volatile compound analysis

TIC REPORT GC/MS- A REPORT THAT CAN BE GENERATED DURING GC/MS ANALYSIS THAT CAN **TENTATIVELY IDENTIFY** AN UNKNOWN **COMPOUND** FOUND IN A SAMPLE ANALYSIS. IT PULLS FROM A LIBRARY OF COMPOUNDS AND TELLS YOU SUGGESTED MATCHES OF WHAT THE COMPOUND COULD BE.

OTM-45 USES LC/MS INSTRUMENTATION (LIMITED IDENTIFICATION ABILITY)

OTM-50 AND OTM-55 USE GC/MS INSTRUMENTATION (CAN SEE PICS,PIDS AND VOLATILE COMPOUNDS)

PRODUCTION OF AND RELEASE OF PIDS (PRODUCTS OF INCOMPLETE DESTRUCTION) ARE TWO OF THE MAIN CONCERNS REPEATED OVER AND OVER IN THE NEW " INTERIM GUIDANCE ON THE DESTRUCTION AND DISPOSAL OF PERFLUORALKYL AND POLYFLUOROALKYL AND SUBSTANCES AND MATERIALS CONTAINING PERFLUORALKYL AND POLYFLUOROALKYL SUBSTANCES- VERSION 2

CleanHarbors

3Ts (Time, Temperature and Turbulence)

Example Stages of Thermal Treatment

MACT Definition (Maximum Achievable Control Technologies)

Examples of Control Technologies and their Functions

Acceptance from Regulators and General Public

3 T’s

 Time

 Temperature

 Turbulence

The 3Ts are like a 3 -legged stool.

The most attention for PFAS destruction by thermal treatment has been focused on temperature. However, the time the material is in contact with an energy source and the turbulence that the material is exposed to are also factors in determining the destruction potential. For instance, hazardous incineration utilizes all three of these components in the design of their systems. Hours for solid materials and a minimum of 2-3 seconds for gases. They also maximize turbulence within the stages of treatment.

Example of Stages of Thermal Treatment and Control Technologies at El Dorado

Rotary Kiln- Combusts waste up to 1850 degrees Fahrenheit (1010 c) measured in seconds for vapors and hours for solids. Solid ash is discharged from rotary kiln in containers and sent to our hazardous USEPA-approved landfill.

Gaseous waste moves from the primary stage to the vertical secondary combustion chamber. The burners in these first two stages are engineered to create maximum turbulence in the waste stream.

The waste is continually monitored in real-time to ensure compliance with USEPA and state regulatory agency.

After secondary combustion (minimum two seconds) all that remains is super-heated acid and salt laden gases that undergo cleaning and neutralization.

This is where multi-stage air pollution control APCS (MACT certification) comes in. **Maximum Achievable Control Technologies.**

CleanHarbors

Six Stage Air Pollution Control System (MACT Certified)

*<u>Performance based</u> **not** every hazardous incineration facility is cookie cutter*

Stage 1. Spray-dryer unit- Serves three purposes. First, the hot combustion gases are quenched, cooling then from 1850 degrees Fahrenheit to a more equipment friendly 325 degrees Fahrenheit. Secondly, it allows brine compounds to solidify and precipitate out and third it performs initial acid gas removal. Halogen acid gases are scrubbed. Hydrogen fluoride, hydrogen chloride and hydrogen bromide.

Stage 2. Baghouse 1- (carbon injection system) Initial particulate matter and salt removed. Ex. dioxin, furan mercury removal from the gases.

Stage 3. Saturator- Gases are further quenched to their saturation point

Stage 4. Condenser-The stream of gases moves through the condenser stage. Condensing moisture in the gases causes particulates to collect. Maximizing particulate removal. It also serves as the primary means of acid removal. Sulfur dioxide, HCL and HF.

Stage 5. Baghouse 2- The remaining gases are preheated to 220 degrees Fahrenheit or greater prior to flowing into the secondary baghouse. Performs much like baghouse 1. At this stage lime is added for residual acid gas removal.

Stage 6. Gas flows downstream to the Denox system. (catalytical removal process)

CleanHarbors

Permitting and Oversight Level

Determine what the facility is classified as and what level of permitting, and oversight is included with that classification

Not all thermal destruction facilities are the same. There are levels of classification that determine what type of material is accepted there and what levels of controls are in place.

Certificate of Destruction from a Permitted Hazardous Facility that Assumes Liability of the material received

Pages 46-62 of the“ Interim Guidance on the Destruction and Disposal of Perfluoralkyl and Polyfluoroalkyl and Substances and Materials Containing Perfluoralkyl and Polyfluoroalkyl Substances- Version 2 provides detailed descriptions of the types of commercially available thermal destruction facilities.

Interim Guidance on the Destruction and Disposal of Perfluoroalkyl and Polyfluoroalkyl Substances and Materials Containing Perfluoroalkyl and Polyfluoroalkyl Substances--2024 (epa.gov)

- **Key questions to consider when reading these descriptions are**
  - What level of testing have they already performed or are planning to perform? OTM-45, OTM-50
  - What is the compound list they used for this determination.
  - Is it permitted for haz or non-haz material
  - What liability protection is available with the destruction choice

Scalability

Is the technology fully vetted and scalable

- Are there exiting infrastructure supports available to meet the expected demand?
- Is there record keeping, reporting, permit compliance, workforce trained on implementing the technology?
- What is the current capacity for throughput available?
- How many gallons or tons per day can be processed?

Cost

What is the total cost per gallon or pound treated

If this not a fixed facility treatment option then you need to factor in mobilization and specialized labor cost as well as in the cost per pound or gallon treated

Energy consumption.

- Material sent to a fixed facility that is already in operation has a system operating and additional energy consumption outside the facility is not required. It would be a wrapped in the cost including transportation.
    - Example-efficiency of milk-run transportation.