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PFAS **FAQ**

This FAQ provides essential information on High Temperature Thermal Conduction Heating (TCH) for PFAS remediation. It covers some of the questions we are being asked most often.

What is high temperature TCH?

High temperature TCH utilizes electrically powered heaters to heat soil to temperatures >100°C and can heat the soil to the effective treatment threshold for recalcitrant constituents like PFAS. During high temperature TCH, the soil temperature is increased above the boiling point of water. Soil temperatures above 500°C have been achieved in our full scale high temperature projects, but typically reaching a temperature between 350 and 400°C is enough to reduce PFAS concentrations to less than laboratory detection limits (low or less than ug/kg levels).

High temperature thermal remediation projects typically operate for seven months to one year from start to finish, with the heating duration typically lasting 3 to 6 months, allowing the achievement of stringent cleanup goals quickly, efficiently, and reliably, even for PFAS.

Is high temperature TCH conducted in situ or ex-situ?

High temperature thermal projects can be completed either in situ or ex-situ.

In-pile thermal desorption (IPTD®) is used for ex-situ applications. IPTD projects require excavation of the contaminated soils and placement of the soil in a specially engineered and constructed pile. PFAS source zones are often present in shallow layers, which may favor excavation and treatment in IPTD.

The key for an in situ application is operating only in the vadose zone. When operating below the water table, full control of the groundwater present is critical to achieve and maintain temperature. A continuous flow of groundwater or surface water into the high temperature area will buffer the temperature at the boiling point and prevent dry-out achievement of the higher temperatures required.

What factors do you consider based on the size of the potential PFAS project? Is there a minimum size that is of concern?

Thermal remediation of PFAS-impacted material (e.g., soil, sediment, soil washing fines) can be performed on any volume. We have designed and implemented high-temperature (e.g., 350 to 450°C) IPTD systems to treat as few as 50 cubic yards (cy) up to >100,000 cy. For large volumes, the factors that need to be considered include the area available for the treatment, schedule limitations, power availability, and optimal size of the off-gas treatment system.

For example, if sufficient area and power are available, the most economical solution with the shortest schedule would be to treat the impacted volume in one batch/pile. For large volumes (>50,000 cy), it may be more practical to treat in two piles at once or to reuse one pile two or more times and treat the volume in consecutive batches.

What are the remediation mechanisms for PFAS in soil at 350 to 400°C?

At temperatures between 350 to 400°C, the PFAS present in the soil undergoes a combination of removal mechanisms:

1) Degradation, defluorination, and mineralization of the PFAS,

2) Volatilization of some of the degraded PFAS, and

3) Direct volatilization of shorter chain volatile PFAS such as perfluoroalkyl carboxylic acids (PFCAs).

What is left in the soil following heating at these temperatures for several weeks is inorganic fluoride and metal fluorides bound to the soil. Importantly, the off-gas extracted from the soil heated to 350 to 400°C may contain volatilized PFAS, and products of incomplete degradation (PIDs) such as volatile fluorinated compounds (VFCs), which will need to be subsequently treated using a combination of thermal oxidation or thermal catalytic oxidation and acid gas scrubbing to remove hydrogen fluoride (HF) formed from the mineralization of the HF.

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Have there been any laboratory studies supporting thermal remediation of soil impacted with PFAS?

Laboratory studies performed by TerraTherm and our European partner Kruger, have closed the fluorine mass balance, tracking and accounting for 100% of the fluorine associated with the starting PFAS in soil. These studies indicate that when native soil containing PFAS is heated to 400°C, near 100% of the fluorine can remain in the soil as inorganic fluoride and metal fluorides from the mineralization of the PFAS. Clean sand spiked with PFOS and heated to 350°C resulted in 40% of the fluorine remaining in the sand as metal fluorides with 60% leaving the soil as a combination of HF and volatile PFAS (likely as PIDs and VFCs).

These results demonstrate the role temperature, the nature of the PFAS, and the presence of naturally occurring minerals such as calcium carbonates play in the fate of the PFAS during thermal remediation. Thermal catalytic systems were also tested that resulted in the near complete mineralization of the volatilized PFAS and fluorinated compounds present in the vapor stream extracted from the heated soil, with less than 0.01% of the fluorine from the PFAS starting in the soil emitted as target PFAS compounds.

Have there been measurements of PFAS precursors and/or total oxidizable/total organic fluoride before and after TCH on PFAS-impacted soils?

Yes, and results from these analyses indicate the removal of both target and precursor PFAS to below detection limits, following heating to temperatures of 350°C or greater.

Are air emissions a potential issue with this treatment technology?

The short answer is potentially yes, practically no. Thermal remediation of PFAS involves heating the impacted material to 350 to 400 °C. Most of the PFAS will be broken down and/or destroyed at these temperatures directly within the soil. Vapors removed from the soil during heating and treatment could contain low levels of target PFAS compounds and some degradation products such as HF and polyfluorinated hydrocarbons. Thus, TerraTherm's patent pending PFAS treatment technology also includes a vapor treatment step to capture or complete the destruction of the fluorinated compounds and neutralize any hydrogen fluoride that is generated, such that vapor emissions meet relevant air emissions standards.

Contact us to learn about our solutions for PFAS:

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