In-heater PCE destruction

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Thermal systems in general
Thermal systems in general
Treatment systems

Direct/Catalytic Combustion

Carbon trap

Supercooling/condensation


Source: http://www.geoinc.org/c3technology.php#process
Thermal systems – the idea: Using the heaters for destruction

A combination of treating the vapors by combustion in the heater could:
• Reduce physical footprint
• Reduce energy consumption
• Reduce carbon footprint
• Reduce cost
The GTR® Thermal Technology

- Based on conductive heating.
- Uses natural gas or propane/butane as the energy source for a flame.
- Runs at relatively high internal temperature.
- Already known to be able to destruct ordinary hydrocarbons in the heater.
- Has an internal applied vacuum in the system to draw heated gas from the soil.

- GTR Clean up in Paris, France

Source: TPC Tech.
Potential combustion pathways for PCE

- Residence time (>1-2 s), temperature (>8-900°), turbulence (3 T’s) & atmospheric composition governs destruction and formation of byproducts

- \( \text{CH}_4 + 2 \text{O}_2 \rightarrow \text{CO}_2 + 2 \text{H}_2\text{O} \quad (\Delta H = -890 \text{ kJ/mol}) \)

- \( 2 \text{C}_2\text{Cl}_4 + 3 \text{O}_2 + 4 \text{H}_2\text{O} \rightarrow 4 \text{CO}_2 + 8 \text{HCl} \quad (\Delta H = -830 \text{ kJ/mol}) \)

- \( \text{C}_2\text{Cl}_4 + \text{O}_2 \rightarrow 2 \text{COCl}_2 \) (phosgene formation)

- \( \text{COCl}_2 + \text{H}_2\text{O} \rightarrow \text{CO}_2 + 2 \text{HCl} \) (phosgene hydrolysis)

- \( \text{C}_2\text{Cl}_4 \rightarrow \) Heavier chlorinated hydrocarbons and/or lighter chlorinated hydrocarbons

- \( \text{C}_2\text{Cl}_4 + \text{O}_2 \rightarrow \)
First questions to be answered

- Is it possible to destruct chlorinated solvents in the flame in the heater at acceptable rates running the system in the normal operation mode?
- Are any toxic byproducts formed by the process?
- One expected degradation product is hydrochloric acid. Are we able to treat the HCl in a simple manner at high temperatures?
- Does corrosion limit the use of the technique?
Experimental setup

- Cooling & GAC (for safety)
- Gas Tank
- Air for burner
- Make up gas
- Air from well
- Inner & Outer PCE dosage
- Heater element

TTx: Temperature Transmitter
PTx: Pressure Transmitter
FTx: Flow Transmitter
PSx: Sampling Point

$\text{CH}_4$

Vacuum pump
Neutralizer
Ventilation filter 1
Ventilation filter 2

Gas Tank
Burner Control Unit

Gas Tank
CH$_4$

Passive heating

Cooler

GAC

Air for burner

Make up gas

Air from well

Inner & Outer PCE dosage

Heater element

Vacuum pump

Neutralizer

Ventilation filter 1

Ventilation filter 2

Make up gas

Air from well

Inner & Outer PCE dosage

Heater element

Vacuum pump

Neutralizer

Ventilation filter 1

Ventilation filter 2
Flow path

TTx: Temperature Transmitter
PTx: Pressure Transmitter
FTx: Flow Transmitter
PSx: Sampling Point
Experimental setup
Experimental setup

- **Pre-run:**
  - Stabilizing temperature in combustion zone regulating all flows.
  - Getting burner to run steady for appr. 24 hour,
  - Testing delivery of PCE at different rates.
  - Measuring PID and HCl by indicative method
  - Collecting temperature, flow and pressure data

- **Test run**
  - Dosage of 12 g PCE/h and 420 g PCE/h (weight controlled).
  - Measurements of:
    - Temperature, flow and pressure in system
    - Chlorinated solvents
    - Phosgene
    - Dioxines/furanes
    - HCl
  - Chemicals sampled with special equipment
  - Corrosion
Results – Temperatures and flow (m³/h)

- GAC
- FT1
- FT5
- TT3
- TT5
- PT3
- PT4
- PS1
- PS2
- PS3
- PS4
- PS5
- FT2
- FT4
- FT3
- FT1
- PT1
- PT2
- FT4
- FT2
- Heater
- Ventilation filter 1
- Ventilation filter 2
- Burner Control Unit
- Cooler
- Neutralizer
- Dosage pumps
- CH₄
- H₂O
- PCE
- 51°
- 114°
- 356°
- 452°
- 0,9
- 20
- 20
- 73°
- 0,5

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Results – solvents (mg/m³)

Dosage 420 g/h

Dosage pumps

PS1

H₂O

PCE

TCE

TeCM

TrCM

Cooler

Burner Control Unit

FT2

FT3

TT1

PT1

PS3

PS2

FT4

FT5

TT5

PT4

PT3

GAC

Ventilation filter 1

Ventilation filter 2

TCETeCMTrCM

31 500/43 500

0,02 / 0,02

12/10

0,1/0,1

35 500/40 500

0,04 / 0,03

11/10

0,005/0,008

0,1/0,9

n.d.

0,01/0,01

0,005/0,008

Dosage pumps

PCE

TCE

TeCM

TrCM

Cooler

Burner Control Unit

FT2

FT3

TT1

PT1

PS3

PS2

FT4

FT5

TT5

PT4

PT3

GAC

Ventilation filter 1

Ventilation filter 2

TCETeCMTrCM

31 500/43 500

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35 500/40 500

0,04 / 0,03

11/10

0,005/0,008

0,1/0,9

n.d.

0,01/0,01

0,005/0,008

Dosage pumps
Results – other components (low/high dosage)

Solvents (mg/Nm³)
HCl (mg/Nm³)
Phosgene (mg/Nm³)
Dioxins/Furans I-TEQ (ng/Nm³)

-/-
4.1/6.7
<0.1/<0.1
<0.04/<0.04

Ventilation filter 1
Ventilation filter 2

Burner Control Unit

Dosage pumps

Cooler

Neutralizer

FT2

FT4

PT1

PT2

PT3

PT4

TT1

TT2

TT3

TT4

TT5

PS1

PS2

PS3

PS4

PS5

FT1

FT2

FT3

FT4

FT5

CH₄

GAC

Solvents (mg/Nm³)

PCE

Dosage pumps

FT2

FT4

PT1

PT2

PT3

PT4

TT1

TT2

TT3

TT4

TT5

PS1

PS2

PS3

PS4

PS5

FT1

FT2

FT3

FT4

FT5

CH₄

GAC

Solvents (mg/Nm³)

HCl (mg/Nm³)

Phosgene (mg/Nm³)

Dioxins/Furans I-TEQ (ng/Nm³)

-/-
4.1/6.7
<0.1/<0.1
<0.04/<0.04

Ventilation filter 1
Ventilation filter 2
Conclusions

- Observed reduction in PCE mass flux over the heater is more than 3 orders of magnitude (> 99.9%)
- Residual PCE concentration in gas phase is up to appr. 1 mg/m³. Danish emission limit of 2.5 were not exceeded.
- No phosgene or dioxins were observed above detection limit in the experiment.
- Hydrochloric acid are kept on vapor phase through the heater and connecting tubing and absorbed in the neutralizer (99% or better).
- No significant corrosion phenomena could be observed during the test run by specialists.
Perspectives & further research

• The successful results so far implies that further work should be performed.
• Experiments to optimize the size and design of the scrubber needs to be performed.
• Experiments with the system running under more vacuum actually dragging air from the soil needs to be performed.
• Longer run times should be tested in order to monitor the corrosion impact on the system.
• Ultimately thermal techniques could be cheaper as a result or a better profit margin for companies using the technique could be another option comparing with todays treatment of the off gas.
• On smaller sites the technique will have a high applicability, due to the low amount of equipment needed and hence a relatively lower cost.