

# **The Internal Combustion Engine as a Low-Cost Soil Vapor Treatment Technology**

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***Solutions, LLC***

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while employed with Parsons Engineering Science, Inc. under contract with the Air Force  
Center for Environmental Excellence (AFCEE) Technology Transfer Division**



**Technology in Support of the Environment**

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- **Develop site-specific and summary reports**

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- Evaluate internal combustion engine (ICE) for SVE and off-gas treatment
- Develop site-specific and summary reports
- Compare ICE to traditional approaches

# Demonstration Sites

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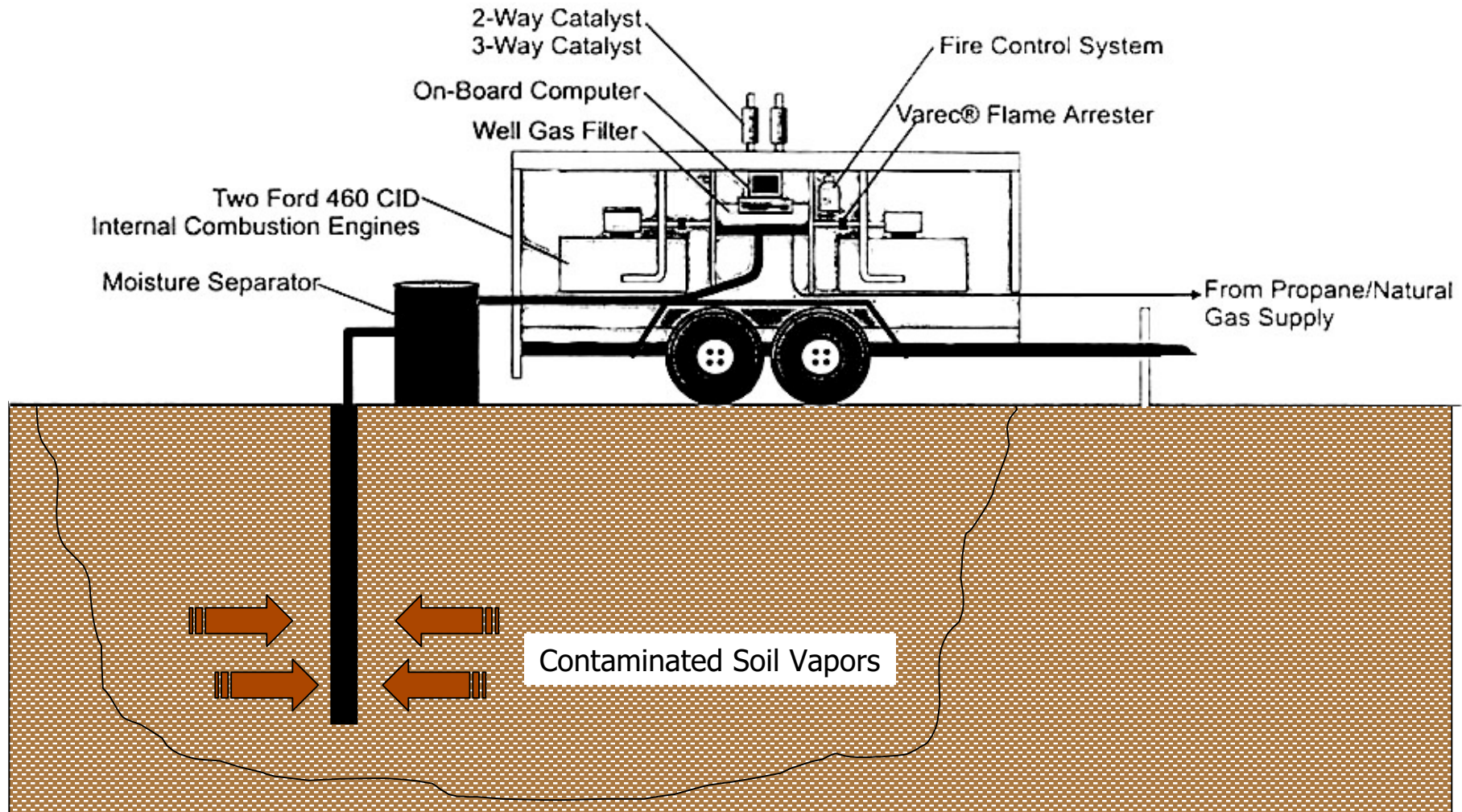
Williams AFB  
(February 1997)

Luke AFB  
(August 1994)

Davis-Monthan AFB  
(September 1995)

Bolling AFB  
(November 1994)

# Conceptual Model of SVE using ICE





# ICE Principles of Operation

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- Remote monitoring options

# ICE Technology - Features

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- Remote monitoring/operation capability

# ICE Technology- Performance Specifications

<i>Feature</i>	<i>V2C</i>	<i>V3</i>	<i>V4</i>
Max. Hydrocarbon Destruction Rate	12 lbs/hr	35 lbs/hr	70 lbs/hr
Destruction Efficiency for TVH / BTEX	>99%	>99%	>99%
Engine Size	140 cid	460 cid	920 cid (2 x 460)
Max. Vapor Flow Rate	25 scfm	70 scfm	140 scfm
Max. Vacuum (Inches of M ercury / Water)	20 / 270	20 / 270	20 / 270
Soil Gas Hydrocarbon Concentration (ppmV as gasoline) required to eliminate supplemental fuel use	30,000	30,000	30,000

# ICE Technology - Considerations

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- Auxiliary fuel required (propane or natural gas) below optimum influent TVH vapor concentrations
- Bimonthly (twice per month) maintenance required
- Can treat only low concentrations of chlorinated hydrocarbons

# Discharge Requirements

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<i>Site</i>	<i>Average Daily TVH Emissions</i>	<i>Discharge Limitations</i>
Davis-Monthan AFB, Arizona	0.70 lb/day	2.4 lb VOCs/day
Luke AFB, Arizona	0.22 lb/day	3.0 lb VOCs/day
Bolling AFB, DC	0.84 lb/day	1.0 lb VOCs/day
Williams AFB, Arizona	1.28 lb/day	3.0 lb VOCs/day



# Site Descriptions

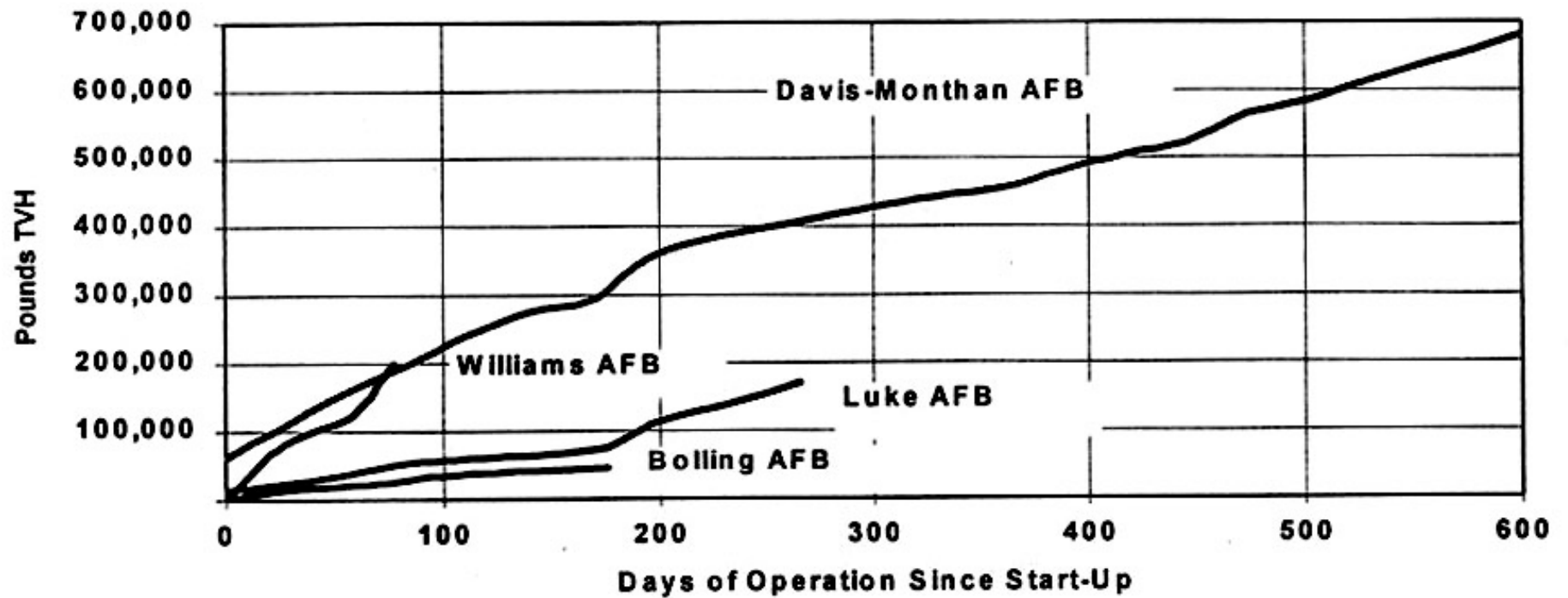
<i>Site</i>	<i>Geology</i>	<i>Depth to Groundwater</i>	<i>Maximum Soil TPH Concentration Range</i>	<i>Initial Estimated Contaminated Soil Volume</i>	<i>Initial Influent Vapor TVH Concentration</i>
Davis-Monthan AFB, Arizona	Intermixed fine and coarse - grained deposits	300 ft bgs	11,000 mg/kg (TRPH)	220,000 yd <sup>3</sup>	43,000 ppmv
Luke AFB, Arizona	Intermixed fine and coarse - grained deposits	320 ft bgs	12,000 mg/kg	9,300 yd <sup>3</sup>	38,500 ppmv
Bolling AFB, DC	Intermixed fine and coarse - grained deposits	20 ft bgs	42,000 mg/kg	43,000 yd <sup>3</sup>	123,000 ppmv
Williams AFB, Arizona	Fine-grained subunits intermixed with coarse-grained beds	200 ft bgs	35,000 mg/kg	100,000 yd <sup>3</sup>	140,000 ppmv

# Site Descriptions (cont.)

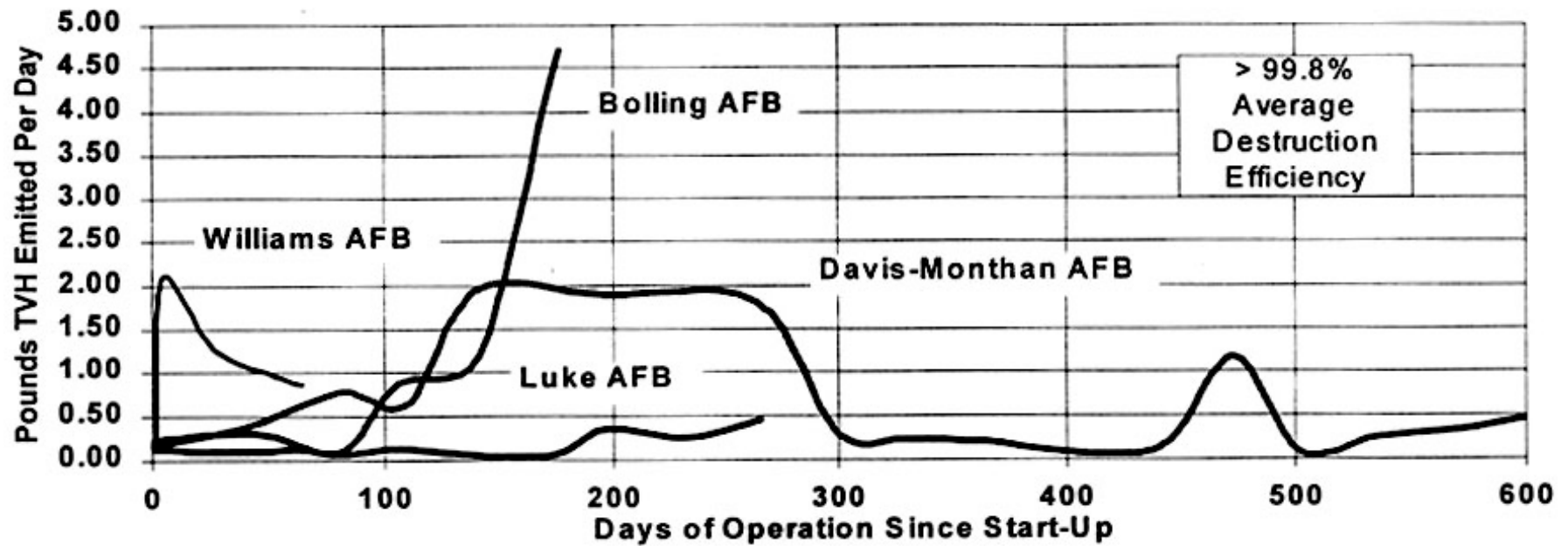
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*Site Average Daily TVH Removal Rate Weighted Average Influent TVH Concentrations Davis-Month*

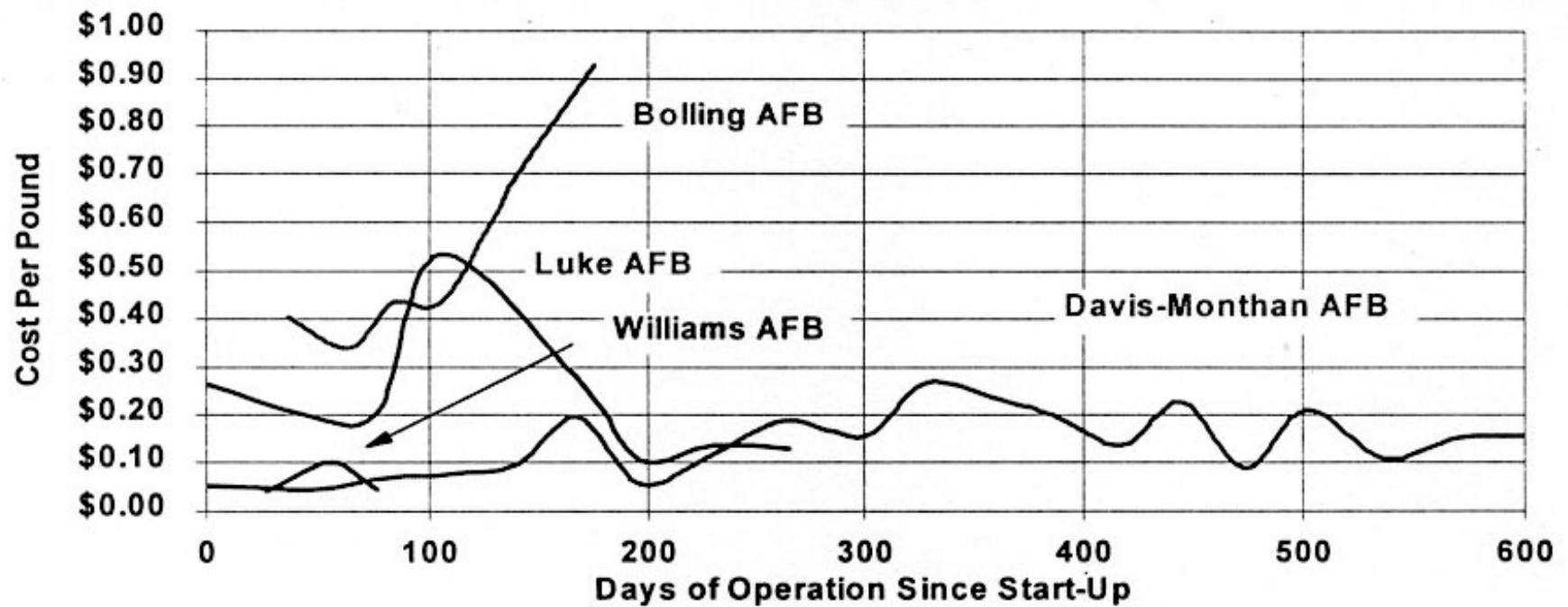
# ICE Performance



# Air Emissions



# Cost of Treatment



# Full-Scale Performance

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- Over 500,000 Pounds of Jet Fuel removed in 240 days

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- 99.9% Destruction Consistently Achieved
- No exceedance of 2.4 lb/day air emissions limit



# O&M Requirements & Costs

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- Monthly engine service

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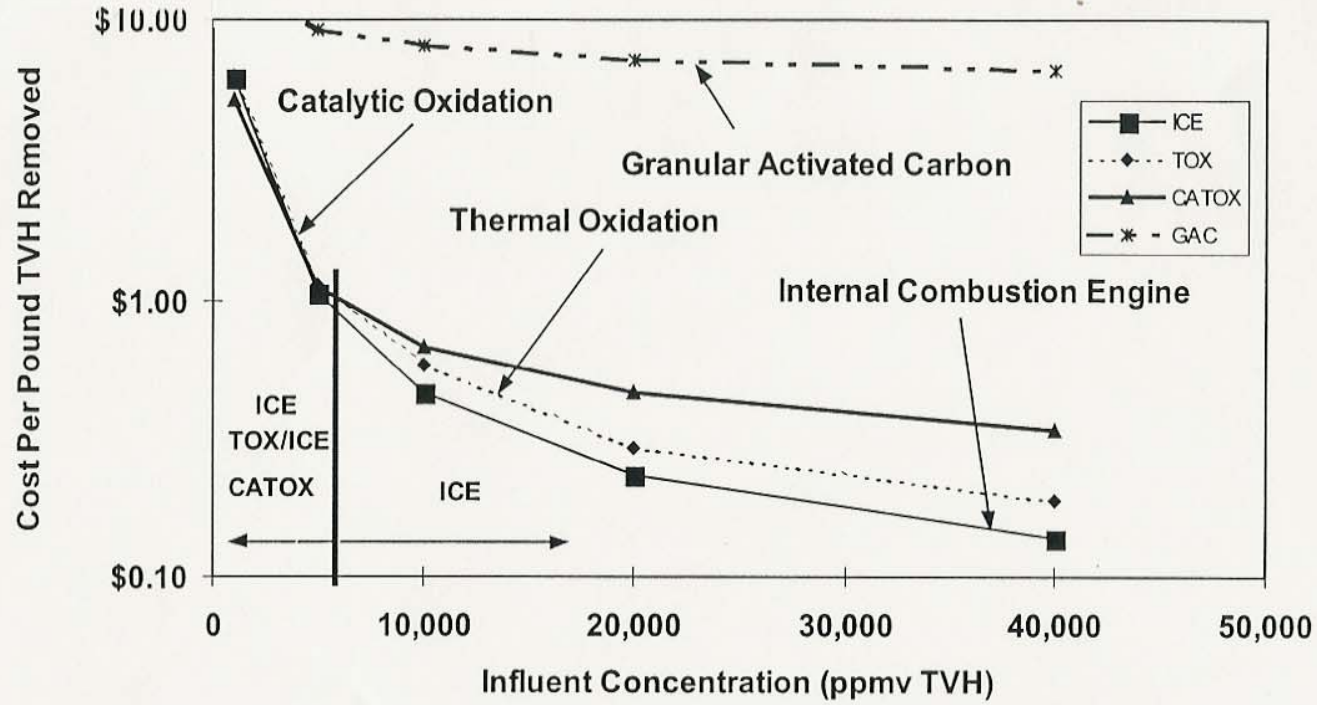
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- Weekly system checks
- Monthly engine service
- Monthly emissions sampling

# O&M Requirements & Costs

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- Weekly system checks (Recommended)
- Bimonthly engine service
- Monthly emissions sampling
- Propane delivery



ASSUMPTIONS:

1. See Appendix C.
2. Well gas flow rate approximately 100 cfm.

FIGURE 3.6

**COST COMPARISON AS A  
FUNCTION OF INFLUENT  
CONCENTRATION**

ICE Demonstration  
Comprehensive Technical Report

**PARSONS  
ENGINEERING SCIENCE, INC.**

Denver, Colorado

# Conclusions

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- Capable of achieving stringent discharge limitations (> 99.9% destruction efficiency)
- Cost per pound of TVH removed: \$0.04 to \$0.46



# AFCEE Final Conclusion

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- **"....ICE technology is similar to that of thermal and catalytic oxidation when influent concentrations range between 3,000 to 5,000 ppmv TVH. Above these concentrations, ICE technology becomes more cost-effective."\***

*\*Excerpt from: "Final Comprehensive Technical Report for the Evaluation of Soil Vapor Extraction and Treatment Using Internal Combustion Technology", the **Air Force Center For Environmental Excellence (AFCEE) Technology Transfer Division, July 1998 (Recommendations Section)***

# Contact Information

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