

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

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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

Project Objectives

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- Develop site-specific and summary reports
- Compare ICE to traditional approaches

Demonstration Sites



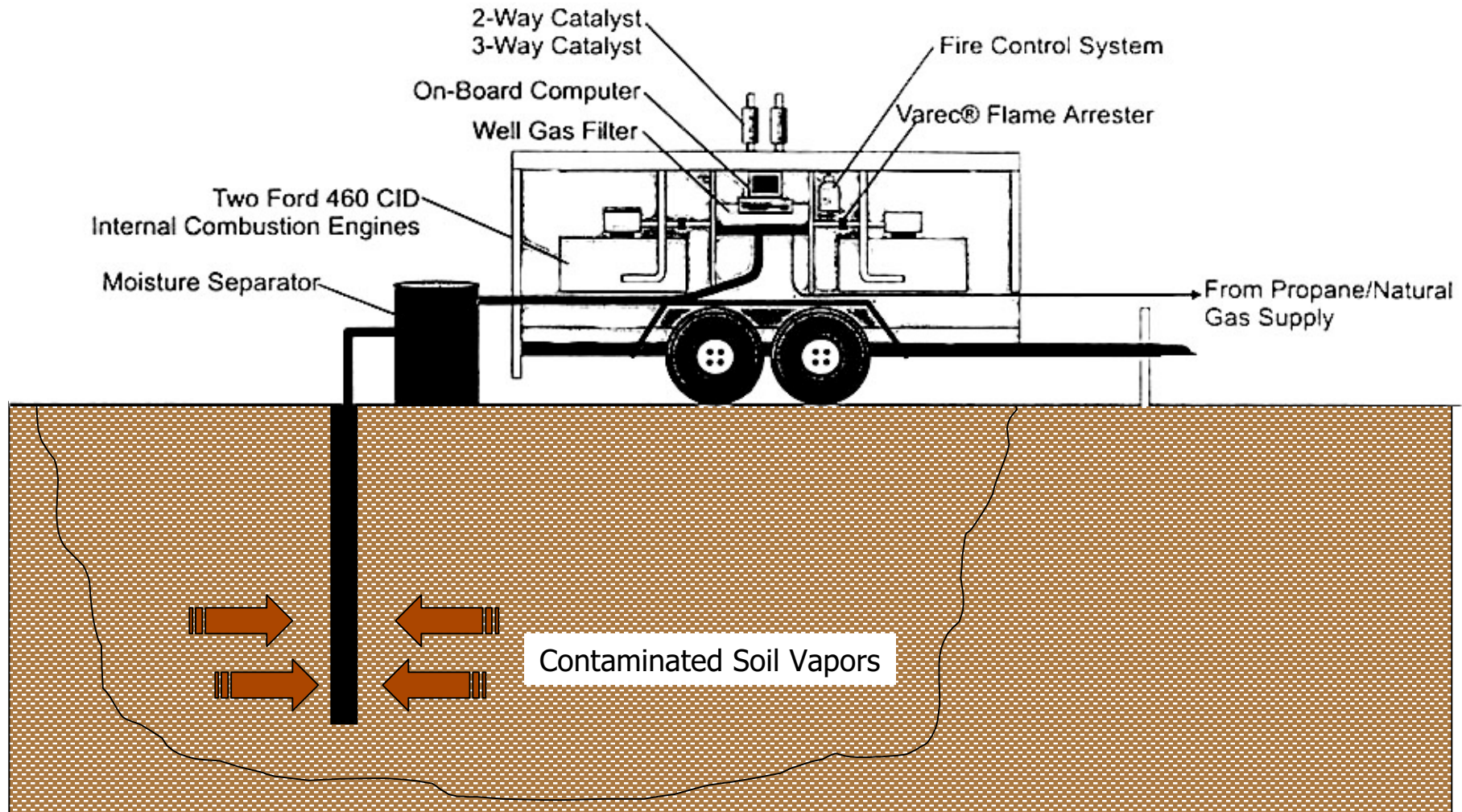
Williams AFB
(February 1997)

Luke AFB
(August 1994)

Davis-Monthan AFB
(September 1995)

Bolling AFB
(November 1994)

Conceptual Model of SVE using ICE



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- Remote monitoring options

ICE Technology - Features

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- Remote monitoring/operation capability

ICE Technology- Performance Specifications

| Feature | V2C | V3 | V4 |
|---|------------|-----------|-------------------|
| 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 |

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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

| <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 |

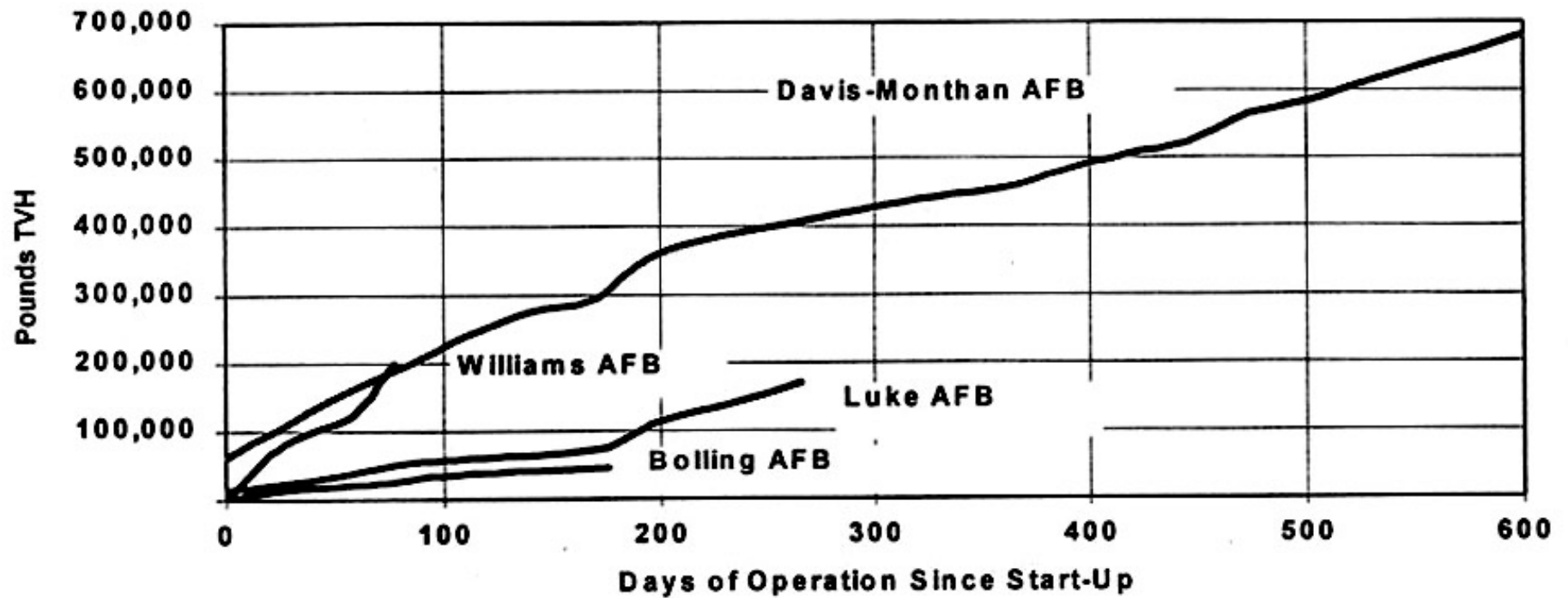
Site Descriptions

| <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 ³ | 43,000 ppmv |
| Luke AFB, Arizona | Intermixed fine and coarse - grained deposits | 320 ft bgs | 12,000 mg/kg | 9,300 yd ³ | 38,500 ppmv |
| Bolling AFB, DC | Intermixed fine and coarse - grained deposits | 20 ft bgs | 42,000 mg/kg | 43,000 yd ³ | 123,000 ppmv |
| Williams AFB, Arizona | Fine-grained subunits intermixed with coarse-grained beds | 200 ft bgs | 35,000 mg/kg | 100,000 yd ³ | 140,000 ppmv |

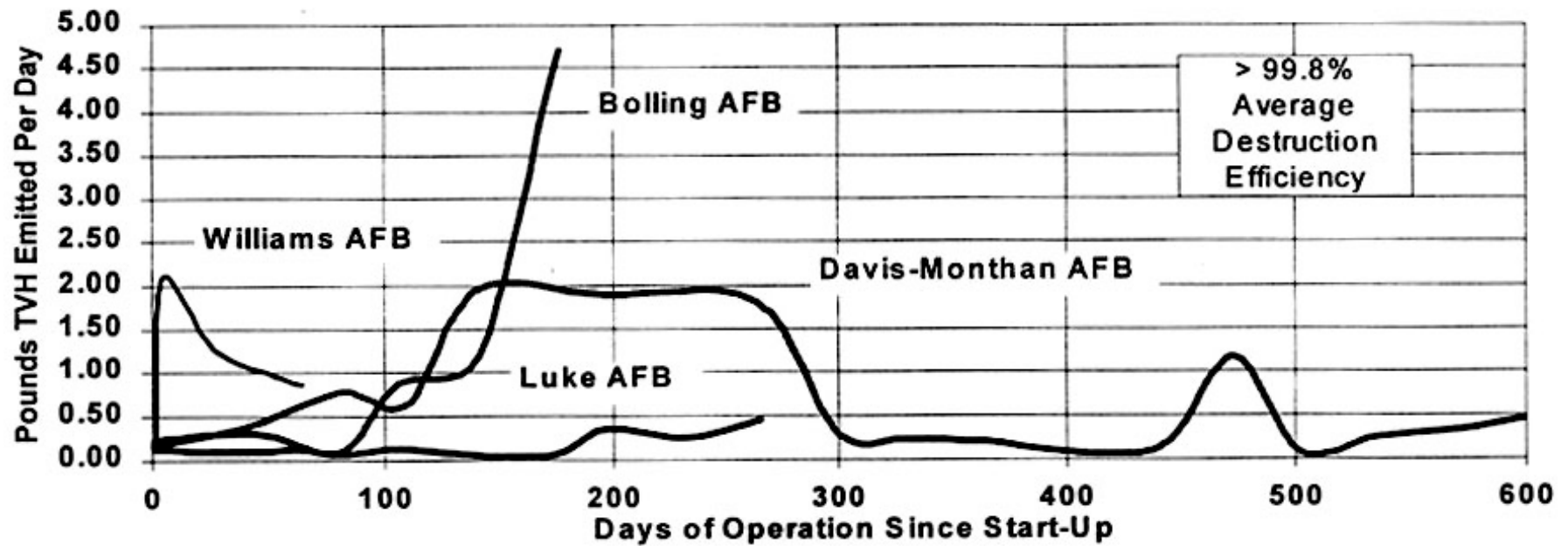
Site Descriptions (cont.)

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

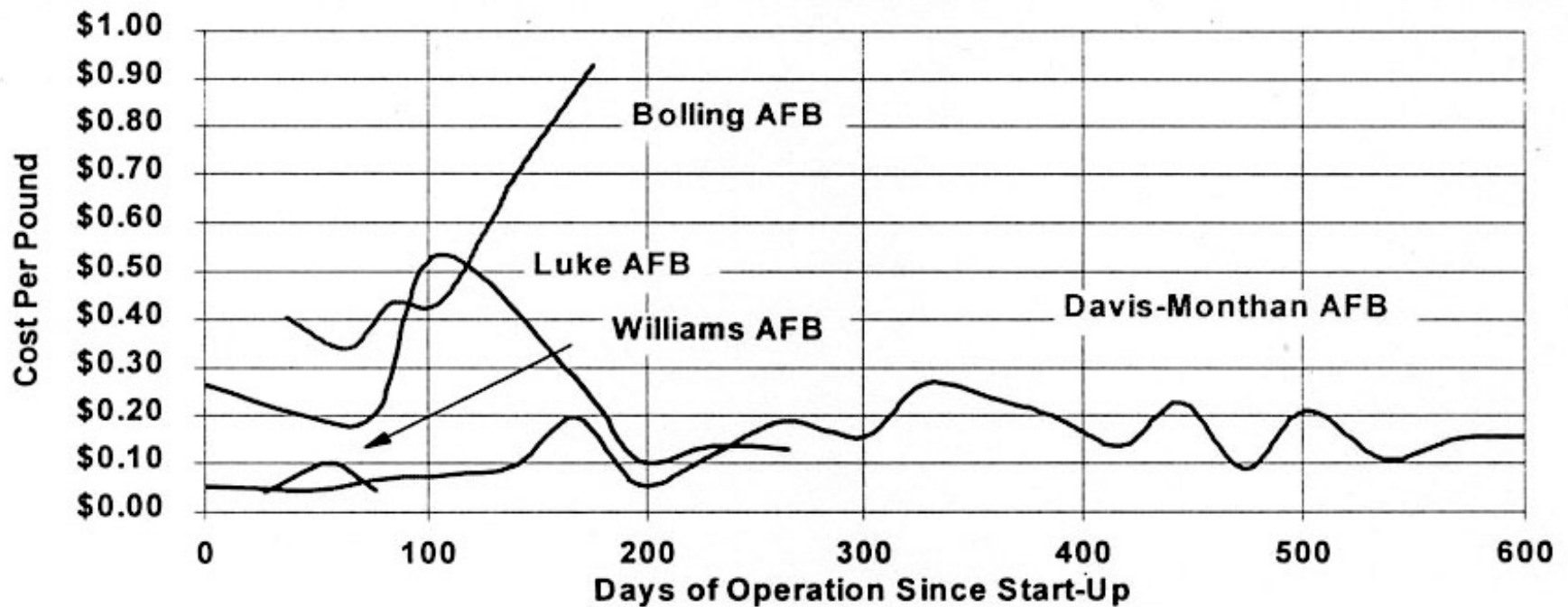
ICE Performance



Air Emissions



Cost of Treatment



Full-Scale Performance

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

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- 99.9% Destruction Consistently Achieved

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- Over 500,000 Pounds of Jet Fuel removed in 240 days
- 99.9% Destruction Consistently Achieved
- No exceedance of 2.4 lb/day air emissions limit

O&M Requirements & Costs

- Weekly system checks

O&M Requirements & Costs

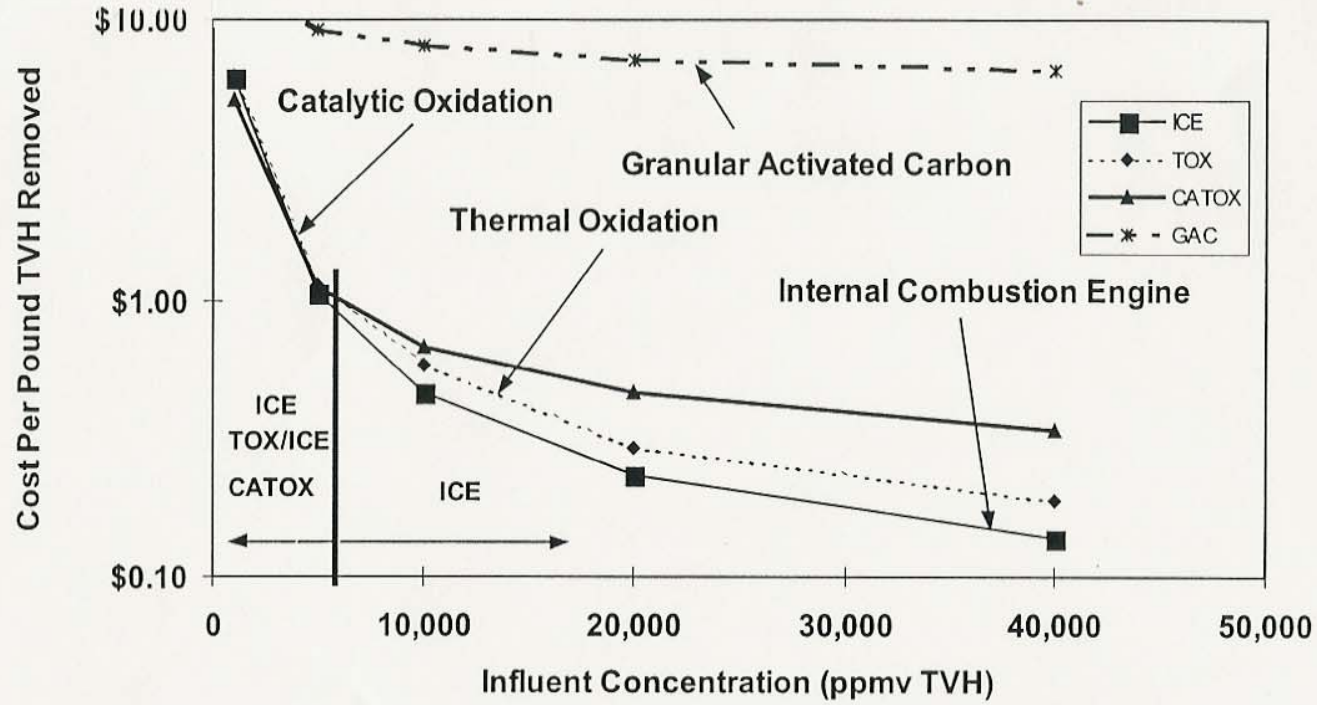
- Weekly system checks
- Monthly engine service

O&M Requirements & Costs

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

O&M Requirements & Costs

- 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)

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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

- **"....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)*

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