TECHNICAL MEMORANDUM

EVALUATION OF VOLATILE ORGANIC COMPOUND EMISSION CONTROL OF RUSMAR AC-900L AND AC-900 FOAM USING THE SURFACE EMISSION ISOLATION FLUX CHAMBER

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EXECUTIVE SUMMARY

Emission rate testing of volatile and some semi-volatile compounds (VOC/SVOC) from contaminated soil was conducted at a licensed commercial hazardous waste landfill on August 6, 7, and 14, 1991. Emission rate measurements were made using the EPA recommended surface isolation flux chamber. Hydrocarbon samples were collected in evacuated stainless steel canisters and analyzed off-site by gas chromatography and mass spectrometry (GC/MS) following EPA Method TO-14.

The primary objective of this testing effort was to determine the efficiency of two Rusmar foam products for controlling emissions of VOC/SVOCs from soil contaminated with petroleum fuel (aviation fuel). EPA Method TO-14 provides for the speciation of a listed 39 air toxic compounds, some of which were routinely identified in these samples. However, most of the sample compounds were aliphatic hydrocarbons and were accounted for by the summation of total non-methane hydrocarbon compounds (TNMHCs). In addition, the analysis included the listing of up to the ten highest tentatively identified compounds found in each sample. As such, improvements in this sample collection and analytical technique, as compared to historical testing, have provided additional test data for this evaluation.

Three test pads were constructed of contaminated soil. Testing included uncontrolled emission rate testing, application of foam products, and retesting of fugitive TNMHC emissions. VOC\SVOC emission control data were calculated by dividing controlled TNMHC emission rate data by pad specific uncontrolled TNMHC emission rate data, subtracting this quotient from one, and multiplying this result by 100 (percent control). Test data were not corrected for foam baseline emissions. Rusmar AC-900L foam demonstrated a 98 percent control efficiency for foam applied immediately after application (replicate test). Likewise, Rusmar AC-900 foam had a 99 percent control efficiency immediately after application (single test). These control efficiencies were also calculated by dividing controlled emission rate data by the average of all uncontrolled emission

rate data. This normalized uncontrolled emission rate accounts for waste heterogeneity. These results show a 99 percent control efficiency for AC-900L and a 98 percent control efficiency for AC-900.

Time-weighted control efficiency data for test pad #1 showed TNMHC emission control efficiencies (calculated using pad specific uncontrolled rate data) for time T=2 hours, T=6 hours, T=24 hours, and T=7 days of 98, 99, 94, and 97 percent, respectively. Time-weighted test data for the other two test pads were of limited use. Control efficiency data for some compounds were calculated for comparison purposes and are provided. These data, along with other compound data, are useful for evaluating other aspects of VOC/SVOC control efficiency.

INTRODUCTION

This technical memorandum describes the field testing that was conducted in order to establish the VOC\SVOC emission control efficiency of Rusmar AC-900L and AC-900 foams for petroleum hydrocarbon wastes. The objective of this testing was to determine the emission rates of organic compounds (VOCs/SVOCs) from uncontrolled waste and then from wastes with representative layers of foams applied to the waste for purposes of emission control. This testing was conducted by Dr. CE Schmidt on August 6, 7, and 14, 1991.

The testing protocol that was used for this program has been used in the past to establish the control efficiency of other foam products developed for the same purpose, namely to control VOC/SVOC emissions from waste/hazardous waste materials. The testing protocol included the use of the EPA recommended surface emission isolation flux chamber technology and the EPA Method TO-14 canister sample collection and GC/MS analytical technique. The testing consisted of constructing test pads of contaminated soils approximately one foot thick and at least six feet in diameter. Uncontrolled emission rate testing was conducted within minutes of shaping the test pads. After uncontrolled testing, a selected foam product was applied (approximately 1-to-3 minutes post application) to a given pad and controlled emission rate testing was conducted. Foam was applied using Rusmar foam application equipment with coverage of about 2-to-3 inches of foam as per recommended vendor application or usage. Foam was applied to the top and all sides of the test pads so that hydrocarbons could not escape from the pad except through the foam layer. Repeat emission rate testing was conducted over time with most of the testing focused on test pad (pad #1). In total, three test pads were constructed and tested; pad #1 and pad #2 were covered with foam product AC-900L and pad #3 was covered with foam product AC-900. The testing included: uncontrolled emission rate testing, controlled emission rate testing as a function of time up to a time period of 7 days, uncontrolled emission rate testing of the pads after the controlled testing with the foam layers removed, system blank quality control testing,

replicated sample analysis, replicate sample testing, foam baseline testing, and other standard analytical quality control testing.

The sections that follow include a discussion of the testing methodology, quality control procedures, the results of this testing effort, and a discussion of these results.

TEST METHODOLOGY

Testing was conducted using the EPA recommended Surface Isolation Flux Chamber (flux chamber) as the emission assessment tool to collect emissions data. The primary reference for this section is the document entitled "Measurement of Gaseous Emission Rates From Land Surfaces Using an Emission Isolation Flux Chamber, Users Guide." EPA Environmental Monitoring Systems Laboratory, Las Vegas, Nevada, EPA Contract No. 68-02-3889, Work Assignment No. 18, February 1986.

The operation of the flux chamber is given below:

1) **Flux chamber, sweep air, sample collection equipment, and field documents were located on-site and at the test location.**

2) **The site information, location information, equipment information, name of sampler, date, and proposed time of testing were documented on the Emissions Measurement Field Data Sheet.**

3) **The exact test location was selected and the chamber was placed on the testing surface (uncontrolled waste, foam, waste controlled with foam layer). The thermocouples were placed in order to monitor soil/air temperature inside and outside of the chamber. The chamber was suspended from a portable tripod when used on foam layers to prevent disturbance of the foam layer.**

4) **The sweep air flow rate was initiated and the rotometer was set at 5.0 liters per minute. Constant sweep air flow rate was maintained throughout the measurement.**

5) **The chamber was operated at 5.0 liters per minute sweep air flow rate, and data were recorded every residence time (6 minutes) for five residence times or 30 minutes. The sample line was continually purged by withdrawing exhaust gas and monitoring with an Organic Vapor Analyzer.**

6) **At steady-state (5 residence times or more), gas samples were collected. Sample collection rate of 2.5 liters per minute was not exceeded at any time. This prevented unwanted entraining of ambient air.**

7) **After sample collection, all samples were labeled and documented on the data sheet.**

8) **After labeling, all samples were properly stored in shipping boxes.**

9) **Sample collection was documented on the chain-of-custody sheet.**

10) **After sampling, the flux measurement was discontinued by shutting off the sweep air, removing the chamber, and securing the equipment.**

11) **Where contact was made with the surface, the chamber was decontaminated using appropriate cleaning supplies.**

12) **Sample equipment was then relocated to the next test location and steps 1) through 12) were repeated.**

Gas samples were collected from the exhaust of the flux chamber in evacuated stainless steel canisters and analyzed by GC/MS following EPA Method TO-14. These samples were analyzed off-site by an accredited, California laboratory.

QUALITY CONTROL

Quality control procedures are described below. The application and frequency of these procedures were developed to meet the program objectives and the data quality objectives.

- **Field Notebook -- A field notebook with data forms was maintained for the testing program.**

- **Laboratory Blank -- A total of five laboratory blank samples were analyzed for the program. No compounds were detected in any of these samples at or above 1.0 ppbv per species or 0.10 ppmv TNMHC. These data indicate acceptable laboratory blank performance.**

- **Blank Sample -- Blank samples were obtained by placing the clean chamber on a clean surface (away from areas of known contamination on the test site). The chamber was operated as described and blank samples were collected prior to and after testing. Blank sample testing frequency was about 5 percent. The blank sample concentrations of compounds were acceptable. Only one compound, 1,2,4-trimethylbenzene at 2.6 ppbv, was detected. Method detection limit for this method was 1.0 ppbv per species and 0.13 ppmv for TNMHC. This results in a system blank test emission estimate of <21 ug/m2,min-1.**

- **Replicate Analysis -- Two canisters were analyzed in replicate (about 10 percent). Six-to-eight compounds were identified per sample and the relative percent difference (RPD) for these replicate analyses ranged from 4.8 to 15 (average of 9.8) for one and 0.0 to 8.9 (average of 3.7) for the other. These data represent acceptable precision as compared to a criteria of 30 percent RPD.**

- **Replicate Sample -- A replicate canister was collected immediately after collection of an initial canister sample during a measurement at one location. Replicate frequency was about 5 percent. The relative percent difference of the duplicate emission test per one location ranged from 14 to 23 for all six compounds detected (average of 19). These data indicate**

acceptable sampling and analytical precision as compared to acceptance criteria of 50 percent.

- **Chain-of-Custody -- Sample labels and sample custody forms were completed and samples were executed as follows: canisters - avoid heat and light, package for shipping, ship priority mail, analysis within 30 days.**

- **Laboratory Quality Control Data -- Laboratory quality control data for canister samples are available upon request. Laboratory surrogate recovery data and matrix sample recovery data are included with sample results. Three matrix samples were analyzed and average recoveries for the TO-14 compounds were 85, 97, and 105 percent for an overall average recovery of 96 percent. These data indicate acceptable performance as compared to recovery criteria 80 to 120 percent.**

RESULTS

Emission rate data for TNMHC are summarized in Table 1 as well as percent control data. In addition to TNMHC, four species were selected and used to calculate percent control efficiency including benzene, toluene, xylenes, and ethylbenzene. These data are reported in Table 2. Other species emission rate data were not summarized or used in this data presentation but are available upon request.

Emission rate data were calculated using measured data. Emission rate data are calculated by multiplying chamber concentration (ug/m3) by sweep air flow rate (5.0 l/min), dividing by chamber surface area (0.13 m2), and converting these data to the appropriate units resulting in emission rate data in ug/m2, min-1.

DISCUSSION

The primary objective of this testing was to determine the control efficiency of two Rusmar foam products for application on soils contaminated with hydrocarbon products. The standard test for foam evaluation was used, namely TNMHC emission measurement from soils contaminated with hydrocarbons, immediate application of the foam to the soil/waste, and controlled TNMHC emission rate measurement on the foam.

These data are presented in Tables 1 and 2 and indicate that AC-900L had a 98 percent control efficiency for TNMHC after immediate application (both test pads #1 and #2), and AC-900 had a 99 percent control efficiency for TNMHC after immediate application. If all uncontrolled waste emission rate data are averaged and used for this calculation of control efficiency (as opposed to per pad uncontrolled emissions), pad #1 and #2 had a 99 percent control efficiency and pad #3 had a 98 percent control efficiency. This normalized uncontrolled waste emission rate (ie., average 1300 ppmv chamber concentration or 210 mg/m2, min-1) may better represent emissions from these waste materials given the heterogeneity of the waste.

Time-weighted control efficiency data are given showing control efficiency of these products up to 7 days after application. Speciation data are also presented for these tests indicating control efficiency for benzene, toluene, o,m,p-xylenes, and ethylbenzene. Specific comment about these data are summarized below.

- **Time-dependent emission rate testing on pad #1 for AC-900L indicate that this product demonstrated a control efficiency of 94 to 98 percent over a 7 day time period with an average control efficiency of 97 percent. Uncontrolled emission rate testing on test pad #1 indicated that these contaminants had been contained by the foam layer. Individual species control efficiencies (Table 2) supported these findings with most species data reflecting these TNMHC control efficiencies.**

- **These foam products have a baseline emissions of hydrocarbon species which compose the foam. Speciation data indicate that there are a variety of generally high molecular weight baseline hydrocarbon emissions from the foam products including aliphatic, aromatic, oxygenated, and chlorinated species.**

- **Baseline emissions were not subtracted from these control efficiency tests. It appears that the foam baseline emissions is consistent and is usually less than 10 mg/m2,min-1. These baseline emissions influence the percent control efficiency expression. For instance, both pad #1 (AC-900L) and pad #3 (AC-900) had about the same controlled emission rate (18 and 21 mg/m2, min-1, respectively), however, the control efficiency for AC-900 was reported at 99 percent and AC-900L at 98 percent. This is because both products are effectively controlling emissions and had approximately the same baseline or foam emissions, but the uncontrolled emissions for pad #3 was about twice that of pad #1 (300 versus 120 mg/m2, min-1). The greater denominator (300 versus 120 mg/m2, min-1) in the calculation of AC-900 control efficiency was responsible for the 99 percent expression.**

- **Test pad #2 showed break-through of TO-14 compounds (xylenes, ethylbenzene, trimethylbenzenes) and TNMHC at T=21 and T=22 hours. Field observations indicated that the texture of the foam under the flux chamber was different than that of the foam around the test area. The chamber was placed exactly on the same area initially tested for exact repeat testing. This foam texture appeared to have a coarse, open-pore structure that was unlike the other foam surfaces. It is likely that the foam was affected by the flux chamber test disturbing the formation of the cell structure and surface as compared to areas not enclosed by the chamber. These test results for pad #2 after T= 0 are considered suspect.**

- **The uncontrolled emissions from the contaminated soils after the foam layers were removed indicated that the emission rates for two of the three test pads (#l and# 2) were higher after the containment experience than before. There is no explanation for this observation except that the waste may have not been at equilibrium for the initial uncontrolled test and the time spent under the foam layer allowed the soil/soil vapor to come to equilibration. Since the purpose of these tests is to demonstrate that the foam contained the contaminants, time-dependent testing conducted on these test pads is considered acceptable. Further, if the uncontrolled emissions were in fact higher than the initial uncontrolled results, these control efficiency data are conservative and the control efficiencies are probably higher than reported. These post-foam data suggest the use of average uncontrolled rate data as opposed to pad specific uncontrolled emission rate data for the control efficiency evaluation.**

Test pad #3 showed lower uncontrolled emissions indicating VOC/SVOC loss, however, the T= 0 hour control efficiency was 99 percent. With the 53 percent TNMHC residual emissions after foam removal, the 100 percent control estimate at T= 6 days for TNMHC control is suspect (ie., VOC/SVOC escaped and the uncontrolled emissions and the control efficiency estimate are lower).

TABLE 1. SUMMARY OF TOTAL NON-METHANE HYDROCARBON (TNMHC) EMISSIONS AND PERCENT CONTROL DATA

SAMPLE I.D.	TEST	TNMHC (ppmv)	TNMHC (mg/m2,min-1)	PERCENT CONTROL
A001	SYSTEM BLANK	<0.13	<0.021	NA
A002	AC-900L	33	5.2	NA
A003	AC-900L, REPLICATE	17	2.7	NA
A004	PAD #1, UNCONTROLLED	740	120	NA
A004	LAB REPLICATE	640	100	NA
A005	PAD #1, UNCONTROLLED REPLICATE	790	120	NA
NA	**PAD #1 UNCONTROLLED AVERAGE**	**740**	**120**	**NA**
A006	PAD #1 : AC-900L, T = 0 HOUR	18	2.8	98
A007	**PAD #2, UNCONTROLLED**	**900**	**140**	**NA**
A008	PAD #2, AC-900L, T= 0 HOUR	19	3.0	98
A009	PAD #1, AC-900L, T= 2 HOUR	18	2.8	98
A010	PAD #I, AC-900L, T= 6 HOUR	6.4	1.0	99
A011	PAD #1 AC-900L, T= 24 HOUR	41	6.5	94
A012	PAD #2: AC-900L, T= 21 HOUR	360	57	60
A012	LAB REPLICATE	350	55	61
A013	PAD #2 AC-900L, T= 22 HOUR	600	95	33
A014	PAD #I: AC-900L, T= 24 HOUR	42	6.6	94
A015	**PAD #3, UNCONTROLLED**	**1,900**	**300**	**NA**
A016	PAD #3, AC-900, T = 0 HOUR	21	3.3	99
A017	PAD #3, AC-900, T = 6 DAYS	0.47	0.074	100[a]
A018	PAD #3, UNCONTROLLED, POST-FOAM	1,000	160	53[b]
A019	PAD #2, AC-900L, T = 7 DAYS	82	13	91
A019	LAB REPLICATE	88	14	90
A020	PAD #2 UNCONTROLLED, POST-FOAM	1,900	300	210[b]
A021	PAD #1: AC-900L, T = 7 DAYS	23	3.6	97
A022	PAD #1, UNCONTROLLED, POST-FOAM	1,400	220	190[b]

NA - NOT APPLICABLE

[a] LESS VOC EMISSIONS FOUND AFTER FOAM REMOVED AS COMPARED TO UNCONTROLLED TEST

[b] PERCENT VOC EMISSIONS REMAINING AFTER FOAM REMOVED COMPARED TO INITIAL UNCONTROLLED TEST (POST-FOAM TEST)

NOTE:PERCENT CONTROL CALCULATED USING PAD SPECIFIC UNCONTROLLED EMISSION RATE DATA.

TABLE 2. SUMMARY OF PERCENT CONTROL DATA FOR BENZENE, XYLENES (o, m, p), ETHYLBENZENE, AND TNMHC

COMPOUNDS	P#l T=0	P#l T=2	P#l T=6	P#l T=24	P#l D=7	P#2 T=O	P#2 T=21	P#2 D=7	P#3 T=0	P#3 D=6
BENZENE	NC	NC	ND	ND	ND	55	81/82	77	87	100[a]
TOLUENE	68	95	96	93/93	99	68	81/77	98	94	100[a]
XYLENES (o,m,p)	99	98	98	95/95	98	94	84/76	97	97	100[a]
ETHYLBENZENE	99	98	98	96/95	98	93	83/76	96	97	100[a]
TNMHC	98	98	99	94/94	97	98	61/33	91/90	99	100[a]

P#- Pad Number T= Time in Hours D= Days

NC - CANNOT CALCULATE; COMPOUND NOT DETECTED IN UNCONTROLLED TEST

[a] LOW RECOVERY FOR POST-FOAM TEST

NOTES:
- TWO DATA POINTS REPRESENT REPLICATE TESTING
- PAD #1 AND #2 TESTED AC-900L
- PAD #3 TESTED AC-900
- PAD #2 EMISSIONS TEST MAY HAVE ADVERSELY AFFECTED CONTROL EFFICIENCY
- PERCENT CONTROL CALCULATED USING PAD SPECIFIC UNCONTROLLED EMISSION RATE DATA.