COMPARISON OF LONG DURATION FOAM, SYNTHETIC TARPAULINS, GEOTEXTILES, AND SOIL AS SUBTITLE D COMPLIANT DAILY COVER MATERIALS FOR SANITARY LANDFILLS.

by

PAUL A. KITTLE and C.E. SCHMIDT

BACKGROUND

Conventional sanitary landfill practice incorporates the use of daily cover at the end of each working day. In general, the six inch soil cover is required to prevent odors, blowing litter, vectors, minimize the risk of fires, as well as improve the general housekeeping and appearance of the facility.

Within the last ten years, the sanitary landfill business community has recognized that the addition of the daily cover soil reduces the efficiency of sanitary landfill operation by limiting the total quantity of incoming refuse. The air space consumed by the daily cover soil is now accepted as a significant permitted volume loss, directly related to reducing the income potential of the sanitary landfill facility.

The non-landfill business community has also recognized this operating inefficiency and over the same time period has developed two technologies directed at the daily cover marketplace - foam products and tarpaulins.

The RCRA Subtitle D requirements specifically address the daily cover requirements, defining that daily cover: assists in disease vector and rodent control; assists in containing odor, litter, and air emissions, which may threaten human health and the environment; reduces the risk and spread of fires; and, assists in the control of rainwater infiltration and therefore leachate generation.

This paper presents analytical data defining the performance of Rusmar Incorporated Long Duration Foam, conventional soil cover, and commercially available tarpaulins/geotextiles as Subtitle D daily cover materials. The criteria used for evaluation include: odor emission control, methane emission control, total non-methane hydrocarbon emission control, and flammability. The evaluation procedures involved include both ASTM and EPA procedures and were executed by independent consultative organizations.

ODOR AND HYDROCARBON EMISSION CONTROL

SUMMARY OF RESULTS

Emission rate testing of odor, volatile, and some semi-volatile compounds (VOC/SVOC) from a municipal solid waste landfill was conducted at the Empire Sanitary Landfill located in Taylor, Pennsylvania, on August 17, 18, 1992. Emission rate measurements were made using the EPA recommended surface isolation flux chamber. Odor samples were collected in tedlar bags and analyzed off-site by olfactory detection following ASTM Method E679-79. Hydrocarbon samples were collected in evacuated stainless steel canisters and analyzed off-site by gas chromatography (GC) following EPA Method TO-12 and, in some cases, by mass spectrometry (GC/MS) following EPA Method TO-14.

The primary objective of this testing was to obtain detailed emission rate data from the working face of a municipal solid waste landfill, with and without surface covers, in order to determine odor and VOC/SVOC control efficiency of these surface covers. Odor Method ASTM E679-79 provided for odor level detection expressed as dilution-to-threshold (D/T) ratio. EPA Method TO-12 provided for methane and total non-methane (TNMHC) quantification and EPA Method TO-14 provided for the speciation of the listed 39 air toxic compounds. In addition, the TO-14 analysis included the listing of up to the ten highest tentatively identified compounds found in each sample.

A lane (approximately 40 feet by 120 feet) of compacted municipal waste (the working face) was selected for testing. Testing was conducted at the end of the day so that the test areas were representative of the "end of the day" daily working face. The compacted refuse layer was two to five feet in thickness. Testing included: uncontrolled emission rate measurement at two locations in the lane; application of five daily surface covers and emission rate measurement after application of cover at the end of the working day; and retesting of surface covers just prior to initiation of the next day landfill operations. Emission control data for these daily covers were calculated by dividing controlled emission rate data by uncontrolled emission rate data and multiplying the result by 100 (percent control). All field data were background corrected using blank system quality control data.

Rusmar Incorporated Long Duration Foam, AC-645, demonstrated a 98 percent control efficiency for odor and 100 percent control for methane and TNMHC for foam applied immediately after application. Time-weighted control efficiency data (overnight) for Rusmar Incorporated Long Duration Foam, AC-645, showed similar emission control efficiencies - odor, 99 percent, methane, 100 percent, and TNMHC, 100 percent. Control efficiency data for some compounds were calculated for comparison purposes and are provided in Table III.

Soil showed control efficiencies similar to those demonstrated by Rusmar Incorporated Long Duration Foam, AC-645. A nine (9) inch layer of compacted soil immediately after application demonstrated a 99 percent control efficiency for odor and zero percent control for methane. The control efficiency for TNMHC was 93 percent. Time weighted control efficiency data (overnight) for the soil layer showed similar emission control efficiencies (odor, 99 percent, methane, zero percent, and TNMHC, 93 percent).

Tarpaulins/geotextiles demonstrated a range of performance with Griffolyn and Air Space Saver showing 99 percent and 100 percent control efficiency for odor, respectively; 100 percent control efficiency for methane (both); and, 100 percent control for TNMHC (both) immediately after application. Percent control was similar for the time weighted (overnight) testing for these covers - odor, 99 percent (both); methane, 85 percent control for Griffolyn and 36 percent control for Air Space Saver; and TNMHC, 98 percent control (both).

A significant difference was observed with Fabrisoil for all test conditions. Control efficiency immediately after application was 82 percent control for odor, 100 percent for methane, and zero percent control for TNMHC. The time weighted (overnight) control efficiency for Fabrisoil was 82 percent for odor, 85 percent control for methane, and zero percent control for TNMHC.

In summary, Rusmar Incorporated Long Duration Foam, AC-645, nine inch soil cover, Griffolyn, and Air Space Saver showed similar emissions control for odor and TNMHC at 98 to 100 percent control. Differences were observed for methane, which appears to be the most difficult species to control. Fabrisoil showed significantly lower emissions control ranging from 82 to zero percent control. Data representing controlled emission measurements made ten to fourteen hours after cover application (time weighted) were similar to percent control documented immediately after application, with some species showing slightly lower control efficiencies over time.

These data are summarized in Table I:

TABLE I
ODOR AND HYDROCARBON EMISSION CONTROL
FOR VARIOUS ALTERNATE DAILY COVER MATERIALS

SUMMARY OF RESULTS

	MEASUREMENT TIMING					
	IMMEDIATELY			NEXT DAY		
COVER MATERIAL	ODOR	CH4	TNMHC	ODOR	CH4	TNMHC
	PERCENT CONTROL					
Rusmar Foam (6")	98	100	100	99	100	100
Soil (9")	99	0	93	99	0	93
Griffolyn	99	100	100	99	85	98
Air Space Saver	100	100	100	99	36	98
Fabrisoil	82	100	0	82	85	0

DETAILS - ODOR AND HYDROCARBON EMISSION CONTROL

The emission testing was conducted by Dr. C.E. Schmidt, a consultant to Rusmar Incorporated, on August 17, 18, 1992, at Empire Sanitary Landfill located in Taylor, Pennsylvania.

The testing protocol used for this emission testing has been used in the past to establish the control efficiency of other surface covers or foam products developed for the same purpose, namely to control emissions from waste materials. The testing protocol included the use of the EPA recommended surface

emission isolation flux chamber technology, EPA Method TO-12, EPA Method TO-14, and ASTM Method E679-79. The testing consisted of selecting a representative area of a sanitary landfill daily working face and conducting uncontrolled emission rate testing. This uncontrolled emission rate testing was conducted within thirty minutes of final municipal waste compaction activities. After the uncontrolled testing was completed, the surface covers were applied starting with Fabrisoil, Air Space Saver, Griffolyn, compacted soil (9"), and Rusmar Incorporated Long Duration Foam, AC-645, applied at a six inch depth (required currently by the Pennsylvania Department of Environmental Resources and, in the future, by Subtitle D).

The tarpaulins/geotextiles were approximately 15' by 15' (225 square feet) each and were placed side by side with about two feet between the edges. Soil was placed around the perimeter of each section and compacted into place, according to the procedures generally suggested for the use of tarpaulins/geotextiles. This procedure virtually guaranteed that communication of landfill gas between the test sections was non-existent.

The nine inch soil cover was prepared using soil routinely used by Empire Sanitary Landfill. It was delivered to the working face area in large 50 ton dump trucks and carefully moved into place by bulldozer, which supplied the final compaction for the soil covered test area, another 250 square feet, approximately. After the soil placement had been completed, three locations within this test area were measured for soil depth, with the average being about nine inches.

The Rusmar Incorporated Long Duration Foam, AC-645, was applied, by handline, over another 250 square foot area directly adjacent to the tarpaulins/geotextiles. The average foam depth was determined to be six inches overall, and specifically at the location of the flux chamber testing.

Within one hour after application, controlled emission rate testing was conducted. Repeat emission rate testing was conducted overnight simulating the time period of daily cover usage. The testing included: uncontrolled emission rate testing, controlled emission rate testing within one hour of daily cover

application, and controlled emission rate testing as a function of time - ten to fourteen hours after application, system blank sampling, replicated sample analysis, replicate sample collection and analysis, and other standard analytical quality control testing.

Testing was conducted using the EPA recommended Surface Isolation Flux Chamber as the emission assessment tool to collect emissions data. The details of the operation and use of this device for emissions measurements is "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.

Quality control procedures were developed to meet the program and data quality objectives. Some of the details of these procedures are listed here for reference.

Laboratory blank samples were analyzed for methane, TNMHC, and speciated hydrocarbons. Methane and TNMHC were not detected above method detection limits of 0.5 ppbv and 10 ppbv, respectively. Likewise, no speciated hydrocarbons were detected above 0.5 ppbv. These are acceptable blank levels.

Blank samples were obtained from each chamber by placing the clean chamber on a clean surface away from areas of known contamination. The chamber was operated in the conventional manner and the blank samples were collected prior to and after testing. Blank sample testing was about 10 percent. The blank sample concentrations of compounds detected were acceptable. Methane was detected at an average of 1 ppbv and TNMHC were detected for an average of 48 ppbv. The odor levels for each chamber were six dilution-to-threshold (D/T) levels, typical for odor blanks collected in tedlar bags. These blank levels were subtracted from the field data.

Replicate Analysis - Two canister samples were analyzed in replicate. The average relative percent difference for these samples is : methane, 4.9 percent; TNMHC, 5.7 percent; and speciated hydrocarbons, 2.4 percent. These data represent acceptable laboratory precision.

Emission rate and percent control data for odor, methane, and TNMHC are summarized in Table II for all test conditions. In addition to methane and TNMHC, sixteen hydrocarbon species were selected and used to calculate percent control efficiency including freons, methylene chloride, 1,1,1-trichloroethane, tetrachloroethane, trimethylbenzenes, 1,4-dichlorobenzene, toluene, xylenes, and ethylbenzene. Only Rusmar Incorporated Long Duration Foam, AC-645, was evaluated for specific hydrocarbons. Immediately after placement the emission control was 100 percent for all species. The next morning the control was still at 100 percent for all the materials except Freon 11 (68%), Freon 12 (75%), and toluene (95%). These data are reported in Table III.

Emission rate data were calculated using measured data, by multiplying the chamber concentration (micrograms/cu.meter) by sweep air flow rate (5.0 liters/minute), dividing by chamber surface area (0.13 sq. meters), and converting these data to the appropriate units resulting in emission rate data in micrograms/sq. meter/minute.

TABLE II
SUMMARY OF EMISSION RATE AND PERCENT CONTROL DATA FOR VARIOUS ALTERNATE DAILY COVER MATERIALS

	ODOR (a)	CH4 (a)	TNMHC (a)	ODOR (%)	CH4 (%)	TNMHC (%)
Blank #1	6	17	3(d)	NA	NA	NA
Blank #2	6	32	12	NA	NA	NA
Uncontrolled #1	220(b)	37	3100	NA	NA	NA
Uncontrolled #2	109(b)	29	7700	NA	NA	NA
Fabrisoil t=0 hrs	29	ND	6500(d)	82	100	0(e)
Air Space t=0 hrs	0	ND	18	100	100	100
Griffolyn t=0 hrs	2	ND	7	99	100	100
Soil t=0 hrs	2	95	370	99	0(e)	93
AC-645 t=0 hrs	2	ND	21	99	100	100
Fabrisoil t=13 hrs	29	5	6200	82	85	0
Air Space t=14 hrs	2	21	93	99	36	98

Griffolyn t=11 hrs	2	5	110	99	85	98
Soil t=12 hrs	2	52	360	99	0	93
AC-645 t=10 hrs	0(c)	0(c,d)	1(c)	100	100	100

(a) Field data blank corrected - Odor, 6 D/T; TNMHC, 7.4 micrograms/sq.meter/minute; Methane, 25 micrograms/sq.meter/minute.
(b) Average uncontrolled data used for percent control calculations - Odor, 160 D/T; TNMHC, 5400 micrograms/sq.meter/minute; Methane, 33 micrograms/sq.meter/minute.
(c) Average of field replicates.
(d) Average of lab replicates.
(e) Emission rate with controls equal to or greater than uncontrolled rate.
NOTES:
AC-645, Rusmar Incorporated Long Duration Foam AC-645.
TNMHC = Total Nonmethane Hydrocarbons.
NA = Not Applicable
ND = Not Detected Above Reported Method Detection Limit
(%)= Percent Control

TABLE III
SUMMARY OF EMISSION RATE AND PERCENT CONTROL DATA FOR RUSMAR LONG DURATION FOAM AC-645

	RATE (a)	Time=0 hrs RATE (b)	Time=0 hrs (%) (c)	Time=10-14 hrs RATE (b)	Time=10-14 hrs (%) (c)
ODOR(d)	160	6.3	98	1.3	99
METHANE(e)	33	ND	100	1	100
TNMHC(f)	5400	14	100	8	100
HALOGENS					
FREON 12(g)	10	ND	100	3.2	68
FREON 11(g)	4.4	ND	100	1.1	75
METHYLENE CHLORIDE(g)	3.8	ND	100	ND	100
1,1,1-TRICHLORO-ETHANE(g)	23	ND	100	ND	100
TETRACHLORO-ETHENE(g)	14	ND	100	ND	100
AROMATICS					
TOLUENE(g)	38	ND	100	1.6	95
ETHYLBENZENE(g)	15	ND	100	ND	100
m,p-XYLENE(g)	57	ND	100	ND	100
o-XYLENE(g)	14	ND	100	ND	100
1,3,5-TRIMETHYL-BENZENE(g)	5.6	ND	100	ND	100
1,2,4-TRIMETHYL-BENZENE(g)	15	ND	100	ND	100
1,4-DICHLORO-BENZENE(g)	1.4	ND	100	ND	100
HYDROCARBONS					
PROPYLENE(h)	4.5	ND	100	3.2	29
HEXANE(h)	5.3	ND	100	ND	100
DECANE(h)	43	ND	100	ND	100
UNDECANE(h)	1100	ND	100	ND	100

(a) Emission rate uncontrolled, micrograms/sq. meter/min.
(b) Emission rate with 6" Rusmar Incorporated Long Duration Foam, AC-645, micrograms/sq.meter/min.
(c) Percent control with 6" Rusmar Incorporated Long Duration Foam, AC-645, micrograms/sq.meter/min.
(d) ASTM Method E679-79, dilution to threshold ratio
(e) EPA Method TO-12, Methane

(f) EPA Method TO-12, Total Nonmethane Hydrocarbons
(g) EPA Method TO-14, Quantitative Compounds
(h) EPA Method TO-14, Tentatively identified compounds
ND = Not Detected Above Reported Method Detection Limit

FLAMMABILITY STUDIES

EXPERIMENTAL DETAILS

Five representative tarpaulins/geotextiles were chosen for a general evaluation of flammability based primarily on a standardized procedure, ASTM E1354, Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products, Using an Oxygen Consumption Calorimeter.

The tarpaulins/geotextiles subjected to this testing procedure include the following: Air Space Saver, Fabrene Incorporated, PO Box 77757, Baton Rouge, LA, 70879-7757 (800-673-1570); Fabrisoil, Phillips Fibers, PO Box 66, Greenville, SC 29602 (803-242-6600); Griffolyn, Reef Industries, PO Box 750250, Houston, TX 77275-0250 (800-231-6074); Typar, Reemay - Exxon Chemical, PO Box 511, Old Hickory, TN 37138 (800-321-6271); Sanicover, Amoco Products, Fluid Systems Incorporated, 32 Triangle Park Drive, Suite 3201, Cincinnati, OH 45246 (800-346-9107).

In order to calibrate the flammability results obtained from the tarpaulins/geotextiles five reference samples were also subjected to the same standardized procedure. These "reference standards" included cardboard, polymethylmethacrylate (PMMA), plywood (5-ply), drywall, and red oak. The objective of the standards was to bracket the generally accepted range of flammability so that the tarpaulins/geotextiles could be internally calibrated - the spectrum included cardboard which would generally be considered "flammable" and dry wall which would generally considered "non-flammable".

One of the most important characteristics of the ASTM E1354, Cone Calorimeter flammability evaluation procedure is the ability to expose the sample to a spectrum of radiant heat flux (kilowatts/sq. meter). Since this evaluation procedure is related to "accidental" fires and the issues related to contributions to the spreading of "small" fires leading to "big" fires, the tests were conducted in a horizontal orientation with an external radiant heat flux exposure of 25 kilowatts/sq. meter, with a spark pilot ignition source and an initial exhaust mass flow rate of 30 grams/second. For reference, 25 kilowatts/sq. meter of radiant heat flux corresponds to a "waste basket" fire.

All of the sample materials, tarpaulins/geotextiles and the standards, were cut into 4" by 4" squares, the standard required by the testing procedure. The thicknesses of the samples varied depending upon "normal use practice" and/or other standardization procedures - please note that red oak and polymethylmethracrylate (PMMA) are generic building material standards used for flammability testing and therefore they were used at their "standard" thicknesses.

The average thicknesses and weights of the tarpaulins/geotextiles were: Air Space Saver, 0.06 mm (3.63 grams); Fabrisoil, 1.02 mm (3.03 grams); Griffolyn, 0.05 mm (3.60 grams); Sanicover, 0.49 mm (2.46 grams); Typar, 0.47 mm (2.33 grams). The average thickness of the standards was: cardboard, 6.47 mm (9.10 grams); polymethylmethacrylate (PMMA), 12.7 mm (143.3 grams); plywood, 5-ply, 12.7 mm (69.4 grams); drywall, 12.7 mm (108.0 grams); red oak, 19.2 mm (133.3 grams). All of these flammability tests were performed in triplicate, and the results reported here are the averages of these replicate tests.

SUMMARY OF RESULTS - FLAMMABILTY STUDIES

The Cone Calorimeter flammability evaluation procedure can define many parameters associated with the combustion of materials, including: the time to ignition (seconds), the maximum heat release rate (kilowatts/square meter), the average heat of combustion (kilojoules/gram), and several other parameters much more related to fires in structures as opposed to the applications of interest here - these include smoke and heat release rates at various times during the combustion cycle.

The Time to Ignition is certainly an important characteristic since it relates the time of exposure to the ignition source to the start of the combustion process. The average Time to Ignition values for the five samples and the five standards are listed in Table IV, in increasing order. These data define clearly that the Time to Ignition of all the tarpaulins/geotextiles are only slightly longer than the cardboard standard, while the plywood and polymethylmethacrylate (PMMA) standards' Times to Ignition are three times the average (51.6 seconds) of all five of the tarpaulins/geotextiles. Therefore, on the basis of the Time to Ignition evaluation, the conclusion is that the daily cover tarpaulins/geotextiles are about as flammable as cardboard.

TABLE IV
TIME TO IGNITION
(LISTED IN INCREASING ORDER)
TARPAULINS/GEOTEXTILES FOR DAILY COVER
AND
GENERIC BUILDING MATERIALS

MATERIAL	TIME TO IGNITION (a) (SECONDS)
CARDBOARD	34(b)
SANICOVER	42
GRIFFOLYN	43
FABRISOIL	44
TYPAR	52
AIR SPACE SAVER	77
PLYWOOD (5-PLY)	151(b)
PMMA	156
RED OAK	266
DRYWALL	N/A

(a) ASTM E1354, Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products, Using an Oxygen Consumption Calorimeter.
(b) These materials include adhesives and bonding agents which affect the data somewhat.

The Maximum Heat Release Rate is important since those materials that cannot release significant heat cannot contribute to the combustion process. Therefore they would be considered nonflammable. The Maximum Heat Release Rate data for the five tarpaulins/geotextiles and the five standards are listed in Table V in increasing order.

Using the Maximum Heat Release Rates as the criteria for evaluating flammability, the conclusion is the tarpaulins/geotextiles release more heat than cardboard or red oak, but less than plywood or polymethylmethacrylate (PMMA).

When the sample weights (listed above) are considered, the Maximum Heat Release Rates for the tarpaulins/geotextiles are significantly higher than the standards, which is entirely logical based on the relative state of oxidation for the comparative materials. It is certainly an indisputable fact that all the tarpaulins/geotextiles are polymerized hydrocarbons - polyethylene or polypropylene - as compared to cardboard, red oak, and plywood, which are all cellulose-based materials, and polymethylmethacrylate (PMMA), which is partially oxidized compared to a hydrocarbon polymer. The data, shown sample weight normalized, in Table VI, support these conclusions.

These data are particularly descriptive in that the average of the five standards is 4.0 kilowatts/sq. meter/gram and the average of the five tarpaulins/geotextiles is 83.4 kilowatts/sq. meter/gram. If this analysis criteria is used as the basis of comparison, then the tarpaulins/geotextiles are about 21 times more flammable than the generic building material standards.

Another important comparison parameter is the Heat of Combustion of each of the tarpaulins/geotextiles and the five standards. These data, in kilojoules/gram, are listed in increasing order in Table VII.

As in the case of the Maximum Heat Release Rate per Gram data, Table VI, the Heat of Combustion results fall into two distinct categories. Of the ten samples evaluated, the materials with the lowest heats of combustion were the generic building materials, with the average of all five being 12.5 kilojoules/gram. By comparison, the five tarpaulins/geotextiles ranged from 28.7 to 33.7 kilojoules/gram, with an average of 31.6 kilojoules/gram or 2.5 times higher than the generic building materials.

TABLE V
MAXIMUM HEAT RELEASE RATE
(LISTED IN INCREASING ORDER)

TARPAULINS/GEOTEXTILES FOR DAILY COVER
AND
GENERIC BUILDING MATERIALS

MATERIAL	HEAT RELEASE RATE (a) (kilowatts/sq. meter)
DRYWALL(Surface Paper)	12.8
CARDBOARD	100.6(b)
RED OAK	152.5
TYPAR	213.4
AIR SPACE SAVER	234.4
GRIFFOLYN	245.6
SANICOVER	240.2
FABRISOIL	287.2
PLYWOOD (5-PLY)	327.2(b)
PMMA	449.4

(a) ASTM E1354, Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products, Using an Oxygen Consumption Calorimeter.
(b) These materials include adhesives and bonding agents which affect the data somewhat.

TABLE VI
MAXIMUM HEAT RELEASE RATE
PER GRAM OF SAMPLE WEIGHT
(LISTED IN INCREASING ORDER)

TARPAULINS/GEOTEXTILES FOR DAILY COVER
AND
GENERIC BUILDING MATERIALS

MATERIAL	HEAT RELEASE RATE (a) (kw/sq.m./gram)
DRYWALL(Surface Paper)	0.1
RED OAK	1.1
PMMA	3.1
PLYWOOD (5-PLY)	4.7(b)
CARDBOARD	11.1(b)
AIR SPACE SAVER	64.6
GRIFFOLYN	68.2
TYPAR	91.6
FABRISOIL	94.8
SANICOVER	97.6

(a) ASTM E1354, Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products, Using an Oxygen Consumption Calorimeter.
(b) These materials include adhesives and bonding agents which affect the data somewhat.

The data presented in Tables IV through VII can be effectively reproduced in graphical form. When the five second time interval heat release data, Table VIII, are plotted for the five tarpaulins/geotextiles and the five generic building materials, the comparative flammability behavior of the combined group of materials becomes obvious. As shown in Figure 1, within 150 seconds from the initiation of the testing procedure, cardboard and the five tarpaulins/geotextiles have been ignited and essentially oxidized (burned) to completion, while the red oak, plywood (5-ply) and the polymethylmethacrylate (PMMA) have not even reached their Time to Ignition, and therefore are not presented in Figure 1.

TABLE VII
AVERAGE HEAT OF COMBUSTION
(LISTED IN INCREASING ORDER)

TARPAULINS/GEOTEXTILES FOR DAILY COVER
AND
GENERIC BUILDING MATERIALS

MATERIAL	HEAT OF COMBUSTION (a) (kilojoules/gram)
DRYWALL(Surface Paper)	1.8
RED OAK	10.4
PLYWOOD (5-PLY)	11.2(b)
CARDBOARD	14.6(b)
PMMA	24.4
GRIFFOLYN	28.7
SANICOVER	31.3
AIR SPACE SAVER	32.0
FABRISOIL	32.5
TYPAR	33.7

(a) ASTM E1354, Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products, Using an Oxygen Consumption Calorimeter.
(b) These materials include adhesives and bonding agents which affect the data somewhat.

TABLE VIII
INSTANTANEOUS HEAT RELEASE RATE

TARPAULINS/GEOTEXTILES FOR DAILY COVER
AND
GENERIC BUILDING MATERIALS

TIME (Seconds)	A	B	C	D	E	F
	(KILOWATTS/SQUARE METER)					
0	0.0	0.0	0.0	0.0	0.0	0.0
5	1.7	2.2	3.0	2.3	2.5	2.6
16	5.3	7.1	9.5	7.3	8.0	8.3
27	9.0	12.0	16.0	12.3	13.4	13.9
38	12.7	16.9	22.5	17.4	18.9	19.6
49	16.3	21.8	29.0	22.4	24.4	25.3
55	18.3	24.4	32.6	25.1	27.4	28.4
60	20.0	26.7	35.6	27.4	29.9	30.9
65	21.7	28.9	38.5	29.7	32.4	33.5
71	23.7	31.6	42.1	32.4	35.4	36.6
76	25.3	33.8	45.0	34.7	37.8	39.2
82	27.3	36.4	48.6	37.5	40.8	42.3
88	29.3	39.1	52.1	40.2	43.8	45.4
93	31.0	41.3	55.1	42.5	46.3	48.0
99	33.0	44.0	58.7	45.2	49.3	51.1
104	34.7	46.2	61.6	47.5	51.8	53.6
115	38.3	51.1	68.1	52.5	57.3	59.3
121	40.3	53.8	71.7	55.3	60.3	62.4
132	44.0	58.7	78.2	60.3	65.7	68.1
148	49.3	65.8	87.7	67.6	73.7	76.3

(A) Air Space Saver (Figure 1 = ASPC)
(B) Fabrisoil (Figure 1 = FABR)
(C) Griffolyn (Figure 1 = GRIFF)
(D) Sanicover (Figure 1 = SCVR)
(E) Typar (Figure 1 = TYPR)
(F) Cardboard (Figure 1 = CBOD)

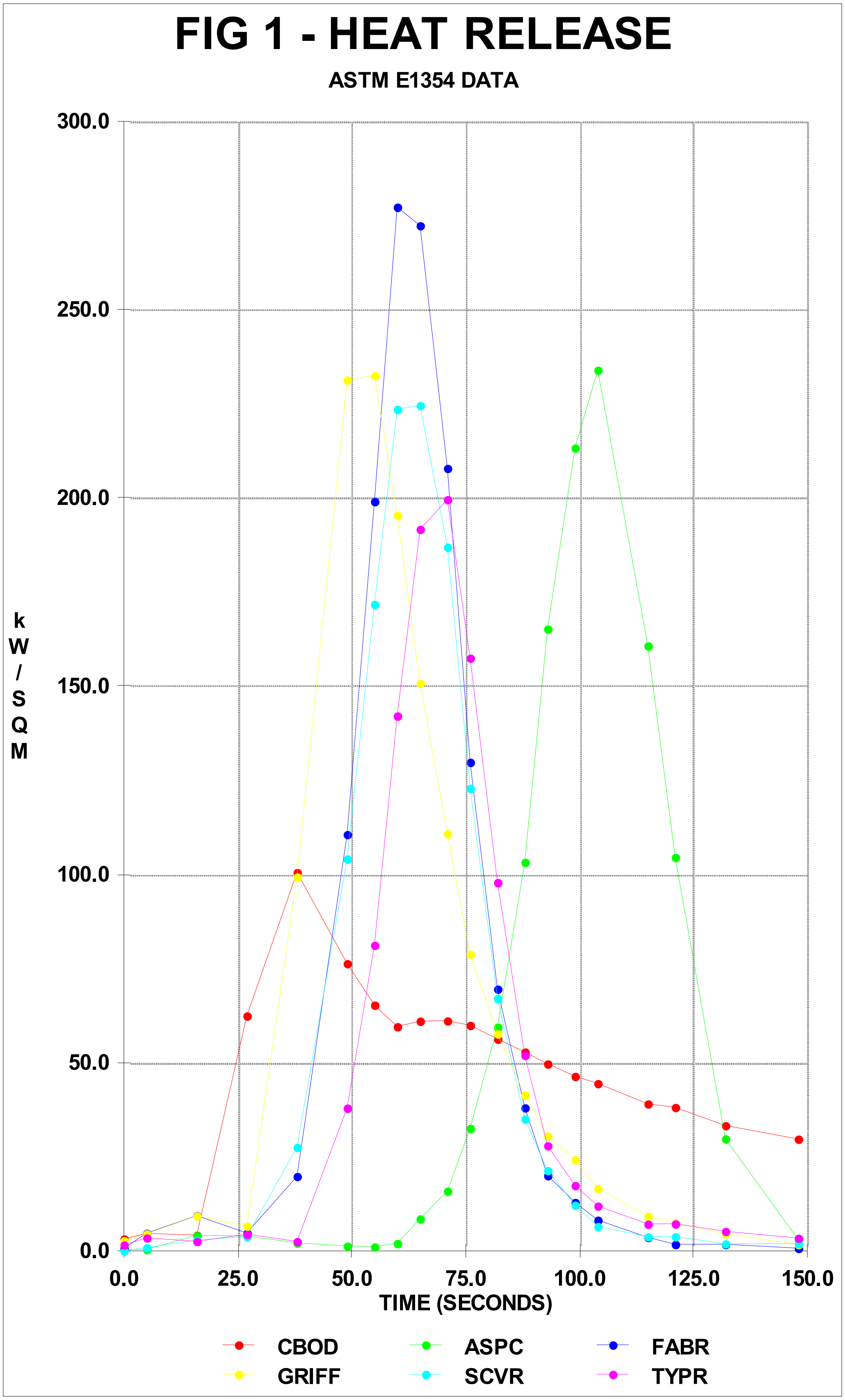
FIG 1 - HEAT RELEASE
ASTM E1354 DATA
300.0
250.0
200.0
150.0
100.0
50.0
0.0
k W / S Q M
0.0
25.0
50.0
75.0
100.0
125.0
150.0
TIME (SECONDS)
CBOD
ASPC
FABR
GRIFF
SCVR
TYPR

When the data are analyzed in this manner it is easy to observe that the onset of ignition of the cardboard and the Griffolyn are essentially identical, followed just slightly later by Fabrisoil and Sanicover, and then Typar a few seconds later. Air Space Saver stands alone in that the Time to Ignition is 77 seconds and by that time all the other materials have progressed beyond their maximum combustion rate (instantaneous heat release rate) and are cooling quickly. Even though Air Space Saver is slower than the other tarpaulins/geotextiles, at time equal to 150 seconds all five of the tarpaulins/geotextiles have cooled to near ambient, completing their combustion cycle, and the cardboard is smoldering, cooling slowly, a result of ash formation, which does not occur with the tarpaulins/geotextiles, as they contain no inorganic (ash forming) components.

SPECIFIC CONCLUSIONS

Conventional soil cover (9"), Rusmar Long Duration Foam, AC-645, and several tarpaulins/geotextiles were evaluated with respect to their performance parameters as defined by current sanitary landfill daily cover practice and RCRA Subtitle D requirements. The evaluation criterion included odor, methane, and total nonmethane hydrocarbon control and, in the case of the tarpaulins/geotextiles, a flammability evaluation comparing them to some standard generic building materials.

Odor was controlled very well by all of the alternate daily cover materials, except Fabrisoil, which was significantly below the average control level of the other materials. This performance behavior was exhibited both immediately after application of the daily cover material and also the next morning, ten to fourteen hours later. In both instances, the average odor control for the daily covers was 99 percent, but Fabrisoil showed only an 82 percent control, both immediately after placement and the next morning. Odor control was determined by ASTM Method E679-79.

Methane control was considerably more difficult. Nine inches of compacted soil did not show any attentuation for methane emissions either immediately after placement or the next morning - the readings in both cases were zero percent control. Methane measurements were determined using EPA Method TO-12.

Rusmar Incorporated Long Duration Foam, AC-645, exhibited 100 percent methane control immediately after the foam placement was completed and also the next morning, ten hours later. This was the expected result since foams in general are known to maintain excellent vapor barriers.

All three tarpaulins/geotextiles evaluated showed 100 percent methane control immediately after placement, but by the next morning, ten to fourteen hours later, the methane control exhibited by Fabrisoil and Griffolyn had decreased to 85 percent, and that exhibited by Air Space Saver had declined to 36 percent.

Total nonmethane hydrocarbon (TNMHC) emission control by Rusmar Incorporated Long Duration Foam, AC-645, Griffolyn, and Air Space Saver was 100 percent immediately after application and the next morning had changed little, with Griffolyn and Air Space Saver declining slightly to 98 percent, while Rusmar Long Duration Foam, AC-645, maintained 100 percent control. Soil was able to deliver a 93 percent control both immediately after placement and the next morning. Fabrisoil showed zero percent control for total nonmethane hydrocarbons at both times. TNMHC emissions were evaluated using EPA Method TO-12.

Rusmar Incorporated Long Duration Foam, AC-645, was evaluated for specific hydrocarbons. Immediately after placement the emission control was 100 percent for all species and next morning the control was still at 100 percent for all the materials except Freon 11 (68%), Freon 12 (75%), and toluene (95%).

Flammability studies were conducted on five tarpaulins/geotextiles and five generic building materials, which were used as reference standards. The tarpaulins/geotextiles used were Typar, Air Space Saver, Fabrisoil, Griffolyn, and Sanicover. The building material references included cardboard, 5-ply plywood, red oak, polymethylmethacrylate (PMMA), and dry wall. The test data were obtained using the ASTM E1354, the Cone Calorimeter technique, with a 25 kilowatt/sq. meter radiation source (waste basket fire).

The data developed were analyzed by several different techniques: Time to Ignition, Maximum Heat Release Rate, Maximum Heat Release Rate per Gram of Sample, Average Heat of Combustion, and Instantaneous Heat Release Rates. Regardless of the analysis technique used, the same conclusions were found, namely:

(1) The Time to Ignition showed that all the tarpaulins/geotextiles ignited in less than eighty seconds, with several below fifty seconds - only slightly slower than cardboard;

(2) The Maximum Heat Release Rate showed that the tarpaulins/geotextiles released more heat during combustion than red oak, and slightly less than 5-ply plywood;

(3) The sample weight normalized data, Maximum Heat Release Rate per Gram, showed the generic building materials had a rate of 4.0 kilowatts/sq. meter/gram, while the tarpaulins/geotextiles exhibited 83.4 kilowatts/sq. meter/gram, nearly 21 times more Maximum Heat Release Rate per Gram;

(4) The tarpaulins/geotextiles had an average heat of combustion value 2.5 times higher than the average of the generic building materials; and,

(5) When evaluated by the Instantaneous Heat Release Rates, the data showed that the ignition and flammability characteristics of the tarpaulins/geotextiles are very similar to cardboard and that they have completed their combustion process before the Time to Ignition of red oak, 5-ply plywood, and polymethylmethacrylate (PMMA) have been reached.

GENERAL CONCLUSIONS

All of the materials evaluated in this study are alternate daily cover materials except, of course, soil. The primary reason for using an alternate daily cover material is to reduce operating costs due to soil cost and soil placement and to save air space. All of the alternate daily cover materials discussed here achieve that goal to varying levels - all the tarpaulins/geotextiles will save soil costs and air space value and so will alternate daily cover foams.

If RCRA Subtitle D regulations are uniformly applied then the Clean Air Act will prevail with respect to odor emissions and total nonmethane hydrocarbon emissions. This additional restriction will impact the use of alternate daily covers, since they will then have to pass specific performance tests to qualify as acceptable.

Therefore several generalizations can be concluded:

(1) The alternate daily cover material must not only control odor but must be odorless itself - the ASTM E679-79 procedure described here can quantify this performance characteristic;

(2) Total nonmethane hydrocarbons are emitted from sanitary landfills and any alternate daily cover material will be required to control those emissions in order to comply with the Clean Air Act - the Surface Isolation Flux Chamber and EPA Methods TO-12 and TO-14 used in this study can quantify this performance characteristic;

(3) It may be necessary to control methane emissions when using an alternate daily cover material, even though it appears that soil does not exhibit any methane emission control at all - the Surface Isolation Flux Chamber and EPA Methods TO-12 and TO-14 used in this study can quantify this performance characteristic; and,

(4) Any alternate daily cover material must meet the flammability specifications of RCRA Subtitle D as they pertain to risk and spread of fires in a sanitary landfill - the ASTM E1354, Standard Test Method for Heat and Visible Smoke Release Rates for Materials and Products, Using an Oxygen Consumption Calorimeter, can quantify the flammability risks for any existing or proposed alternate daily cover material.

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AFFILIATION

Paul A. Kittle, PhD. is founder and President of Rusmar Incorporated located in West Chester, PA.
C.E. Schmidt, PhD. is an independent environmental consultant located in Red Bluff, CA.