WSRC-TR-93-293

665465

MECHANICAL DEGREDATION TEMPERATURE OF WASTE STORAGE MATERIALS (U)

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A document prepared for:

at
from thru

DOE Contract No. **DE-AC09-89SR18035**

DISCLAIMER

May 13, 1993

Keywords: Plastics, PVC, Polyethylenes, Bags

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SUMMARY

Heat loading analysis of the Solid Waste Disposal Facility (SWDF) waste storage configurations show the containers may exceed 90 °C without any radioactive decay heat contribution[1]. Contamination containment is primarily controlled in TRU waste packaging by using multiple bag layers of polyvinyl chloride and polyethylene. Since literature values indicate that these thermoplastic materials can begin mechanical degradation at 66 °C, there was concern that the containment layers could be breached by heating. To better define the mechanical degradation temperature limits for the materials, a series of heating tests were conducted over a fifteen and thirty minute time interval. Samples of a low-density polyethylene (LDPE) bag, a high-density polyethylene (HDPE) high efficiency particulate air filter (HEPA) container, PVC bag and sealing tape were heated in a convection oven to temperatures ranging from 90 to 185 °C. The following temperature limits are recommended for each of the tested materials:

- Low-density polyethylene 110 °C
- Polyvinyl chloride 130 °C
- High-density polyethylene 140 °C
- Sealing tape 140 °C

Testing with LDPE and PVC at temperatures ranging from 110 to 130 °C for 60 and 120 minutes also showed no observable differences between the samples exposed at 15 and 30 minute intervals. Although these observed temperature limits differ from the literature values, the trend of HDPE having a higher temperature than LDPE is consistent with the reference literature. Experimental observations indicate that the HDPE softens at elevated temperatures, but will retain its shape upon cooling. In SWDF storage practices, this might indicate some distortion of the waste container, but catastrophic failure of the liner due to elevated temperatures (<185 °C) is not anticipated.

BACKGROUND

For continuing operation of the Solid Waste Disposal Facility, Waste Management Engineering must develop interim Operational Safety Requirements (OSR) and a Justification for Continued Operation (JCO). To meet these requirements Solid Waste Engineering (SWE) requested that heat load limits be defined to prevent a fire from occurring in any of the waste storage containers.

Typical job-control waste is put into a polyvinyl chloride (PVC) bagout bag and placed into a 5 gallon pail lined with a low density polyethylene bag. This double-bagged material, commonly referred to as a "cut," is removed from the pail and placed into a high density polyethylene liner and 55 gallon TRU drum. The drum liner is also equipped with a polyethylene bag. Although polyethylene and polyvinyl chloride are not characterized as flammable materials, there is concern that contamination containment could be breached at elevated temperatures (>90 °C). Perusal of the reference literature, shows the mechanical degradation and melt/failure temperature of high and low-density polyethylene (HDPE and LDPE) and PVC varies considerably. Based on the reference literature, the following average mechanical degradation and melt temperatures were calculated:

- LDPE is 82.5±31.8 °C and 92.8±17.7 °C
- HDPE is 109±24.7 °C and 123.5±23.3 °C
- PVC is 66 °C and 89.3 °C±17.9 °C [2,3,4,5,6]

To better define these failure limits, a series of heating tests were conducted and any observable physical changes were noted.

RESULTS

Procedure

Samples of low-density polyethylene (caption 23, item 390.00), PVC (caption 23, item 482.05), high-density polyethylene (caption 23, item 2900.00) and the pressure sensitive film tape (caption 4, item 29810.00) used to seal the cuts were heated in a single wall gravity convection laboratory oven. The oven was manually controlled and monitored with a calibrated thermometer. Sample size was approximately a 2 cm square, which was placed in a ceramic crucible for heating in the oven. The material thicknesses were 5 mil (0.005") for the LDPE, 12 mil (0.012") for the PVC, and 125 mil (0.125") for the HDPE. To determine if any significant volatilization had occurred, the samples were weighed before and after heating. Eighteen tests were run at a unique exposure time and oven temperature. The temperature ranged between 90-185 °C depending on the material, and test times were 15 and 30 minutes at each temperature increment. The temperature was raised by 10 degree increments. The temperature and time range for each of the different materials tested is shown in Table 1.

Table 1. Test Conditions

Material	Temperature Range(°C)	Time Range(min)
HDPE	90-185	15-30
LDPE	90-140	15-30
PVC	90-185	15-30
Tape	90-140	15-30

Discussion

Mechanical degradation of LDPE, PVC and the film tape was confirmed by observing the physical appearance of the materials. Any degradation of the HDPE could only be identified by handling the sample. For example, the material would soften and loose its rigidity, but the sample's appearance remained unchanged. All samples were weighed before and after heating and any weight loss was considered negligible. Observations from the tests are shown Table 2.

Table 2. Sample Observations Due to Heating (110-160 °C)

Material	Temperature (°C)	Observations
LDPE	110	Crinkling and hardening of the edges and corners
	120	Edges curl and hardening is more severe
	130	The material "shrinks," becomes cloudy white, and becomes rigid
PVC	130	First sign of yellow spotting
	140-150	More prominent yellow spotting
	160-170	Material forms to the crucible and has a "glassy" look
	180	Sample turns a translucent yellow and looks "glassy"
HDPE	140	The sample softens with heat but regains rigidity upon cooling
	160 +	Softens with heat, retains the shape it has upon cooling
Tape	140 +	The tape melts against the crucible and gets sticky

Based on these observations, the following limits were defined for each of the materials:

- LDPE - 110 ± 5 °C
- HDPE - 140 ± 5 °C
- PVC - 130 ± 5 °C
- Sealing Tape - 140 ± 5 °C

Although these tests were only carried out at 15 and 30 minute increments, testing of the polyethylene and PVC was also conducted at 60 and 120 minutes. The samples that were exposed for the longer time periods showed no observable differences between the samples exposed to temperatures ranging from 110 to 130 °C at the 15 and 30 minute intervals. Comparison of the literature temperature failure limits to experimental values show good agreement between the upper limits for HDPE and LDPE. Comparison of the PVC temperature limit to the reference literature, however, is significantly different with over a 25 degree difference between the two defined upper limits (e.g. 107 to 135). Such differences are expected in these polymers because the material is not required to meet any ASTM standard for flammability or burn rate. The different additive and fillers are bound to affect the material physical properties.

Statistical Analysis
To determine the confidence interval for the temperature, a minimum of 4 data points were taken during each 15 and 30 minute test. Student's "t" distribution was calculated to determine a 95% confidence interval around the mean for each test.

CONCLUSIONS

The temperature limits for 4 materials used in waste packaging at the Solid Waste Disposal Facility were defined. The variability in the measured temperature values were also defined and significantly reduced, compared to accepted literature values. Physical observations indicate that the HDPE softens at elevated temperatures, but will retain it's shape upon cooling. In SWDF storage practices, this might indicate some distortion of the waste container, but catastrophic failure of the liner due to elevated temperatures (<185 °C) is not anticipated.

QUALITY ASSURANCE

All data for this test is contained in a controlled laboratory notebook WSRC-90-299, p. 115-128. This notebook is maintained by Michael L. Meyer.

PEER REVIEW Michael R. Poirier Michael R Poirier 7/9/93
Printed Name/Signature Date

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