Potential for Odor and Gas Generation due to the Transport of Municipal Solid Waste in Sealed Containers

SANITATION DISTRICTS OF LOS ANGELES COUNTY

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Solid Waste Management Department
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Introduction

The Sanitation Districts of Los Angeles County (Districts) are in the process of developing a Waste-by-Rail system that will transport municipal solid waste (refuse) from the Puente Hills Intermodal Facility (PHIMF) in Los Angeles County to the Mesquite Regional Landfill (MRL) in Imperial County. The refuse would first be loaded into cargo containers at a nearby materials recovery facility. The container would be closed (container openings would have gaskets or other measures that would ensure a tight seal) prior to the container being transported by truck to the PHIMF, where it would be loaded onto a rail car. The individual rail cars would be assembled into a continuous unit train approximately one-mile long on tracks adjacent to the PHIMF located in an industrial/warehousing area. The tracks would be built on property owned by Union Pacific Railroad (UPRR), adjacent to UPRR's existing tracks (see attached exhibit). Once the train is assembled, UPRR would transport the train the MRL.

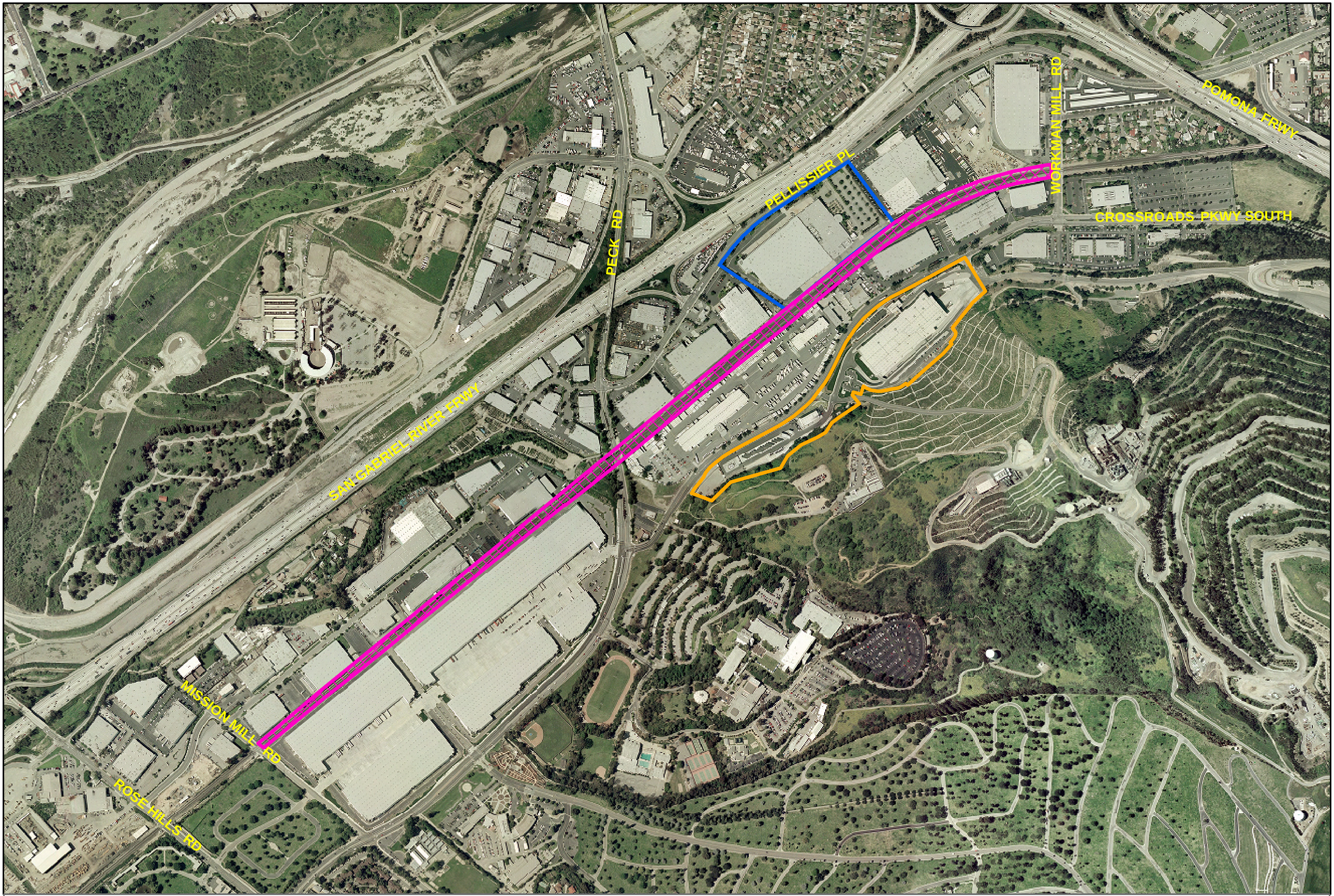
Based on discussions with the UPRR, the Districts expect the train loading and transport process to be complete within approximately 24 hours, and in almost all cases within 48 hours, limiting the potential for odors to occur. Moreover, the Districts will abide by a strict limitation that no containers loaded with solid waste will be stored at the facility, which includes the storage tracks on UPRR property, for more than 96 hours.

One of the concerns expressed by the local community is the potential for refuse odors and gas to buildup in the containers and be released to the atmosphere during the time period it takes for the sealed containers to be loaded onto the rail cars and transported to the MRL. Adjacent business owners and residents are concerned that the buildup of odors could cause a nuisance and affect their quality of life or business activities. In addition, they have expressed concerns that gas could buildup resulting in unsafe flammable or explosive conditions within the containers.

To address the community concerns, the Districts conducted a study to determine if refuse odors would be noticeable outside a container or if gas buildup would cause unsafe operating conditions. The study was carried out over several months and was based upon prior landfill operating experience and research, supplemented with a comprehensive field study.

One of the primary drivers for conducting the field study was the need to characterize the odors potentially associated with storage of refuse in sealed containers. Districts' staff has visited other waste-by-rail operations in the Pacific Northwest, which have a long history of operating successfully in urban areas and are a good model of how to implement a waste-by-rail system. However, the proposed PHIMF has some unique characteristics that could result in different results, including: 1) hotter, drier weather conditions, 2) different characteristics of refuse (i.e. different percentage of organic compounds), 3) use of state-of-the art container designs, and 4) proximity to businesses and residents.

Identification and characterization of odors can be a complex endeavor. However, the long history of operating solid waste facilities in urban areas has provided the Districts with a great deal of experience in odor identification and characterization. Methods typically used at Districts' facilities to identify odors include: a) modeling and wind tunnel studies to understand dispersion and atmospheric affects on odor movement, b) laboratory analysis of odor samples to



Proposed Location for Puente Hills Intermodal Facility Staging Tracks

Legend

- Proposed Staging Tracks Area
- Puente Hills Intermodal Facility
- Puente Hills MRF

identify concentrations of known odor causing compounds, and c) use of technicians' observations in the field and an odor panel[1] study or air samples to quantify magnitude and unpleasantness of the odor[2]. Although, some experts believe that odor quantification can only be reliably made through observation[3], Districts' experience has proven that these methods can reliably detect and characterize odors. The Districts modeling and wind tunnel studies have verified that odor movement is difficult to predict and is highly dependent on localized atmospheric conditions. In general, wind speed, relative humidity and atmospheric stability have the most impact on odor movement[4]. Similarly, gases associated with odors naturally disperse, or scatter, under normal conditions. Dispersion of gases leads to decreasing concentrations in the air, which leads to less identifiable odors for a receptor. Based on these factors, it is not prudent to rely solely on theoretical analyses of potential odor impacts associated with the waste-by-rail system.

In addition to analyzing odor impacts, the Districts wanted to be able to characterize gas formation, temperature rise, and pressure rise associated with the operation to specifically address community concerns. Thus, to supplement the Districts' experience and theoretical findings in quantifying odors and generation of gas, the Districts performed the field study to simulate the actual conditions expected during the operation of the PHIMF.

The field study, carried out at the Puente Hills Landfill and Puente Hills Materials Recovery Facility, included monitoring refuse placed in containers similar to those that will be used in the waste-by-rail system. Over a period of January to July 2007, on seven separate occasions, two containers were filled with residential waste, which is typically high in organic content. In all but one of these seven tests, water was added to the containers to promote higher levels of decomposition[5]. Prior to beginning the tests, the containers were modified so monitoring equipment could be inserted into the container to allow for gas samples from the interior of the container to be drawn. The containers were monitored daily for temperature, pressure, oxygen, and odor. Samples of the air internal and external to the container were drawn and captured in sample bags every two to three days. These samples were taken to a laboratory for subsequent analysis. At the laboratory, analyses for methane and other gases were performed on each sample as well as subjecting each sample to an odor panel to characterize and evaluate the intensity of any identified odors.

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[1] An Odor Panel is a group of trained human odor assessors who detect and characterize odors from gas samples, which are presented to them through sniffing ports of an olfactometer.

[2] For example, peppermint may be a strong odor, but most people would not characterize it as an unpleasant odor.

[3] "Thus far the only reliable instrument for quantifying odor is the human nose. The nose can detect certain odorous compounds at concentrations far below that achievable with standard chemical analysis. Also, combinations of these gases impact the nasal receptors differently than single gases. These synergistic effects cannot be detected using standard measurement techniques." Schmidt, David. *Odor- From Research to Practical Solutions.* Presented at the Manure Management Conference Sponsored by West Central Region of the Soil & Water Conservation Society. February 10-12, 1998.

[4] Schmidt, David.

[5] Decomposition of refuse is a biological process. Adding water to the refuse creates more favorable conditions for biological activity and should increase the rate of decomposition.

A schematic of the test containers showing the monitoring ports is presented in Appendix A. A description of the monitoring protocol is included in Appendix B. Pictures of the containers and testing activities are included in Appendix C.

Gas Formation and Odors

Odors associated with refuse are generally a result of the gases produced during biological decomposition of the refuse. Refuse with a higher organic content, and decaying under anaerobic (without air) conditions is likely to be more odorous. Even though a small amount of the decomposition gases are responsible for odors, they can create the strongest objectionable odors. Examples of these odorous compounds include hydrogen sulfide, dimethyl sulfide and mercaptons. Hydrogen sulfide (H_2S) is familiar to many people and can be characterized as a "rotten egg" smell.

One indicator of the potential for odors from decomposing refuse is the development of methane gas. Although methane gas itself is non-odorous, odorous gases such as H_2S can typically also be found in air samples when methane is present, which leads to methane being a good indicator of the potential for odors. In addition to its correlation with odorous compounds, methane gas generation could be a concern because it is inherently flammable and explosive if allowed to accumulate[6].

The ability to predict methane gas generation has been studied extensively by the academic community, and the waste management industry, including the Districts. This experience has led to the development of a model[7] that is used industry wide to predict the rate and amount of gas formed in landfill conditions. This model, however, assumes that methane formation is already occurring. A 1989 University of Wisconsin[8] study, which is still considered the definitive work on this subject, determined that methane formation does not occur until all existing oxygen in the refuse is depleted and acid-forming phases of decomposition are complete. The study revealed that it took approximately 20 days for oxygen to be consumed, the acid-forming decomposition phase to be complete, and the onset of methane formation to occur.

As noted above, the proposed Waste-by-Rail operation will be predicated upon storing containers no longer than four days (96 hours). Thus, the results of the University of Wisconsin study predict that no methane gas would be formed in the containers within this time period.

The field study data was used to confirm the theoretical predictions. Table 1 below shows the results of the laboratory analyses performed to determine the concentration of methane gas both inside and two feet outside of the container. After four days, the methane concentration was negligible in all seven of the field tests and in most cases below the detection limit of the laboratory analyses (<0.005%).

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[6] Methane gas is flammable and its flammability increases with its concentration in air. Methane gas is also explosive at concentrations between 5% and 15% by volume in air.

[7] United States Environmental Protection Agency (USEPA) Landfill Gas Emission Model, 2001.

[8] "Bacterial Population Development and Chemical Characteristics of Refuse Decomposition in a Simulated Sanitary Landfill" was published in Applied and Environmental Microbiology January 1989 by authors: Barlaz, Schaefer and Ham.

TABLE 1
Methane Concentrations[1] in the Interior and Exterior of Containers

Date Filled	Date Sampled	Container 1		Container 2	
		Interior (%)	Exterior (%)	Interior (%)	Exterior (%)
1/18/07	1/22/2007	<.005	<.005	<.005	<.005
2/15/07	2/20/2007	<.005	<.005	<.005	<.005
3/15/2007	3/22/2007	<.005	<.005	<.005	<.005
4/12/2007	4/16/2007	<.005	<.005	<.005	<.005
5/10/2007	5/14/2007	<.005	<.005	<.005	<.005
6/7/2007	6/11/2007	<.005	<.005	<.005	<.005
7/5/2007	7/9/2007	<.005	<.005	<.005	<.005

1. Concentration is expressed a percentage by volume of the sampled air.

In addition to the methane gas monitoring, the laboratory analysis also included quantification of H_2S. Table 2 shows the results of the laboratory analyses performed for H_2S gas in samples taken both inside and just outside (2 ft.) of the container. In some instances, small amounts of H_2S were formed within the container. However, in all instances the H_2S levels outside of the container were below the detection level of the laboratory analysis (<0.1 ppm). Laboratory analyses for other odorous compounds (e.g. mercaptons and other sulfide compounds) confirmed this trend. Data for these other compounds are presented in Appendix D.

TABLE 2
Hydrogen Sulfide Concentrations in the Interior and Exterior of Containers

Date Filled	Date Sampled	Container 1		Container 2	
		Interior (ppm)	Exterior (ppm)	Interior (ppm)	Exterior (ppm)
1/18/07	1/22/2007	<0.1	<0.1	0.1	<0.1
2/15/07	2/20/2007	<0.1	<0.1	<0.1	<0.1
3/15/2007	3/22/2007	1.2	<0.1	<0.1	<0.1
4/12/2007	4/16/2007	0.1	<0.1	<0.1	<0.1
5/10/2007	5/14/2007	<0.1	No data	<0.1	<0.1
6/7/2007	6/11/2007	<0.1	<0.1	<0.1	<0.1
7/5/2007	7/9/2007	2.9	<0.1	12	<0.1

Although the presence of methane and other gases can be an indicator of odors associated with decomposition of refuse, actual odor perception is a complicated phenomenon, as noted above. To determine the potential for odors to be observed outside the containers, technicians monitored for the presence of odors and noted odor intensity at progressively further distances from the containers. Air samples were also collected and sent to an odor panel for evaluation.

On every working day during the field testing, a trained[9] technician noted instances of odors emanating from each container. Table 3 presents a summary of the technician's odor

[9] As noted, the Districts have extensive experience with odor monitoring at existing facilities. As such, a standard protocol has been established to train technicians in odor identification and characterization.

observations. In some instances, mild odors were identified close to the container and up to about 15 ft. However, in no instances did the technician detect any odors at distances over 15 ft from the container.

TABLE 3
Maximum Distance (feet) Odor from Container was Detected

Date Filled	Date Monitored	Container 1 (ft.)	Container 2 (ft.)
1/18/07	1/19/2007	2	2
	1/22/2007	5	5
2/15/07	2/16/2007	2	10
	2/20/2007	2	10
3/15/07	3/16/2007	No data	No data
	3/20/2007	2	10
4/12/07	4/13/2007	No data	No data
	4/16/2007	4	9
5/10/07	5/11/2007	10	10
	5/14/2007	5	5
6/7/07	6/8/2007	7	7
	6/11/2007	15	2
7/5/07	7/6/2007	15	7
	7/9/2007	5	2

The samples used for the odor panel tests were taken at a distance of 2 ft. from the container. For reference, container interior and background[10] samples were also taken. Odor panel data is presented in Table 4. The Districts routinely use an odor panel to characterize odor samples from landfill and wastewater operations. The methodology used by the odor panel is consistent with the current ASTM standard methodology, ASTM E679-04[11], which was promulgated in 2004, for odor panel analysis of the collected air samples. In this test, six to ten people determine if there is an odor in a sample, when compared to a background sample (a carbon filtered "blank") and evaluate the intensity of any detected odor.

The odor panel results are expressed as a dilution to threshold ratio (D/T). A D/T unit is defined as the ratio of the clean dilution gas to that of the sample gas in order to reduce the sample gas to below the detection level. Various experts and agencies have different means of calibrating the D/T value in terms of how people being subjected to the odor may react to the pleasantness or unpleasantness of the actual odor. As noted above, the Districts have over 30 years of experience conducting odor characterization and odor panel analyses related to its functions as an operator of wastewater treatment and solid waste management facilities. The general rule used for the Districts' operations is that when evaluating landfill or refuse related odors, a D/T value over 100 would be quite noticeable and values over 1,000 would be offensive.

[10] Background air samples were taken up wind of the containers to identify the presence of odors not related to the container testing that might be noted by the odor panel.
[11] ASTM E679-04 replaced the older ASTM E679-91.

As shown in Table 4, the odor panel's analyses of the samples collected from within the containers found intensities in the range of 1,500 to 44,000 D/T, generally indicating strong, offensive odors inside of the containers. However, the odor intensities of the air samples collected just two feet downwind of the containers were in the range of 20 to 660 D/T, with most being in the 20-50 D/T range. Moreover, comparing the odor intensities downwind of the containers to the background air odor intensities showed the two values to be generally indistinguishable[12].

TABLE 4
Odor Intensity (D/T) in the Interior and Exterior of Containers

Date Filled	Date Sampled	Container 1 (D/T)		Container 2 (D/T)		Background (D/T)
		Interior	Exterior	Interior	Exterior	
1/18/07	1/22/2007	5,400	130	4,500	46	No data
2/15/07	2/20/2007	3,500	75	1,500	25	31
3/15/2007	3/22/2007	39,000	28	31,000	660	580
4/12/2007	4/16/2007	15,000	50	10,000	50	40
5/10/2007	5/14/2007	6,400	50	11,000	100	50
6/7/2007	6/11/2007	11,000	50	16,000	40	40
7/5/2007	7/9/2007	28,000	30	44,000	20	130

One of the most important considerations in odor characterization is evaluating distance from the source of the odor to the receptor. As the distance between receptor and source increase, odors decrease due to natural dispersion (dilution). Thus, to evaluate the odor causing potential of the containers filled with refuse for the Waste-by-Rail system requires that the specific locations of the odors sources and potential receptors be evaluated. Containers filled with refuse would only be stored within the PHIMF site or on tracks within UPRR property between Mission Mill Rd. and Workman Mill Rd. The nearest residential neighborhoods to these filled containers would be more than 350 ft. away. The closest receptors would be the industrial developments that abut the UPRR property, which are mostly comprised of light industrial and warehousing facilities.

Note that the samples used for the odor panel analysis to characterize odors outside of the containers were taken just 2 ft. from the exterior of the container. Focusing instead on the technician's monitoring data, in no instances were odors detected at distances greater than 15 ft. Thus, based on the field data, there should be no identifiable odors associated with the filled refuse containers that cause a nuisance condition at any of the industrial developments adjacent to the UPRR property where the filled containers would be stored.

[12] In particular, note the 660 D/T value on 3/22/07 outside of Container 2. The background value is 580 D/T indicating that odor panel is likely picking up background odors and not odors associated with the refuse in the container.

Other Parameters

One of the concerns expressed by the local community was the potential for gases to build up to levels that could cause releases to the atmosphere or in the most extreme case cause a container to expand or "explode". To evaluate this potential, the study looked at factors that could indicate the potential for an accumulation of gases, including temperature and pressure rise.

Temperature

Temperature increase is a sign that aerobic decomposition is occurring. A marked increase in temperature could also indicate that the air, or gases, inside the container are expanding and causing internal pressure. If expanded to a point where they could no longer be held in the container, the gases could vent through the seals or rupture the container. Another concern with temperature increase would be spontaneous combustion, which occurs in refuse at temperatures above 200^{o}F. Factors that could contribute to temperature increase are the ambient temperature outside the container and the heat generated as a byproduct of refuse decomposition. To evaluate the potential for this to occur, the tests were conducted into the summer months when ambient temperatures reached close to 100^{o}F. Technicians monitored the temperature in the containers twice a day. As shown in Table 5, at no time did the temperature increase to a point that indicated that gases were accumulating in the container or that the biological activity was causing an unsafe amount of heat to be generated.

TABLE 5
Temperature Monitoring Results

Date Filled	Date Monitored	Temperature (^{o}F) within Containers		Ambient (^{o}F)
		Container 1	Container 2	
1/18/07	1/19/2007	58	59	72
	1/22/2007	95	121	72
2/15/07	2/16/2007	79	86	92
	2/20/2007	69	112	64
3/15/07	3/16/2007	No data	No data	No data
	3/20/2007	74	130	62
4/12/07	4/13/2007	No data	No data	No data
	4/16/2007	90	129	79
5/10/07	5/11/2007	121	97	86
	5/14/2007	116	121	82
6/7/07	6/8/2007	102	92	81
	6/11/2007	115	110	82
7/5/07	7/6/2007	99	110	94
	7/9/2007	111	108	88

Pressure

Once a container is closed, the internal pressure could increase either due to generation of gas or increases in temperature[13]. The results, shown in Table 6, indicate that there was no increase in pressure in any of monitoring events. These results are consistent with the findings that there was no appreciable buildup of methane or other gases that could contribute to increased pressure within the containers.

TABLE 6
Pressure Monitoring Results

		Pressure (psig) within Containers	
Date Filled	**Date Monitored**	**Container 1**	**Container 2**
1/18/07	1/19/2007	0	0
	1/22/2007	0	0
2/15/07	2/16/2007	0	0
	2/20/2007	0	0
3/15/07	3/16/2007	0	0
	3/20/2007	0	0
4/12/07	4/13/2007	0	0
	4/16/2007	0	0
5/10/07	5/11/2007	0	0
	5/14/2007	0	0
6/7/07	6/8/2007	0	0
	6/11/2007	0	0
7/5/07	7/6/2007	0	0
	7/9/2007	0	0

Conclusions

After a comprehensive review of established research, supplemented with operating experience, field monitoring, and laboratory analysis, the Districts had the following findings and conclusions regarding the behavior of refuse in sealed containers as part of the Waste-by-Rail system:

- The Waste-by-Rail System planned by the Districts is predicated upon regular delivery of refuse between the Puente Hills Materials Recovery Facility and other materials recovery/transfer facilities in the Los Angeles County area and the destination at the Mesquite Regional Landfill. As part of typical operations, containers will be filled and unloaded within 48 hrs. Under normal operating

[13] According to established principles of physics (Ideal Gas Law), temperature rise that occurs in a fixed volume will increase internal pressure. Thus, if a container were to be fully sealed, an increase in the internal temperature as a byproduct of the decomposition process can be expected to lead to an increase in the internal container pressure.

conditions, the storage of containers filled with refuse for prolonged periods of time will not occur and in all cases, refuse would not be stored for more than 96 hours;

- Refuse would be enclosed in water tight and sealed containers. All openings will include gaskets or other measures to ensure tight seals;

- Most odorous compounds are formed during anaerobic decomposition. Methane gas formation is a good indicator of anaerobic biological activity and presence of odorous gases. Methane gas will not form or accumulate inside the containers within 96 hours;

- Other odorous compounds (e.g. H_2S) associated with anaerobic decomposition did not occur in significant quantities within the containers and the small quantities that did occur were below the laboratory detection level in all samples taken outside of the containers;

- Odor levels in the interior of the containers were in 1,500-44,000 D/T. Odor levels just outside of the container were typically in the 20-50 D/T range and generally indistinguishable from ambient air samples. Thus, the container seals are an effective odor control measure;

- The monitoring data confirmed that odors dissipate and are not detectable beyond 15 feet from the container;

- Although the study did not identify any significant odor related impacts associated with the transportation of refuse in containers, operational practices will be incorporated to further reduce the potential for these impacts, some of which are detailed below;

- There would be no gas pressure buildup inside the containers; and

- Interior temperatures may increase due to decomposition and hot weather conditions; however, temperatures would not increase to the point where spontaneous combustion would be a concern.

Operational Practices

As noted above, the study indicated that the proposed transport of refuse in containers would not cause any impact to the community due to noticeable refuse odors outside a container or gas buildup causing unsafe operating conditions. However, operational practices will be incorporated to further reduce the potential for these impacts. These practices include:

- All containers will be transported away from the PHIMF within 96 hours of receipt;

- All containers will be fully sealed during transport;

- All doors and openings on the containers will include gaskets or other measures to ensure tight seals;

- The containers will prevent the leakage of any liquids;

- To ensure that odors associated with the operation of the PHIMF, including odors associated with refuse in containers, are not a nuisance, the Districts will implement an Odor Management Plan. As part of the Plan, the Districts will continue to staff a 24-hour hotline to receive complaints. A technician will be dispatched to investigate the complaint within two hours of receiving the call. If the odor is confirmed, the Districts would take remedial action that could include identifying the container(s) generating the odor, resealing loose openings, applying odor neutralizers, and venting gas through carbon filters or other gas filtering devices;

- The Districts will make sure that severely odorous refuse loads are not placed into the Waste-by-Rail containers at the PHMRF. This will be accomplished by either rejecting severely odorous loads, mixing odorous refuse with normal refuse, allowing odorous loads to aerate before loading, or by using odor control substances;

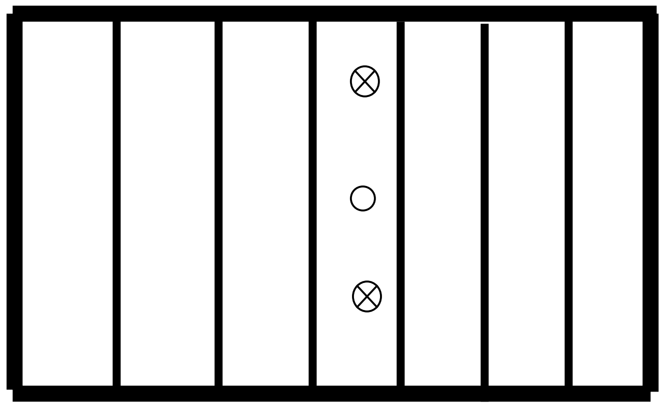
- Odorous containers from other materials recovery facilities will be rejected and sent back to the originating facility for mitigation;

- Container vents will be securely closed during transportation; and

- To ensure that all containers are in good working order, LACSD would implement a Container Inspection, Maintenance and Repair Program. Elements of the Program would include: 1) inspecting all containers for dents, punctures, structural damage, and graffiti, 2) monitoring the proper working condition of the lid, doors, seals, and vents, 3) implementing a container tracking protocol that will allow for regular, preventative maintenance (e.g. door seal replacement) to occur according to manufacturers specifications, and 4) establishing a program of regular cleaning of containers. Records of all container inspection, maintenance and repair activities would be made available for inspection to ensure the Program is effective.

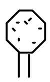
Appendix A: Schematic of the Test Containers

Schematic of the Test Containers



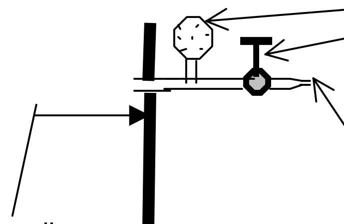
Container side: Two sampling ports & one thermocouple
Other side: Two sampling ports

⊗ gas sampling port (installed on container) (four)

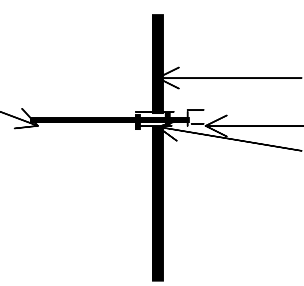
 pressure gauge (low pressure) on gas sampling port (four)

○ thermocouple port (one)

Gas sampling port



Thermocouple port



Appendix B: Monitoring Protocol

Monitoring Protocol

The container study consisted of seven tests conducted over seven months. Each test involved filling two containers with mostly residential refuse, sealing and storage of the containers, monitoring and testing of the containers for odors, gas, temperature and pressure and unloading of the containers. The testing methodology used in the study is detailed below.

Container Loading

The containers were filled with residential waste with high organic content at the PHMRF or PHLF. In all but one of these seven tests, water was added to the containers to promote higher levels of decomposition.

Refuse identified as originating from residential areas was used to fill the containers. Loaders on the PHMRF floor or at the PHLF carried out the sorting and separation of refuse. To the extent possible, the refuse added to each container was similar (e.g. from same pile and with no visible difference in composition). After each load was placed in the container, water was uniformly sprayed over the entire refuse surface for approximately one minute. The containers were then closed with lids.

Container Storage

The sealed containers were stored for approximately four days at the PHLF, approximately half a mile west of the active disposal area.

Daily Monitoring

Each working day, the containers were monitored in the field. A technician was dispatched twice each working day at about 8:30 a.m. and 1:30 p.m. to monitor the containers in field. The following measurements were recorded:

- Inside temperature

  A handheld digital thermometer was connected to the thermocouples installed in both containers to read interior temperature.

- Inside pressure

  A low range pressure gauge was connected to sampling ports installed in both containers to read interior pressure.

- Oxygen (O_2) readings

  Oxygen concentrations were analyzed in field using a GEM 2000, which is commonly used for landfill gas monitoring.

- Odor Monitoring

Characterization of exterior odors was performed at 2, 10 and 20 feet from the containers. The maximum distance with noticeable odors was also recorded.

Gas Sampling

In addition to the field tests noted above, the technician also was responsible for retrieving gas samples from the interior and exterior of the container. Sampling of gas from interior of the test containers was accomplished through the use of sealed ports installed in the containers. Each interior sample was a composite sample of gas drawn from four ports installed on each container (see Appendix B for a schematic showing the location of the sample ports). Other gas samples retrieved included, ambient air just outside the containers and background air. Sampling occurred every two to three days during storage of the refuse. The samples were collected in Tedlar bags and transported to the Districts' laboratory at Joint Water Pollution Control Plant (JWPCP). Standard chain of custody methods and forms were used during the sample transportation. The following analyses were performed for each sample at the laboratory:

- Methane (CH_4) and total non-methane organic gases.
- Permanent gases.
- Volatile organic gases and other gases typically found in landfill gas.
- Odorant gases such as hydrogen sulfide, reduced sulfur compounds and mercaptons.
- Odor panel analyses including odor intensity, characterization and identification.

Appendix C: Photos of Test Activities

Photo 1 – A typical pile of refuse with high food content used in the test containers

Photo 2 – Water is being sprayed on refuse in test container

Photo 3 – Refuse is being tamped down in test container with an excavator

Photo 4 – Interior pressure monitoring

Photo 5 – Interior temperature monitoring

Appendix D: Odor Testing

Odor Testing

Odor Testing Methods

Odor testing was conducted in the field as well as in laboratory. A technician performed field monitoring each work day during the tests to determine the maximum distance from the containers with noticeable odors.

Laboratory analysis of container interior and exterior gas samples was performed for each test independent of field monitoring described above. Gas samples were collected from interior and exterior of stored containers in each test and sent to the JWPCP laboratory for olfactometry analysis. The Districts currently employ two different olfactometry methods. The first method is triangular forced-choice dynamic dilution ascending concentration series olfactometry, with an odor panel of six to ten odor assessors. The method, also known as ASTM E679-04[1], measures odor intensity of odorants. The second method uses gas chromatography/mass spectrometry-olfactometry (GC/MS-OLF) to identify odorants.

Odor Identification results

Hundreds of known odorants were analyzed, and a number of them were identified in the interior samples. In the exterior samples, collected within 2 feet from the containers, only a few known odorants were identified in low concentrations. This is consistent with the odor intensity results, which showed much weaker intensities in the exterior samples than in the interior samples. The laboratory analysis data for major odorants identified in the samples is presented in the Tables 1a to 1e.

[1]The Districts' odor panel operations exceed the requirements of ASTM E679-04 standard, which is the current ASTM standard for odor panel analyses promulgated in 2004. The older ASTM E679-91 standard, dates back to 1991.

Laboratory Analysis of Odorant Compounds

Table 1a Methyl Mercapton (ppm)

Date Filled	Date Sampled	Container 1 Concentration		Container 2 Concentration	
		Interior	Exterior	Interior	Exterior
1/15/07	1/22/2007	0.2	<0.1	<0.1	<0.1
2/15/07	2/20/2007	0.2	<0.1	0.9	<0.1
3/19/2007	3/22/2007	4.8	<0.1	3	<0.1
4/12/2007	4/16/2007	1.2	<0.1	0.1	<0.1
5/10/2007	5/14/2007	<0.1		0.1	<0.1
6/7/2007	6/11/2007	0.8	<0.1	0.6	<0.1
7/5/2007	7/9/2007	22	<0.1	14	<0.1

Table 1b Carbonyl Sulfide (ppm)

Date Filled	Date Sampled	Container 1 Concentration		Container 2 Concentration	
		Interior	Exterior	Interior	Exterior
1/15/07	1/22/2007	2	<0.1	0.1	<0.1
2/15/07	2/20/2007	<0.1	<0.1	0.2	<0.1
3/19/2007	3/22/2007	0.3	<0.1	0.2	<0.1
4/12/2007	4/16/2007	0.1	<0.1	0.3	<0.1
5/10/2007	5/14/2007	<0.1		0.1	<0.1
6/7/2007	6/11/2007	0.3	<0.1	0.1	<0.1
7/5/2007	7/9/2007	0.8	<0.1	1.7	<0.1

Table 1c Carbonyl Disulfide (ppm)

Date Filled	Date Sampled	Container 1 Concentration		Container 2 Concentration	
		Interior	Exterior	Interior	Exterior
1/15/07	1/22/2007	0.2	<0.1	0.1	<0.1
2/15/07	2/20/2007	1.1	<0.1	0.7	<0.1
3/19/2007	3/22/2007	0.2	<0.1	0.6	<0.1
4/12/2007	4/16/2007	0.7	<0.1	1.4	<0.1
5/10/2007	5/14/2007	0.2		0.2	<0.1
6/7/2007	6/11/2007	0.4	<0.1	0.4	<0.1
7/5/2007	7/9/2007	2.3	<0.1	2.1	<0.1

Table 1d Dimethyl Sulfide (ppm)

Date Filled	Date Sampled	Container 1 Concentration		Container 2 Concentration	
		Interior	Exterior	Interior	Exterior
1/15/07	1/22/2007	0.3	<0.1	0.1	<0.1
2/15/07	2/20/2007	1.2	<0.1	0.4	<0.1
3/19/2007	3/22/2007	1.2	<0.1	1.2	<0.1
4/12/2007	4/16/2007	0.5	<0.1	0.2	<0.1
5/10/2007	5/14/2007	0.4		0.1	<0.1
6/7/2007	6/11/2007	0.4	<0.1	0.9	<0.1
7/5/2007	7/9/2007	5.3	<0.1	5.4	<0.1

Table 1e Dimethyl Disulfide (ppm)

Date Filled	Date Sampled	Container 1 Concentration		Container 2 Concentration	
		Interior	Exterior	Interior	Exterior
1/15/07	1/22/2007	0.2	<0.1	0.1	<0.1
2/15/07	2/20/2007	0.4	<0.1	0.7	<0.1
3/19/2007	3/22/2007	0.1	<0.1	7.7	<0.1
4/12/2007	4/16/2007	0.8	<0.1	0.6	<0.1
5/10/2007	5/14/2007	0.3		0.3	<0.1
6/7/2007	6/11/2007	0.2	<0.1	0.6	<0.1
7/5/2007	7/9/2007	1.5	<0.1	2.1	<0.1