Diverting organics like food and yard wastes from landfiling to some form of processing and recycling is a popular topic today. Organics recycling facilities are manufacturing plants, making compost, mulch and/or biogas, and they need the same attention to H&S that regular manufacturing plants require.
These are the topics I’m going to cover in this presentation
Health Concerns

- Dust
  - Inhalation
  - Eye irritants
  - Bioaerosols

Processing of organic wastes into mulches and composts is an inherently dry, dusty process, so dust inhalation and irritation are common problems. Many citizens opposed to organics processing facilities will often cite concerns about bioaerosols escaping the site.
The predominant bioaerosols observed in organics recycling are fungi and fungal spores. Bioaerosols are present in any facility handling woody materials.
As you know, composting requires a certain time-temperature relationship to kill off pathogens and fecal coliform. Yard waste composting facilities are often exempt from those requirements due to a perceived low pathogenicity potential. However, yard waste is often contaminated by pet feces and high temps (above 131o F.) are needed to reduce fecal to acceptable levels (< 1,000 MPN/g)
Prions

- Small, abnormally-folded, infectious proteins
  - may be found in animal carcasses and meat processing wastes
- Some are associated with transmissible spongiform encephalopathy (TSE) diseases
  - Chronic Wasting Disease (CWD) - deer, elk, moose
  - BSE ("Mad Cow Disease") – cattle
  - Scrapie - sheep
  - variant Creutzfeldt-Jakob disease - humans
- Composting may not be appropriate for disposal of animal carcasses or products in which TSE is known or suspected to be present

Prions are not inactivated by composting and research results are mixed for inactivation in anaerobic digesters. Animal carcasses or parts that may have risk of exposure should not be processed in an organics recycling facility.
Microbiological Risks, cont.

- Two main routes of exposure to compost microorganisms
  - ingestion - main route of infection - can be controlled by good hygiene
  - inhalation of bioaerosols - unlikely to cause infection, major route of exposure to allergens and toxins
- Microorganisms can be aerosolized during shredding, turning, & screening
- Control of bioaerosol inhalation is complex
- Anyone with compromised immune system should not work in a compost or mulch operation

It is advisable to keep persons with respiratory ailments, like asthma, or with compromised immune systems, away from employment at organics processing facilities. This can cause issues with compliance with HR rules regarding hiring, so work with your HR staff to develop appropriate questions to ask applicants. As for visitors, if you allow them, then either notify them that they may be at risk and need PPE, or ask them to sign a waiver of liability.
Agents of Respiratory Infections

- Viruses: influenza, measles (rubeola), chickenpox (herpes varicella-zoster) and rhinoviruses (colds); Hantavirus (from a rodent; mouse)
- Bacteria: Legionella spp., tuberculosis and other mycobacteria (Mycobacterium spp.), anthrax (Bacillus anthracis), and brucellosis (Brucella spp.).
- Fungi: diseases: histoplasmosis, cryptococcosis, blastomycosis, coccidiodomycosis, and aspergillosis
- Protozoans: Pneumocystis carinii pneumonia; prevalent in immunodeficient hosts such as AIDS patients.
- Acanthamoeba encephalitis; primary amebic meningoencephalitis (PAM)

These are some of the diseases that respiratory infections cause.
Preventing infections is largely a matter of common sense and good sanitation practices. If you can, provide a room where employees can change out of uniform/work clothes before going home.
Preventive Measures – Allergens & Toxins

- Minimize the production of dust by:
  - Controlling moisture:
    - by avoiding over-drying during pile/windrow teardown
    - during screening (40-60% ideal)
  - Keeping hard surfaces clean
  - Avoiding dry sweeping and use of compressed air to clean equipment
- Wear dust mask or half-mask respirator (requires fit test & training)
- Use filters or air conditioning in cabs of front-end loaders etc. and keep windows closed

As inhalation of most allergens is associated with dusty conditions, keeping materials handling operations under control is important.
I have tinnitus, probably from too much rock-n-roll when I was younger! It’s a constant high-pitched whine I can never turn off and there is neither a cure, nor any medication that reduces it.
May 2018 – 8,600 daily heat records broken. May 28 in Minneapolis, MN, it hit 100 deg. F.!

As this may become the new normal, heat exhaustion is a very real risk to anyone working in an outdoor environment.

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**Health Concerns – Heat Exhaustion**

- Composting takes place in 140° – 160° F. environment
- Causes include exposure to high temperatures, particularly when combined with high humidity, and strenuous physical activity
- Possible heat exhaustion signs and symptoms include:
  - Cool, moist skin with goose bumps when in the heat
  - Heavy sweating
  - Faintness
  - Dizziness
  - Fatigue
  - Weak, rapid pulse
  - Low blood pressure upon standing
  - Muscle cramps
  - Nausea
  - Headache
As we have discussed, composting involves taking feedstocks often contaminated with pathogens. These bacteria can cause diseases by entering the body through the nose, mouth, or open cuts on the body. Keeping hands and face washed while at work can greatly minimize risk of disease.

The risk of injury from moving equipment is very real in composting. Mobile equipment that has engines, chain and belt drives, rotating flails and hammers, and other moving parts are risks for significant injury and death.

Another risk is exposure to hydrogen sulfide due to the anaerobic decomposition of compost fines washed into storm drains. In 2012, two workers were overcome and died when they entered a storm drain to clean out accumulated fines.

With growing interest in anaerobic digestion of solid wastes,
exposure to methane (a toxicant and an explosion hazard) needs to be managed.
Safety in any manufacturing operation is a corporate culture phenomenon. If management really buys into it and actively promotes a strong safety mindset, the risk of injury drops off dramatically. If management doesn’t really care about safety, that lack of care will infect the entire facility workforce, putting employees at risk.

Take the time to prepare a written Health and Safety Plan. This must be a living document that contains all the policies for keeping employees safe and one that is continuously updated. If a waste generator customer wants to see your facility’s H&S plan before they will do business with you, you will have one ready.

Discussion topic: Describe your facility’s Health and Safety Program
## Health & Safety Plan

**Elements:**
- Bloodborne pathogens
- Disciplinary policy
- Fire prevention plan
- First Aid program
- Self-powered industrial trucks
- Hydrogen sulfide policy
- Fuel management
- Hazard communications
- Hearing conservation
- Lockout/tagout
- Personal protective equipment
- Rigging material handling
- Site management

These are the different elements that make up a complete health and safety plan for a composting facility. Let’s look at each one.
Plan elements

- Bloodborne pathogens
  - How blood-producing injuries handled at facility?
- Disciplinary policy
  - How are violations of the H&S Plan to be handled?
- Fire prevention plan
  - How will risks of fire be minimized?
- First aid program
  - How will first aid be administered when needed?
- Self-powered industrial trucks
  - How will injuries be prevented around mobile equipment?

Each element of the plan aims to address a particular health and safety concern.

Discussion topics: Describe how your facilities handle these issues?
Plan elements, cont.

- Hydrogen sulfide & confined spaces
  - How will risks of exposure be minimized?
- Hazard communications
  - How will toxic chemicals in Equipment Maintenance be handled?
- Hearing conservation
  - What practices will employees follow to minimize hearing damage?
- Lockout/tagout
  - Procedures for working on powered equipment

Discussion topics: Describe how your facilities handle these issues?
Plan elements, cont.

- Personal protective equipment
  - What is to be worn and when?
- Rigging material handling
  - How are equipment and material lifts to be conducted to minimize risk of injury?
- Site management
  - Practices and policies to minimize risk of injury
  - Fuel delivery and management practices
  - Emergency Action Plan

Discussion topics: Describe how your facilities handle these issues?
Confined spaces & \( \text{H}_2\text{S} \)

- A confined space has at least these three properties; any type of space that (1) is large enough and configured such that an employee can bodily enter and perform work, (2) has limited openings for entry and exit, and (3) is not designed for continuous employee occupancy.

- Other common characteristics of confined space: existing ventilation that is not sufficient to remove dangerous air contamination,

- Access for the removal for a suddenly disabled employee is difficult due to the location and/or size of the openings.
Confined spaces & H₂S, cont.

- A confined space is an enclosed or partially enclosed area that is big enough for a worker to enter.
- It is not designed for someone to work in regularly, but workers may need to enter the confined space for tasks such as inspection, cleaning, maintenance, and repair.
- A worker is considered to have entered a confined space just by putting his or her head (or any other body part) across the plane of the opening.
Two laborers, 16 and 22-year-old brothers, died while cleaning the drainage system of an organic waste recycling facility in California. Both were exposed to excessive levels of hydrogen sulfide. The brothers were part of a three-man crew that was flushing out the drainage system consisting of 24-inch diameter underground pipes accessed by approximately 14 manhole shafts. While using a high-pressure water hose to flush residual compost, the 16-year-old was overcome by hydrogen sulfide and fell to the bottom of a 10-foot shaft. The 22-year-old collapsed at the bottom of the shaft after attempting to rescue his brother. Contributing factors identified in this investigation were the high concentration of hydrogen sulfide in the shaft, failure to implement a confined space and hazard communication program, and the age of the youngest victim.

At a mushroom composting operation in British Columbia, on Sept. 5, 2008, five workers spent five hours trying to unclog a pipe when hydrogen sulfide gas spewed out and overwhelmed the workers. Two were injured and three died. The pipe had been blocked for
several days with straw and manure.
Hazardous Energy

- Energy sources including electrical, mechanical, hydraulic, pneumatic, chemical, thermal, or other sources in machines and equipment.
- During the servicing and maintenance of machines and equipment, the unexpected startup or release of stored energy can result in serious injury or death to workers.
- Always practice Lock-out / Tag-out

Energized equipment is a major source of occupational injury in manufacturing.
Lock-out / Tag-out

- Lock-out. Locking power off. Some physical device to keep power from being turned on.
- Tag-out. Putting a tag over switches, valves, handles or any other part that can turn power on.
Safety meetings should be more than just once a year. Hold daily “tailgate” meetings outside before work begins to reinforce the concept that “Today, everyone works safely”. Monthly, or bi-monthly, hold meetings with all staff to get feedback on how programs are working, or not working.

For sites open to the public, make sure there is adequate signage around warning of hazards. People are remarkably unaware of moving machinery around them so you, and your employees, must keep your eyes open for possible hazards. Discussion topic – How many of you have seen potential safety problems with the public at your facilities?
Compost Personal Protective Equipment

- Obvious
  - Steel toed boots
  - Long pants
  - Gloves
  - Dust protection
  - Hearing protection
  - High visibility vests
  - Hard hats
  - Eye protection

- Subtle, specialized, and unexpected
  - Personal breathing apparatus
  - Full body harness
  - Personal H2S monitor
OSHA

- Occupational Health & Safety Administration
  - Part of Dept. of Labor
  - www.osha.gov
- Covers private sector employers
  - Exempt: on-farm and government workers
- Provides training courses, materials, and resources
- Conducts enforcement
  - Inspections without warning
- Protects workers’ rights
  - Will accept complaints from employees

The Federal Occupational Health and Safety Administration (OSHA) is charged with implementing a lot of worker protection laws that have been passed in the last century. They also have a lot of useful training information.
The incident reports are a good place to keep track of near-misses also so you can identify where possible hazards in your operation exist. The Form 300 and Form 301 have to be submitted annually and your workers compensation insurance company may require them also.
Fires at composting facilities are quite common. You have oxygen present because it’s an aerobic process, you have fuel available in the form of woody material in the pile, and you have heat in the pile created by the microbes. Piles allowed to dry out below 40% moisture are at the greatest risk of combustion.
Numerous sources can set a compost pile on fire: lightning, carelessly-tossed cigarettes, sparks from welding equipment.

Spontaneous combustion is one of the more common problems. If the pile doesn’t have adequate porosity, heat from biological activity will take over and raise the heat in the pile. Above 175° or so, bacteria die off, but self-heating chemical reactions take over. Above 300° or so, the compost will catch fire. This is a smoldering-type fire, but when you open up the pile and expose that fire to fresh oxygen, you can get an open-flame event.
Some of these fires have cost many millions to extinguish. The June 2013 fire in Austin, TX cost the city over $9 million.

What’s wrong with this picture from Milford, CT? The fire dept cannot put out a compost fire by pouring water on it. You have to break the piles down into smaller piles before you douse them with water.
Fire prevention

- Meet with your local Fire Dept
  - Discuss & agree on guidelines
  - Have good access roads
  - Have proper equipment on site
- Assure adequate ventilation of piles or windrows
- Avoid pile depths greater than 12 feet
- Watch for vents
- Monitor temperatures on all piles weekly
- Locate the fire & open with front-end loader
- Water embers
Hazard & Operability Analysis (HAZOP)

- Process failure analysis technique
  - Examine each step or unit operation
  - "What can go wrong here?"
  - Analyze operations and maintenance separately
- For each component:
  - Consider potential causes of problems
  - Analyze possible consequences of problems
  - What preventive measures might avoid problems?

The particular nature of solid waste digestion and biogas production requires consideration of environment, health and safety issues that go beyond just moving machinery and electrical lock-out/tag-out to include measures to avoid asphyxiation hazards, fire and explosion hazards, and accidental releases of biogas or digestate. These types of hazards, along with the conventional hazards of manufacturing, can be addressed in a Hazard and Operability Analysis (HAZOP) and in a Job Safety/Hazard Analysis.
The common element in all four: STUPIDITY!!
HAZOP analyses examine manufacturing from both an operations and a maintenance perspective separately, and for each component, consider potential causes of problems (called a “deviation” in HAZOP language), the possible consequences of those problems should they occur, and what preventive measures or actions might be warranted to minimize the possibility that a deviation will occur.

- Potential causes of problems:
  - Human error
  - Design problems
  - Fire or explosion
  - Natural disasters
  - Power failure
  - Sabotage/vandalism
  - Terrorism

- Potential consequences:
  - Injury/illness
  - Environmental contamination
  - Property damage
  - Lost or contaminated products
  - Monetary losses
  - Loss of time
Conducting a HAZOP

- Starts in the design process
- Can be done anytime in any facility
- Diverse team assembled to conduct HAZOP
- Procedure explores both quantitative and qualitative failure modes
- Participants encouraged to be creative in thinking
- Guidewords used:
  - No or Not – negation of design intent
  - More/Less – quantitative increase/decrease
  - As Well As/Part Of – qualitative increase/decrease
  - Reverse – Logical opposite of design intent
  - Other Than – Complete substitution

The timing of a HAZOP study is determined by the objectives of a study, which in turn, determines the benefits that may be gained. A project may be studied several times during the development process and during operations. The concept design of a process may be examined to highlight any major omissions or significant features. As further design work is carried out, e.g. when the process design is complete, the full study may be appropriate.

In order to identify deviations, the team applies (systematically, in order) a set of guide words to each section of the process. Guide words should be chosen which are appropriate to the study and neither too specific (limiting ideas and discussion) nor too general (allowing loss of focus).
This sequential and structured approach is applied to each step in the biological manufacturing process. For example, one of the processes in AD is the distribution of biogas from gas storage to ultimate use or flaring. Table shows how these guide words are used to evaluate and assess various “what if?” scenarios for biogas flaring.
<table>
<thead>
<tr>
<th>GUIDE WORDS</th>
<th>DEVIATION</th>
<th>POSSIBLE CAUSES</th>
<th>CONSEQUENCES</th>
<th>ACTIONS</th>
</tr>
</thead>
</table>
| MORE             | More combustion at flare than desired; flame too hot or too high | • Too much gas flow to flare  
• Gas composition of methane and other combustibles higher than expected | • Damage to flare  
• Risk of gas leakage  
• Inability to process gases efficiently | • Install pressure gauge on gas flow to flare to warn of high flow; with alarm  
• Test digester gas composition |
| LESS             | Less combustion at flare than desired               | • Low gas flow to flare; piping partially blocked or leaking; partial failure of water seal trap  
• Intermittent ignition at flare; ignition source fails intermittently or ignition power source interruptions  
• Low gas flow from digester; digester over-pressurized; digester partial process failure (decline of bacterial growth); possible intermittent gas flow (flow new going toward digester) | • Uncombusted digester gases emitted to the atmosphere.  
• Environmental (air) pollution violation  
• Gas emissions or gas leak producing exposure to people or potential fire or explosion  
• Possible indicator of digester impending process failure | • Test air for uncombusted digester gases at flare and vapor piping; install gas detection equipment at flare to measure for combustion products or uncombusted digester gas components; measure for explosivity  
• Install pressure gauge on gas flow to flare to warn of low flow; with alarm  
• Test for digester bacterial impending process failure |
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<tr>
<td>AS WELL AS</td>
<td>Other materials entering gas line as well as the digester gas</td>
<td>• Excessive gas pressure from the digester pushes water from water seal into the gas line with the digester gas • Air leaks into gas line</td>
<td>• Pressure differential between digester and gas piping at generator or at flare allows water to be pushed into piping; high moisture level decreases BTUs of gas • Leaks in gas line; lower pressure in the gas line compared to atmosphere allows inward leak; creates potentially explosive atmosphere</td>
<td>• Install water trap to remove water or absorb it, drying the gas. • Inspect piping for leaks. • Develop leak detection methods. Preventive maintenance of gas lines. In-line measurement of explosivity with alarm at 10% LEL or greater with interlock to prevent flame ignition and shut down any nearby ignition sources</td>
</tr>
</tbody>
</table>

<p>| PART OF | Digester gas becomes part of something else: leak to air | Digester gas leaks to atmosphere or to building or into building | Potential fire or explosion in vicinity of piping or inside building. | Along piping or in building, measurement of explosivity with alarm at 10% LEL or greater with interlock to turn on building's exhaust ventilation; and shut down any nearby ignition sources. Inspection of gas lines to determine leaks. Develop leak detection methods such as detergent solution. |</p>
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<tr>
<td>REVERSE</td>
<td>Reverse gas flow from flare</td>
<td>Lower gas pressure at digester causes gas to</td>
<td>Flashback occurring in close proximity to a</td>
<td>Install flame arrestor into gas piping system. Periodically clean</td>
</tr>
<tr>
<td></td>
<td></td>
<td>flow from flare back towards digester causing</td>
<td>rubberized digester cover could damage cover or</td>
<td>arrestor to avoid clogging. Extend wall of gas reception pit upward</td>
</tr>
<tr>
<td></td>
<td></td>
<td>flashback.</td>
<td>ignite cover and digester itself.</td>
<td>to shield the digester from flashback.</td>
</tr>
<tr>
<td>OTHER THAN</td>
<td>Other materials entering the gas</td>
<td>Water from water seal in gas line. Inward</td>
<td>Pressure differentials and leaks (as described</td>
<td>Potential solutions as described above.</td>
</tr>
<tr>
<td></td>
<td>line, but no digester gas</td>
<td>leak of air into piping.</td>
<td>above).</td>
<td></td>
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</table>

![Diagram](image.png)
Job Hazard Analysis

- It is very important to involve your employees in the hazard analysis process.
- Discuss with your employees the hazards they know exist in their current work and surroundings.
- Brainstorm with them for ideas to eliminate or control those hazards.
- Walk the organics processing site together and discuss “close calls”, hazards of all types, possible solutions. Do this more than once. You need to decide if you need annual, twice a year, or any other appropriate frequency.
Every organized work effort has a safety culture; they tend to fall somewhere along this spectrum.
Where we should all be.
If there is time, I’d be happy to entertain any questions. My contact information is shown here and I invite interested parties to contact me with follow-up questions or requests for additional information. Thank you.