Integrated Waste Management

SWANA Old Dominion Chapter

Health & Safety Considerations in Organics Management

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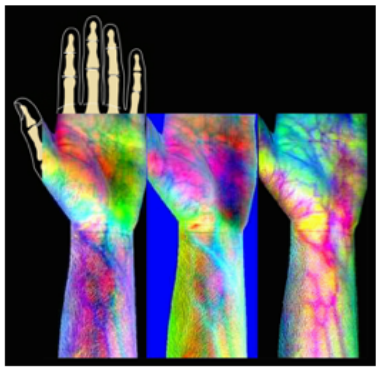
Coker Composting & Consulting



Diverting organics like food and yard wastes from landfilling 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.

Overview

- Health
  - Dust
  - Microbes
  - Noise
  - Equipment
  - Heat
- Safety
  - Site safety
  - Fires
  - Injury
  - Confined spaces
  - OSHA
  - Lock-out/Tag-out
  - Compost PPE
  - HAZOP Analysis

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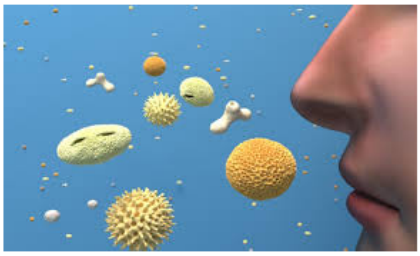
These are the topics I'm going to cover in this presentation

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

Bioaerosols

- A collection of aerosolized biological particles (e.g. microbes, by-products of living organisms) capable of eliciting diseases that may be infectious, allergic, or toxigenic with the conditions being acute or chronic
- Size range 0.02–100 micrometers (typically 2-10 microns size range of most concern)
- Composition of the particles varies with source and environmental conditions
- Some are colloidal particles of soil, vegetation, other material
- Viruses, bacteria and fungi (spores and hyphae) in aerosols due to small size
- Many protozoa too large to remain airborne

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The predominant bioaerosols observed in organics recycling are fungi and fungal spores. Bioaerosols are present in any facility handling woody materials.

Microbiological Risks

- High concentrations of bacteria & fungi key to successful composting
- Most human pathogens like fecal coliforms should be killed off by high temperatures
  - Pathogen = organism that causes disease through infection-the invasion and growth of microorganisms in tissue
  - Inadequate composting can lead to survival of pathogens in cooler layers of compost
  - Example: E. coli O157:H7 can survive for several days in soil
- Prions are not inactivated by heat generated during composting

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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

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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

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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)

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These are some of the diseases that respiratory infections cause.

Infections: Preventative Measures

- Control vermin populations
- Practice good hygiene
  - Wash hands well prior to:
    - eating, drinking, or smoking
    - entering any offices or other 'clean' rooms
  - Wear gloves for handling feedstocks/unfinished compost
  - Never eat, drink, or smoke on site, except in 'clean' areas
  - Immediately wash and disinfect any cuts or skin abrasions & cover with waterproof dressings
  - Change from work clothes before leaving the site & clean work clothes on regular basis

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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

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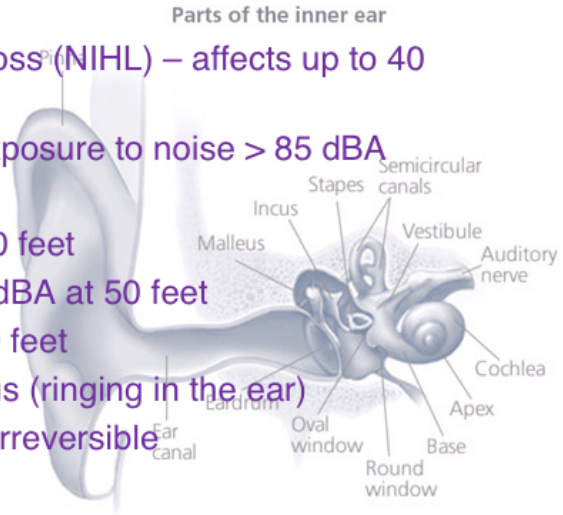
As inhalation of most allergens is associated with dusty conditions, keeping materials handling operations under control is important.

Health Concerns - Noise

- Noise-induced hearing loss (NIHL) – affects up to 40 million adults
- Caused by prolonged exposure to noise > 85 dBA
- Equipment noise levels:
  - Grinder: 89 dBA at 50 feet
  - Trommel screen: 81 dBA at 50 feet
  - Loader: 79 dBA at 50 feet
- NIHL can result in tinnitus (ringing in the ear)
- NIHL is permanent and irreversible



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.

Health Concerns – Heat Exhaustion

- Composting takes place in 140º – 160º 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

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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.

Other health concerns in organics management

- Infection
  - Feedstocks often contaminated with bacteria
  - Robust sanitation practices needed
- Heavy equipment & machinery
  - Thrown objects
  - Injury from accidents
  - Electrocution
- Confined spaces
  - H_2S accumulation in storm drains
- Biogas
  - Methane toxicity and explosion hazard

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 management in composting

- The key to safety is common sense and good business practices
- Management <u>must</u> lead by example
- Waste generators are requiring composters to prove they have viable H&S programs in place
- Develop a Health & Safety plan for your facility

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 & H_2S

- 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.

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Confined spaces & H_2S, 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.

Confined spaces & H_2S, cont.

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.

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Safety program

- Hold regular scheduled safety meetings
  - Both inside class and outside "tailgate" meetings
- Have a monthly safety topic
- Train employees to recognize potential problems
- Provide warning signs to public
- Report injuries and near-misses as per your organization's guidelines
- Provide personal protective equipment
  - Hard hats, steel-toe shoes, safety vests & glasses, hearing protection, gloves, dust masks

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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

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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.

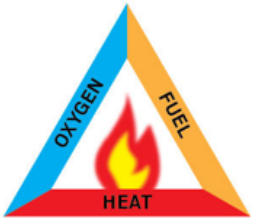
OSHA reports

- Incident reports - Form 301
  - Complete within 7 days of incident
  - Keep on file for 5 years
- Log of Work-Related Illness and Injury – Form 300
  - You must record information about every work-related injury or illness that involves loss of consciousness, restricted work activity or job transfer, days away from work, or medical treatment beyond first aid.
- Summary of Work-Related Illness and Injury – Form 300A
  - Annual report

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

- Fires are always a possibility
- Formula for a fire:



- Take away one leg of triangle, then no fire
- Typical compost materials ignite when
  - Moisture content is 40% or less
  - Just enough oxygen is present (vent holes)
  - Usually in large mass piles

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.

Ignition sources

- Sparks from welding equipment
- Cigarettes
- Lightning
- Biological – uncontrolled microbial activity
- Spontaneous combustion
  - Biological activity builds up heat
  - Poor porosity traps heat in pile
  - Above 175° F., bacteria die off, but self-heating chemical reactions take over
  - Heat continues to build in pile
  - Combustion occurs between 300°-400° F.

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, self-heating chemical oxidation reactions take over, driving the heat up. 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.

Compost fires

Austin, TX June 2013

Milford, CT Nov. 2014

Maple Valley WA Aug 2009

Durham NC Sept 2006

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

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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.

What could go wrong here?

The common element in all four: STUPIDITY!!

HAZOP, cont.

- 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

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.

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).

HAZOP of AD Biogas Flaring

GUIDE WORDS	DEVIATION	POSSIBLE CAUSES	CONSEQUENCES	ACTIONS
NO or NOT	No combustion at the flare	• No gas flow to flare; piping blocked or leaking; loss of water seal trap • No ignition at flare; ignition source failed or ignition power source failed • No gas flow from digester; digester over-pressurized; digester process failure (death/loss of bacterial growth); possible negative gas flow (flow now 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 process failure	• Test air for uncombusted digester gases (explosivity) at flare and along 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 flow failure or impending failure; with alarm • Test for digester bacterial process/failure

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.

GUIDE WORDS	DEVIATION	POSSIBLE CAUSES	CONSEQUENCES	ACTIONS
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	• 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 now 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 along 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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GUIDE WORDS	DEVIATION	POSSIBLE CAUSES	CONSEQUENCES	ACTIONS
AS WELL AS	Other materials entering gas line as well as the digester gas	• Excessive gas pressure from the digester pushes water from water seal into the gas line with the digester gas • Air leaks into gas line	• 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 the atmosphere allows inward leak; creates potentially explosive atmosphere	• 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 flare ignition and shut down any nearby ignition sources
PART OF	Digester gas becomes part of something else: leak to air	Digester gas leaks to atmosphere or to building air	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.

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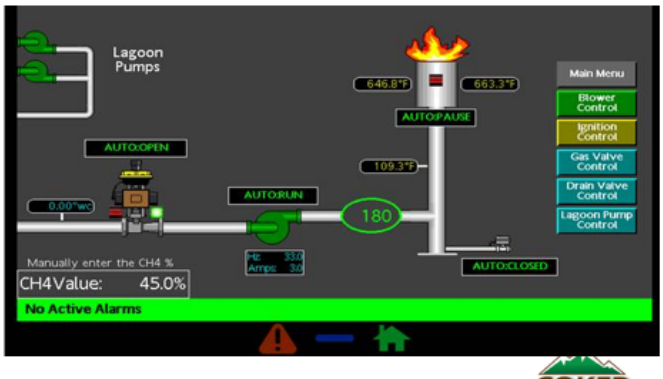
GUIDE WORDS	DEVIATION	POSSIBLE CAUSES	CONSEQUENCES	ACTIONS
REVERSE	Reverse gas flow from flare	Lower gas pressure at digester causes gas to flow from flare back towards digester causing flashback.	Flashback occurring in close proximity to a rubberized digester cover could damage cover or ignite cover and digester itself.	Install flame arrestor into gas piping system. Periodically clean arrestor to avoid clogging. Extend wall of gas reception pit upward to shield the digester from flashback.
OTHER THAN	Other materials entering the gas line, but no digester gas	Water from water seal in gas line. Inward leak of air into piping.	Pressure differentials and leaks (as described above).	Potential solutions as described above.



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.

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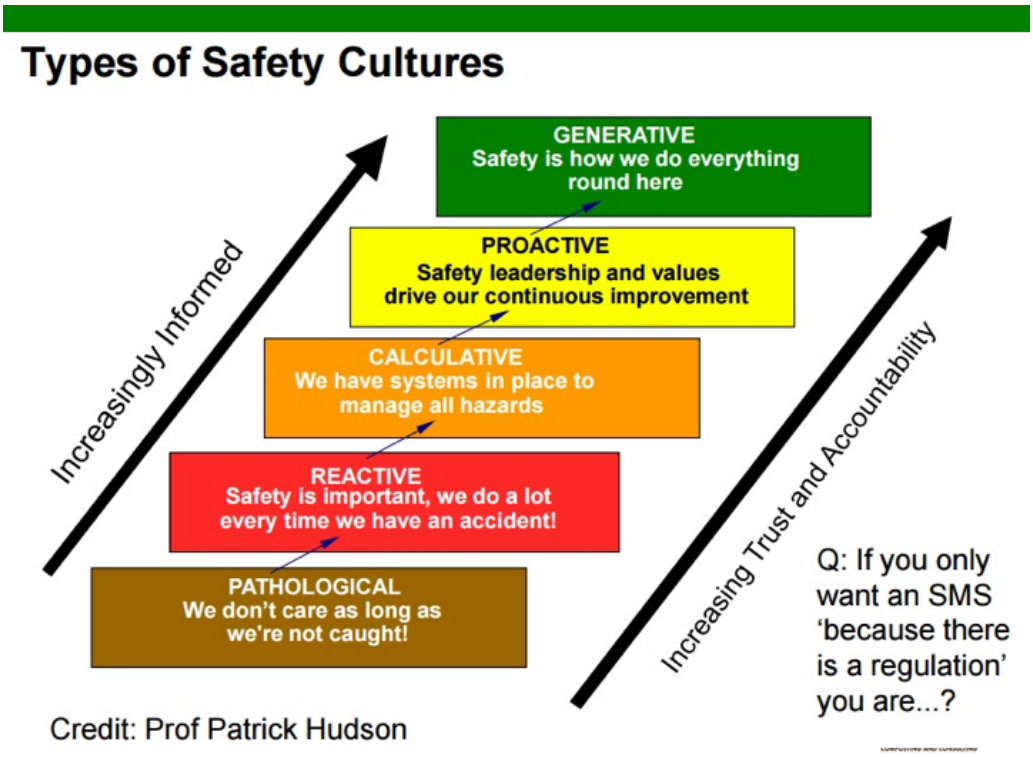

Every organized work effort has a safety culture; they tend to fall somewhere along this spectrum.

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.