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Composting Safety and Health

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Abstract
[Excerpt] This chapter describes safety and health issues related to composting and the practices that minimize the associated risks. While safety and health are not inseparable, in this chapter, safety is informally associated with physical trauma, such as an equipment accident, a fall or impact from a projectile. In contrast, health risks are loosely linked with physiological injury or illness to a person, usually from continued or repeated exposure to a hazard.

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INTRODUCTION

Like farming, composting is rugged work. It involves mechanical equipment, physical labor and handling of diverse biological materials. It is usually practiced outdoors for long hours, in all types of weather. Even when composting takes place indoors the environment can be difficult for workers. By its nature, composting exposes operators to assorted microorganisms (e.g. molds and bacteria), dust, vapors, noise, sharp objects, heavy objects, fog, sunlight, heat, extreme cold, strain, fatigue and mechanical and electrical machinery. Thus, composting inherently entails safety and health hazards. Even when composting facilities employ sound practices, there will always be risks associated with day to day operations, and occasional accidents. However, awareness of the hazards, prevention and preparedness keep the risks from becoming safety incidents and health problems.

Although there are a few general safety and health guidelines (see sidebar, page 6), different composting operations face different sets of hazards. Facilities vary in scale, the feedstocks handled, composting methods, types of equipment, climate, worker skills and training, seasonality, hours of operation and level of management. The feedstocks handled, methods employed, the equipment used and the work practices followed strongly affect the specific safety and health hazards encountered and the associated levels of risk. Tables 10.1 and 10.2 provide an overview of the general hazards that composters may encounter in different facets of an operation.

Safety and health hazards should be addressed using a hierarchy of control measures (Figure 10.1). Ideally, the source of the hazard should be eliminated first; for instance, by altering the process, redesigning equipment, changing tools, installing ventilation, isolating the machine, or adding machine guards. If the hazard can't be eliminated, it should be reduced through management practices like improving working procedures or establishing administrative controls, such as job rotation or reduced work time. To guard against any potential hazards that remain, the next step is adequate protection, like using personal protective equipment.

This chapter describes safety and health issues related to composting and the practices that minimize the associated risks. While safety and health are not inseparable, in this chapter, safety is informally associated with physical trauma, such as an equipment accident, a fall or impact from a projectile. In contrast, health risks are loosely linked with physiological injury or illness to a person, usually from continued or repeated exposure to a hazard.

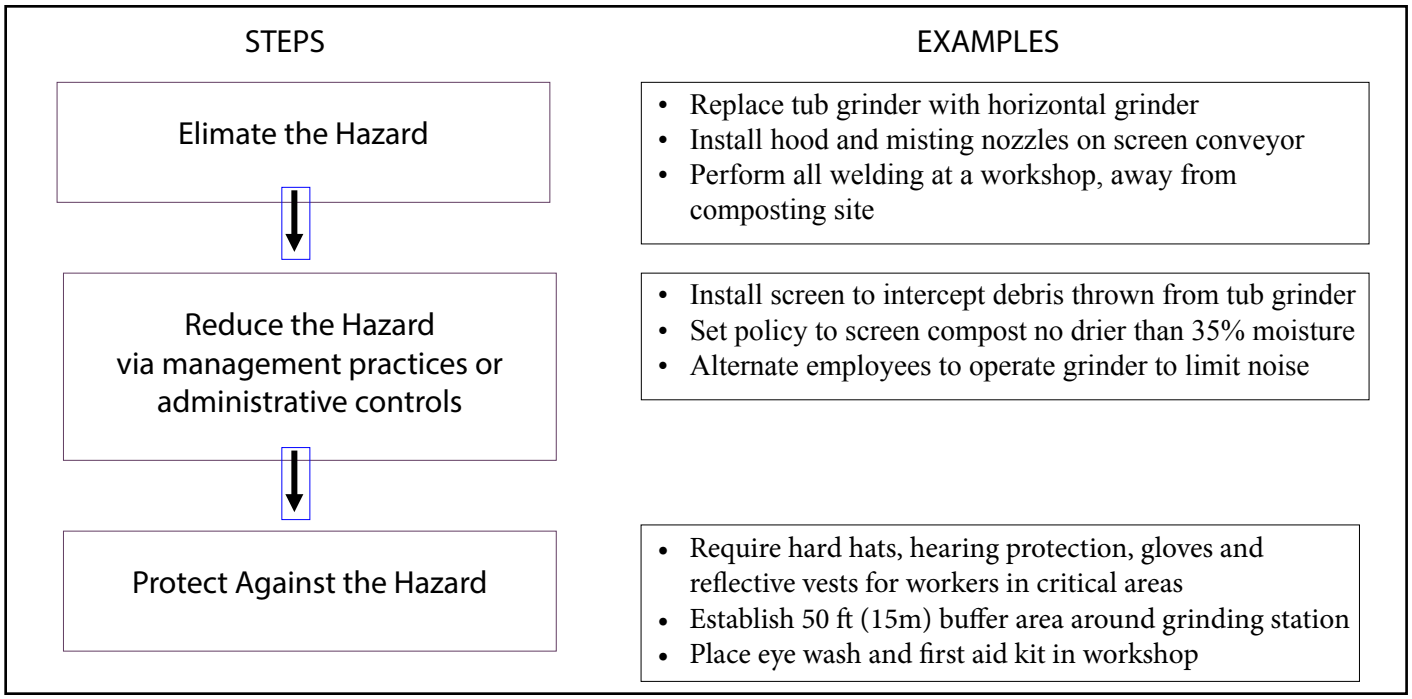

Figure 10.1. Hierarchy of safety and health hazard control

Table 10.1. Relative risk of safety and health hazards, at a glance (see Table 10.2 for specific descriptions)

Hazard	Receiving-Sorting	Grinding	Mixing and Pile-Windrow Forming	Turning	Screening	Bagging-Shipping	Materials Handling	Site Mgt. & Monitoring
Physical injury from machinery	✓	✓✓	✓✓	✓✓	✓	✓✓	✓✓	
Projectiles		✓✓✓	✓	✓✓	✓		✓	✓
Vehicle accidents	✓	✓✓	✓✓	✓✓	✓✓	✓	✓✓✓	✓
Electrocution			✓	✓✓		✓	✓✓	
Engulfment	✓				✓		✓✓	✓✓
Hearing damage from noise	✓	✓✓✓	✓	✓✓	✓✓	✓	✓✓	✓
Exposure to bacteria, viruses and other pathogens	✓✓	✓	✓✓	✓			✓✓	✓
Exposure to dust and bioaerosols	✓✓	✓✓	✓	✓✓	✓✓✓	✓✓	✓✓	✓
Exposure to volatile chemicals	✓		✓	✓✓			✓	✓
Heat stress, cold stress, extended sun exposure, dehydration	✓	✓	✓	✓	✓	✓	✓✓	✓✓
Physical overexertion: sprains, strains	✓✓	✓	✓	✓	✓	✓✓	✓✓	

Relative risk rating: (✓) Relatively no to little risk: (✓✓) Little to moderate risk; (✓✓✓) Moderate risk

Table 10.2. Summary of the potential hazards associated with composting

Potential Hazard	Comments	Relevant Operations and Activities
Physical injury from machinery	Accidents ranging from pinches, cuts and scratches to loss of fingers and limbs, even strangulation.	All operations involving rotating and moving parts, such as conveyors, grinders, chippers, PTO drives, bagging lines, motors and engines, etc.
Injury from projectiles	Examples include rocks and whole pieces of fruit ejected during turning, hammers and bolts thrown from grinders.	Windrow turning; grinding of feedstock; screening (less so).
Vehicle accidents	Between vehicles or between vehicles and individuals. Vehicle operators' vision can be obscured by steam, fog or piles. Also, loaders or other materials handling equipment can inadvertently entrain unseen workers.	Any activity that includes moving equipment; simply walking the site.
Electrocution	From electric power supply wires or equipment.	Any operation near, under or above high voltage lines (digging near buried cable) Welding. Maintenance.
Engulfment in piles, hoppers, bins and other enclosures	May occur from the collapse of piles or supporting materials underfoot.	Maintenance, process monitoring, sample collection, sorting, dislodging objects wrenched in machinery, simply walking the site.
Hearing damage and stress from noise	Risk depends on noise level, proximity to source and ear protection. Electric motors produce less noise than combustion engines of similar power.	Especially grinding, but all operations with equipment employing engines, vibrations and abrasive action.
Exposure to bacteria and fungi by inhalation, skin contact and hand-to-mouth contact	Each type and source of plant material, bedding, manure, sewage sludge, and animal mortalities brings its own mixed population bacteria and fungi. Risks are greater prior to high temperature composting. Very dependent on individual's susceptibility (e.g. allergies, immune system).	All operations involving materials handling, including receiving (feedstocks and bulking agents), grinding, mixing, pile windrow formation, turning, screening, compost handling and application, sampling and monitoring.
Exposure to dust by inhalation	A constant factor, especially with dry materials and under dry conditions. Applying moisture with mists or sprays suppresses dust.	Vehicle movement on the site. All operations involving handling dry materials, including turning, screening, compost handling and application, bagging.
Inhalation of volatile chemicals	Ammonia from the composting process is the primary risk.	Turning; receiving and handling of raw feedstock from storage; handling, pumping, transferring leachate.
Physical stress	Includes fatigue, extreme cold or heat, extended sun exposure, dehydration.	All operations, especially those occurring outdoors.
Physical overexertion	Includes heavy lifting, repetitive movement, general overexertion, sprains, strains.	All operations, including materials handling and maintenance tasks.

General Guidance for Reducing Safety and Health Hazards for Composting Operations

- Have an educated workforce trained on process control, process hazards, hygiene practices, signs and symptoms of overexposure or overexertion and emergency response
- Exercise good process control; recognize the beginnings of trends that lead to process failures and take prompt corrective action. Better process control will produce more consistent and predictable exposures and hazards and probably overall lower risks.
- Meet occupational safety and health regulations where they exist; follow well-respected recommendations even where there are no regulations
- Practice good personal hygiene to protect the worker and his/her family
- Provide proper protective equipment to match the hazards of the specific site

SAFETY AND HEALTH REGULATIONS

In the U.S., the Occupational Safety and Health Administration (OSHA) oversees and establishes occupational health and safety regulations on a federal level. In addition, individual states establish their own worker safety regulations, although most states tend follow OSHA's lead and adopt most of the federal requirements.

In countries other than the U.S., health and safety regulations vary greatly and may be more or less restrictive than the U.S. regulations. Compared to the U.S., some other industrialized countries have more prescriptive regulations or approaches to risk assessment. For example, in England it has been recommended that bioaerosols and dusts should be assumed to be present in sufficient quantities to harm individuals who work within a distance of about 30 meters of a source. Countries with developing economies tend to have fewer and more general regulations. Readers in other countries, and in specific states and provinces, are encouraged to consult the regulations of their own country and local jurisdictions.

OSHA regulations generally apply to a specific hazard wherever it is encountered in the workplace. Specific U.S. regulations that may apply to composting situations are listed in the book's appendix. The federal Occupational Safety and Health Act of 1970 was initially intended for, and applies to, the private sector. By Executive Order of the President, it applies also to workplaces of the federal government; however, it may or may not apply to other public sector facilities, depending upon the individual state.

So, for a private industry or commercial composting facility, the OSHA standards apply. For a public (city, town, county, or state) entity, other than the federal government, the state may have developed its own safety or may have adopted Federal OSHA standards. To determine which regulations apply to a given public facility, check with the state's Department of Labor or the OSHA's website (www.osha.gov).

Although some safety and health regulations are written specifically for the agricultural sector, most of the general regulations do not apply to agriculture. The information provided in the appendix indicates whether a particular regulation applies to agriculture. However, even when a regulation does not apply to agriculture, it is important to recognize that these regulations provide excellent health and safety guidance, including warnings, advice and hazard reduction. As such, the recommendations should be seriously considered.

For workplaces under its jurisdiction, OSHA can cite and/or fine employers for failure to comply with regulations. Where a state has assumed this responsibility, the state can cite or fine workplaces for noncompliance. If a specific health and safety regulation does not exist, a citation or fine may be issued for noncompliance with the "general duty clause" of the OSHA Act.

The "general duty clause" of the OSHA Act applies if a health and safety hazard does not have its own regulation. The general duty clause states:

SEC. 5. (a) Each employer ---

(1) shall furnish to each of his employees employment and a

place of employment which are free from recognized hazards that are causing or are likely to cause, death or serious physical harm to his employees;

(2) shall comply with occupational safety and health standards promulgated under this Act.

Teen workers are a special case because they tend to suffer a higher rate of injury than their adult counterparts in similar jobs. U.S. child labor laws prohibit teenagers from performing certain kinds of work, depending upon their age. In the U.S., a youth 14 or 15 years old can work in agriculture, on any farm, but only in non-hazardous jobs (see exception below). A list of hazardous jobs can be found on the OSHA website (www.osha.gov). For example, the following composting-related jobs would not be permitted for a youth under 16 working on a farm,

- operating or helping to operate any of the following machines: feed grinder, auger conveyor, and earthmoving equipment (although wood chippers are not specifically listed in the law, the National Institute for Occupational Safety and Health, the research arm for OSHA, believes that wood chippers are unsafe for operation by youth under the age of 18 years.);
- operating a tractor of over 20 PTO (Power-Take-Off) horsepower, or connecting or disconnecting implements or parts to such a tractor.

In the U.S., a 14- or 15-year-old teen who has completed a 4-H Training Programs or agriculture certifying programs for tractor operation and/or machine operation may conditionally work in occupations for which they have been trained. The necessary conditions are:

- the teen has a certificate of completion of the course;
- he/she has been instructed by the employer on safe and proper operation of the specific equipment to be used;
- and she/he is continuously and closely supervised by the employer where feasible;
- or, where not feasible, the teen's work and work environment are checked for safety by the employer at least at mid-morning, noon, and mid-afternoon.

Student-learners in a bona fide vocational agriculture program may work in certain hazardous occupations under a written agreement which includes safety instruction, direct and close supervision during short periods of work, and work is incidental to the training. The U.S. Department of Agriculture and the Cooperative State Research, Education, and Extension Service have developed a program for teenagers working on farms called the Youth Farm Safety Education and Certification Program. The training is conducted by the local offices of the 4-H. For further information, contact your local Cooperative Extension office in your county.

SAFETY CONCERNS

Composting involves mechanical equipment, typically large machinery and typically several types. Equipment ordinarily employed in composting include bucket loaders, skid loaders, tractors, turners, trucks, excavators, grinders, chippers, turners, mixers, screens, conveyors, fork lifts and bagging devices. Any piece of machinery presents general safety risks and therefore deserves respect, usually in proportion to the size and power of the machine. Some machines are mobile (i.e. vehicles), which carry a separate set of safety considerations. In addition, specific operations employ specific pieces of equipment that pose specific hazards. This sections covers the safety hazards and practices associated with composting equipment, starting with general equipment safety and moving on to safety issues related to specific operations.

General Equipment and Site Safety

All types of equipment have at least two common features -- moving parts and power units that move those parts. Several common safety concerns arise from the operation and maintenance of mechanical devices.

- Moving parts of equipment can grab or entangle hair, clothing, and people during operations or maintenance. The moving parts require guards, shielding, and good work practices. To prevent clothing and extremities from being caught by moving parts, guards or shields should be installed and maintained wherever pinch points or scissors points exists. Loose clothing, long unbound hair and hanging jewelry should not be worn when

operating equipment with exposed shafts, chains, gears and other moving parts that can grab.

- Unprotected power-drive lines, such as on augers or the power take-off (PTO) shafts, are potential hazards. Injuries resulting from entanglement in an open PTO shaft include amputations, severe lacerations, multiple fractures of limbs, spine and neck injuries or complete body destruction. PTO shafts have historically had little or no shielding. As shields can get "in the way" or become bent or broken, people often remove them. Recent models have totally-shielded shafts, which are less likely to be removed. However, there continue to be a large number of inadequately shielded drives in use. Both open drive lines or partially covered drive lines (e.g. "U" shaped shield) should be replaced by totally-shielded shafts.
- Rescue procedures to remove a victim from the PTO shaft should start by shutting off the tractor and making sure it will not re-start. Next, chock the tractor wheels so that the tractor cannot move. It may be possible to extricate the victim by disconnecting the PTO shaft from the tractor or by putting the drive unit in neutral, and turning the shaft counterclockwise to unwrap the victim's clothing. If the shaft is solid, the rescuers may have to cut it with a cutting device such as a portable power grinder, hacksaw or oxyacetylene torch. If there are combustible materials in the area, rescuers should be extremely careful when using any type of flame-producing equipment, or even portable grinders that produce sparks. If a part of the body was amputated, it should be located, covered or wrapped cleanly and placed in ice for possible reattachment.
- Wet and oily feedstocks, wet weather or ponded leachate can create slippery conditions at a composting facility. These conditions can occur on the ground surfaces and on equipment platforms. Non-skid shoes or boots should be worn to reduce this problem.
- Some composting equipment -- screeners, grinders, chippers, windrow turners -- can throw objects. Eye protection such as shatter-resistant glasses with side shields or goggles are needed to protect against potential impact and injury.
- Workers should be appropriately protected from dust. Dust can also be a potential fire hazard and should be kept from accumulating in welding areas, on engine manifolds, mufflers and on other equipment components that get hot.
- Be aware of overhead power lines and the possibility of electrical shock. When power lines are located over composting operations such as windrows and storage piles, the elevated part of the vehicle should be kept a distance of at least 10 feet (3 m) from the power lines to prevent the equipment from becoming energized and shocking the operator.
- Identify and permanently mark the location of underground utilities (electricity, gas, water, cable). Notify the utility company when digging or trenching on site, especially in the vicinity of known underground utilities.
- Foreign objects delivered with some composting feedstocks are damaging to machinery and potentially hazardous to human operators. Examples include gas cylinders, containers with chemicals, cables, chains, rope, metal strapping, and large or sharp metal items. Policies for accepting feedstocks should prohibit such damaging items from deliveries. Procedures should be in place for sorting and discarding them before they come into contact with equipment, especially shredders, grinders, mixers, turners and screens.
- Equipment jams are a regular occurrence at composting facilities, in part because of, the diverse and difficult materials encountered. Conveyors, grinders, shredders, chippers, mixers, screens and even turners are each prone to jams. Operators have been known to climb inside the tub of a grinder with a sledge hammer and pickax to break up the jam. Climbing into such equipment should be avoided; wherever possible, the task should be done from outside.
- When removing a jam from any equipment, the equipment first should be disconnected from the power source. If the unit is electric, power should come from an outlet equipped with a ground-fault interrupter (GFI) to stop electrical current if a short occurs in the system. The moving parts then blocked and chocked. It is possible that parts may still be able to move under their own weight once the jam is removed. Some equipment may have residual energy that is held back by the jam. After the jam is removed, mechanism may thrust forward

or blades, augers and paddles could rotate. A block and chock helps to prevent injury. If the jammed mechanism is driven by a PTO, the PTO should be disconnected.

Vehicle Safety

A composting site can be an active place with several vehicles (trucks, loaders, turners) moving amid each other and amid people on foot. Furthermore, the vehicle operator's view is occasionally obstructed by steam rising from windrows, fog and piles of material. The situation demands extra caution and attention to safety. Operators of bucket loaders and skid loaders, and those working near loaders, must be especially diligent as loaders maneuver at a rapid pace and frequently change direction.

- Operators must make sure that co-workers and visitors are clearly out of the way. Each day an operator should start with an understanding of the general whereabouts of coworkers and visitors on that day and presume that they will remain there.
- Similarly, pedestrians walking in the vicinity of mobile equipment must make their presence known to the operators, and that they are actually be seen by the operators. Brightly colored clothing (e.g. reflective vests) is highly recommended. As a rule, do not approach an operating vehicle until you make eye contact with the operator.
- All large mobile equipment (loaders, trucks) should have an audible back up alarm. If the view to the rear is obstructed, a vehicle must not be used in reverse unless there is a reverse signal alarm or a coworker signals that it is safe to do so.
- A slow-moving vehicle sign must be placed on vehicles that would travel less than 25 mile per hour (16 kilometers/hr) on public roads.
- Moving equipment can generate dust. In vehicles, exposure is best reduced by the use of an enclosed cab with well-sealed, air-conditioned and heated cabs with filtered air intakes. Filters should be removable and washable or replaceable and employees should be instructed to remove and clean or exchange filters frequently.
- As a basic rule, vehicle operators should use seatbelts. When driving a tractor, the driver should tighten the seatbelt sufficiently to keep him/herself within the area provided by the roll-over protection structure. The seatbelt should be inspected regularly to make sure it has not become worn or brittle – in which case, it should be replaced.
- Mobile equipment, especially tractors, could upset or roll over. Tractor roll-over continues to cause more fatalities than any other type of farm accident, despite increased emphasis on safer design and roll-over protective. Some older tractors have profiles, especially narrow wheel spacing that can easily upset the vehicle, causing injury or death to the operator. As 85% of all tractor overturns are to the side, the typical injuries tend to include a broken or crushed pelvis. In the U.S., OSHA regulations require that agricultural tractors manufactured after October 1976, must have roll-over protective structures (ROPS), seatbelts and protection from spillage of batteries, fuel tanks, oil reservoirs, and coolant systems. Also, all sharp edges and corners at an operator's station have to be designed to minimize operator injury in the event of an upset. Older tractors need to be modified with roll-over protection and seatbelts. (If a tractor without ROPs rolls over, it may be easier to rescue the victim from under the tractor by digging, after first stabilizing the tractor with cribbing and chocking the rear wheels they cannot turn.)

Safety Provisions for Specific Operations

All operations at a composting facility – receiving, sorting, grinding, turning, screening, shipping materials handling and maintenance – involve large equipment. Most operations also rely on vehicles as materials are transferred between operations. Thus, every operation demands respect for and attention to the general hazards associated with operating any mechanical device and vehicle, as previously discussed. In addition, specific operations and equipment bring specific hazards and safety concerns.

Site Monitoring, Process Management--Engulfment

Operators and managers frequently need to walk the composting site to perform a variety of management tasks including monitoring the composting process, taking temperatures, recording data, inspecting feedstocks, performing maintenance, sampling materials and generally assessing operations. Simply

walking on site exposes workers to several often-overlooked hazards, from accidents with vehicles (see previous section) to engulfment in piles.

- It is possible for workers walking on windrows, piles or bins to drop down into the material and be engulfed -- trapped or buried alive. This problem is particularly risky when tall piles are loosely packed or have sufficient surface moisture to experience "crusting" – causing them to mistakenly look and feel solid underfoot. Furthermore, the interior of such piles can be very hot and cause burns, even if a person is only partially immersed. This situation has occurred on farms with bins or silos of corn or other grain, as well as in other industries. On a composting site, relatively free flowing bulk materials like wood chips and dry compost have the potential to collapse and partially engulf a person. Semi-solid materials (e.g. manure, fruit pomace) stored in lagoons or depressions in the ground also pose this hazard to a person who attempts to walk over an apparently solid crust. It is possible to eliminate this hazard altogether by not walking onto lagoons, or climbing onto windrows, piles, vessels or bins. If there is no alternative, one should not work alone but with a co-worker observing from a safe stable point (e.g. not also on top of the windrow). Preferably a body harness should be worn with retrieval line attached to a fixed point. Even better protection is provided with the retrieval line attached to a mechanical retrieval device with at least a 4:1 mechanical advantage (e.g. winch or come-along). Also, before climbing onto piles or windrows, check temperatures of those that could generate or retain heat.
- Piles and bins that are burning internally (i.e. spontaneous combustion) can collapse due to the voids created inside as the material burns. A pile that is smoldering, or suspected of burning, should never be walked on or driven on for any purpose, whether it is simply checking temperatures or extinguishing the fire.
- As noted earlier, workers walking on site and operators of equipment must be conscious of the whereabouts of co-workers, and continually look out for them in any case. A worker standing near a pile, checking temperatures or taking samples for example, can go unnoticed by an equipment operator and inadvertently get run over, scooped up or buried by a loader or other equipment. Such accidents have happened at composting facilities. When working on the site, notify equipment operators and wear reflective clothing.

Conveyors

Conveyor belts are used for many tasks at composting facilities, by themselves and as integral components of other equipment such as grinders, screens and turners. Conveyor belts accidents could involve stepping onto the belt, falling onto the belt, or otherwise having clothing or limbs caught or crushed by drive rollers, idlers or belts. Conveyor chute openings should have covers or guard rails to protect workers from falls. Guards need to be in place to protect from pinch and shear points such as terminals, drives, take ups, pulleys, and snub rollers. Critical points occur where a belt changes direction including where belts wrap around pulleys, at the discharge end of the belt, on transfer and deflectors and at take-ups. Warning signs should be posted around conveyor belts -- especially if guards are not practical. Operators should be trained on general rules for working around conveyors; including

- only authorized maintenance personnel can make adjustments to conveyors;
- always lockout the conveyor before working on it;
- always make sure that the emergency stop is reachable, secured and in working order;
- when shoveling on a belt, always face the opposite direction from the belt movement;
- no one is allowed to ride conveyors.

Windrow Turning

- Turning takes place at the point where heat, water vapor and other gases are released from piles and windrows. Thus, the immediate working conditions can be especially harsh. Operators are potentially exposed to concentrated levels of moisture, ammonia and other gaseous products of decomposition. The abundant moisture released can literally fog the operator's vision. This situation is worse when the operator is situated at or behind the point of turning (bucket loaders, some straddle turners and tractor-driven turners that are pushed). Excavators and tow-behind turners allow the

operator more distance. In any case, enclosed cabs with air filters are a necessity. Operators should also be aware of slippery footing on equipment platforms due to condensation or freezing of the water vapor.

- Most turners that employ a rotating shaft with paddles can fling objects behind them at high speed when they start moving into a windrow. The flying objects, which can be anything from rocks to tennis balls, represent a potential accident. Once the turner housing is fully enclosed by the windrow, it no longer ejects material, until it reaches the end of the windrow. Bystanders should never stand behind a windrow turner while it is entering a windrow (even to take photographs). Operators should not begin turning a windrow without first making sure that no one is behind the turner.
- When debris needs to be cleared from the shafts and belts of windrow turners, operators should wear safety gloves, eye protection and a hard hat. Items wedged in the turning mechanism may retain some energy and spring outward when pulled loose. When working near the turner housing, operators need to be aware of projecting structural and mechanical elements, as well as slippery footing.

Screening

- Screening can be a busy operation with multiple conveyors and one or more vehicles concurrently loading the screen and removing different piles of screened materials. Attention to the movement of co-workers, vehicles and bystanders is crucial.
- As screens rotate or vibrate, sharp objects, small particles, and dusts may become airborne, causing impact for the eyes and body and/or inhalation. Dust is a particular problem because materials tend to be relatively dry when screened. Loader cabs should have a properly operating air filter. When working outside of cabs, operators should wear safety glasses with side-shields or goggles and an N95 dust respirator or a respirator with particulate cartridges.
- Clear dust and debris from engine manifolds and other components that can get hot .
- Sharp or pointed objects can be present in the screened material, especially the overs pile. Appropriate safety gloves are necessary when sorting material by hand.

Mixing

- Many types of mixing equipment involve rotating paddles or augers and hoppers with open tops. Falling into an operating mixer can be fatal. Operators should stay clear of the top of the mixer when it is being loaded or otherwise operating. Material is preferably loaded using of a front-end loader, grapple or conveyor, rather than by manual feeding.
- Mixers are prone to jamming from dense, rigid and stringy feedstocks or foreign objects. Presort troublesome items from the feed material. In clearing jams, observe the general safety precautions previously described.

Size Reduction--Grinding, shredding and chipping

- Size reduction is an especially aggressive operation involving high-powered machinery and very fast rotational speeds. Therefore, size reduction deserves particular respect in regard to safety. Grinders, chippers and shredders present common hazards but also some that are specific to the type of equipment at work.
- Hoppers and loading chutes for grinders and shredders are often open on the top or sides. Guards or shields are often impractical because the operator needs to continually load feed material. Because they potentially can be pulled into moving parts, operators should stay clear of open top hoppers and feed chutes. As much as possible, avoid manual feeding material into hoppers and chutes. Recognize that there are feed mechanisms (e.g. rollers, chains, conveyors) operating behind hanging curtain deflectors.
- Operators should wear either safety glasses with side shields or goggles to protect the eyes from flying objects, as well as a hard hat.
- Size reduction equipment is subject to jams from especially hard, pliable or stringy material. Presort troublesome items from the feed material. Observe proper maintenance procedures when clearing jams, as previously discussed.
- Size reduction is an especially loud operation. Hearing protection is needed. Noise levels can vary

with the model and whether it is powered by gas or electric.

- Like screening, size reduction is an active operation with multiple vehicles and mechanisms working simultaneously. Operations need to remain alert to the whereabouts of other equipment, workers and bystanders.
- Because grinders and shredders typically are open on the top or sides, flying debris is possible. Nearly every type of size reduction equipment can throw debris from the grinding chamber but the risk of projectiles is greatest with tub grinders because of the often-uncovered tub that opens into the hammermill chamber. Projectiles from tub grinders have been known to fly hundreds, even thousands, of feet. Flying objects can include hammer bolts, wood chips, stones, broken hammer tips, nails and other metal objects in the feed material. Several precautions can be taken to reduce the risk of accidents from projectiles.
  * Keep the tub loaded with feed material when the grinder is operating to intercept items ejected from the hammermill chamber.
  * Establish a zone around the grinder where no one but the grinder/loader operator is allowed. The radius of the zone depends on the grinder model and should be based on the manufacturer's recommendations. *Ask the manufacturer to specify the grinder's "thrown object zone.*"
  * Erect a tall screen to catch flying debris. Objects can be ejected from tub grinders in any direction but they predominantly fly toward the direction that the hammers rotate at the top of the chamber.
  * Remove metals, rocks and other hard items from the feed material prior to loading in the grinder.
  * Install covers, partial covers, deflectors or other safety devices designed to contain thrown objects.
  * Minimize use of tub grinders near areas frequented by pedestrians and cars. In such areas, preferably use another type of grinder, such as a horizontal feed grinder, which is much less likely to eject objects.
- Wood chipping equipment presents specific hazards because many models are fed manually. Both fatal and nonfatal injuries have resulted from working with chippers. Nonfatal injuries most commonly involve an injury to an upper extremity, including amputation. Operators can become caught in the feed mechanism and pulled into the rotating chipper knives. Chipping equipment also can produce flying objects, including a loose hood from the chipper itself. If the machine is being opened or closed with the knives still rotating, the hood can fly off if it contacts the rotating blades. The following safety precautions should be observed with chipping equipment.
  * The chipper should be thoroughly inspected each day before start-up. The hood should completely cover the chipper knives, and workers should ensure that knives come to a complete stop before opening the hood.
  * The area around the chipper should be kept clear to reduce tripping hazards.
  * A long branch should be used as a push stick to feed shorter material into the chipper. If shredding leaves, use the tamper on the unit to push leaves into the shredding chamber.
  * If purchasing a chipper, it is important to consider those with an interlock system where the chipper hood cannot be opened while the cutter disk is turning. Chipper-shredders should have a certification symbol of safety from the Outdoor Power Equipment Institute (OPEI) and the American National Standards Institute (ANSI).
  * Personal protective equipment is mandatory when operating chippers due to close proximity of workers to chippers and the danger from flying debris, blowback from the hopper, and the potential for entanglement of clothing in moving parts. The personal protective equipment recommended includes hard hat, eye protection (either safety glasses with sideshields or goggles), hearing protection, safety boots, and close-fitting outer clothing. Gloves help prevent cuts if a tree limb is pulled from the operator's grasp, as well as reducing the effects of limb vibration as items are fed into the chute.
  * Training for workers operating chippers should emphasize: 1) correct operation of safety devices and controls consistent with the recommendations of the manufacturer; 2) the need to keep hands

and feet away from the feed chute; and 3) proper procedures for feeding items into the feed chute (including standing to the side in reach of the emergency shut-off when feeding items).

Manure Pit Gas Hazard

A confined-space hazard that often claims multiple lives before anyone realizes there is a danger is manure gas. Manure pits can be oxygen- deficient, toxic and explosive. There are four gases in manure pits that are of primary concern.

Hydrogen Sulfide is a highly toxic gas that is heavier than air. It can cause dizziness, unconsciousness and death. At low concentrations it may smell like rotten eggs, but at higher concentrations it deadens the sense of smell so that no odor can be detected.

Carbon Dioxide is an odorless, tasteless gas that is heavier than air. It displaces the oxygen supply in the bloodstream, which can cause unconsciousness and death.

Ammonia is a gas that is lighter than air. It has a pungent smell and can irritate the eyes and respiratory tract. Ammonia also displaces oxygen in the bloodstream.

Methane is also a gas that is lighter than air. The primary hazard of methane gas is that it can create an explosive atmosphere. This gas also displaces oxygen.

Welding Safety on Compost Sites

Although not normally considered at a composting operation, the arc welder can be the busiest piece of equipment at a composting facility. Repairs done by welding or brazing involve simultaneous safety concerns – intense light, which can damage eyes and skin; burns from sparks or hot metal; fires from sparks igniting nearby oil spills, wood chips, or dry compost; and fumes that can damage lungs and other organs or produce cancer. The hazards from gases and fumes increase in confined spaces.

Light

- In addition to the intense visible light, the invisible ultraviolet (UV) light and infrared light generated by a welding arc can damage the eyes; the UV can damage the skin, as well. Barriers should be used to protect bystanders in the area from viewing the welding arc.
- For comfort, the welder needs to wear a face shield with the highest level of shade (10 – 14) compatible with viewing the work adequately. If the arc is hidden by the work piece, lower shade levels may be possible, a minimum of 7 – 11.

Sparks, Burns, Fire

- In addition to a face shield, necessary personal protective equipment includes gloves, headcap, hard-toed shoes, button-down shirt pockets, long-sleeved shirts, and cuffless pants. For heavy-duty welding, leather gauntlet gloves, jacket, apron, and shoe covers may be needed. For overhead or vertical welding, a cape or other shoulder protection may be needed. Ear plugs can protect from flying sparks as well as from the noise of a noisy welding operation.
- Although arc welding is usually done with low voltage (less than 100 V), there is always the hazard of electrical shock – especially when hot weather and dampness are present. Be aware of the location of electrical contacts. Replace wires with cracked or worn insulation.
- Welding should take place away from potential fuels such as oil spills, wood chips, or compost. A water supply or Class A portable fire extinguisher kept nearby enables rapid response for fires that start from wayward sparks.

Gases and Fumes

- Welding gases and fumes are a complex mixture which may include: ozone and nitrogen oxides; metal vapors and other gases from the substrate being welded or from the welding rod; and carbon monoxide, carbon dioxide and other gases from coatings and oils on the substrate (carbon dioxide may also be used as a shielding gas).
- When welding inside a building, sufficient ventilation is extremely important to dilute and remove gases and fumes. At the benchtop, the best arrangement is a slot hood connected to a blower that draws the gases and fumes to the outside. General building ventilation is not as effective. Welding curtains and other barriers can help to reduce drafts and improve the capture of air contaminants. If sufficient ventilation is not possible, a respirator with cartridges for welding fume and oxidizing gases could be worn.
- Cylinders of welding gases should be chained to a wall or bench and transported after fastening to a cylinder cart. The valve should be protected by a valve cover during transport or when the cylinder is not in use.

Dangers of Working in Confined Spaces

- The OSHA standard on confined spaces provides excellent work practices for any confined workspace (e.g. storage bin, container). If welding is done in a confined space, gases can collect and increase to hazardous levels. Ventilation must be provided in the confined space to dilute and flush out these air contaminants and to provide sufficient oxygen for the welder to replace that consumed by burning the welding gases. A blower and hose can be used, with the blower kept outside the space in an area of clean air and the hose dropped into the confined space to provide good air overturn.
- It is important to inspect welding gas lines to prevent leaking gas lines. Gases such as acetylene or oxygen that leak into a confined space could reach explosive levels or lead to a rapid, intense fire.
- To determine if the atmosphere in a confined space is safe before and during a welding task, use an air tester with a direct readout that check the air for levels of oxygen, explosive gases, and toxic gases (typically hydrogen sulfide and carbon monoxide). By monitoring the air during the task, an alarm can alert workers to exit the space if the atmosphere becomes unacceptable.

PHYSIOLOGICAL HEALTH CONCERNS

Composting workers are subject to the hazards generally associated with performing physical labor near large equipment in an outdoor environment including noise, physiological stress, extreme heat and cold and fatigue.

Noise

Heavy equipment and processes of composting can be noisy, to the point of being potentially damaging. As most loud noise does not produce pain, hearing damage typically happens so gradually that there is no warning or indication that injury is taking place. The OSHA standard on noise (does not apply to agriculture) endeavors to reduce exposure to levels below damaging levels. The level of noise considered acceptable is an 8-hour time-weighted average of 90 dBA (dBA is decibels, a measure of noise intensity, weighted on the "A" scale, which gives more weight to exposure to higher-pitched noises). For levels of noise higher than 90 dBA, the time of exposure allowed for an employee decreases. At noise levels of 115 dBA, the amount of exposure allowed per day drops to 15 minutes.

If noise exposures equal or exceed an 8-hour time-weighted-average of 85 dBA, the employer must institute a hearing conservation program, which requires monitoring of noise levels. Equipment used at composting sites for wood chipping, shredding, grinding, turning piles, or other tasks has been reported as exceeding 90 dBA; with shredders as high as 98 dBA. Thus the compost site's equipment should be evaluated to determine the exposure of the employees, along with the length of time the equipment is typically used.

A hearing conservation program requires audiometric testing of employees' hearing to establish a baseline level for each employee and note trends that indicate hearing damage. The program should also reduce exposure using administrative or engineering controls or, if not feasible, personal protective equipment. For some equipment, an enclosed cab may serve as an engineering control that sufficiently reduces the noise exposure for the operator. When acquiring equipment, noise hoods and mufflers should be specified and then these should be properly maintained. For people running chippers and grinders, personal protective equipment such as ear plugs or ear muffs are needed. If staffing levels permit, it may be possible to reduce exposure by an administrative control – such as rotating workers among a variety of tasks so that the actual duration of exposure per day does not exceed the OSHA standard.

Physiological Demands: overexertion, sprains, or strains (ergonomics)

The daily tasks involved in operating a composting facility can be physically demanding. Frequently, the work requires heavy lifting and prolonged postures (such as operating heavy equipment). These stressors can be compounded by exposure to heat or cold and the ultraviolet light from the sun.

Ergonomics refers to the interaction of humans with their working and living environments. Ergonomic

injuries such as overexertion and fatigue can occur when operating heavy equipment with repetitive use of machine controls and prolonged sitting. These tasks could involve acute and/or repetitive injury to muscles and joints. Musculoskeletal injury can be triggered by direct trauma (e.g. falls, impact and bruising) or a single over-exertion (e.g. pulling a muscle while lifting). Repetitive strain can result from static or dynamic work including prolonged sitting, holding the muscles in a tense, fixed position for extended periods, such as carrying something over a long distance; holding tools continuously, bending the wrists to hold or repeatedly move a tool or prolonged exposure to vibrations. Typical symptoms of repetitive strain include soreness, pain, discomfort, redness and swelling, limited range of motion, stiffness in joints, weakness and clumsiness, numbing, tingling sensations ("pins and needles"), popping and cracking noises in the joints, and "burning" sensations. The symptoms occur more readily as people age. Repetitive trauma does not allow for complete repair of the tissue during rest. In the worst stage, pain persists even at rest, and sleep is often disturbed. Severe pain, limited mobility or muscle weakness may make it impossible to perform most tasks.

Preventing ergonomic injuries involves evaluating the job for risk factors and obtaining symptom reports and observations from workers. Often the best ideas and solutions come from the people doing the work, especially if they know the risk factors. Job analysis tools and checklists are available on OSHA's website (http://www.osha.gov). Table 10.3 list some general risk factors that reflect the body's limitations, along with several suggested solutions. It is important to report injuries at their earliest stages so that the risk factors of the job or task can be evaluated and modified or eliminated.

Heat Stress

Heat stress occurs when the body is subjected to temperatures that cause the core temperature to stay above 100.4ºF (38ºC), over the course of the workday. Sweating and the surrounding ambient air simply cannot cool the body sufficiently. Wearing protective clothing or a respirator can add to the risk. Workers may notice symptoms of irritability, low morale, increased numbers of errors or increased frequency of unsafe behavior. Usually, adaptation to heat exposure takes about 5–7 days; so abrupt changes in the weather can produce more discomfort than a gradual change in air temperature, which gives the body time to adjust its temperature and pulse rate. People with chronic illnesses of the heart, lung, kidney, or liver tend to have lower heat tolerance and may be at greater risk. In this situation, seek the advice of a physician.

Prolonged heat stress can lead to related disorders such as fainting, prickly heat rash, heat exhaustion and heat stroke. Heat exhaustion and heat stoke are especially serious and require immediate attention. Heat Exhaustion should be suspected if a worker appears disoriented or confused or experiences inexplicable irritability, malaise, dizziness, lightheadedness, headaches, upset stomach, vomiting, decreased or dark-colored urine, fainting or passing out; pale, clammy skin. If any of these symptoms appear, the worker should be moved to a cool location with rapidly circulating air for rest. Loosen and remove any heavy clothing. Have the person drink cool water (about a cup every 15 minutes) unless he/she is sick to the stomach. Cool the person's body by fanning and spraying with a cool mist of water or applying a wet cloth to the person's skin. Keep the person under observation. Call for emergency help if the person does not feel better within a few minutes. If sweating stops and skin becomes hot and dry, the person may be experiencing heat stroke and immediate emergency care with hospitalization is essential.

Hygiene practices can relieve some of the heat stress or assist in acclimation to abrupt changes in the weather. Such practices include:

- Fluid replacement -- Drink small quantities frequently (5–7 ounces every 15–20 minutes). Do not depend upon thirst as a warning. Salt intake in a normal diet is usually sufficient to meet salt demands. However, if workers are not acclimated to hot weather, consider beverages containing about 0.1% salt. Workers on salt-restricted diet should never use salt tablets without consulting a physician.
- Training and self-determination -- By providing accurate verbal and written instructions and training on heat stress, workers can limit heat stress and recognize symptoms in themselves and others.

Table 10.3. Ergonomic risk factors and solutions

Risk Factors	Some Solutions to Consider
Joints (any joints including the back) are bent rather than neutral or relaxed; sometimes tasks involve joints bent as far as they can go – the surrounding muscles are stretched and weaker, easier to injure.	Use better designed tools and equipment; for example, modern pay loaders have better and more adjustable seats. Use ergonomically-designed shovels and tools which put the bend in the tool (rather than a bend in the user).
Work or load is too far out from the body – this places considerable strain on the lower back especially.	For any lifting job, bring the load as close to the body as possible. Use a tool to reach the distance, rather than extending the spine. Provide instruction on proper lifting techniques – if they are not or cannot be used for the job, figure out why not. If a load cannot be brought close to the body, such as a wide object that will not fit between the knees, buddy-lift or use a machine to perform the lift.
Body bent forward – the surrounding muscles are stretched and weaker, easier to injure.	Lift using a squat position rather than a bent back. Buddy-lift or use a machine to perform the lift.
Twisted trunk – twisting the back places strain on muscles, tendons, and discs; lifting and twisting are a combination with a high risk for back injury.	Avoid any twisting. If lifting and carrying an object, lift while facing forward and then take steps to make the turn.
Sudden movements and forces – never swing things, especially as a way to lift heavier weight; the muscles can be forced to stretch faster than they are able to respond, producing over stretching or tearing and injury.	Avoid swinging motions. If an item is too heavy to lift alone, get help or use a machine.
Posture or movement maintained for a long period of time – this is the prolonged static and/or dynamic work described above. Also keep in mind prolonged contact stress such as pressing or leaning the body, hands, or wrists against a hard or sharp edge like the edge of a table.	Plan for breaks and recovery/rest periods. Divide the jobs among several people, so no one person does it for very long. Put padding on sharp edges.
Continuous stress on certain muscles producing localized muscle fatigue – sometimes a job or task involves overworking just a few muscles, such as sitting in place but using the hands and bending the wrists over and over again.	Modern heavy equipment tends to have controls which conform to the hands and produce better positions for the arms, wrists, and shoulders.
Working to the point of exhaustion – as muscles become tired, they can suffer from insufficient oxygen supply and a build-up of waste products; once exhaustion occurs, muscle injury is more likely. Also, when workers become exhausted yet must continue working, they do the job any way that they can get it done – often with swinging of a lifted object, twisting of the back – anything to keep on going: this further increases the risk of injury.	Plan for breaks and recovery/rest periods. Frequent short rest periods reduce cumulative fatigue better than a few long breaks. The worst procedure is to let the worker work through the breaks and go home early, exhausted. Divide tasks among several people; do a variety of tasks to use different postures and muscles.
Vibration – using vibrating tools, handling vibrating machine controls, or sitting on vibrating equipment. Prolonged vibration can produce damage to tiny nerves and blood vessels.	Padded or gel-filled gloves for vibrating tools or machine controls; good seat cushions and proper seat shape to protect the lower back. Plan for breaks and recovery/rest periods.

Managers and workers themselves can adapt to hot days by leveling out the work effort over the allocated time, rotate jobs and take more frequent breaks. People who have been away from work for 3 or more days may require acclimation.

- Diet and life-style – Avoid large meals during work breaks because they increase circulatory load and metabolic rate. Adequate sleep; good diet and regular exercise reduce the risks of heat stroke. Abuse of alcohol or drugs increase the risks.

Cold Stress

With extreme cold temperatures, workers face the risk of hypothermia, even to the point of frostbite. Cold temperatures are aggravated by wet clothing, wind or contact with metal machine controls. Older workers or workers with circulatory problems require special precautionary protection against cold injury (e.g. extra insulating clothing, reduction in the exposure period). Some diseases and some medications reduce tolerance to work in cold environments. A physician should be consulted for workers who are at an elevated risk of cold stress.

Hypothermia occurs as the body chills and its core temperature drops. It generally reduces mental alertness, rational decision-making, and manual dexterity – each of which can lead to accidents or unsafe behaviors. As body temperature lowers further, loss of consciousness is possible with the threat of fatality. Symptoms of hypothermia include shivering, minor frostbite (frostnip), the feeling of excessive fatigue, drowsiness, irritability, or euphoria. If these symptoms arise, the person should be moved to a warm area and wet clothing removed. Modest external warming should be provided using external heat packs or blankets. If the person is conscious, he should drink warm, sweet fluids. The person should be transported to the hospital. A person experiencing hypothermia should not be given drinks with alcohol or caffeine (coffee, tea, or hot chocolate).

Frostbite involves freezing into deep layers of skin and tissue. Typically the fingers, hands, toes, feet, ears, and nose are at the greatest risk. The skin appears waxy, unusually pale or dark and becomes hard and numb, or blisters form. With frostbite, it is necessary to address freezing of damaged tissues. The tissue should be treated as a burn and the affected area should not be rubbed.

Practices that reduce the risk of cold stress, hypothermia and frostbite include:

- Where clothing may become wet on the job site, for light work, the outer layer of clothing should be impermeable to water. For heavier work, the outer layer should be water repellent and changed as it becomes wetted.
- More frequent indoor breaks may be needed when work is performed continuously in the cold, below 19.4°F (-7°C) (or equivalent wind chill temperature).
- Work should be planned to minimize sitting still or standing still for long periods.
- Protect the worker from drafts to the greatest extent possible. The cooling effect of the wind should be reduced by shielding the work area or by wearing an easily removable windbreak garment.
- Do not use unprotected metal chair seats. When working outside and using tools or machine controls, to prevent contact frostbite, workers should wear anti-contact gloves. If the air temperature is 0°F or below, wear mittens or gloves. Machine controls and tools should be designed for handling without needing to remove the mittens.
- Dehydration can occur in a cold environment and may increase the susceptibility of the worker to injury due to a change in blood flow to the extremities. Warm sweet drinks and soups should be consumed to provide caloric intake and fluids. Consumption of coffee and other caffeinated beverages should be limited.

Exposure to Sunlight – UV Radiation

Exposure to sunlight is a health concern because ultraviolet (UV) radiation increases the risks of skin cancer. Be particularly careful in the sun if you burn easily. Employees who regularly work outside should frequently check their body for early signs of skin cancer, especially for a spot on the skin that is changing in size, shape, or color during a period of one month to two years. If such symptoms appear, a health care professional should be seen immediately

as skin cancers detected early can almost always be cured.

When working outside, to protect against ultraviolet rays of the sun, workers should:

- Wear tightly-woven clothing.
- Wear a sunscreen with SPF of at least 15.
- Wear a wide brim hat that shades the back of the neck (not a baseball cap).
- Wear UV-absorbent sunglasses to block 99 – 100% of UVA and UVB radiation.
- Limit exposure to the sun between 10 AM and 4 PM.
- Wear special safety goggles or UV-absorbent sunglasses to protect the eyes, including from UV radiation reflected from snow in the winter.

Can someone with a health disability, such as asthma, work at a composting facility?

Given the bounty of biological stimuli and bioaerosols at composting sites (and farms), a standard hiring policy might be to immediately exclude individuals with certain health impairments, such as allergies to fungal spores or respiratory disorders. However, such a policy is not only unfair, it may also be illegal, and unnecessary. Many governments have regulations that protect workers with disabilities from discrimination. For instance, in the U.S., the "Americans with Disabilities Act" requires the employer to provide a reasonable accommodation for the employee unless he/she constitutes a direct threat to the safety of him/herself or others. "Direct threat" is determined by:

- the likelihood (probability) that an injury will occur; this is high probability not just elevated risk or a remote or speculative risk; and
- the certainty (predictability) that an injury will occur; especially based upon individual factors.

The employer in conjunction with the employee and the occupational physician can determine if there is a significant risk of substantial harm by evaluating the individual employee's medical status and prognosis in relation to:

- probability -- the statistical likelihood of the harm occurring
- severity -- the nature and severity of the potential harm
- imminence -- the time frame in which the harm is likely to occur
- duration -- how long the risk is likely to be present

The employer must determine that all reasonable accommodation cannot reduce the employee's risk to acceptable levels. Appropriate process management, engineering controls (where possible), work practices, hygiene practices, and personal protective equipment (respirator, powered air-purifying respirator) are often able to satisfactorily reduce the level of exposure for most people. This approach could afford more and better opportunities for employment for persons with disabilities. However, for some individuals, exposure still cannot be reduced sufficiently, even with the best practices and personal protective equipment. For example, someone with occupational asthma may still respond to very low-level exposures, even when wearing a full-face respirator. If, after this evaluation, the person with a disability truly cannot do the job without significant risk to him/herself or others, then the decision not to hire or retain such a person must be made on a sound scientific basis.

BIOLOGICAL AND CHEMICAL HEALTH CONCERNS

Composters are exposed to the resident organisms involved in decomposition, and their components (e.g. spores, endotoxins), plus the volatile compounds and dusts generated during composting. When these biological and chemical elements become airborne (usually with dust particles and mists), they are referred to as bioaerosols. The bad news is that both acute and chronic adverse health effects could potentially arise from these biological and chemical agents if ordinary safety practices are ignored. The possible health effects range from short term symptoms, like skin or eye irritations, to more worrisome allergic reactions and illnesses. The good news is that workers, compost users or neighbors rarely experience adverse health effects because of the body's ability to defend itself and because these biological elements are present most everywhere in the environment.

While these potential health concerns are real and merit attention, it is unclear if they make composting a risky occupation. Compost workers are an under-researched group and research results to-date are inconclusive, if not contradictory. Some of the potential adverse effects depend to a great extent on the susceptibility of the individual. Again, there is little evidence to suggest that compost workers -- the group most exposed to the hazards -- have any greater incidence of health problems than the population at large. Ordinary safety practices and the body's inherent defenses are apparently effective in keeping the risks low.

Routes of Entry

The first step in minimizing the risks from biological and chemical substances is understanding their potential routes of entry into the body. Chemicals and biological agents enter or make contact with the body through eye contact, skin absorption, injection through the skin, or ingestion and inhalation. Common sense, hygiene and personal protective equipment (see following section) block these routes of entry.

- **Eye contact:** When present in high concentrations, water-soluble gases such as ammonia and hydrogen sulfide, volatile fatty acids and aldehydes can dissolve in eye moisture and produce eye irritation. Dusts and aerosols can also enter via eyes and produce irritation, while microorganisms in the eyes could produce infection. Defense mechanisms for eyes, including tears and blinking, exclude or remove most airborne hazards. However, eye protection is still recommended to lower the risks from bioaerosols, dust, and chemicals (in high concentrations) as well as flying particles. Hand-to-eye contact (e.g. rubbing eyes) is another pathway for irritation and infection, which is minimized by frequent hand-washing and wearing gloves.
- **Skin contact or absorption:** The skin is an incredibly effective barrier to microorganisms and most chemicals. While rare, irritation or burns may result from skin contact with a few abrasive chemicals that may be used at some composting facilities, such as cleaning acids or caustics or laboratory chemicals. Skin reactions to plant toxins, such as poison ivy or poison oak, are more likely. Protection practices include appropriate clothing and gloves and awareness of the hazardous chemicals and plants that might be present.
- **Injection:** Chemicals and organisms are much more likely to cause infection or injury once they penetrate the fortress of the skin. Damaged skin (punctures, cuts, abrasions) can become infected, as well as serve as an entrance to the bloodstream. There are numerous opportunities for composting workers to acquire cuts and scrapes while walking near or handling materials containing sharps (e.g. glass fragments), scrap metal and wood with protruding nails and while working with equipment and tools. Cuts and scrapes should be cleaned and treated immediately and then kept protected with bandages and washed frequently. Existing wounds must remain protected and cleaned. Appropriate gloves and footwear (e.g. steel soles) should be worn, and sharp, protruding objects should be removed promptly from harm's way.
- **Ingestion:** Assuming that you are not taste-testing compost nor drinking the compost tea, dusts and particles carrying microorganisms landing on lips can be inadvertently swallowed. In addition, hand-to-mouth transfer can occur by eating food or smoking cigarettes without first washing hands. If the microorganisms proceeded to the digestive

tract, some may be killed by stomach acid and some may survive to infect the intestine or other body systems. Good hygiene greatly reduces hand to mouth ingestion. Respirators and masks worn in dusty situations minimize inadvertent ingestion.

- **Inhalation:** The atmosphere carries small to microscopic bioaerosols that people routinely inhale including gases, dusts, mists, vapors, bacteria, fungal spores, viruses and protozoa. At composting sites (and other locations where organic materials are disturbed; e.g. raking leaves), bioaerosols are present at concentrations that are much higher than normal and thus present greater health risks. Most bioaerosols are removed before reaching the lungs by fluids in the nose, throat and bronchial tubes (Figure 10.2). Particles that are not water soluble or smaller are more likely to be carried into the air sacs of the lungs. Here white blood cells, called macrophages, engulf and destroy many bioaerosols and guard against infection. As with ingestion, most organisms that are inhaled die inside the body, while some may persist. Respirators and masks should be used in dusty situations to reduce inhalation of bioaerosols. In addition, fewer bioaerosols become airborne when materials are kept moist.

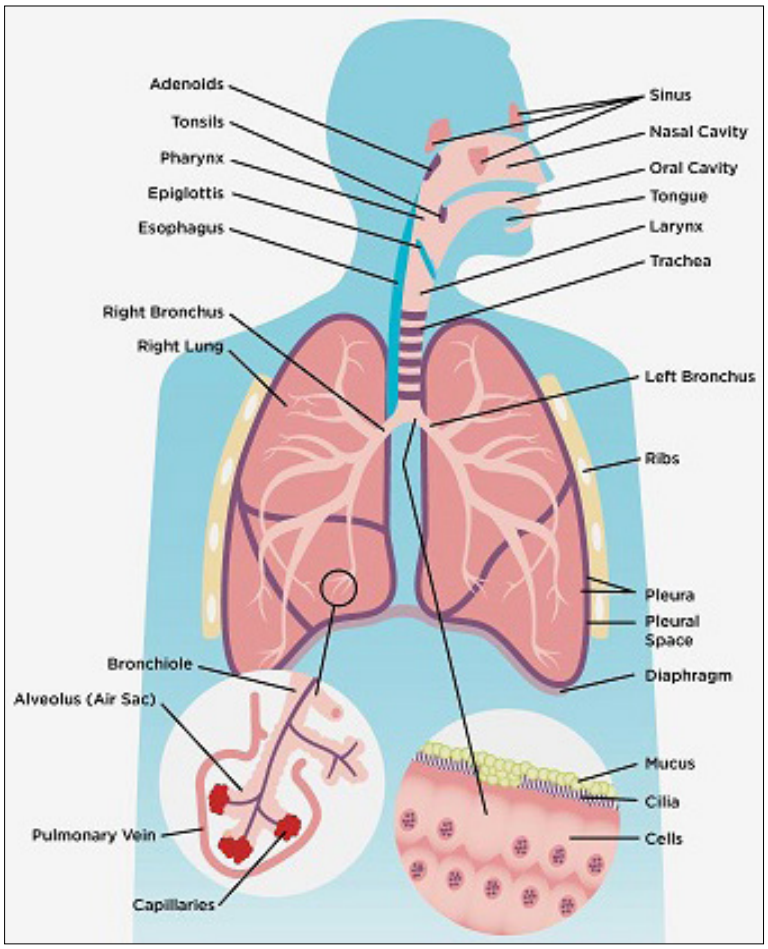

Figure 10.2. Respiratory System. Inhalation and fate of particles and gases in the lung.

Chemical Hazards

In general, chemicals are not used widely at most composting facilities. The primary potential chemical hazards are due to gaseous compounds released during decomposition including carbon dioxide, ammonia, nitrous oxide, methane, hydrogen sulfide, and carbon disulfide. These gases are health hazards when they are present in high concentrations or displace fresh air needed for proper breathing. In the normal environments of a composting site, these gases are generated gradually and either further decompose or dissipate well before accumulating hazardous levels. However, high concentrations can occur in certain situations, such as inside composting vessels, enclosed storage bins or when an actively decomposing pile is opened. In these situations, the fumes can potentially overcome a worker. For example, ammonia has even been observed to exceed OSHA limits in enclosed composting facilities. In poorly aerated areas of buildings or in a confined space (such as in-vessel composting), carbon dioxide may reach levels which could affect those with pre-existing heart conditions.

To prevent accidents from exposure to chemical vapors it is important to ventilate enclosed spaces before entering. Safety protocols for working in confined spaces should be observed when entering a composting reactor. Loaders and turners that are opening piles should have enclosed cabs with filtration on the intake air. While it may be possible to provide both particulate filtration and gas (such as ammonia) scrubbing for the intake air, it is also possible for the operator to wear respiratory protection which provides protection for both.

The only way to know about the level of exposure by inhalation of chemical vapors is to analyze air samples collected in breathing zone. However, serious overexposure can be indicated by symptoms listed in Table 10.4. These symptoms are typical for acute

Table 10.4. Symptoms of overexposure to gaseous chemicals

Structure or Function Affected	Possible Effects
Central nervous system (brain)	headache, dizziness, lightheadedness, euphoria, drunkenness, slowed response time, lack of coordination
Respiratory system (lungs)	changes in rate or depth of breathing, chest tightness, irritation, difficulty breathing, feeling of "warmth" in the chest
Eyes	tears, irritation, "burning" feeling, blurred vision, sensitivity to light
Heart or circulatory system	heartbeat is rapid, slowed, or irregular; change in EKG, change in blood pressure, fainting
Digestive system	vomiting, nausea, malaise, diarrhea, constipation
Skin	swelling, redness, rashes, irritation, bumps, boils, increase or decrease in pigmentation

exposures; chronic exposures may produce subtle damage or effects without such obvious signs (see Medical Monitoring section, page 26). *It is important for workers to report any and all symptoms, injuries, and illnesses so that hazards and overexposures can be addressed.*

Dust

Dust is a common nuisance at composting sites. It is generated under dry conditions from materials handling, processing operations and movement of vehicles on the site. When inhaled in large concentrations, or consistently over long periods, dust can interfere with a person's respiratory functions and can eventually lead to damage to the lungs and other organs. In addition, dust can be a bioaerosol as it carries biological elements including fungi, bacteria, and other particles (see Biological Hazards section).

Dust is minimized by keeping materials and surfaces moist. Exposure to equipment operators is best reduced by the use of an enclosed cab on the vehicle with well-sealed and air-conditioned/heated cabs with filtered air intakes. Filters should be removable and washable or replaceable; employees should be instructed to remove and clean or exchange filters frequently. Workers outside of cabs should use respirators in situations where dust is generated (see Personal Protective Equipment section, page 28).

Biological Hazards

Biological health concerns include potential exposures to bacteria, endotoxins, fungi (molds and yeast), parasites (protozoa, protistans), worm cysts, and viruses. While all of these biological agents exist in the environment, they are likely to be present in higher concentrations at composting sites, and also farms, due to the nature of the feedstocks and the fact that composting fosters biological decomposition. A compost facility is a source of bioaerosols -- airborne particles including fungi, bacteria, and endotoxin. Elevated levels, sufficiently high to cause potential harm to workers, occur both upwind and downwind of activity areas, within a distance of about 90 feet (25m) of the source.

Disease-causing organisms represent only a very small fraction of the microbial community in compost piles, and they are effectively destroyed by the high temperatures and antagonistic environment of the compost pile. However, this sanitation should not be cause for over confidence. It occurs only after the feedstocks have been mixed and the composting is well underway (one to three days). Because new feedstocks are continually coming on the site, a resident population of pathogenic microorganisms inhabits the site to some degree, again depending on the feedstocks and their handling. In addition, some biological hazards are associated with agents that are not ordinarily considered pathogens (e.g. organic dust, fungal allergens) and that persist through the composting process. In short, despite the capabilities of composting process and methods, potential biological hazards deserve respect and precautions that include minimizing exposure, sensible hygiene practices, personal protective equipment and health

monitoring. Immunization recommendations for compost workers are not different from the general population. Due to the potential for cuts and puncture wounds, compost workers should consider keeping their tetanus vaccination up-to-date.

The type and number of organisms present, and the predominant routes of entry, depend largely on the feedstock but the processing activities are also a factor. The primary groups of concern are summarized below.

Bacteria:

Bacteria are simple singled cell organisms present in composting feedstocks in tremendous variety and number. Bacteria are the dominant composting organisms. Although only a small fraction pose health risks to humans or animals, bacteria infections are responsible for numerous diseases and general infections. Symptoms differ among the various diseases and organisms. Infections can occur by any of the routes of entry discussed earlier. The bacterial species Salmonella and fecal coliform bacteria, including Esherichia coli (E.coli), are commonly used as indicators for the presence of pathogenic bacteria generally. Materials and environments are tested for these representative groups rather than each potentially pathogenic species of bacteria.

The greatest risk of bacterial infection appears to be in the initial stages of composting, and from raw feedstocks like manure, biosolids and post consumer food scraps. They pose little risk in final stages because pathogenic forms die at the high temperatures of composting. Potentially pathogenic bacteria may better survive low temperature processes but other factors, including microbial antagonism and competition, tend to contain pathogenic populations. The risks associated with pathogenic bacteria are reduced by maintaining high temperatures for an extended time period. Regulations require that biosolids must be composted at specified temperatures for a specified time -- 131°F or 55°C for 3 to 15 days, depending on the composting method. Some jurisdictions have extended this requirement to all composting feedstocks. Testing for Salmonella and fecal coliform is frequently performed to verify the destruction of bacteria. To avoid infection, it is equally important to minimize exposure and hinder the routes of entry with appropriate protection (e.g. gloves and dust masks) and sensible hygiene.

Endotoxins:

In addition to exposure to live bacteria, handling organic materials can expose workers to pieces of dead bacteria, known as endotoxins. Endotoxins are parts of the cell walls of gram-negative bacteria. At high levels of exposure, endotoxins could decrease lung function by producing inflammation. Dust containing endotoxins can be mechanically irritating to the mucous membranes of the eyes, nose, and throat and to the skin. The health effects of endotoxin exposure may include fatigue, fever (organic dust fever or organic toxic dust syndrome), chills, headache, malaise, cough, chest-tightness, and shortness of breath. In some cases, sweating, nausea, abdominal discomfort, and sometimes vomiting may occur. Endotoxin symptoms may develop from one to eight hours after exposure and usually last for up to 24 hours, although the individual may feel unwell for a longer period of time. Repeated, prolonged exposure may lead to persistent airway disease, such as bronchitis and bronchiolitis. In some individuals, repeated exposure may lead to a tolerance for endotoxins.

Endotoxins are potentially present in nearly any feedstocks and the composts made from them. They are heat-stable and not substantially inactivated by composting temperatures. They are most often associated with dust. This association plus the fact that endotoxins affect the respiratory system suggests that inhalation is the primary entry route of concern. Dust suppression and respirators minimize exposure.

Fungi:

Composting fosters the growth of fungi, especially with woody feedstocks and in the latter stages of the process. Up to 100 species of fungi have been found in compost. While predominant fungal species vary, common organisms include various species of Aspergillus and Penicillium – organisms that produce tiny, easily airborne spores. Aspergillus fumigatus is one species that has received particular attention in regard to composting because it is common and a well-known allergen.

Typical reactions to fungal spores are irritation, allergy, or infection in susceptible people. However, the effects differ among individuals. Individuals who are not allergic and have a healthy immune system are rarely affected. People with specific allergies can exhibit immediate allergic reactions that may include irritation of the eyes, nose, and throat; lethargy, and headache.

Most fungi commonly encountered in the environment are unable to cause infectious disease. However, some species of fungi are considered opportunistic -- they can cause infection in people whose immune system is compromised (i.e. immunodeficient) by other diseases or treatments for those diseases. Examples include: diabetes, cancer (especially leukemia), cystic fibrosis, alcoholism, inherited immune deficiency, acquired immune deficiency (AIDS), invasive medical procedures and certain medications (e.g. antibiotics, immunosuppressive drugs). Persons with weakened immune systems, fungal allergy, or medical conditions that compromise the body's ability to fight infection should use caution when handling compost. Recent attention has turned to fungal production of substances called mycotoxins. Mycotoxin-contaminated dust inhalation in farm workers has been linked to liver cancer, fungal irritations, inflammations and infections of the lung (mycotoxicoses). It is suggested that compost workers face similar or greater levels of exposure, although long-term epidemiological studies have not yet been reported for compost facilities.

Fungi and fungal products (e.g. spores, glucans, mycotoxins) are prominent bioaerosols. High levels of fungal spores and mycelium fragments in the air can be generated from composting piles and activities that produce dust. The principal routes of entry for compost workers are inhalation and skin/eye contact.

Viruses:

Virus are very small pieces of genetic material wrapped within a protein cover. As a group, viruses cause a variety diseases from the common cold to polio. In general, viruses do not survive well beyond their host environment and appear to be inactivated readily during composting. Also, viruses tend to be retained well in the pile and not readily airborne. The type of virus present primarily depend on the feedstocks and their sources. Most of concern is for those in manure, biosolids and food. Insect and tick bites can spread several viruses including West Nile virus. At a composting site, control of West Nile virus involves management of the composting site to reduce mosquito breeding, rather than process or feedstock management (see Protecting Against West Nile Virus, page 25).

Viruses of veterinary importance include Foot and Mouth Disease (FMD) and avian influenza (AI). Studies of animal mortality composting have demonstrated that these viruses are readily destroyed by the composting process. However, the viruses remain viable in the raw feedstocks, which is one reason why European countries have generally not embraced composting as a means to dispose of dead animals. Avian influenza (AI), or bird flu is a growing concern as a human health issue because the virus has infected humans. Infected poultry have been successfully composted as a means of controlled disposal. However, as of this writing, the topic continues to receive much attention and policies enacted in the near future may impact composting of AI-infected birds and manure.

Parasites, protozoa and worms:

A number of parasitic species of protozoa and worms (i.e. helmiths) can inhabit composting feedstocks, especially manure and biosolids. For example, workers at a biosolids composting project apparently were infected with Giardi from handling raw biosolids, probably via accidental ingestion. Protozoa such as Cryptosporidium are reportedly killed by composting and Giardia lamblia appears to be even less hardy than Cryptosporidium. However, little is known about the survival of most parasites during composting. Most likely, the harsh conditions during composting substantially destroy parasitic organisms. In any case, good hygiene is strongly recommended to avoid possible infection, especially when handling raw feedstocks.

Infectious prions:

Infectious prions are the suspected cause of diseases such as mad cow disease (BSE), scrapie (affecting sheep), and chronic wasting disease (CWD, affecting mainly deer and elk). A prion is not a living organism,

nor a virus, but an abnormally-shaped protein that triggers other proteins in the brain and spinal tissue to also change shape. The possibility of prion-infected material coming into a composting site is extremely small, and that possibility almost exclusively applies to animal carcasses (e.g. farm mortalities, deer). In infected animal carcasses, the prions are concentrated in the brain and spinal tissue. It is best to keep potentially-infected carcasses out of compost piles where there is any intention to use the resulting compost. Prions can conceivably find their way into municipal biosolids, MSW and some food wastes but only at extremely low concentrations. The effect of composting on prion survival is unknown. Until research demonstrates composting can destroy prions, it should be presumed that compost made from infected material also carries the prions.

Protecting Against West Nile Virus and Other Mosquito Transmitted Diseases

West Nile Virus is a virus that is a mosquito-spread virus that causes West Nile encephalitis, an inflammation of the central nervous system. Because many composting sites contain or abut reservoirs of water (even containers and puddles), they can also harbor mosquitoes that carry the disease. Prior to 1999, West Nile Virus was found only in Africa, Eastern Europe, and West Asia. In August of 1999, it was identified in the United States, and has spread across most of the country since then. There is no specific treatment for infection in humans. Elderly people are at the greatest risk of developing severe symptoms. In severe cases, hospitalization and intensive supportive therapy may be needed.

Certain species of birds act as reservoirs for the virus, and certain species of mosquitoes act as vectors. Mosquitoes pick up the virus when they bite, or take a blood meal, from infected birds and then with the next blood meal transmit the virus to people and other animals.

The best method of reducing the risk of West Nile virus is to eliminate mosquito breeding sites. Mosquitoes lay eggs and develop in stagnant water, so reduction of these sites involves eliminating stagnant water sources. Where water is a permanent feature, using chemicals to kill mosquito lava (larvicides) may be possible.

- Use landscaping to eliminate standing water that collects on the composting site. Mosquitoes may breed in any puddle that lasts for more than four days. Grade the site regularly to minimize puddles and ruts.
- Drill holes in the bottom of containers left outdoors. Containers with drainage holes located only on the sides collect enough water to act as mosquito breeding sites.
- Old tires provide a place for water to collect and thus a breeding ground for mosquitoes. Old tires should be promptly removed from the site and recycled. Tires that are used to hold down tarps or other purposes should be sliced, quartered, drilled with drain holes or filled with foam plastic to exclude water.
- Where water reservoirs cannot be eliminated, consider using larvicides. Consult with the local pesticide regulation authorities before going this route. Usually, larvicides must be applied by a certified pesticide applicator.
- Periodically inspect the site for dead birds, such as crows. Any suspicious birds should be reported to the local Department of Health. Use gloves to handle dead birds and place the birds in plastic bags, as directed by the Department of Health.

PREVENTION AND PREPAREDNESS

Prevention begins with the goal of removing a hazard and finishes with protecting workers from those hazards that cannot be eliminated. It includes, but is not limited to, sensible hygiene, personal protective equipment and medical monitoring. However, while prevention practices reduce the risks and number of incidents, there are no guarantees that accidents and illnesses will never occur. In fact, it is a good policy to expect and anticipate safety and health incidents and be prepared to react to and treat them.

Proper training of workers is probably the best means to reduce the safety and health risks associated with composting. Training starts with adequate instruction for the workers on how to perform their jobs and operate the required equipment. The work environment becomes even safer when workers are further trained about potential hazards, hazard reduction practices, emergency preparedness and first aid. With training, workers can contribute valuable input and service to prevention and preparedness.

Reducing Safety and Health Hazards

Safety and health hazards can and should be reduced via a hierarchy of practices that seek to: first, eliminate a hazard (e.g. process or engineering controls) and second, reduce the risk of or exposure to the hazard (e.g. administrative controls) and then protect workers from hazards that remain (e.g. protective equipment).

Process and engineering approaches to safety and health change the nature of the work in order to minimize and preferably eliminate a hazard. Examples include paving roads and other surfaces to reduce dust and standing water and providing enclosed environmentally-controlled cabs for equipment. Many safety-conscious engineering controls have been suggested in previous sections of this paper.

Administrative controls are more procedural in nature and can affect process and site management as well as worker activities. Limiting employee work hours to reduce fatigue is an administrative control that reduce hazards in different ways. In particular, it is important to establish and encourage facilities and practices that encourage good hygiene (Table 10.5). It is highly desirable for any composting operation to have hygiene facilities – restrooms, change rooms, showers, clean-up facilities, lunchroom – to reduce the potential for exposures to chemicals and diseases, as well as to prevent these items.

Improvements in safety and health of any facility can be identified through hazard evaluation tools such as job hazard analysis, vulnerability analysis and process hazards analysis. Specific programs include “Hazard and Operability Analysis” and “Hazard Analysis and Critical Control Points” (HACCP). HACCP, for example, systematically identifies the critical points in a production system responsible of potential hazards, sequentially corrects the problems at those points and then continues to monitor, test and improve the system at new critical points (Evans, 2003).

Medical Monitoring: to evaluate health and establish a health baseline

Regular monitoring of a worker’s health status, beginning before the employee’s first day on the job, can signal whether site conditions may be contributing to health problems. Monitoring is especially important for chronic ailments and those that may be due to cumulative or repeated exposure. The following recommendations for medical surveillance are adapted from those recommended for wastewater workers, considering the potential health effects and exposures associated with composting:

- A pre-placement examination that should include from working at a composting site: a comprehensive physical examination, liver and kidney function tests, hematologic function tests, lung function tests.
- Yearly periodic health assessment, including: a review of systems for symptoms suggestive of diseases (such as hepatitis, intestinal infections, respiratory infections) and for reactions to exposure to toxic gases (such as ammonia); update of immunizations (e.g. influenza, tetanus, diphtheria, polio). The U.S. Centers for Disease Control suggests that the immunizations for wastewater workers should be the same as those for the general population. Operators that handle biosolids should consult a doctor regarding the need for a vaccine for Hepatitis A.

Table 10.5. Elements of good hygiene for composting facilities

Water and Facilities

- Provide a source of potable water for drinking, hand/body washing, cooking, food and food preparation and eating utensils washing, and personal service rooms.
- Drinking water should be provided in single-use cups or by fountains
- Non-potable water, such as that used for fire fighting, should be clearly identified and distinguished from potable water. Non-potable water sources and outlets should also be labeled as unsafe for drinking.
- Provide toilet facilities with toilet rooms, preferably separate for each gender. If the toilet room can only be occupied by one person at a time and can be locked from the inside.
- Provide changing rooms so that employees can wash and change into street clothes before leaving work. Showers are also highly desirable.
- Provide a lunchroom so that employees do not consume nor store food or beverages in any area exposed to potentially hazardous materials.
- Prohibiting eating, drinking and smoking on the site except in designated locations (note the risk of fire as well as disease-prevention)

Personal Hygiene

- Wash hands with soap and water before eating or smoking or whenever hands come into contact with compost or feed stocks.
- Shower at work and change into clean clothes and shoes.
- Wash hands before and after using the bathroom.
- Remove excess contaminants from footgear prior to entering a vehicle or a building.
- Do not wear work clothes home or outside the work environment. Remove contaminated clothing at the end of the shift. If possible, avoid laundering work clothes at home.
- If home laundering id necessary, place work clothes in a bag and leave them bagged until they are actually to be placed in the washing machine. Wash separately from other clothing using the hot water cycle and chlorine bleach (if appropriate).

Injuries and Illness

- Thoroughly but gently flush eyes with water if contaminants contact the eyes.
- Care for cuts and abrasions promptly. Keep wounds covered with clean, dry bandages.
- Promptly report injuries, illness, and symptoms
- Keep current the vaccinations recommended by the CDC (i.e. for the general population). If biosolids are handled, also consider hepatitis A vaccine.

- On-going health monitoring: prompt reporting of illnesses lasting longer than two days to employer or safety director; evaluation of suspected work-related illnesses as needed.

Personal Protective Equipment

Given the nature of composting, some potential hazards remain despite the best process, engineering and management practices. In situations where workers are exposed to such hazards, personal protective equipment (PPE) provides an important line of defense. PPE includes: visible clothing, hard hats, eye and ear protection and dust masks and respirators. In addition, workers should wear appropriate clothing, gloves and footwear (e.g. steel toes).

- ***Overall visibility***: To ensure that they can be clearly seen by equipment operators, workers should wear brightly-colored (e.g. orange or yellow) clothing or vests. Reflective tape or strips on clothing are also helpful.
- ***Head protection***: Unless one is working in an enclosed cab, a hard hat should be used to protect the head from impact for any tasks involving flying or falling objects including mixing, turning, grinding and wood chipping.
- ***Eye protection***: Protecting the eyes is necessary from dusts and bioaerosols and from potential impact from projectiles. Unvented goggles give the best protection for gases and vapors, while still providing impact protection. A face shield could be used over goggles and is available in a style that attaches to a hard hat. A full-face respirator provides the same protection as goggles and a face shield.
- ***Hearing protection***: Ear muffs, plugs, semi-inserts, and other noise reduction devices are available and must be worn (as described above) during exposure to noisy work or equipment. Hearing protection devices must reduce the worker's exposure below the regulatory limit. These items are labeled with the manufacturer's assessment of their Noise Reduction Rating (NRR); however, OSHA requires that the NRR rating be adjusted: the value of 7 dBA is subtracted from the manufacturer's NRR to adjust for uncertainty regarding the frequency of the noise (the actual noise could be high-pitched to low-pitched, depending on that task or equipment). Then, the adjusted NRR is divided by 2 to produce a 50% safety factor. If two noise reduction devices are used (such as ear plugs plus ear muffs), the NRR of the most effective protective device is used, then 5 dBA is added for the second piece of protective equipment. The actual noise level of the noise source minus the adjusted NRR must be below the regulatory limit.
- ***Respirator***: Respiratory protection should be worn for all the dust-generating tasks, unless working inside an enclosed cab with its own air filtration equipment. Any respirator used must be marked as approved by NIOSH (the National Institute for Occupational Safety and Health) and must show a rating indicating its filtration level. The minimum level of protection from dusts and bioaerosols is an N95 NIOSH-approved disposable respirator. This respirator is able to filter 95% of particles at 0.3 microns in diameter or greater – thus removing mold spores and other fine dusts. A disposable particulate respirator can be worn repeatedly until its filtering capacity has been used up. At this point, the wearer will notice that it is difficult to breathe through the respirator. Disposable dust respirators can be purchased with or without an exhalation valve; which more effectively removes exhaled moisture.

  If protection is needed from gases or vapors, a half-face or full-face respirator is necessary. This type of respirator uses disposable cartridges that can remove a specific gas (such as a cartridge for ammonia gas). A dust cartridge can be layered over the gas cartridge to provide simultaneous protection from both types of air contaminants. If the worker is unable to tolerate the stress of using these types of negative-pressure respirators, it may be possible for the person to use a powered air-purifying respirator *with* the appropriate cartridges. This type of respirator uses batteries to provide the power to draw in the air and deliver it to the wearer's breathing zone.

  Every time a respirator is put on, the wearer must use a fit-check, as described in the manufacturer's instructions, to make sure that it fits tightly to the face and the seal does not leak. The OSHA respiratory protection standard (not applicable to agriculture), requires that workers must be

physically able to wear a respirator, must be fit-tested so that their respirator makes a good seal on the face, must be clean-shaven where the respirator seal touches the face and must be trained on donning, inspecting, using, and replacing the respirator. Even one day's beard growth can cause substantial leakage.

Emergency Action Planning and Fire Response

Regardless of the safety precautions implemented, it is always important to consider, well in advance, what potential emergencies your facility might encounter -- accidents, fire, tornadoes, blizzards, hurricanes, floods, equates and any emergencies unique to a particular area. A written emergency plan should be in place, and employees should be trained on what they are expected to do in an emergency, including:

- how to report the emergency and how to raise the general alarm (the alarm should be a loud and distinguishable noise),
- roles and responsibilities in the event of a fire or other emergency,
- who is expected to leave the area and who remains to perform critical functions,
- what rescue and medical duties are expected of employees,
- where people should gather after evacuation; what is the refuge or safe area (parking lot, open field, or street), and how are they all to be accounted for.

Fire preparation

Before or soon after the composting enterprise begins operating, the local fire department should be contacted and consulted so that, in the event of an emergency requiring their assistance, they will have already visited your facility, know its layout and potential problems. A local fire company may not be familiar with fires at composting facilities, especially spontaneous combustion. If possible, provide them with information about the nature and recommended procedures for fighting compost fires.

In order to respond to a fire on site, selected (or all) workers should have access to water or other extinguishing methods and should be trained to use them. For a fire in a building, Class A portable fire extinguishers, which deal with wood and paper, should be located within 75 feet for rapid access. For a fire involving a vehicle (oils, fuels, etc.), a Class B portable fire extinguisher should be located on the vehicle or within 50 feet of travel distance. In addition, it is a good idea to have emergency fire fighting equipment on site that contains the necessary equipment and materials such as a fire extinguisher, fire hose and couplings, instructions and keys to loaders and access gates.

Water systems used for the composting process should be available to suppress a fire in an emergency. The recommended amount of water reserved for short term fire fighting is 3000 gallons, enough to supply 100 gallons per minute for 30 minutes (or 114 m3 at 380 liters per minute). The soft hose should be at least 31/2 inches (90 mm) in diameter to accommodate this flow rate.

With an enclosed composting facility, the building could be constructed with an automatic sprinkler system. For other enclosed structures on the site, local fire codes determine the requirements for building sprinkler systems (an enclosed structure means a structure with a roof or ceiling and at least two walls).

Means of exiting from a building

For any buildings on the composting site, workers should be able to exit or escape during an emergency, such as a fire. At least two exits should be available that provide free and unobstructed exit – with no locks, chains, or fastenings to prevent free escape from the inside, and free of obstructions or impediments. Exit doors should swing outward and all the exit door hardware should be functional and operational. The exit should be clearly visible and the route to it conspicuously indicated so everyone readily knows the direction of escape from any point. Use internally illuminated or self-luminous signs reading "EXIT" with letters at least 6 inches high. Clearly visible signs and arrows should be used if the way to the exit is not readily apparent. A sign reading "Not an exit." should identify any door, passageway, or stairway that is not an exit or a path to an exit. Exits should discharge directly onto a street, yard, court, or other open space that gives safe access to a public way.

First aid

It is unrealistic to expect that accidents will not happen. Therefore, employers must provide medical and first aid personnel and supplies commensurate with the hazards of the workplace. Proper first aid training is more important than the best first aid kit. A first aid kit is useless if a person does not know how to use it.

According to OSHA standard 29 CFR 1910.151 – for non-agricultural workplaces that are not located in proximity to a hospital or medical facility, a person or persons must be adequately trained to render first aid. First aid refers to medical attention that is usually administered immediately after the injury occurs and at the location where it occurred. It often consists of one-time, short-term treatment requiring little technology or training to administer – such as cleaning minor cuts, scrapes, or scratches; treating a minor burn; applying bandages and dressings; use of non-prescription medicine; draining blisters; removing debris from the eyes; massage; and drinking fluids to relieve heat stress.

Table 10.6 sets forth the minimally acceptable number and type of first-aid supplies for first-aid kits according to the OSHA standard. The table also lists additional items recommended for first aid kits for tractors and other farm machinery. Make sure your emergency kit contains personal medical information and supplies for those with special medical conditions. For example, a sting to someone who's allergic to bee venom could be life-threatening, so appropriate anti-toxins must be included. The name and telephone number of a family doctor for everyone who might be involved in a medical emergency also should be included.

The contents of the first-aid kit listed should be adequate for small work sites, consisting of approximately two to three employees. For operations with more employees, the supply qualities should be increased or additional kits provided. Label the kit and place in an easily-noticed and reachable easy-access location. Consider having a first aid kit in all vehicles and buildings, and restock supplies as they are used from the kit.

Eyewashes and emergency (drench) showers are important for rapid response to chemical exposures. OSHA requires non-agricultural workplaces to have eyewashes and drench showers where corrosive materials are present. These devices also are useful for fuel accidents or for the rinsing of dusts from the eyes. Table 10.7 provides some recommended features of eyewashes and drench showers. Be sure to remove contact lenses and flush the eyes well. Although 15 minutes of flushing is typically recommended for chemical exposures, field studies of eye incidents indicate that at least 20 minutes are needed for chemicals which are alkaline/caustic in nature (some scientific literature suggests 30 minutes of rinsing). A small piece of pH test paper (or litmus paper) can be used to check eye moisture to determine when eye irrigation has been sufficient (the pH of the human eye is 7-7.4). In any case medical attention should be sought after any eye injury.

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4. The Science of Composting, Eliot Epstein, 1997. Technomic Publications.
5. A Practical Safety Manual for the Composting and Mulching Industry. The University of Tennessee Center for Industrial Services. 1997.

Table 10.6. Recommended contents for workplace first aid kits

Minimum contents (per OSHA standard 29 CFR 1910.266 Appendix A)

- Gauze pads (at least 4 x 4 inches).
- Two large gauze pads (at least 8 x 10 inches).
- Box adhesive bandages (band-aids).
- One package gauze roller bandage at least 2 inches wide.
- Two triangular bandages.
- Wound cleaning agent such as sealed moistened towelettes.
- Scissors (strong enough to cut through denim; e.g. stainless steel bandage scissors).
- At least one blanket.
- Tweezers.
- Adhesive tape.
- Latex gloves.
- Resuscitation equipment such as resuscitation bag, airway, or pocket mask.
- Two elastic wraps.
- Splint.
- Directions for requesting emergency assistance.

Additional items recommended for tractor accidents

- Several quarters taped to the carrying case to make an emergency phone call.
- A basic first aid manual.
- Two triangular bandages with 36” sides (e.g. made from bed sheets).
- Spray antiseptic (not a pressurized can).
- Sterile saline solution.
- Twelve adhesive bandages and four safety pins.
- Eye goggles.
- Three small packages of sugar.
- Cold pack.
- Amputation preservation kit (set of plastic bags: one large garbage bag, four kitchen-sized and two bread bags).

Table 10.7. Recommended features for emergency eye wash and showers

Eyewashes	**Emergency Showers**
Aerated potable water.	Chain pulls should be provided with a large ring or with a double ring at right angles; pull ring should not exceed 77 inches from floor; for disabled persons, the maximum height should be determined functionally
Tempered water @ 70ºF; mixing valve with "anti-scald" feature is desirable.	Shower head should be at least 84 inches from the floor.
Copious and gentle flow; 3-7 minimum of 15 minutes of water flow.	The horizontal distance from the center of the shower head to the pull bar should not be greater than 23 inches.
Hands should not be required to maintain the water flow.	Valve should open readily and remain open until intentionally closed.
Test on a regular basis; keep a record of the testing; for plumbed installations, flush the lines once per week.	Water flow must be sufficient to drench person rapidly; minimum flow of 30 gpm (113.6 lpm) of potable water.
Locate eyewash units no more than 10 seconds in time or greater than 100 feet in distance from the hazard.	Water may be tempered at 70 – 90ºF (20 – 32ºC); should be equipped with a mixing valve and "anti-scald" feature.
For a disabled persons' use, the hand-held spray on a hose is the recommended unit.	Flow should accommodate more than one person, if necessary.
Label the location.	Locate shower units no more than 10 seconds in time nor greater than 100 feet in distance from the hazard.
	Shower area should be kept free of obstructions.
	Label the location.
	An associated floor drain is desirable, but its absence should not prohibit installation of a safety shower.
	Test on a regular basis and keep a record of the tests.

OSHA REGULATIONS - Collected

OSHA Regulations Pertaining to *Vehicles and Equipment*

REGULATIONS AND RECOMMENDATIONS THAT APPLY TO AGRICULTURE	REGULATIONS AND RECOMMENDATIONS THAT APPLY TO PRIVATE SECTOR (OTHER THAN AGRICULTURE)
29 CFR 1928.51 – roll-over protective structures for tractors used in agricultural operations 29 CFR 1928.57 – guarding of farm field equipment, farmstead equipment, and cotton gins 29 CFR 1910.266 – logging operations (chipping, machine guarding; as per 29 CFR 1928.21(a)(3)): This standard establishes safety practices, means, methods, and operations for all types of logging, regardless of the end use of the wood including the operations of felling and chipping, the employer must provide personal protective equipment, first aid kits, and portable fire extinguishers. For vehicles equipped with roll-over protection or falling object protective structures, seat belts must be provided. Machines must be equipped with guarding to protect employees from shafts, pulleys, belts on conveyors, gears, and other exposed moving elements. Procedures are cited for logging operations near overhead electric lines and for the inspection and maintenance of hand and portable powered tools. Employees must work within visual or audible contact with another employee; signaling and signal equipment are specified and must be given only by a designated person, except in an emergency. Procedures are included for flammable and combustible liquids, including chain-saw and diesel fuel, and for explosives and blasting agents. 29 CFR 1910.145 – slow-moving vehicles (as per 29 CFR 1928.21(a)(4))	29 CFR 1910.212 – machinery and machine guarding, requirements for all machines 29 CFR 1910.266 – logging operations (chipping, machine guarding) 29 CFR 1910.147 – control of hazardous energy sources (lockout/tagout of equipment for maintenance work) 29 CFR 1910.333(c)(3) –operations near overhead electric lines (29 CFR 1926.602 – material handling equipment; construction industry standard used for guidance, only) 29 CFR 1910.145 – slow-moving vehicles 29 CFR 1910.132 -- general requirements for personal protective equipment 29 CFR 1910.133 -- eye and face protection 29 CFR 1910.135 -- head protection 29 CFR 1910.136 -- foot protection 29 CFR 1910.138 -- hand protection 29 CFR 1910.95 -- occupational noise exposure 29 CFR 1910.252 – welding, cutting and brazing 29 CFR 1910.1000 – air contaminants 29 CFR 1910.147 -- permit-required confined space

OSHA Regulations Pertaining to *Chemical and Biological Health Hazards*

REGULATIONS AND RECOMMENDATIONS THAT APPLY TO AGRICULTURE	REGULATIONS AND RECOMMENDATIONS THAT APPLY TO PRIVATE SECTOR (OTHER THAN AGRICULTURE)
29 CFR 1928.110 – field sanitation (only applies to agricultural establishments where eleven or more employees are engaged on any given day in hand-labor operations in the field; but useful for guidance for composting operations)	Some of the chemicals are regulated by OSHA as air contaminants in 29 CFR 1910.1000 et seq.; but not the toxins (endotoxin, mycotoxin) The nature of the dusts/fragments appears to strongly indicate that these organic dusts are not "nuisance dusts." Some may produce organic toxic dust syndrome. OSHA has no regulations on biological hazards which would be applicable to compost, but does have an advisory on mold (fungi). 29 CFR 1910.141 -- sanitation 29 CFR 1910.1030 – blood-borne pathogens (applies if an employee is required to provide first aid as part of the job duties, not as a Good Samaritan); this issue is discussed below under Emergency Response. OSHA regulations on respiratory protection and other forms of personal protective equipment: 29 CFR 1910.132 General requirements 29 CFR 1910.133 Eye and face protection 29 CFR 1910.134 Respiratory protection 29 CFR 1910.135 Head protection 29 CFR 1910.136 Foot protection 29 CFR 1910.138 Hand protection

OSHA Regulations Pertaining to *Ergonomics*

REGULATIONS AND RECOMMENDATIONS THAT APPLY TO AGRICULTURE	**REGULATIONS AND RECOMMENDATIONS THAT APPLY TO PRIVATE SECTOR (OTHER THAN AGRICULTURE)**
See the next column.	OSHA has no standard on ergonomics but has issued guidelines for several high-hazard industries, along with recommending an overall strategy to address musculoskeletal disorders. OSHA does conduct inspections for ergonomic hazards and issue citations under the General Duty Clause of the Occupational Safety and Health Act of 1970. There are also well-respected guidelines issued by NIOSH for lifting. OSHA has no regulations on heat stress nor cold stress, but has issued advisories for them. NIOSH and professional societies such as the ACGIH have recommendations

OSHA Regulations Pertaining to *Chemical and Biological Health Hazards*

REGULATIONS AND RECOMMENDATIONS THAT APPLY TO AGRICULTURE	REGULATIONS AND RECOMMENDATIONS THAT APPLY TO PRIVATE SECTOR (OTHER THAN AGRICULTURE)
29 CFR 1910.266 – logging operations (as per 29 CFR 1928.21(a)(3); includes providing first aid kits and first aid training for all employees and supervisors): For employees engaged in operations including felling and chipping, the employer must provide personal protective equipment, first aid kits, and portable fire extinguishers.	29 CFR 1910.151 – medical services and first aid; in the absence of an infirmary, clinic, or hospital in near proximity to the workplace, an employee shall be adequately trained to render first aid; adequate first aid supplies shall be readily available 29 CFR 1910.1030 – bloodborne pathogens (applies if an employee is required to provide first aid as part of the job duties, not as a Good Samaritan) 29 CFR 1910.36 – design and construction requirements for exit routes 29 CFR 1910.37 – maintenance, safeguards, and operational features for exit routes 29 CFR 1910.38 – employee emergency plans 29 CFR 1910.39 – fire prevention plans 29 CFR 1910.157 – portable fire extinguishers 29 CFR 1910.158 – standpipe and hose systems 29 CFR 1910.165 -- employee alarm systems