DEATH BY DESIGN

BY JASON CONTANT

On the morning of September 5, 2008, a plumber was called to A-1 Mushroom Substratum Ltd. in Langley, British Columbia for the second time in as many days. There, he found an intake pipe at the bottom of a pump shed completely blocked and informed a supervisor at the mushroom composting facility that a company with expertise in sewer pump-out would be needed.

Instead, two workers, under the direction of the supervisor, tried to clear a blockage at a butterfly valve in the pipe. Within seconds of prying open a flange, one worker dropped face down into water at the bottom of the shed, believed to have been felled by a sudden release of hydrogen sulphide (H_2S) gas in the oxygen-deficient environment. He would die.

In the minutes that followed, two would-be rescuers at the multiple-employer mushroom growing and processing operation would meet similar fates. Another two workers — the lucky ones — would suffer near fatal, irreversible brain damage.

In its investigation report, released in late November, WorkSafeBC would point to a litany of failures in the design, construction and operation of the facility. Calling the investigation probably "the most complex in WorkSafeBC's history," a board statement notes "it took months to access key areas of the work site; many more months to fully understand the industrial process involved and the chronology of events and decisions over a five-year period that played a role in the incident."

IMAGE: THINKSTOCK

PUZZLING POSSIBILITIES

That September day, two workers were attempting to clear a blocked pipe inside a recessed pump shed while their supervisor watched from the structure's entrance, about three metres above. Standing in about 40 centimetres of process water and sludge that had accumulated at the bottom of the shed, the workers removed eight corroded bolts from the valve's flanges and loosely installed four new bolts to keep the valve in place.

At about 5 pm, one of the workers pried the top flange from the valve using one screwdriver and used another to free straw, sludge and other material stuck in the valve. "A small amount of liquid started to flow out," notes the investigation report by WorkSafeBC, based in Richmond, British Columbia.

As the worker removed the straw, he complained to the supervisor that there was a strange smell, prompting the supervisor to tell the workers to exit the shed.

The worker at the valve took a step and then collapsed face-first into the water and sludge. The supervisor climbed down and helped the second worker prop the unresponsive employee into a sitting position against the shed wall. The supervisor then called the property owner to obtain emergency assistance.

When paramedics arrived at about 5:20 pm, they found the supervisor outside the shed disoriented and in respiratory distress. "The ambulance crew noticed the foul smell, suspected a hazardous atmosphere, and decided to pull back from the shed area," WorkSafeBC reports, preventing other workers who had arrived with a ladder from entering the shed.

In all, five workers from the three businesses that make up the processing facility — A-1 Mushroom Substratum, H.V. Truong Ltd., a mushroom-growing business, and Farmers' Fresh Mushrooms Inc., a packing and marketing firm — were removed from the shed. Ut Van Tran, 35, Chi Wai Chan, 55, and Han Duc Pham, 47, died; Tchen Phan remains in a wheelchair, and Michael Phan is in a coma.

The WorkSafeBC report points to numerous deficiencies: complete absence of an oh&s system at the site; failure to correct anaerobic (without oxygen) conditions that had developed in the process water tank that pumped water through the pipes, leading to a build-up of H_2S in the intake pipe; lack of engineering controls to prevent solids from entering the pipes; lack of regulatory compliance; and flaws in the design, construction and operation of the facility dating back to 2004.

"We recognize that the families have had to wait a long time to know more about what happened to their loved ones, and we hope this investigation provides them with some understanding of what led to this tragedy," Jeff Dolan, director of investigations for WorkSafeBC, says in a release.

In August of 2010, 29 occupational health and safety charges were laid against A-1 Mushroom Substratum, H.V. Truong and four individuals. The following May, the two companies and three individuals pleaded guilty to 10 counts revolving around the general failures to ensure worker health and safety; provide workers with information, instruction, training and supervision; and ensure confined space hazards were eliminated or minimized and associated work was performed in a safe manner.

Sentencing last November ended with fines of $200,000 for A-1 Mushroom Substratum (which has since gone bankrupt), $120,000 for H.V. Truong and $15,000, $10,000 and $5,000 for the three individuals.

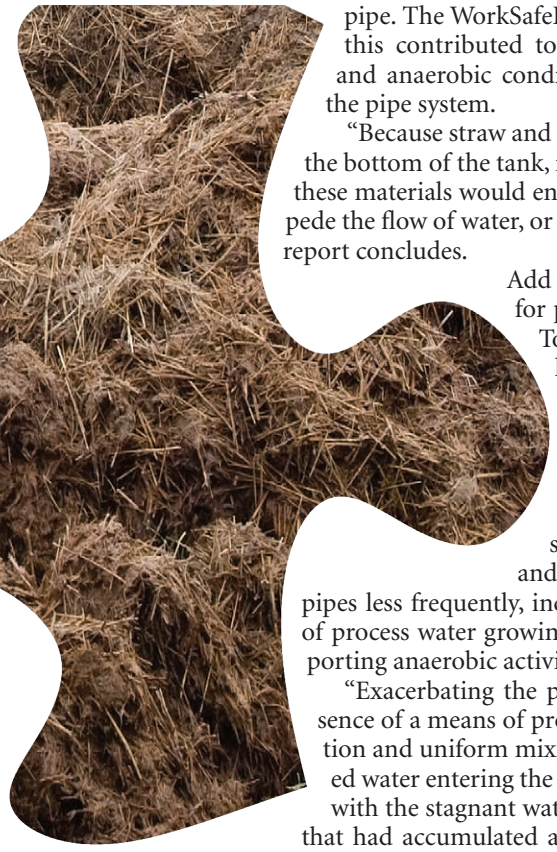
Raj Chouhan, labour critic for the New Democratic Party in British Columbia, was among a choir of voices demanding tougher sentences. Characterizing the final penalties as slaps on the wrist, Chouhan reports

that "the families were really hoping something would come out of this that would help other families and other workers."

In a bid to explain the circumstances that allowed the deadly events to unfold, one need consider the process for composting mushrooms at the facility. In a 3-D animation mock-up, WorkSafeBC notes that the pipe system was built to supply both fresh and process water from separate large tanks within a walled containment area. The water mix is then pumped through a series of pipes; first into the composting barns and then sprayed onto composting piles that contain straw, chicken manure and agricultural gypsum.

Operational problems and reduced compost production, however, caused the process water tank and containment area to fill with process water, straw and sludge. To protect the pumps and pipes from freezing in winter, the shed was constructed against the containment wall in 2007.

Also relevant is the design and construction of the process water recycling system, which drew process water from the bottom of the tank into the intake pipe. The WorkSafeBC report notes that this contributed to blockages forming and anaerobic conditions developing in the pipe system.



"Because straw and sludge had settled to the bottom of the tank, it was inevitable that these materials would enter the pipe and impede the flow of water, or form blockages," the report concludes.

Add the reduced demand for process water — the Township of Langley had shut down one composting barn in late 2007 for breach of by-laws — and this meant water entering the system stayed longer and flowed through the pipes less frequently, increasing the chances of process water growing stagnant and supporting anaerobic activity.

"Exacerbating the problem was the absence of a means of promoting the circulation and uniform mixing of any oxygenated water entering the [process] water tank with the stagnant water, sludge and solids that had accumulated at the bottom of the tank," the report explains.

PIECE BY PIECE

Les Mackoff, who served as defence counsel for the accused, says that the property owners "worked with these folks everyday and they feel horrible that this happened."

Prior to the deadly incident, the owners had hired experts and sought engineering advice on how to install biofilters to help minimize the potential for smell, Mackoff reports. However, he points out, "the construction was flawed. There was a serious breakdown of the facility."

Neil McManus, a certified industrial hygienist at NorthWest Occupational Health & Safety in Vancouver, says his view is that engineers control occupational safety because "their designs create the conditions of work that affect other people."

In his experience, McManus says that most composting operations have submersible and removable pumps. Without these, people have to go down inside the "chamber to service the pump or stuff that blocks it," he adds.

David Nguyen, an agricultural health and safety specialist with the Farm and Ranch Safety and Health Association (FARSHA) in Langley, British Columbia, says the incident "was a pretty big eye-opener for that particular industry, everyone in agriculture." Nguyen reports that he has visited the workplace and, since the incident, has been working with employers to improve work-related health and safety.

Engineering problems were an issue, he says, but adds he believes other things — such as precautions revolving around confined space risk assessment, hazard identification and exposure control — could have helped prevent the incident.

Prevention may also have been advanced by reading the signs. About two months before that deadly day, on July 15, 2008, the British Columbia Farm Industry Review Board received a complaint from township councillor Charlie Fox and his wife regarding odour and wastewater discharges from the composting operation.

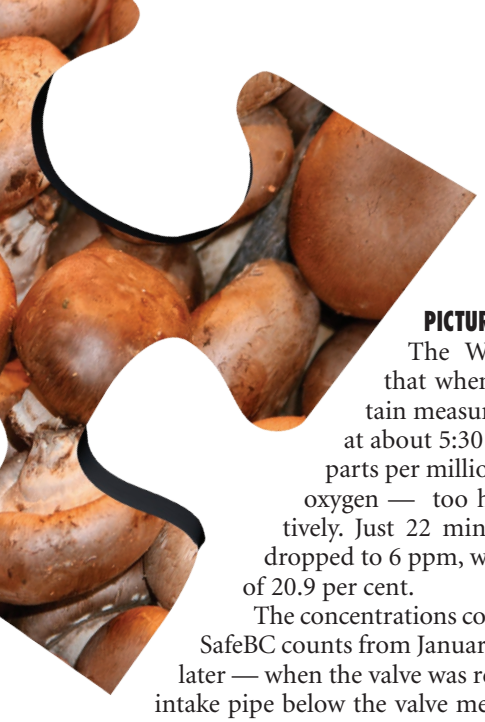
The township had commenced legal action to shut down the facility for a second time. In fact, a court hearing on the second complaint was set for three days after the accident.

"The tragedy happened in exactly the spot we know the odour was emanating from because it was basically an uncovered cesspool," Fox contends. "In my opinion," he says, "it was this sludge that came out afterwards and sat in these massive open settling ponds that was the problem."

McManus reports that less than a year after the Langley incident, he visited another mushroom farm in British Columbia where he saw the same "mechanism in action" and found "astoundingly high levels" of H_2S at a pump station.

"We had to get out of there immediately," he recalls. "There was zero odour until something changed. My nose is telling me there was H_2S here and I looked around and could not see any change to account for what happened. It was the pump. We could see froth at the bottom," McManus says.

He speculates "the froth floating above the liquid can trap at least one atmosphere of gas pressure," some of which may be H_2S. "This is a highly constrained system, highly unstable. So if you have H_2S molecules trapped in bubbles in that thickened up fluid and some sheer force applies to it and loosens up the fluid, there's a way for the bubbles to get out," he says. "The culprit is gone rapidly… When the investigators go looking for what caused the deaths, they can't find anything."



PICTURE IMPERFECT

The WorkSafeBC report notes that when the township's fire captain measured the air inside the shed at about 5:30 pm, H_2S levels were at 36 parts per million (ppm) with 15 per cent oxygen — too high and too low, respectively. Just 22 minutes later, gas levels had dropped to 6 ppm, with a normal oxygen level of 20.9 per cent.

The concentrations contrast sharply with WorkSafeBC counts from January 29, 2009 — five months later — when the valve was removed and air inside the intake pipe below the valve measured. "H_2S was present at levels exceeding 500 ppm (the maximum reading on the monitor), indicating that anaerobic conditions in the pipe could result in levels of H_2S high enough to cause unconsciousness and rapid death," the investigation report states.

Why did one worker inside the shed become unresponsive within seconds of the H_2S release and later die, while the other survived?

"When you look at occupational hygiene, not everybody is affected the same way by the same substance," explains Shelley Gray, an occupational hygienist with Nova Scotia's Department of Labour and Advanced Education in Halifax. "There are a lot of smokers out there. Not all of them develop lung cancer," Gray notes by way of example.

Factors that could influence response to exposure include ventilation, proximity to the point of release and rate of respiration, she says. "One [worker] could have been doing more work and actively taking in more of the environment than the other person beside them," she notes.

Gray reports that all gases will displace oxygen, but the concentrations have to be very high to do so. "To displace one per cent of oxygen, you would have to have really high, high concentrations," she says, although another possibility may be an oxygen scavenger, "which actually binds the oxygen and takes it out of the atmosphere."

At 15 per cent oxygen, "you're not going to have a serious impact on people's survivability," McManus says. "That's why in all likelihood it was the H_2S that did it," he speculates.

The deaths spurred repeated calls for a coroner's inquest by the provincial New Democrats and the British Columbia Federation of Labour (BCFL) in Vancouver. Chief coroner Lisa Lapointe answered that call in December.

"After reviewing all the information available in the case, including the WorkSafeBC report, [Lapointe] concluded that there is benefit to holding an inquest to examine some of the broader circumstances of the incident in an attempt to prevent future deaths from happening in similar circumstances," notes a statement from the Vancouver-based BC Coroners Service. During the inquest, scheduled to begin May 7, presiding coroner Norm Liebel and a jury will hear evidence from numerous witnesses.

The NDP's Raj Chouhan says he is hopeful there will be recommendations "that would help us to prevent these kinds of tragedies in the future."

BCFL president Jim Sinclair also welcomes the provincial inquest, noting in a statement that it "gives hope of a legacy of greater safety on British Columbia farms."

IMAGE FORMING

Before the incident, "no one appears to have focused on the potential development of anaerobic conditions in the pipes forming part of the process water recycling system, even where other parts of that system are kept aerobic," states the WorkSafeBC report.

"While there is industry and regulatory recognition of the production of gases as a by-product of these operations, the focus in industry literature is more on environmental protec-

EXPOSURE EFFECTS

WorkSafeBC's bulletin, "Hydrogen Sulphide in Industry," notes that workers are exposed to unsafe levels of H_2S every year. Called sour gas, sewer gas, stink damp and hydrosulphuric acid, H_2S in high enough concentrations can kill in seconds.

Concentration Parts per million	Observations/Health Effects
Less than 1	Most people smell "rotten egg" odour.
3 to 5	Odour is strong.
20 to 150	Nose and throat feel dry and irritated; eyes itch or water. Prolonged exposure may cause coughing, hoarseness, shortness of breath and runny nose.
150 to 200	Sense of smell is blocked.
200 to 250	Major nose, throat and lung irritation occurs, along with headache, nausea, vomiting and dizziness. Prolonged exposure can cause fluid build-up in the lungs (pulmonary edema), which can be fatal.
300 to 500	Symptoms as above, but more severe. Death can occur within one to four hours.
Above 500	Immediate loss of consciousness. Death is rapid, sometimes immediate.

LACK OF AIR

In its guidance document, "Selection, Use and Care of Respirators," the Canadian Standards Association's Z94.4-02 standard outlines the effects of oxygen deficiency. Below are some examples:

% of Oxygen in Air	Effects
20.9	No symptoms.
16	Increased heart and breathing rates, some impairment in thinking and co-ordination.
14	Fatigue, emotional upset, impaired judgement and faulty co-ordination.
12	Very poor judgement and co-ordination, nausea, vomiting and impaired respiration.
Less than 10	Nausea and vomiting, loss of all movement, unconsciousness, convulsions and death.

tion and odour abatement rather than the potential hazards arising from the production of these gases," the report adds.

Scott Fraser, director of programs at FARSHA, agrees the level of awareness of hazards in mushroom composting operations was limited before the accident. "When it first happened, I don't think anyone knew what was really going on or the amount of hydrogen sulphide that could come off this stuff," Fraser says.

Since the incident, written information has been distributed to similar operations and exposure controls plans for mushroom composting have been put in place, he reports.

Nguyen says workers at the Langley facility spoke Vietnamese, which he speaks as a second language. "The folks that are employed in [agriculture] tend to be first-generation immigrants, so English is not always their first language."

This could give rise to confusion over a provincial safety requirement or directive, he says. "If there's situations like that out there, make sure they do understand and understand in their own language," Nguyen adds.

FARSHA supplies some information in Vietnamese, Punjabi and Spanish, among other languages.

The WorkSafeBC report notes a language barrier likely contributed to poor communication between the plumber and A-1 Mushroom Substratum's operations manager, both of whom spoke only English, and among the property owner, supervisor and workers, who spoke Vietnamese and/or Cantonese, but little or no English.

"The pump shed was never identified as a confined space and no plan was in place for workers to enter the shed and work safely," notes the report. "None of the workers who attempted rescue had any knowledge of confined spaces or the hazardous atmosphere that they would encounter."

To make matters worse, the "most significant features of a confined space that applied to the pump shed were that the shed was enclosed and that it had restricted means for entry and exit that could complicate evacuation and rescue in an emergency," WorkSafeBC notes.

For example, although the shed could be accessed through a door at the top of the structure, to get to the bottom, workers either had to climb down the framework or walk on the pump motors and framework to access a short aluminum ladder resting against the framework.

"The restricted means of entry and exit also meant that workers could not quickly escape the hazardous atmosphere in the shed," the report states. It is likely oxygen deficiency would not only have affected the workers' judgement and co-ordination, but also their "ability to rescue themselves and exit the shed."

Nguyen says his understanding is that WorkSafeBC has stepped up enforcement at farms and mushroom processing facilities in the province.

Megan Johnston, a communications officer at WorkSafeBC, says that board officials anticipate participating in the inquest and declined further comment until that time.

As councillor Charlie Fox sees it, there did not seem to be a co-ordinated plan among various agencies with jurisdiction over the facility — including WorkSafeBC, the township and British Columbia's agriculture and environment ministries — to provide oversight at the workplace. "I'm not saying any one agency is responsible, but this is one example of bureaucracy falling through the cracks," Fox contends.

The WorkSafeBC report notes that neighbours and the Township of Langley logged four complaints about the facility — such as workers without personal protective equipment and chemicals to which they might be exposed — before the incident. A prevention officer discussed the matter with the township inspector, but decided not to conduct a site visit, notes the WorkSafeBC report.

Board officers responded to complaints in 2007. However, the officers "did not return to the facility after that time in response to a specific complaint and missed an opportunity to inspect the facility to determine compliance with occupational health and safety legislation," the report adds.

Hindsight may be 20/20. But starting May 7, the hope is that airing all available facts offers a clear view of how to ensure that safer working conditions exist at other mushroom composting operations across the land. •OHS

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Jason Contant is editor of CANADIAN OCCUPATIONAL HEALTH & SAFETY NEWS.