Hazardous materials - UN class 6:

toxic and infectious substances

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In this month's article, we continue our series on hazardous materials. We will deal with toxic and infectious substances. These are substances that are liable to cause death or injury if inhaled, swallowed or absorbed through skin contact. Within UN Class 6 toxic and infectious substances are divided into two classes:

Toxic substances – The UN defines a toxic substance as "a poisonous material, other than a gas, known to be so toxic to humans that it presents a health hazard during transportation".

Infectious substances – Is defined as "a material known to contain or suspected of containing a pathogen". A pathogen is a virus, micro-organism or proteinaceous infectious article that has the potential to cause disease in humans or animals.

Toxic substances

Toxic substances affect the body at the cellular level; they will either destroy cells, slow down their functioning or affect the cells to such an extent that they go out of control and form tumours or cancers (this can take several years to develop). When these chemicals reach certain sensitive parts of the body at specific concentrations for a certain period of time, they can cause enough harm to kill or seriously harm that body. These chemicals can enter the body in four different ways.

1. Inhalation

Generally, gasses and vapours can be the easiest to be inhaled but, depending on their size and shape, mists, dust, fibres and smoke can also be absorbed this way. The decisive factor here is the size and shape of the particles. While smaller particles will penetrate the lower respiratory tract, larger particles tend to get stuck in the upper respiratory tract and could eventually relocate to the oesophagus. From the oesophagus where it can move through the intestines and present the same toxic effect as substances that have been ingested. Inhaled dust may enter the gastro-intestinal tract directly and affect the micro-organisms located there or cause chemical imbalances that could be harmful. Asbestos fibres and manmade mineral fibres can cause fibrosis or cancer while insoluble particles such as coal and silica can lead to lung fibrosis.

The volume of air inhaled and exhaled obviously increases with physical exertion. This means that a person could inhale more harmful products ▸

in a toxic environment if they are involved in a more strenuous atmosphere.

2. Ingestion

This occurs when substances enter the system through the gastro-intestinal tract. It normally happens by accident although poor operational discipline such as consuming food in the vicinity of the substance, can also be a cause. The physical state, such as the water solubility of the product will generally determine the ease at which the substance can be absorbed.

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3. Dermal absorption

Certain substances have the physical and chemical properties, which allow them to be absorbed through the skin. Liquid products such as methanol, organic mercury compounds, organophosphate pesticides and benzene are examples of such products. These substances can also enter the body through cuts and abrasions and it is therefore important that such, even superficial injuries, must be sufficiently protected in a hazardous material environment.

4. Injection

As the word says, this is when a substance is directly introduced into the system by means of a puncture wound. This can happen either by a direct injection, from an animal (dog bite) or reptile (snake bite) or from a cut caused by a sharp object. These wounds have the potential of introducing the substance directly into the blood stream.

Dosage: How much will kill you?

Certain substances that may not necessarily be poisonous could in certain higher concentrations cause severe damage usually resulting in acute effects. The toxicity of the substance is therefore not the only factor to consider when determining the exposure risk. The duration of the exposure and physical properties of the substance such as its size and texture, affinity for human tissue and solubility with human tissue fluid, will be important. The physical state of the 'victim' such as age, health state and sensitivity of the human organs and tissue to the product, will also determine the effectiveness of the product.

In order to ensure protection of persons working in potentially hazardous environments, legislation has been developed to manage the occupational exposure limits of workers in a particular environment. This is calculated by determining to what level a worker will be exposed to a harmful substance over the course of a normal working day. The control levels for gasses, vapours and other airborne particle are measured in 'parts per million' (ppm) by volume or parts of gas per million parts of air. Dusts, smoke or fumes are calculated as milligrams per cubic metre (mg/m3) of air at standard temperature and air pressure. While workplace exposure limits are meant to indicate the maximum allowable safe working period in a potentially hazardous atmosphere, they do not cover emergency situations. An accidental release of a hazardous product in a (otherwise) controlled environment, will in all probability increase the concentrations thereof to limits that are technically described as 'immediately dangerous to life and health' (IDLH) or reach what can furthermore be described as reaching a 'lethal dose'. It is unfortunately here where the boys and girls of the emergency services will have to make it their problem.

Biohazards and infectious substances

A biohazard (biological hazard) is any microorganism, cell culture or human endoparasite that can cause infection, allergy, toxicity or any other harm to human health. They are formed by exposure to a range of pathogenic or disease causing organisms. Acute or chronic infectious diseases may be caused by bacteria, viruses, protozoa or fungi. As with toxic substances these pathogens enter the body through a variety of ways including direct skin contact, puncture wounds, cuts, inhalation and ingestion of contaminated foodstuffs or liquids. They are found in a huge range of locations and it is when they reach their 'toxic dose level' that they become a major health and life risk. Some of the more common locations of biohazards include hospitals (mortuaries, quarantine areas, laboratories), university laboratories, veterinary laboratories, farms, zoos, sewage treatment installations, postal service facilities and pharmaceutical businesses.

Due to the high levels of risk associated with these materials, a high level of security is normally involved in their locations. These include the electronic control of unauthorised personnel and automatic locking mechanisms. In high level risk facilities, a negative internal pressure is maintained in order to prevent the release of biological agents to the outside. These types of premises are usually located above ground. They also generally have an uninterruptable power supply and there may be certain radiation systems on site to perform sterilisation processes.

The presence of various chemicals, including acids, bases, alcohols, volatile agents and toxic or carcinogenic organic compounds must be anticipated. Also note that such facilities are regularly disinfected by means of gaseous formaldehyde fumigation, which normally takes place over a twelve hour period. In addition to this, other hazards such as compressed gasses, such as oxygen, nitrogen, hydrogen and helium, could also be present. You may also encounter certain animals in laboratories, which are being used for research purposes.

Pathogenic organisms

Biohazards generally arise from a range of single-cell organisms. These are referred to as pathogenic or disease causing organisms and are classified into the following four groups:

Bacteria: While most forms of bacteria are relatively harmless some can produce toxins which can lead to diseases such as tuberculosis (TB), anthrax, tetanus and bubonic plague. Bacteria are a necessary part of the soil and in animal and human bodies and is capable of rapidly multiplying in ideal, mild conditions. In elevated temperatures (60 degrees Celsius) bacteria will generally be destroyed within thirty minutes.

Viruses: Viruses are much smaller than bacteria and consist of nuclear materials ie ribonucleic acid (RNA) and deoxyribonucleic acid (DNA) and are surrounded by a complex outer layer of protein. Virus cells will generally attach themselves to a host cell to reproduce and then infect the other cells. Common examples of viruses include human immunodeficiency virus (HIV), Lassa fever, rabies and smallpox.

Protozoa: These are larger single cell, often water borne organisms similar to bacteria. Malaria and amoebic dysentery are examples of protozoa.

Fungi and spores: These organisms live as parasites on a host and include thrush and ring worm.

Pre-planning

It is obvious that the type, physical state and quantity of the product will inform the level of emergency service response. Certain products will have an immediate threat to human life while others may pose no threat to humans but may threaten animals, marine life or the environment. All premises containing hazardous materials are required to have adequate contingency plans. This includes the availability of on-site specialist advisors who should be reachable even after normal operating hours. These specialists will be able to provide the necessary information on the products involved such as how it will react in a fire (microorganisms will generally be destroyed if exposed to a fire) toxicity levels, packaging, location of high risk materials etc.

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It is also important to note that if you are responding to a fire incident in a laboratory environment a number of other potential hazards such as cryogenic gasses, hydrogen cylinders, chemicals (acids, alkalis, flammables) and the possibility of radiation.

Within a large laboratory, it is crucial that the exact location of the bio-hazard is known. Generally, it will be made fairly obvious by on-site personnel but an additional amount could be in storage.

The response to a facility containing toxic substances and bio-hazards will ultimately require a multi-agency response and it is therefore important that all health, law enforcement and environmental stakeholders are included in the emergency planning.

Emergency response

It would be disingenuous to refer to any hazmat incident as a 'standard incident' but clearly there are a range of activities that should form part of all hazmat standard operating procedure (SOPs) and must most definitely be implemented on UN Class 6 incidents. These include approaching from an upwind position (as far as possible), establishing safety zones around the incident and limiting access into these zones. Your hazmat unit should obviously form part of your first response.

Establish early contact with the site safety supervisor and any product specialists that might be required. Together with these persons and the incident safety officer, devise a plan of action and plan a thorough briefing to all personnel prior to the commencement of any operational tasks. In the event of a fire incident try to limit the runoff of water to prevent the spread of harmful substances into nearby water courses or drainage systems. If it is a large and/or intense fire, microorganisms could be carried into the air currents and therefore downwind evacuation should be considered. Incident discipline during such an incident is critical and eating or drinking should be prohibited at all times.

Personal protective equipment (PPE) will be a major factor when responding to these types of incidents. The level of PPE will depend on the nature of the hazard as well as the potential for exposure. As with any ▸

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rescue situation the decision needs to be taken to place your personnel at risk only if the dividend is high ie if the probability of saving life is high then it will substantiate the risk being taken. If there is no possibility of saving any lives, don't take any chances.

A thorough decontamination of all staff and equipment involved in the incident must be conducted. This will include a screening process immediately after the incident as well as ongoing screening for as long as is recommended by specialists on the particular substance.

EMS response

Paramedics and emergency medical services (EMS) personnel will be at greater risk of exposure to toxic substances than fire fighters. They may be called upon to respond to incidents where patients have been overcome by some sort of toxic substance such as commercially available insect or rodent poison or weed killer. They will often not have the correct personal protective clothing available. It is therefore difficult to cover any eventuality and therefore important to check for any signs that a potentially toxic substance may be present. The location of the patient, signs and symptoms and presence of containers that possibly could contain such substances should be noted. There are not many signs that a patient may be suffering from toxic exposure. Some examples could include a fever from metal fume intoxication, copious secretions accompanying organophosphate poisoning, rhinitis, conjunctivitis and pharyngitis as seen in irritant gas exposure and rales and dyspnoea from pulmonary injury.

If it is suspected that a patient may be contaminated by a toxic substance, the EMS must immediately withdraw to a safe position and make prepare the necessary personal protection. No patient must be moved to a hospital without undergoing at least a basic, first-stage decontamination. Ideally a hazmat unit must respond to an incident where a patient may be exposed and a thorough decontamination system set up. Preplanning must be done with hospitals that are capacitated to receive affected patients. Do not take a contaminated patient to a hospital without prior notification and confirmation that the hospital will accept the patient. They will normally generally have a specially designated area to where they can be taken for further decontamination and treatment.

In the event that a contaminated patient has been transported, the EMS crew should also be thoroughly screened and treated as patients until they are cleared of any signs and symptoms. The ambulance that was involved should also be taken out of service until they are properly surveyed and only if safe can they be placed back into service.

In closing

Not every incident involving a toxic substance will be completely obvious when you get the call or even arrive on scene. Remember the old saying: "Fools rush in where angels fear to tread". Gather as much information as you can, be observant. Speak to the site representatives, bystanders. Ensure that you have all the information you need before committing your troops. It might be the most important thing you do on the entire incident.

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