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Safety in Industrial and Occupational Settings

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Abstract

Safety procedures and standards in the workplace have adapted to encompass a large variety of different hazards and threats in the workplace. Psychological and physical hazards are sometimes difficult to detect but are essential to understanding and researching different protective methods for limiting bodily harm to an individual. Federal and state agencies have been established for the purpose of creating, testing, and regulating the new safety standards as well as revising old measure as new technology and research arise that provide better results. The main categories that are at high risk for causing harm are chemical, biological, fire, air quality, confined space, and fall hazards. Agencies develop standards for practices and equipment that are to be utilized in certain situations. The standards created are for preventing, containing, and managing hazards before and after they cause an accident. Employers and personnel are to be trained in dealing with these potential threats so as to not endanger the public or increase the risk to themselves.

Keywords: Safety, Fire, Confined Space, Chemical, Biological, Hazards, Personal Protective Equipment, Fall Prevention, Stressors, OSHA

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Introduction

When you look at any company, one of the most important assets are the workers and they need to be healthy and safe when on the jobsite to preform effectively. Industrial and occupational hygiene looks at the different strategies, standards, and equipment used to ensure workers safety. “Industrial hygiene is the science of protecting and enhancing the health and safety of people at work and in their communities. Health and safety hazards cover a wide range of chemical, physical, biological and ergonomic stressors” (*IH Defined*, n.d., para. 1). Some of these items include but do not exclude correct PPE, effective hazard communication, protective strategies against biological, chemical, fire hazards, and confined or stressful work environment. Safety in the workplace makes employees feel at ease and allows them to think clearly about the task at hand without fear of injury or death. These are only a few of the components that go into creating the area of industrial and occupational hygiene, but what are often overlooked, not as easily understood, and are specialized for each individual are psychological stressors. Psychological stressors, as defined by Monroe and Slavich, are social and physical environmental circumstances that challenge the adaptive capabilities and resources of an organism. Distinguishing between the different hazards, both physical and psychological, and devising ways to safely deal with these hazards are what companies and others should strive for. With safety measures in place to combat the potential hazards on the jobsite then work can be completed more efficiently.

Psychological Hazards

Stress, anxiety, and depression are all relatable states of being that individuals have all felt at some point in their life. They are typically caused by external forces that affect an individual’s life by causing mental and emotional decline. They also vary in what causes them to

arise and the intensity of effects on a person's life. Even dispelling these negative feelings can have alternate outcomes or may not work at all. The first step to combat these unsettling and exhausting feelings is to first identify what the individual is going through, anxiety, stress, depression, or a combination, and what that person's stressor is. "Despite general agreement about the importance of psychological stressors for health and well-being, determining exactly what it "is" about stressful circumstances that is deleterious has proven challenging" (Monroe & Slavich, 2007, p. 111). Stress itself is a feeling of tension and is usually brought on by an event or thought that makes the individual feel frustrated, angry, or nervous (*Stress and your health: MedlinePlus Medical Encyclopedia,* n.d., para. 2). This is not to say that any and all stress is negative. If the stress is not continuously in effect but instead only an occasional thing then it can actually be a healthy stimulus. Much like when someone is working on a project with a deadline, the stress of that deadline can help the individual be more attentive to the project, be more thorough in their research, and more organized with their time management. Some individuals use stress to give themselves a boost in their life, like people who play sports rely on stress to get their 'blood pumping' and release adrenaline. This type of stress is classified as acute stress. It is when the stress becomes chronic that it starts to have negative effects on mental and physical health. When the stress becomes too frequent, like problems with money, it can have adverse effects on an individual's body and cause high blood pressure, heart disease, diabetes, obesity, depression, anxiety, acne, and eczema. An individual suffering from too much stress, according to MedlinePlus Medical Encyclopedia (n.d.), can present signs of this that include; diarrhea or, constipation, forgetfulness, frequent aches and pains, headaches, lack of energy or focus, sexual problem, stiff jaw or neck, tiredness, trouble sleeping or sleeping too much, upset stomach, use of alcohol or drugs to relax, and weight loss or gain (paras. 2-3). This makes the individual a

potential hazard by subject of human error. Human errors are blamed for a plethora of different events and accidents. According to Steve (n.d.), "Pilot error blamed on over 70% of airplane accidents, operator error blamed on over 60% of nuclear power plant accidents, doctor/Nurse errors in ICU occur at a rate of 1.7/patient per day" (Safety, Accidents, and Human Error). Therapy is the most proper way to coping with stress, but there are other methods that help different individuals depending on their personality and the stress that is afflicting them. These methods include meditation, retreating to a comfort place, or releasing the built-up stress in a healthy manner such as working out or talking to someone about it. There are some medications that one can take if nothing else seems to be working or the stress if in some way or another unavoidable. The unavoidable stress in an individual's life can come from anywhere and in any form but is generally the manifestation of the stress into another form. Anxiety is classified as an emotional state where individuals have feelings of tension, worried thoughts, and physical changes, like increased blood pressure (*Anxiety*, n.d., para.1).

Anxiety is an emotion that effects everyone and most can handle the everyday worries that make them feel anxious. Those who cannot manage their anxiety may suffer from anxiety disorders. "People with anxiety disorders usually have recurring intrusive thoughts or concerns. They may avoid certain situations out of worry. They may also have physical symptoms such as sweating, trembling, dizziness, or a rapid heartbeat" (Anxiety, n.d., para.1). Examples of intense or excessive anxiety disorders that effect their life are phobias. People with phobias have an extreme fear of an object or scenario. Most common phobias include arachnophobia, the irrational fear of spiders, glossophobia, the fear of public speaking, and acrophobia, the fear of heights. Phobias are not easily overcome and they require a fair amount of therapy to deal with them. If personnel have a phobia, then it is to be treated similarly to any other disorder. Another

common phobia amongst personnel is a social phobia, or social anxiety disorder. As Schneier explains social anxiety disorder is the fear or avoidance of most social situations and will most likely begin to show in their teens. This chronic disorder may be more frequently viewed as someone being introverted or shy but more extreme. According to Schneier (2006)

> Persons seeking treatment often have had symptoms for 10 years or more, and coexisting psychiatric disorders are common. Among such persons, the lifetime rate of phobias is greater than 50%; major depression and alcohol abuse occur in 15 to 20% of cases. (p.1029)

People suffering from this disorder will go out of their way to avoid certain situations, like staying quiet in meetings and not attending most social functions where they would have to engage with people. This kind of action is not healthy for several reasons especially for those in the workplace. If there was a potential danger on the worksite that was not relayed to other personnel or other personnel are engaged in dangerous behavior and are not stopped because of this avoidance then there could be severe complications. As of recently there are only two ways to help those who endure with this disorder and that is medication and cognitive behavioral therapy. Cognitive behavioral therapy is an effective treatment option for those who suffer from depression, anxiety disorders, alcohol and drug use, marital problems, eating disorders and severe mental illness according to the American Psychological Association division twelve the Society of Clinical Psychology. Treatment using cognitive behavioral therapy aims toward teaching the patient that their way of thinking is harmful to their health and readjusting that frame of mind. The therapist will try and understand the patient's motivation towards certain goals. This will help the individual gain confidence and develop more beneficial problem-

solving skills. In the process the individual will have to face their fears, role-play through difficult scenarios, and try to relax both mind and body.

> Cognitive behavioral therapy therapists emphasize what is going on in the person's current life, rather than what has led up to their difficulties. A certain amount of information about one's history is needed, but the focus is primarily on moving forward in time to develop more effective ways of coping with life. (APA Div. 12, 2017, para. 5)

Depression is caused by stress and anxiety and is defined by the National Institute of Mental Health as a common but serious mood disorder that can severely affect how someone thinks, feels, and handles their daily life. Depression is a diagnosable disorder that is common to find in people but that does not mean it should be left unattended. Some signs of depression are irritability, decreased energy, pessimism, weight changes, difficulty concentrating and sleeping, and thoughts or attempts at suicide. The severity of an individual's case will depend on the number of factors and can be triggered by a host of different life events that may be traumatic to an individual. Someone who is suffering from depression might lash out against others who 'don't understand them' and cause harm to themselves and others. As an employer there should be a sense of security with employees. Checking up on them when their work is suddenly changing or simply consulting with them on how they are doing sometimes can create a feeling of trust so that the individual is comfortable enough to open up about their problems. It is at this time that the concerned party should recommend counseling if they do not feel comfortable in their ability to help. Counseling should be viewed as a means of guidance and not as a place to fix broken people. Counseling can help people change harmful behaviors to improve their life. If work is too difficult, encourage personnel to help one another out. In counseling after a diagnosis is concluded the counselor will prescribe medication and/or implement some different techniques

to help alleviate the problem. Only a licensed counselor or doctor should prescribe medication for disorders so self-diagnosis should not be used when determining what to implement.

There are some self-help steps that can be taken to improve an individual's mental state. According to the National Institute of Mental Health spending time with trusted friends, not isolating themselves, being more active, and postponing any major life changing moments may help gradually improve an individual's life. Much like stress and anxiety, depression is not so simple as to be treated at a single glance. Each case is unique in what the cause is and what combination of treatment methods will work. Trial and error is necessary to find the right treatment options for an individual so encouragement for persisting is required for some severe cases. There are a number of hotlines, brochures, and websites to visit if someone is suffering from some form of depression and needs help.

Identifying Hazards

When it comes to safety in the workplace, there are multiple aspects that need to be considered. Individuals must understand each aspect in order to properly manage the health and safety of workers while keeping company costs and resource usage minimized. Identifying the type of hazard, designing a plan to enact when the hazard is unstable or active, and implementing the plan to efficiently combat the problem while not negatively effecting the workers progress is the top priority for safety personnel. In the public setting individuals encounter safety rules on a daily basis. Most laws in effect in the legal system are essentially safety standards and regulations that are applied to everyone. Traffic laws are a perfect example of this. These laws make it safer on roadways, such as enforced speed limit zones and stop signs/lights and allow easier access for first responders to provide their services, like pulling safely out of the way on

emergency vehicles that have their lights and sirens on and not allowing parking in front of emergency areas primarily fire hydrants and fire zones.

In the commercial setting workers are constantly exposed to a plethora of different hazards, so implementing a single plan is more difficult than one might think. Some plans need to be complex enough to deal a multitude of different situations while remaining simple enough to be understood by personnel that might not be well versed with safety knowledge. It is the job of the safety supervisor to identify the hazards that the personnel might face and develop safety protocols and standards for the personnel to have an idea of what materials or processes are dangerous enough to warrant extra caution. In the field of safety there are numerous circumstances, processes and materials that include: confined spaces, air quality, fire, PPE, hazardous chemical materials, biological hazards. Having a firm understanding of what could happen at any given moment means an individual will be more prepared to deal with whatever happens.

There are several guidebooks and other helpful resources, such as the *1910 OSHA General Industry Regulations and Standards guidebook*, the *Emergency Response Guidebook*, and *NIOSH Pocket Guide to Chemical Hazards*, that outline the standards and regulations that are to be followed by all commercial businesses. These guidebooks cover some of the more hazardous materials that need special rules in order to keep the workers and public safe from any disastrous incidents, but there are some rules that seem obvious or simple that some people might over look by accident. Some of these rules fall under a ‘housekeeping’ idea, like keeping work spaces clean of foreign objects and debris and keeping storage areas neat and organized. These rules help maintain a safer working environment by reducing the number of hazards. For example, if there were a hazard in the building and evacuation was necessary then personnel in

areas that possess a large amount of clutter would have a difficult leaving the building efficiently.

Simple rules such as keeping walking spaces clear have a similar importance to most hazardous material procedures. Personnel in the workforce can have a number of different hazards that they work around. An example of this is if an individual works in a chemical factory, then they could be exposed to not only chemical hazards, but also fire, air quality, and confined space hazards. If there is ever one hazard, then there are more than likely two or more hazards to also contend with. Producing plans and implementing safety protocols can have a drastic impact on the workers involved in the company. The plans authorized can be something as simple as safety signs or as complicated as an emergency action plan. Safety signs can be used to help identify the different hazards that can be expected from the object area. Safety signs describe what potential the hazard has and the effects I can have on the human body. Emergency action plans rely on the personnel to act and react to an incident or accident quickly with the intent to either contain the hazard or to abandon the facility.

The way to process the any potential incident to ensure that personnel has the proper means and training to deal with an emergency is by using what is known as a risk assessment. Risk assessment is as the name suggests. All potential hazards are identified and studied to best protect any individuals in the area if an incident were to ever occur regardless of what caused it. Risk assessment is pertinent for any safety plans to be implemented and success. If not all the hazards are identified then the personnel on site and any members of the public might suffer from the effects. There are three main categories of hazards that are considered when processing a risk assessment that encompass any potential hazard. The first being any common natural phenomena, storms, earthquakes, diseases, etc. Then human caused incidents which cover any

accident involving human interaction, transportation accidents, workplace accident, and intentional actions like riots and robbery to name a few. The final category is concerning technological hazards, power loss, explosions, hazardous material spill, utility outage, and transportation failure. Once the hazards have been identified then an emergency action plan can be developed or adopted to protect against or mitigate the threat. Different plans can work in similar ways, but some are better than others. For this reason and the increasing hazards and incidents in the workplace organizations, such as OSHA and the NFPA, were created to assist in collecting, researching, testing, and combining safety measures to create a guideline for businesses to follow.

Background of OSHA

In the late 1960s, America was facing many hardships and challenges both in the country and abroad. In this troubled time a group of people took notice to the detrimental state that industrial workers were in. Factories were in high demand due the country rapidly industrializing. These factories drew in all types of people to work, including the more uncommon women and immigrants. Since workers were plentiful, factory workers were expendable and could be kept around for extraordinarily little pay. Worker's health and safety were held at a lower priority to the factory's efficiency and productivity.

> At the same time, occupational injuries and illnesses were increasing in both number and severity. Disabling injuries increased 20 percent during the decade, and 14,000 workers were dying on the job each year. In pressing for prompt passage of workplace safety and health legislation, New Jersey Senator Harrison A. Williams Jr. said, "The knowledge that the industrial accident situation is deteriorating, rather than improving, underscores the need for action now." He called attention to the need to protect workers against such

> hazards as noise, cotton dust, and asbestos, all now covered by OSHA standards. (Department of Labor logo UNITED STATESDEPARTMENT OF LABOR, n.d., para. 2)

On December 29, 1970, President Richard Nixon signed into effect The Occupational Safety and Health Act of 1970 which led to the establishment of three agencies: The Occupational Safety and Health Administration, the National Institute of Occupational Safety and Health, and the Occupational Safety and Health Review Commission. Each agency implemented helps protect workers while on the jobsite from past, immediate, and future hazards. The Occupational Safety and Health Administration (OSHA) is within the Department of Labor and is used to prepare and enforce safety laws and standards in the workplace. The National Institute of Occupational Safety and Health was created to conduct research on safety and health in the workplace. The Occupational Safety and Health Review Commission is an independent agency that uses the standards and regulations provided by OSHA and NIOSH resolve enforcement actions contested by employers. Since their establishment, these safety agencies have encompassed many different workplaces and have covered multiple incidents to help keep the everyday workers protected from workplace hazards. According to the United States Department of Labor (n.d.),

> The OSH Act, known initially as "the safety bill of rights", charged OSHA with assuring safe and healthful conditions for working men and women. When the agency was opened for business in April 1971, OSHA covered 56 million workers at 3.5 million workplaces. Today, 105 million private-sector workers and employers at 6.9 million sites look to OSHA for guidance on workplace safety and health issues. (para.6)

OSHA was tasked with setting up some essential programs, such as the American National Standards Institute, the National Fire Protection Administration, and the American Conference of

Governmental Industrial Hygienists. These programs provided assistance in helping the rest of the country adopt the new standards and regulations that were proposed in the congressional mandate.

Personal Protective Equipment

The first line of defense for personnel on the worksite is the PPE, or Personal Protective Equipment. This equipment is any device, tool, or apparel meant to aide an individual when in hazardous environments or dealing with hazardous materials. Since there are a vast variety of hazards that personnel or first responders to an incident need to be aware of, there are equally as many personal protective equipment. Personal protective equipment can include items such as gloves, protective eyewear, hard hats, body suits, masks and respirators, proper footwear like steel toe shoes, and earplugs.

Employers, they are responsible for providing their workers with the proper equipment and train them in the correct procedure of how to use them. There is supposed to be training on how to properly identify when it is necessary, what kind is needed, how to properly wear, adjust, and take equipment off, the limitations of the equipment, and the proper maintenance, useful life, and disposal of the equipment (Department of Labor, n.d., paras. 1-2). “If PPE is to be used, a PPE program should be implemented. This program should address the hazards present; the selection, maintenance, and use of PPE; the training of employees; and monitoring of the program to ensure its ongoing effectiveness” (Department of Labor, n.d., para. 3). In the 29 CFR 1910, General Industry, the subpart I covers the standards upheld by OSHA for personal protective equipment for common protective necessities, eyes and face, respiratory, head, foot, electrical, hand, and fall protection equipment. First responders are the other individuals that need personal protective equipment, but they require even more and sometimes more specialized

equipment and training. Hazmat teams or Hazardous Materials clean-up crews are specially trained teams that come in to safely remove hazardous chemicals after an incident occurred and rendered the area unsafe for normal human activity. These specialty devices help with protecting the individual from harmful environments as well as detecting and monitoring the environment for spread of the harmful agent. Breathing apparatuses, chemical protective clothing, handheld chemical identification devices are all included as mandatory protective equipment for hazmat teams.

A breathing apparatus is a device, or series of devices that provide the user with proper air circulation and ventilation. The breathing apparatuses certified by NIOSH and OSHA for hazmat teams are the self-contained breathing apparatus or SCBA, air-purifying respirators or APR, and powered air-purifying respirators or PAPR. The breathing apparatuses and the users are tested for effectiveness and how well they grasp the understanding on how to use the devices before they can be put to use in the field. Madigan (2017) states that "NIOSH has embarked on upon a program to develop and establish testing criteria and certification standards for breathing systems for weapons of mass destruction, or WMD, chemical, biological, radiological, and nuclear substances" (p.70). SCBAs can be both open or closed circuit, positively pressured, and provide the best protection in areas where air contaminates may be unknown and are at or above Immediately Dangerous to Life and Health, or IDLH, thresholds. IDLH level is the measurement of the concentration of contaminates and the condition of the environment they are in, size of space, humidity, and the contaminate itself, to determine the risk to health and life of those exposed to the area.

> IDLH values are established to ensure that the worker can escape from a given contaminated environment in the event of failure of the respiratory protection equipment

> and to indicate a maximum level above which only a highly reliable breathing apparatus, providing maximum worker protection, is permitted (Immediately Dangerous to Life or Health, 2019, para. 2)

An APR is a full-face piece respirator that is negatively pressurized and is outfitted with the appropriate canister that follows certified guidelines for particulate and gas filtering air-purifying criteria as stated in 42 CFR 84. These respirators are used for lower concentrations of biological, chemical, or particulate hazards. The level of air contaminates must be well below IDLH levels to use an APR safely. PAPRs are essentially the same as the APRs except that they are not negatively pressurized and they are rated and certified for use in biological, chemical, radiological, and nuclear contaminates. Aside from the exceptions listed previously, this style of respirator must be used in low levels of contaminate concentration that are below IDLH levels. These breathing apparatuses are important to maintaining an individual's respiratory health, but that is the extent of their purpose. Responsibility of protection of the body falls to the chemical protective clothing. Chemical protective clothing, or CPC, are protective garments made of high-quality materials to protect the wearer from any chemical, biological, and physical hazards. The NFPA is the only organization that handles the development and performance standards for chemical protective clothing. These standards are reviewed every five years as a means to update current standards with the most relevant knowledge. NFPA standards related to CPCs are 1990-1992, 1994, and 1999. There are necessary factors that need to be accounted for when determining the standard or standards appropriate for the situation and the type of CPC needed to perform the task safely, the classification and the threat-based performance. Therefore, the NFPA created a means of classification based on what class, or level, CPC is needed for the hazard. The class one designation is left vacant, so the classification of the hazard is low level

vapor based. Class two is designed to handle concentrations of vapor or liquid chemical hazards are at or above IDLH. Class three covers concentrations of vapor or liquid chemical hazards that are lower than IDLH. The final class, class four, covers concentrations of biological or radiological hazards that are lower than IDLH levels. Each class is paired with the respective breathing apparatus according to the IDLH levels in the classification. Although these classifications help match the hazards with the appropriate CPCs, the apparel is only effective for a limited time. To determine the CPCs effectiveness the NFPA standards are, according to Madigan (2017), "developed using performance criteria that are risk (i.e., time) and hazard (i.e., threat chemical) driven" (p. 77). These criteria are what is known as the threat-based performance.

The final set of tools used by first responders and emergency personnel are handheld chemical identification devices. These devices allow personnel monitor the area effected and gauge the risk either increasing or decreasing. A Handheld Chemical Identification Analyzer detects the chemical make-up of unknown substances. Gas Chromatographers/Mass Spectrometer analyze volatile organic compounds in the air in around ten minutes. A Portable Flame Ionization Detector is used to detect potentially explosive environments. A handheld radiation device is used to detect, identify, and locate sources of radiation. Lastly, a multi-gas monitor provides a more advanced system to detecting air particulates, is easily customizable, versatile, and has five fast acting alarms to alert the incident control's command center. Not all the devices used are technology based, although they do provide impressive amounts of information, like pH paper. A strip of pH paper can identify corrosive atmospheres, which is important to ensuring that other devices do not become damaged. These devices need to be well maintained and constantly checked for anomalies. They would be used in the field other long

periods of time and because of their purpose, need to be in perfect working condition. Madigan (2017) stresses the importance of all three types of the personal protective equipment for hazmat teams and first responders stating these individuals "are summoned to assess, neutralize, and dispose of the most dangerous chemical, biological, and radiological substances in serious, life-threatening situations. Team members must know immediately what threats they face, what gear to wear, and when the area is safe" (p. 112).

Hazardous Materials

There are more materials that could be considered hazardous to the body than one might think, and it is because there are so many that there needs to be an importance on the awareness on what type of type someone is dealing with.

> The U.S. Department of Transportation (DOT) and the International Air Transportation Association (IATA) define hazardous materials as articles or substances which are capable of posing a risk to health, safety, property, or the environment; are listed or classified in the regulations; and are transported in commerce (Hazardous Materials Description, 2019, para. 3).

This means that the hazardous materials, by OSHA's own definition, can be basically anything. Due to the vast variety of hazards, the U.S. Department of Transportation created a system to distinguishing the different types of materials. The Hazardous Material Table categorizes materials by certain classifications. The categories are labeled as, explosive, gases, flammable liquids, flammable solids, oxidizers and organic peroxides, poison and infectious substances, radioactive, corrosive, and miscellaneous. These hazardous materials use this labeling system for

easy identification for events, like emergency situations, and so worker personnel can understand what potential hazard is in an area or container.

In emergency situations quick and precise identification is crucial to devising the next steps to take in decreasing the harmful effects to the health and safety of responders, the public, and the environment. This is accomplished by color coded, diamond-shaped placards or signs that provide a specific number, and in some cases an emblem, to correspond with what material is being transported or stored. These placards are distinguishable by color and number in this order; explosives use the color orange and the number one, gases use green and the number two, flammable liquids use red and the number three, flammable solids use red and white stripes and the number four, oxidizers use yellow and organic peroxides has a placard with a red top and yellow bottom with both using the number five, poisons use white and the number six, radioactive has a placard with a yellow top and white bottom and the number seven, corrosive has a placard with a white top and black bottom and the number eight, and miscellaneous has a placard with a white and black striped top and a white bottom and the number nine.

For example, material labeled as Flammable Liquids will be confined within their appropriate container, while using a red placard with the number three at the bottom point of the placard, an emblem of a flame at the top point of the placard, and a unique identification number in the center of the placard for the specific material. The identification number is tailored specifically for each individual hazardous material. This makes the identification of the material much easier for any individual. An example of the importance of this use would be in transportation of hazardous materials. When transporting hazardous materials, if there were to be an accident involving a hazardous material there would need to be a clear and concise understanding of what the material exactly is to avoid worsening the situation. It is for this

reason the U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration, created the *Emergency Response Guidebook* to help emergency responders, safety personnel, and hazardous material clean-up crews to safely combat the incident. This guidebook provides the information on all certified hazardous materials. This includes the identification numbers of the hazardous materials with the specific name of the material and the proper container needed to transport the material. These identification numbers are paired with another number that takes the individual to the guide plans to follow for that material. It lists the potential hazards posed by that material in order from most likely to occur to least likely to occur. It identifies the steps to take to protect the public, emergency numbers to call, protective clothing, and evacuation plans, and the emergency response plan.

Much like the potential hazardous the emergency response plans are listed in order of priority from most likely to happen to least likely. The most common of the plans involve the case of a fire and spills or leaks. Since most materials are most volatile with the involvement of fire and the rest are dangerous through any contact, ingestion, inhalation, or simply skin contact, the plans for fire and spills or leaks are extremely important to follow. In some instances, there needs to be an evacuation of the area if the threat to safety is too great. For these instances the guidebook refers the individual to yet another section for further instructions on what to do. The last section provides two tables, the table for initial isolation and protective action distances and the table for water reactive materials which produce toxic gases. The first table provides the responsive action plan for determining the safest distances and positioning for emergency personnel to set up to contain the threat by looking at the size of spill, material involved in the incident, location of the incident, and wind direction. It covers the for both day and night events and how to determine the size of the spill. The second table offers information on what specific

materials, when mixed with water, release toxic gases. This is important to note if there is a fire or a body of water nearby the incident. The table could use the material's name, identification number, or the guidebook's page to the action plan for that material to give the information needed. The action plan section lists the page number for this table in the evacuation part of the plan so crucial information does not go missed. The tables guidance gives the individual the chemical makeup and chemical name so that proper safety equipment can be implemented. This can be particularly important if someone came in contact with the material or the gas.

If someone was to come in contact with the material the emergency response plans also include the first aide, you can apply to anyone who was affected. Signs and symptoms of exposure can be carefully watched for and can be treated quickly with the correct identification. If an individual does have signs of being affected by a hazardous material, there are a few things to consider. One is the exposure time the individual had contact with the material. The limits for exposure time vary from chemical, amount and concentration of the chemical when they came in contact with it, and the pathway in which they came in contact with it. Different chemicals vary in their effects on the body. Some cause burns, irritation, blindness, suffocation, or other forms of bodily damage.

According to the CDC the top five most common injuries from chemical materials come from carbon monoxide, ammonia, chlorine, hydrochloric acid, and sulfuric acid.

> For all of the top five chemical releases, the majority of injured persons (range: 58%–68%) were treated at a hospital but not admitted. Carbon monoxide had the highest percentage of fatalities; 3% of injured persons died. Chlorine had the lowest frequency of fatalities, less than 1% (Table 4). For sulfuric acid, ammonia, and hydrochloric acid, the majority of injured persons were employees (235 [74%], 716 [62%], and 179 [55%]

> respectively). For carbon monoxide and chlorine releases, the majority of injured persons were from the general public (49% and 48% respectively). The most frequently reported injury for ammonia, chlorine, and hydrochloric acid releases was respiratory irritation. Dizziness was the most frequently reported injury for persons exposed to carbon monoxide, and burns were the most frequently reported injury for sulfuric acid releases. (Anderson, 2015, paras.11-12)

Most chemicals have colorless and odorless characteristics so they are difficult to identify with a sensor or symptoms from an individual. There are some chemicals that are artificially combined with additives to give them a visible look or smell, if the fumes are not hazardous, for easier identification, like gasoline. Those suspected of coming in contact with chemical material are washed down and/or given oxygen to remove the toxins from their body. Flushing their system is another necessary option if the individual ingested any of the chemical or if it entered their bloodstream.

Fire Safety

One of the most common and one of the more well-known hazards in the workplace are fire related hazards. Fire hazards encompass a large array of components for identification. They are viewed by the effect they have on actually causing a fire, how much they hinder, or restrict, workers in the event of an emergency and evacuation is necessary, and if there are proper steps in place to slow the growth of the fire. These components can have a dramatic impact in the event of an emergency. It is the job of safety specialists to create prevent plans, organize and coordinate workers, and train them in preparation for any emergency situations. The most well-known examples of neglect for fire safety is known as the Triangle Shirtwaist Factory Fire. The Triangle Shirtwaist Factory was a garment company located in New York City, New York in the

ninth, tenth, and eleventh floors of the Asch building at the east corner of Washington square around the late 1800s to early 1900s. This was in the midst of the Industrial Revolution and the heart of the epicenter for factories. At this time the factory was a miserable place for immigrants moving to America to struggle to make a living. The work was typically done by women workers in poor, cramped quarters for incredibly low wages. “Many of the garment workers before 1911 were unorganized, partly because they were young immigrant women intimidated by the alien surroundings” (*Sweatshops and Strikes*, n.d., para. 7). Around 1909, Unions had begun to form to help these workers to better organize and strengthen themselves against their opposition, the greed of their employers, to improve their working conditions. They practiced means of retaliation in the ways of strikes and pickets to further support their cause.

By 1910, their efforts finally bore fruit and a grievance system was put together for workers in the garment industry to express concerns about the working conditions. Unfortunately, stated by the article *Sweatshops and Strikes*, the workers did not receive the relief they desired because the factories were still run by “unscrupulous owners, who disregarded basic workers' rights and imposed unsafe working conditions on their employees”. On March 25, 1911, a fire broke out at the Triangle Shirtwaist Factory claiming the lives of 146 of the 500 workers. Upon investigation of the incident, it seemed to have been started by a worker smoking near the workplace. Although the owners claimed to have a clean and hazard-free establishment for their workers, there would be evidence come to light that this was far from the truth. The building, contrary to what the owners stated, was not fireproof. In fact, it was the exact opposite “In December of 1913, the interior of his factory was found to be littered with rubbish piled six feet high, with scraps kept in non-regulation, flammable wicker baskets” (*Sweatshops and Strikes*, n.d., para. 24). The floor was covered in highly flammable materials which was the cause

of the fire to spread throughout the building. The building was not equipped with any proper means to slow or extinguish the blaze. That coupled with the location of the fire in the factory being in the upper levels of the building this meant workers would have had to escape through the stairs to safety and that brought about many other issues though.

The fire started on the ninth floor meaning that workers on the other two floors wouldn't have known about the fire until it was on their floor. To make matters even more dire the building layout and the employer's greed worked against the workers in their haste. The employers were known to lock the doors to prevent workers from stealing and the doors to reach the stairs would only open in towards the room. This meant that as people, panicking to escape to rapidly growing fire, would push up against the escape route and prevent the doors from ever being opened. As for the upper levels, the smoke would have reached them first and ensuring that the fire was already in the stairwells. The only means of escape at that point were by the fire escape on the outside of the building, escaping to the adjoining building, or have outside assistance.

Some did manage to make it to the build adjoining the factory, but for some that option was not available. The fire escape was working well until an influx of people tried to use it all at once causing it to fail. The building was too densely populated for one fire escape and it was later confirmed that there should have been at least two fire escapes for the amount of people in the building. The final option was exhausted as well due to the lack of safety concerns at the time. Since the factory and the fire started on the ninth floor, the firefighters at the time could not reach the necessary floors because their ladders only reached to about seven floors high. Emergency personnel and passersby had to watch helplessly as people took their chances jumping out of the building to avoid burning to death or suffocating from the smoke. The

repercussions from this needless loss of life were unjust. The employers paid very little, if anything, in terms of settlements for lost loved ones, they received essentially no punishments for their negligence towards worker's health and safety, and they were allowed to remain operational. The good that did come from this tragic incident were the new standards and regulations created to prevent incidents like this from ever reoccurring. OSHA has developed detailed standards for fire prevention and fire related incidents. 29 CFR 1910 covers standards for general industry compliance. 29 CFR 1910 subpart E 39, Fire Prevention Plans, explains what is expected and what is to be followed by all businesses regulated by OSHA. The subpart includes having a prevention plan in place that is written down and available for the employees to review on the worksite and must include certain components.

> The minimal requirements for a fire prevention plan by OSHA's standards are that a list of all major fire hazards, proper handling and storage procedures for hazardous materials, potential ignition sources and their control, and the type of fire protection equipment necessary to control each major hazard, procedures to control accumulations of flammable and combustible waste materials, procedures for regular maintenance of safeguards installed on heat-producing equipment to prevent the accidental ignition of combustible materials, the name or job title of employees responsible for maintaining equipment to prevent or control sources of ignition or fires, the name or job title of employees responsible for the control of fuel source hazards (*29 CFR 1910 OSHA*,2017 p. 51).

Although there have been improvements to fire safety regulations and standards over the years and there has been a decrease in overall fire incidents, fire hazards and safety standards are still not enough. According to Ferguson and Janicak (2015) the industrialized world has greatly

improved on decreasing the fire death rates with the United States and eastern European countries improving quicker than other countries, but the United States remains one of the countries with higher fire related deaths (p.5). The reason behind the decline in the U.S. is due because of organizations, such as the NFPA, whose sole function and goal is to improve standards, practices, and equipment to mitigate the fire related incidents. “During 2011-2015, there were an estimated 37,910 fires at industrial and manufacturing properties (including utility, defense, agriculture, and mining) reported to U.S. fire departments each year, with associated annual losses of 16 civilian deaths, 273 civilian injuries, and $1.2 billion in direct property damage” (Campbell, 2018, p.1).

For more about fire safety, safety specialists must know how fires can occur, what dangers a fire can produce, and how to safely extinguish it without putting people in harms way or have a way for them to escape. A fire can only occur with the presence of three components, an energy source, fuel, and oxygen, and a chemical reaction between the three components. This combination of elements is known as the fire tetrahedron. In industrial and occupational settings these components can be found in abundance. An energy source can be anything that produces enough heat for the ignition of a material to occur. Klinoff (as cited by Ferguson and Janicak, 2015, p.18) explains that the ignition temperature is “the minimum temperature of a material required to initiate or cause self- sustained combustion of the material”. Most commonly energy sources are electrical currents, flames, and sparks, but can ultimately be something as friction if the right conditions are met. Fuel is the material used to sustain the fire, such as Wood and flammable liquids or gases. The final component, oxygen, is the most difficult to control. There can be safety measures in place to keep the energy source and the fuel sources apart, but next to impossible to keep oxygen away from the other two. There are also some compounds known as

oxidizers that will help provide the fire with the oxygen it needs. Oxidizers, as described by Klinoff (2012), are substances that gain an electron from a fuel in a chemical reaction and release oxygen during combustion (Ferguson & Janicak, 2015, p.18)This is why the last piece of the fire tetrahedron requires there be a chemical reaction between the three components. For example, if there was a match stick laying on a table it will never light. There is the fuel source and oxygen present, but it is not until friction on the match head occurs that there will be fire. What makes fires so dangerous though is that they can be unpredictable, due to the abundance of its components to start, and from what the fire produces as a result of burning. Since fires have multiple fuel sources in a typical worksite there can be any number of unfortunate byproducts or effects. The temperature of the fire can vary depending on the fuel source and the size of the fire. According to *Home Fire Facts*, provided by the San Francisco fire department

> In only 3 1/2 minutes, the heat from a house fire can reach over 1100 degrees Fahrenheit. In rooms that are not even on fire the temperature can reach over 300 degrees; this is hot enough to melt plastic and kill the people in those rooms. (n.d., para.1)

If the fire is not directly in or adjacent to the room with personnel it can still cause some detrimental effects. The NFPA states that more people perish as a result as smoke inhalation rather than burns from the fire. When a fire burns in an enclosed area the smoke accumulates in that space, this makes the room extremely hard to navigate and breathe in. The smoke from a normal campfire has the ability to render individuals incapacitated from the lack of oxygen. The NFPA created a chart that describes the oxygen levels in the air and what an individual breathing that air would experience as a result (Bush, 2021). The chart shows oxygen levels in the air outside are twenty-one percent so everyday air is nearly one quarter oxygen. When the levels lower to seventeen percent oxygen judgement and coordination become impaired. Twelve

percent headache, dizziness, nausea, and fatigue, at nine percent the individual is unconscious, and if the oxygen levels get as low as six percent the cardiac and respiratory arrest occur followed by death. In a room engulf in smoke breathing in air that contains less than seventeen percent could get someone killed. They could stumble around the room looking for the exit while suffocating on toxic fumes. Bush (2021) explained

> The NFPA explains another problem is the synthetic materials used so commonly in-home construction and furnishings today. When burning, they produce extremely dangerous substances that are released into the air. These toxic gases may replace the oxygen and be inhaled by victims struggling to find their way out of the burning structure. Carbon monoxide is one well known substance that can be very deadly even in small amounts. When plastics such as PVC pipes burn, the hydrogen cyanide released can interfere with cellular respiration. Another product, phosgene, is formed when household products, including those containing vinyl, burn. Low levels of phosgene may result in itchy eyes and cause a sore throat while higher levels can cause death (para. 3)

After an individual is extracted from the building and treated for their condition, the danger is not yet over. There are a number of potential hazards among workplace items that must be accounted for and restricted access to until the fire is completely neutralized. Amongst the fire, heat, and smoke one of the last potential threats to personnel and the surrounding public is the event of an explosion.

There are two types of explosions, mechanical and chemical explosions. Mechanical explosions occur when the pressure of the container exceeds its limits. A BLEVE, or Boiling Liquid Expanding Vapor Explosion, is a common example of a mechanical explosion. For a BLEVE to occur the contained elements that were heated by the fire in their sealed containers

would reach their boiling point and turn into a gas or vapor. This causes the pressure inside the container to increase until the it inevitably fails and releases all that pressure. A simple example of this would be like filling up a balloon with too much air and it pops as a result. Preventing any containers that have the potential cause a BLEVE are accomplished by double checking materials are away from any potential ignition sources or if possible stored in an area that will burn out quickly. This prevents the fire from producing enough heat boil the chemicals inside and ensures that a BLEVE will not transpire.

Mechanical explosions are most likely to occur while the fire is still occurring since the element inside the container needs to be heated to create more pressure, whereas the chemical explosion does not necessarily need the fire to continue. A chemical explosion requires a chemical reaction to occur in order to activate. One example of this is a bullet. The gunpowder in the shell of the bullet is ignited all at once by the firing pin being struck hard enough to set off the firing cap inside. That creates a rapid expanse of heat and energy as the gunpowder is burnt all at once and turned into gas. Some more unconventional explosions that can occur are dust explosions and explosions involving chemical explosions with no fire required. When pure sodium and water comes into contact there is a violent reaction that releases energy. A team of chemists from the Academy of Sciences of the Czech Republic and a team from Braunschweig University of Technology worked together to determine the cause for this reaction.

> The team observed that within a fraction of a millisecond of contacting water, the Na/K droplets form numerous spikes that protrude into the water. Molecular dynamics analysis indicated that nearly instantaneous transfer of electrons from the spikes to the water rapidly generates positively charged alkali ions, which vigorously repel and cause a so-called Coulomb explosion. It is the speedy manner in which that process propagates and

generates reactive metal surfaces that triggers the overall explosion (Jacoby, 2015, para.6).

Factors that prevented initial reactions to occur were the cleanliness of the surface of the metal and temperature. The metal could not fully connect with the water in order to react properly if the metal was dirty. Explosions need a certain combination of circumstances to occur and the most difficult is a dust explosion. Just because this is a particular set of circumstances does not mean it should be overlooked. A dust explosion is when combustible dust in fine particles is suspended in the area in a certain concentration and is then ignited by heat source. Dust explosions can only occur when five conditions are met, heat, fuel, oxygen, dispersion, and confinement, also known as the Dust Explosion Pentagon. Much like the fire tetrahedron, if one component is missing then an explosion will not occur. The explosion relys on particulates to be suspended in the air in order to cause the chain reaction to explode, so the initial blast may cause more particulates to be dispersed in the air and cause a second setting for another explosion. The inherit danger of this type of explosion is that it can occur from lack of upkeep or cleanliness of a workstation. The most common industries that at a higher risk of dust explosions, specified by OSHA, are industries like food, agriculture, mining, and some manufacturing plants. Removing the essential components needed for detonation can be a tedious but ensures the safety of workers and equipment. OSHA recommends for dust control to regularly clean and inspect areas that may accumulate dust. Proper access to all areas that can harbor dust, respiratory masks or surgical masks to prevent inhalation whilst cleaning, vacuums with dust filters, and appropriate ventilation systems can help prevent the collection of dust. If any of fire or explosion were to happen on site then employees must be prepared to evacuate to safety. OSHA has identified many standards to aide those in these situations by enforcing regulations on fireproofing

materials for buildings, fire extinguishment equipment and training, and evacuation protocols. Many buildings are designed with multiple goals in mind and fire safety is one of the most important. Ferguson and Janicak explain that during the preplanning of the building design phase fire protection is determined. They continue stating, " A well designed building will consider flame and fire spread, life safety, and smoke spread during the preplanning stage so that construction materials and design features can be selected to reduce or eliminate potential exposures" (2015, p. 106). There are two classifications of a fire protection system and that is active and passive. According to Schroll (2015), active is a system that works to combat the fire and slow its spread, like a sprinkler system, while passive systems work to "reduce fire ignition, limit fire development, and/or reduce or eliminate the spread of smoke, such as a fire wall" (Ferguson & Janicak, 2015, p. 107).

Most major commercial and industrial buildings are made of metal, mainly steel, and concrete, but there are some more flammable materials used, like wood and some forms of insulation. It is important to understand what each component is capable of withstanding when under its designed function. For example, if there is a wooden load bearing wall or beam it needs to have fire resistant protection on it to guarantee that the wood will last as long as possible before it fails. According to the NFPA fire resistance is the measure of material, product, or assembly to withstand fire or given protection of it for a period of time. To find out the extent to which the material is fire resistant the NFPA has adopted tests and created criteria to meet a high standard of efficiency. There are three tests conducted which are the Standard for Fire Tests of Building Construction and Materials, Standard Test Methods for Fire Tests of Building Construction and Materials, and Standard Methods of Test of Fire Resistance of Building Construction and Materials. Failure of these tests by NFPA standards are defined by

> failure of test specimen to support a load, an increase in the temperature on the unexposed surface of 250 degrees Fahrenheit above ambient, passage of heat and/or flame sufficient to ignite cotton waste, excess temperature on steel members, and failure of walls and partitions when exposed to a hose stream (Ferguson & Janicak p. 116, 2015).

After extensive testing, fire resistant materials are then divided into different classes of effectiveness and function. They are labeled as type one through five and identifiable by the type and the number as a roman numeral. Type I has the highest level of fire resistance and are members that are non-combustible. Type II are structural components made of non-combustible or limited combustible materials, such as steel and masonry. Type III consists of " construction where the exterior walls are non-combustible with a two-hour fire resistance, but the interior may be constructed of non-combustible or approved combustible materials" (Ferguson & Janicak, 2015, p. 119). Type IV is a structural type using unprotected wood that is larger and used for major weight bearing instances. Type V is essentially unprotected and combustible materials that provide very little to no fire protection.

Once a fire starts, the materials used during construction will prevent it from spreading quickly, but the building will some items inside that probably not created to withstand fire. Small fires will grow and consume whatever they can and if a worker can get to it quickly enough they may be able to stop it before it gets out of control. Employers are required to provide a means to extinguish the fire or slow the spread. This comes in the form of fire extinguishers and sprinkler systems. If personnel are attempting to extinguish the fire themselves then they must be able to properly identify the class of fire. There are five classes of fire and are classified as A-D and K. Class A fires consist of combustible materials like wood and paper, Class B is flammable and combustible liquids and gases like gasoline, Class C is a fire using electrical equipment, Class D

covers combustible metals like aluminum, and Class K is a cooking media. It is imperative that those trying to extinguish the fire know what class the fire is so they do not harm themselves or escalate the fire. For example, if there is a small grease fire in a pan on a stove and an individual panics and throws water on it the fire could spread to other areas of the room. Another example is if there is an electrical fire and an individual throws water on it throw sparks around the room and make getting near it much more hazardous. The most common agents used to extinguish fires are water, carbon dioxide, halogenated extinguishing agents, and wet and dry extinguishing agents. Water is the most abundant source and has been proven effective against fires for centuries, but as society adapts and grows water has become not as useful in certain situations like the prior examples. Water is used in sprinkler systems and by firefighters in an effort to suppress and contain the fire, but for small unknown fires it is better to find another source.

Most commonly used in emergency fire situations, fire extinguishers are used to starve the fire of oxygen. They are designed to carry a gas, typically a mixture of carbon dioxide, to be sprayed on the source of the flame and as a result replace the air in the vicinity of the fire with the gas. Fire extinguishers are required in all buildings that house personnel and are to easily located and acquired. They must be inspected and replaced according to the manufactures instructions and vary depending on the type of element used. A rating system is used to determine the effectiveness of the extinguisher on the fire. Extinguishers used for class A and B fires follow this rating system because the other class's effectiveness are dependent on the size of the fire. Fire extinguishers are not designed to be used for long durations of time since they contain a very limited supply of their chemical.

Other concerns of extinguishing a fire are that it might create a flashover or a backdraft. These are two of five unique combustion phenomena discussed by Ferguson and Janicak.

Ferguson and Janicak (2015) reference Schroll (2002) who stated, “A flashover is a fire in an enclosed area that the buildup of heat; when the temperature reaches the ignition temperature of the majority of combustibles in the area, there is a spontaneous combustion of the combustibles in the area” (p.23). This is similar to how ovens operate. When you heat the area around combustible materials enough to where they reach the object’s ignition temperature then the object will catch fire with direct contact with the fire. A backdraft occurs when the room is filled with smoke from the fire. When the fire is starved of oxygen and replaced with the carbon monoxide from the smoke, the fire begins to suffocate itself. This is dangerous because if any oxygen rich air is reintroduced into the room the carbon monoxide will combust rapidly and cause an explosion to occur similarly to a dust explosion. The existence of these two phenomena make fires even more dangerous even if the room seems fine. Some rules to follow that if a room is extremely hot then do not enter it because some of the items may combust and start a fire in there. If there is a fire in a room and it seems like it is about to be extinguished or is full of smoke do not attempt to enter the room. If the fire is not affected by the extinguisher the personnel should start evacuating the facility and alerting others on their way out.

When exiting the building, the individual must remain calm and swiftly proceed to an exit. If signs of the fire are visible then in the immediate area should remain as low to the ground as they can with their mouth and nose covered with their arm or a piece of cloth to reduce smoke inhalation while they escape. They should not attempt to enter any rooms especially if they are shut. Once the fire reaches a certain threshold, the sprinkler system should activate and sound an audible alarm. Sprinkler systems are not deigned to extinguish a fire but to render its fuel source unusable. The alarms that are used come in a variety that is based on what they detect. Some use smoke or heat to detect a fire or personal can activate the system manually from an easily

accessible lever on walls near exits. The system should be connected to an alternate power source in the case of a power outage and should be tested and inspected according to the style of system used and NFPA's safety standards. The alarm will alert personnel that there is a fire in the building and that they should evacuate. Emergency exit signs are to be above doors and easily identifiable. They must be above a door that leads outside the facility and unobstructed for swift exits. Pathways to emergency exits are to be outlined on evacuation plans that are displayed in the facility. Personnel must be aware of their route for evacuation and trained on how proceed if a fire emergency situation arises.

Air Quality

Taking in a deep breath is an easy way for some to clear the mind and collect their thoughts. This is a simple but effective means of calming people and lowering a stimulated heart rate. When the air is not abundant or there are contaminates in it though it can have dangerous effects on the body. Dizziness, nausea, hallucinations, irritability, unconsciousness, bodily damage, and in some cases death. Depending on the air quality in the area people can suffer from a variety of different ailments and side effects, so determining the causes for them are a high priority since airborne hazards are one of the most difficult hazards to approach. Since these hazards are microscopic and are able to linger in the air, they are hard to contain completely and impossible to see in some cases. They can affect people without their knowledge and remain undetectable until the individual starts to show symptoms of whatever hazard it may be. The guidelines to finding harmful air contaminants and the standards for suitable air quality are provided by the EPA, Environmental Protection Agency, who set forth the National Ambient Air Quality Air Standards according to the Clean Air Act.

> The Clean Air Act identifies two types of national ambient air quality standards. Primary standards provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings. (*NAAQS Table*, 2021, para.1)

The Clean Air Act was established in the 1970s because of dense and visible accumulations of hazardous air particulates in major cities in the nation. This accumulation is known as smog and is still present in major cities around the world, such as Los Angeles, Hong Kong, London, and Paris. Smog is typically the result of high concentrations of air pollutants which are produced in these cities due to high motor traffic and factories. The EPA is required by the Clean Air Act to establish air quality standards for the U.S. These standards are revised as new research into air quality is provided. “EPA has set air quality standards for six common "criteria pollutants": particulate matter (also known as particle pollution), ozone, sulfur dioxide, nitrogen dioxide, carbon monoxide, and lead” (*NAAQS Table*, 2021, para.1). All states are required to abide by these standards and create or adopt plans to maintain the standards at all time. This means industrial standards to monitor and control harmful emissions from plant and factories. The plans are to encompass the state border and maintain control of the air in their area and restrict harmful airborne toxins from leaving the state.

The most notable advancement in limiting harmful emissions is the movement towards alternate forms of energy, like solar, wind, nuclear, geothermal, and electrical. A drastic change in energy sources is difficult and expensive to enact though since they are not as efficient and readily available as fossil fuels. Although the solutions are hard to obtain, the EPA has improved the overall air quality in many areas around the nation and continues to adapt and revise previous

standards. In recent years the EPA has revised standards regarding five of the six common air pollutants and new research is still being conducted with local and federal agencies to create better plans. One example of this is the EPA's establishment of new standards for motor emissions.

> EPA is helping states to meet standards for common pollutants by issuing federal emissions standards for new motor vehicles and non-road engines, national emissions standards for categories of new industrial equipment (e.g., power plants, industrial boilers, cement manufacturing, secondary lead smelting), and technical and policy guidance for state implementation plans. EPA and state rules already on the books are projected to help 99 percent of counties with monitors meet the revised fine particle standards by 2020. The Mercury and Air Toxics Standards for new and existing power plants issued in December 2011 are achieving reductions in fine particles and sulfur dioxide as a byproduct of controls required to cut toxic emissions. (*NAAQS Table*, 2021)

It is due to the efforts of the EPA and other government agencies that air quality monitoring is now an important safety practice for multiple industries. Air particulates are now measured and monitored every moment the emission source is active, especially if in an enclosed area. No area in a building or factory should be completely enclosed unless in an emergency situation and the room needs to be sealed to prevent a hazard from escaping and effecting more areas. Proper ventilation systems should be in place to provide the room with clean breathable air and filter out any particulates in the air before expelling the air from the building. Ventilation systems be as simple as fans with low grade filters that bring in air from one side of the room and expel air on the other side of the room or as complex as multilayered filtration systems that filter and sterilize the out going air to thoroughly clean the air before it leaves the building. Careful

inspection and testing should be conducted on air systems after installation before being cleared for human occupancy. After installation is complete the air systems should be monitored and cleaned regularly to prevent system failure or improper filtration of the air. Air quality sensors are becoming smaller, more affordable, and faster at detecting any anomalies and abnormalities in the air. The sensors being developed are capable of detecting particulates in the air by continually circulating air through itself and analyzing any particulates that come in contact with its sensor.

Most commonly air particulates are measured in parts per million when determining if the air is at safe enough levels to breathe. There are some special instances where some sensors are used to detect parts per billion but it all depends on the hazard involved. For example, you have special sensors for detecting gases instead of particulates. Gas sensors are important for those who work with dangerous chemicals that are toxic to inhale and/or flammable. Regardless of the sensor used, if the air contains excessive amounts of a particular substance then an alarm on device will notify personnel of what the hazard is and the level it is currently at. Most sensors are built into the building, with the exception to handheld devices, so if the sensor is set off then a safety protocol should engage and either flush out the air from the room to a secure container or filter and/or seal the room off. Defensive measures that are in place for air quality are vastly different for the intended hazard, but all accomplish the same goal.

Biological Hazards

The term biological hazard occurs in most forms of entertainment, such as movies and books, to describe a foreign agent that has entered the body and causes many negative effects. In reality this description is not wrong, although some causes and effects are much more exaggerated and fictious in the film industry. The term biological hazard, or biohazard, is used to

describe “any biological substance that poses a threat to the health of living organisms” (Madigan, 2017, p. 93). It is the medical field that typically takes care and handles biohazards, but there are many more areas that deal with biohazards. The substances to watch for are any bodily fluids and any surfaces that may contain hazardous microorganisms, viruses, or toxins. Sanitation workers could come in contact with these substances while cleaning up a work site, landscapers can pick up a poisonous insect by accident, a factory worker can cut their hand on something and spread a sickness to anybody who comes in contact with it, and any employee can obtain a small cut or splinter that gets infected.

The possibilities for where these hazards come from are numerous, so workers need to be prepared and equipped to manage any incidents. Biohazards can be initially identified by their symbol and by their UN number. The symbol for biohazards were created under certain criteria to make it easily distinguishable from all other symbols without causing confusion as to what it is. The UN number assists in classifying biohazardous agents. UN 2814 is a category A and means that it is an infectious substance that is “in a form capable of causing permanent disability, life-threatening, or fatal disease in an otherwise healthy human or animal when exposure to it occurs” (Madigan, 2017, p.93). UN 2900 is still a category A but is a substance that is not in a form that generally causes harm. Category B is identified as UN 3373 and is any biological substance transported for investigative purposes. The final category and least dangerous is identified by UN 3291 and are any waste or reusable material that is from medical treatment.

These unique numbers and the biohazard symbol are both important for first responders and emergency personnel to identify that there is a dangerous agent present and what the unknown agent is potentially capable of. However, the CDC, Centers for Disease Control and Prevention, delve deeper into classifying the risk level for the different types of agents. The UN

classification covered biohazards in the act of transportation, where the effects of the agents are prioritized, whereas the CDC created a level system prioritizing the risk of the agents on personnel in the lab or factory setting. This system provides the essential precautions when handling or managing biohazards. It ranks biohazards on a scale of one to four with level one being a minimal risk, needing basic protective equipment to avoid contamination, and level four being a major risk, needing more advanced protective equipment and safety guidelines to avoid contamination. Level one includes some bacteria and viruses and requires a small amount of protection, masks and/or safety googles and gloves. Level two has bacteria and viruses that cause mild infectious diseases. The diseases include those that are harder to contract from airborne particles, such as mumps, measles, Lyme disease, and HIV. Level three is more severe and can, at times, be fatal, but there are vaccines or treatment processes that are available to cure the disease. Examples of this level of disease or infection are West Nile Virus, tuberculosis, Rocky Mountain spotted fever, and *Plasmodium falciparum*, a cause for malaria. Level four is the most dangerous of the levels because it features viruses with severe and fatal diseases that have no known cure or vaccine. Since there are no treatment methods available for any disease with a level four classification, Lassa fever virus, Ebola, and Crimean-Congo hemorrhagic fevers, the procedures to handling them are to be explicitly followed to the most minor of details. Level four viruses require personnel to wear positive pressured suit and an appropriate respirator with a partnering air supply tank. Areas containing these viruses require multiple airlocks and decontamination showers for entrances and exits to it. This is important to destroying any trace of the virus that might be present on personnel leaving the infected area so that the agent does not spread to the outside the confined and regulated area to the public.

Containment of these agents regardless of severity is the first priority for personnel handling the bacteria or virus. There are three types of containment, primary, secondary, and agriculture, that are used. Primary containment refers to the storage container that the infectious material is in. The container needs to be labeled with the proper materials like some identify characteristic for easy identification and must be appropriate for the infectious material inside. This typically requires the container to be strong so that it will not easily break and release the biohazard. “Secondary containment is the protection of the environment external to the laboratory from exposure to infectious materials and is provided by a combination of facility design and operational practices” (Madigan, 2017, p. 100). Secondary containment is the facility and the protective procedures that are in place to restrict the infectious materials from escaping and spreading to the public. This type of containment is more inclusive so every step must be carefully planed out and implemented correctly to ensure public and personnel safety. Agricultural containment is more focused and structured around keeping the environment, plants, animals, etc., safe from certain pathogens that are being tested and studied in laboratories and other facilities. These pathogens effect the environment verses humans, so different practices are necessary for proper containment.

The safety procedures are pointless though if there is improper or no decontamination. Decontamination is “the process of removing or neutralizing contaminants that have accumulated on personnel and equipment”. The nature of decontamination is that of containing the biohazard to a fixed location and preventing the spread to other areas, so the decontamination equipment and plans must be established first before personnel can be allowed to handle the material. Medical practices are the most common places to find the decontamination processes used properly. There are multiple methods of decontamination, and they are typically used

separately but can be combined if the biological hazard is highly resilient and/or highly infectious. The first method is physically cleaning and is as simple as it sounds. This cleaning takes place in a chemical shower where the contaminated individual is scrubbed down with powerful cleaning agents that are harmless to the individual. Physical cleaning is best used immediately after the individual comes into contact with the biological agent, since the agent did not get enough time to absorb into the individual. There are some cases where the cleaning will be conducted with the individual's clothes on but if the biological hazard is extremely difficult to contain and if it is safe to conduct then the clothes of the individual will have to burned as a precaution, so no outbreak is possible. The next method is water purification. This method cleans contaminated water by removing the any hazardous materials in the water. Water purification is a common practice nowadays in most homes. Water facets, dispensers, and sinks are connected to a filter or flirtatious system that consists of sand, carbon paper, and/or other minerals to catch and trap the contaminants as the water passes through the filter. Water purification is decontamination for water so that it can be reused in certain applications, such as cooling for industrial components or to return it to safe drinkable water. Ultrasonic cleaning is the process of cleaning using ultrasound (usually from twenty to four hundred kHz) and an appropriate cleaning solvent (sometimes ordinary tap water to clean items (Madigan, 2017, p.102). This style of cleaning is used primarily to clean hard to reach areas and delicate instruments.

Another method of decontamination is by using disinfectants and antiseptics. Disinfectants are antimicrobial that are employed to nonliving surfaces to destroy any biological agents and antiseptics are also antimicrobials but are applied to living surfaces to reduce infection in the subject. Disinfectants are part of common household cleaners, like Lysol and Clorox, to keep surfaces free of contaminates that may be hazardous to the occupants of the

home. This keeps diseases like the flu and the cold from spreading around the public. In industrial settings it helps keep surfaces clean from bacteria and viruses so personnel and the public do not become ill. Antiseptics work to combat the infectious substances that are already on the subject. Madigan (2017) states “antiseptics can be differentiated from antibiotics by the latter’s ability to be transported through the lymphatic system to destroy bacteria within the body, and from disinfectants, which destroy microorganisms found on nonliving objects” (p.102). This simply means that antibiotics are similar to antiseptics because of their function but are distinctly different by how each one works to achieve that function.

The final form of decontamination is sterilization. Sterilization is the most potent form of decontamination because it removes or destroys all forms of biological agents. This is much more effective than the other forms of decontamination but is at the same time more dangerous to use on living subjects. The process of sterilization is done so through the use of heat, chemicals, irradiation, high pressure, and filtration. Some processes of sterilization can be potentially hazardous to individuals since they are designed to destroy all traces of biological agents.

Aside from the harsh nature in how sterilization is conducted, complete destruction of all bacterial and microbial life could also be harmful to the individual. Dr. Yttri from the National Center for Health Research states there are beneficial colonies of bacteria that people house in their bodies that help the immune system develop and grow stronger. “The bacteria on our skin, in our airways, and in our digestive system are the first line of defense against foreign “invaders” (pathogens) that can cause infection and other problems” (Yttri, 2017, para.1). If sterilization is used it could cause the subject to have a weaker immune system if practiced excessively.

Proper wipe down and clean up practices should be implemented at all times regardless of the circumstances. If a worker receives a cut while on the worksite, then proper cleaning of the wound with sterilized or at least disinfected materials should be used. After the worker's wound is clean, antiseptics should be applied to the wound before wrapping it in sterilized or disinfected gauze or other wrappings to stunt the bleeding. If there is someone helping the injured party with this first aide then they should, at the minimum, be wearing glove to help tend to the wound. This prevents the responder from getting infected by anything in the wounded individual's blood and prevents the responder from transmitting anything to the wounded individual. To clean any blood that may have landed on another surface during this process or the incident itself, the individual tasked with cleaning should be wearing gloves and using disinfectants to clean the areas touched by the blood.

Confined Spaces

There are some individuals that have an extreme fear or a strong uneasy feeling about specific things or situations. These people typically are diagnosed to have a phobia if this psychological factor manifests itself to affect the body physically. The symptoms for phobias are that of a panic attack caused by the psychological stress that the individual is under. These symptoms, according to Black, are sweating and chills, dry mouth, headache, numbness, tightness in the chest, chest pain, nausea, disorientation, confusion, lightheadedness, fainting, dizziness, high blood pressure, and an accelerated heart rate. An example of this would be claustrophobia, or the fear of small and confined spaces. "Studies have generally indicated that about 7% of the population, or up to 10%, is affected by claustrophobia, says Bernard J. Vittone, MD, founder and director of The National Center for the Treatment of Phobias, Anxiety and Depression" (Black, 2019, para.2).

Confined spaces are defined by OSHA as spaces that are not designed for people but are large enough for worker personnel to enter and perform certain jobs and has limited or restricted means of entry and exit. This means that the space was not designed for prolonged occupancy. Spaces of this nature could be storage containers, silos, pipelines, manholes, pits, tunnels, equipment housings, and ductwork. This has the potential to be extremely hazardous due to the limited access that is offered and the specialty equipment needed to safely enter and work in such areas. Thus, a confined space permit must be acquired before any work is begin in that area.

> OSHA uses the term "permit-required confined space" (permit space) to describe a confined space that has one or more of the following characteristics: contains or has the potential to contain a hazardous atmosphere; contains material that has the potential to engulf an entrant; has walls that converge inward or floors that slope downward and taper into a smaller area which could trap or asphyxiate an entrant; or contains any other recognized safety or health hazard, such as unguarded machinery, exposed live wires, or heat stress (U.S Department of Labor, n.d., para. 2)).

When in a confined space personnel involved must be aware of the different potential hazards that may appear while work is to be conducted. Some things to consider when dealing with a confined space are that proper equipment and safety standards are used to enter the area, personnel entering the area have a way to monitor their environment, personnel entering the area have a means of contacting those outside the area, and that personnel have a mean of escape and rescue plans are in place in the case of an emergency. For a confined space atmospheric quality is the highest concern due to the size of the area and the design of the area not being suitable for prolong use. The air might be consumed to quickly in which a respirator must be used or the work required might contaminate the air during the operation. Atmospheric quality must be

acceptable before and during the operation and continuously monitored for oxygen concentration, the presence of toxic gases, and flammable materials as stated by Madigan (2017) (p.192). If atmospheric quality is not upheld to OSHA standards then heavy fines and/or injuries may occur. Without proper breathable air, personnel inside the confined space will become dizzy, disoriented, nauseous, have trouble breathing, and other symptoms depending on the toxins in the air. When oxygen concentration is not between nineteen and a half and twenty-three and a half percent, personnel could become unconscious and unable to leave on their own accord. If they do not exit or are not retrieved when this happens they may suffer permanent bodily damage or death. “To protect against toxic gases, contaminants have permissible exposure limits (PELs), which are set by OSHA. Work also cannot continue if the concentration of a material reaches or exceeds ten percent of its lower explosive limits” (Madigan, 2017, p.192).

Other environmental factors that can be potentially to personnel in a confine space are heat, noise, flooding of materials, or not properly securing the worksite. In an enclosed space heat and noise will become trapped in the space with the worker. For example, if it is a hot day and a car is parked in a vacant lot the temperature in the car will rise to dangerous levels. Noise will be bounced off the walls of the space, much like an echo in a cave, and if done at high enough decibels then it can cause hearing loss. The space could become flooded with a material that could suffocate the worker, like someone working on a pipeline being flooded by water because of a failure to secure some aspects of the site. Securing the site properly means making sure that all equipment in the vicinity of the space is locked down and disconnected from the power source to prevent accidental activation.

The process of securing the work site is called lock down and tag out. This procedure ensures that it is impossible for machinery or equipment to turn on while it or areas near it are

being serviced. The power source is disconnected no matter what it may be, hydraulic, steam, electricity, etc., and the switch or valve release that would turn it back on is locked in place with a tag on it that states the employee's name that put the tag on and in some cases where or why they have locked it. This is so any personnel unaware of the work being down cannot turn on the machine while workers are inside. Even so the area must still be marked off so people do not wander into the area. One example, is when workers must enter the sewers or storm drains they establish bars and/or orange traffic cones around the manhole they are preparing to enter. This allows passersby to see that there is a potential hazard ahead and prevents them from falling into it. All personnel are required to make certain that no one is still within the area when they reconnect the energy and unlock the switch. The standards and regulations for lock down and tag out procedures are covered by OSHA in CFR 29 1910.147 subpart J. If any of these hazards start to occur or are present then immediate evacuation or retrieval is necessary. Rescue teams need to be assembled by trained team with appropriate equipment for the emergency.

Since confined spaces are as hazardous as they are without any major factors, rescue operations are typically much more difficult and require quick and precise action. The area is more than likely poorly lit and may be compromised of all the prior hazards. Madigan (2017) exclaims that "Approximately sixty percent of fatalities involve would-be rescuers, and more than thirty percent of fatalities occur in a space that has been tested and found to be safer to enter" (p.193). This means that around two-thirds of teams sent in to rescue personnel trapped in a confined space died as a result of underestimation of the situation and one-third of them died in an area that had been approved through testing to have been safe. It is difficult to determine accurate numbers because, as Madigan (2017) further explained, many states in the U.S. do not note the presence of confined spaces in incident reports submitted to OSHA (pp.193-194, 2017).

Regardless of the numbers, personnel and rescuers must be extremely careful, calm, and observant when in confined space emergencies. There are classifications of rescue concerning confined spaces and they are self-rescue, nonentry rescue, and entry rescue. Self-rescue is when the person in the hazardous area is able to escape on their own. They might notice something wrong or the personnel outside the area monitoring may notice concerning readings and inform the personnel that they need to exit immediately. This is the preferred means of rescue since it is before the incident escalates to the point where it becomes even more dangerous. Nonentry rescue is means to retrieve personnel without anyone else entering the area. This is the next preferred method of rescue as it puts no further life in danger. Nonentry rescue is conducted using various tools, such as ladders, ropes, harnesses, and many other devices to allow trapped personnel to escape either by them climbing out or being pulled out. An example of this would be some people who become trapped in cave-ins are usually using nonentry rescue techniques. Entry rescue is to used if all other methods fail. Entry rescue involves someone entering the area, usually via rope, ladder, or whatever may be necessary, to extract the personnel. Since this method means someone is entering the hazardous area the all hazards need to be reassessed so those entering do not fall victim to any hazards.

The equipment used by the rescuers will vary depending on the hazards present. Commonly used pieces of equipment are a way to ventilate the area, a wristlet attached to a rope, a full body harness, protective clothing, a breathing apparatus, headgear, explosion proof lighting, air monitoring devices, and a rope and winch pulley system. The wristlet, harness, rope and winch pulley system are retrieval devices to help rescuers in and out of the area. The ventilation is used to clear the air in the area from hazardous gases, vapors, or fumes and the air monitoring devices ensure that the air is stable at safe levels. The protective clothing, breathing

apparatus, and headgear are used to protect the rescuer while the explosive proof lighting provides light for the rescuer to properly see their surroundings without igniting any lingering gases or vapor. In some fields of industry, like mining, the retrieval is too much for the onsite trained personnel and specially trained and equipped rescue teams should be called in.

Urban search and rescue teams are task forces that are used to locate, extract, and provide medical stabilization of victims trapped in structural collapses due to natural disasters, mines, and collapsed trenches (Madigan, 2017, p.196). These task forces are comprised of fire departments, law enforcement, federal and governmental agencies, and private companies so that there are highly trained personnel that can mobilize quickly for an incident. Madigan describes that urban search and rescue teams are designed to be able to handle many complex situations and provide support for each other to provide the best results. Madigan (2017) stated that

> USAR Teams bring together, in an integrated response: highly trained personnel from emergency services along with engineers, medics, and search dog pairs, specialized equipment effective communications established methods of command and control logistical support procedures to request international if required under an international search and rescue framework (p.197).

Since they are so complex and capable they are able to maneuver manpower, equipment, and resources wherever they are needed in shorter periods of time.

Urban search and rescue teams are self-reliant and can operate without any outside assistance for the first seventy-two hours of deployment. In that window of time, these task forces go through three distinct phases that consist of studying the incident, actively searching for the trapped individuals, and rescuing them. The first phase is crucial to assuring the team

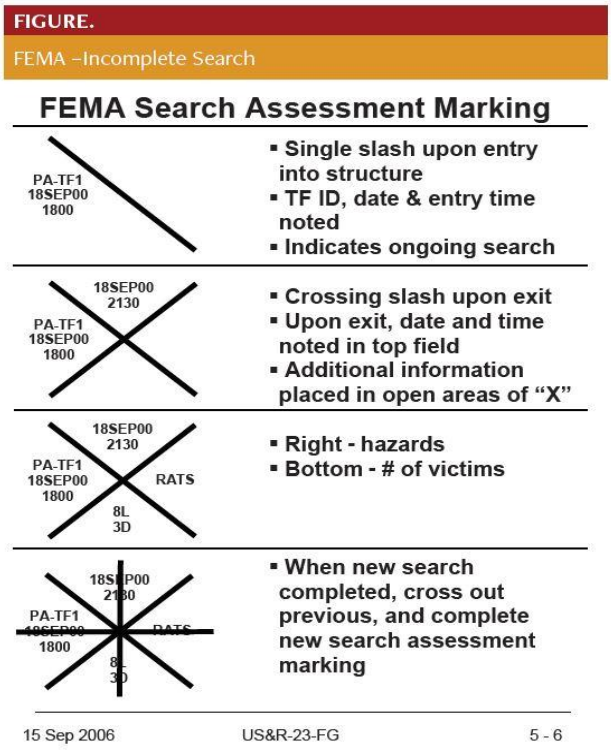
members do not become injured or killed while searching and rescuing the subjects. They look at the structural integrity of the area, what other hazards may have changed or presented themselves, and what resources they have readily available to them at that moment. This provides the team with valuable information on how dangerous the area still is and how to proceed with the safe retrievals of the subjects. In these cases, the subjects refer to the trapped individuals since the prior term used, victims, was determined to be inappropriate. This phase only terminates after the rescue teams have concluded that all subjects are extracted and the rescue teams have ended the search effort.

The second phase is the search phase where teams are dispatched to find voids and spaces where individuals could be trapped in. The searchers goal is to find these voids and figure out if anyone could be in that space. Members are dispatched into teams of two or more depending on the search area size, resources available, and potential hazard of the area. Madigan (2017) describes three search patterns that are used in search and rescue "triangulation (using three searchers approaching a potential area of entrapment from three different directions), a right/left search pattern (one team searches the left side, and one team searches the right side of the building), or a bottom-up/top-down search pattern" (p.199). The spaces could be as big as a house or as small as a bathtub depending on the layout of the building and the extent of damage in that area of the building. Commonly people will be found in voids where multiple floors collapsed on top of one another diagonally, where one wall has fall on another, or inside or underneath an object that protected them from debris. When an area has the potential to contain someone or has signs of containing someone, yelling from the void, light from a source that they are controlling, visibly seeing into the space, or other means, the members that find it must communicate this information to other teams so that the proper assistance can be provided. Noise

is particularly helpful to searches so during the search team members stop periodically to listen for subjects or other searchers. Once teams have notified other members of the void or the subjects they have found then a rescue team is sent to that location to relieve the searchers so they can continue with their work. Rescue teams are trained to identify the best means of extricating the subjects without excessive difficulty. To safely free the subject, debris must be removed from the to create an exit.

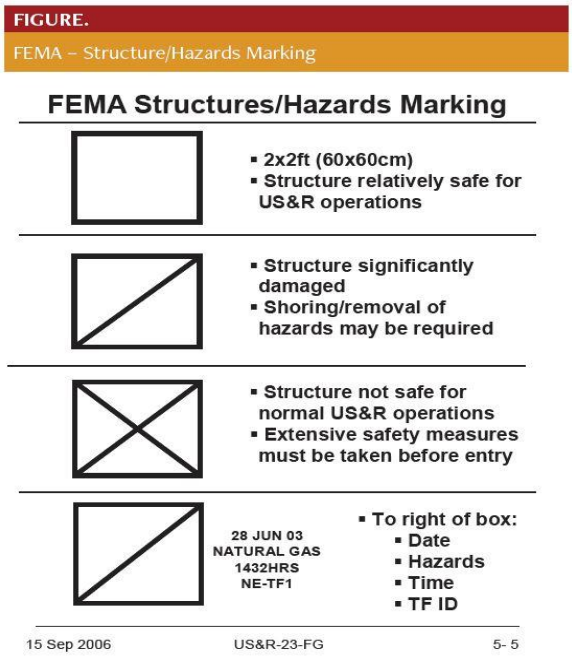
Removing the debris takes time and is a delicate process since the pieces in the way may be what is holding other pieces back and maintain the stability of the void. The common practice used to remove debris is known as leveraging and cribbing. Cribbing is a technique used by creating a frame, mainly of wood, to replace the pieces of debris that are removed. This creates a hole for the subjects to escape through without disturbing the fragile integrity of the void's walls. The two techniques can be used separately or combined to guarantee the chance of success. Once an area has been searched, markings are established to inform searchers that the area has already been searched and whether or not the area is still safe. The Federal Emergency Management Agency, also known as FEMA, has created a marking system to communicate time and date that the rescue team left the structure, hazards that are present, rescue team involved, and the number of live and dead individuals found in the structure.

Figure 1



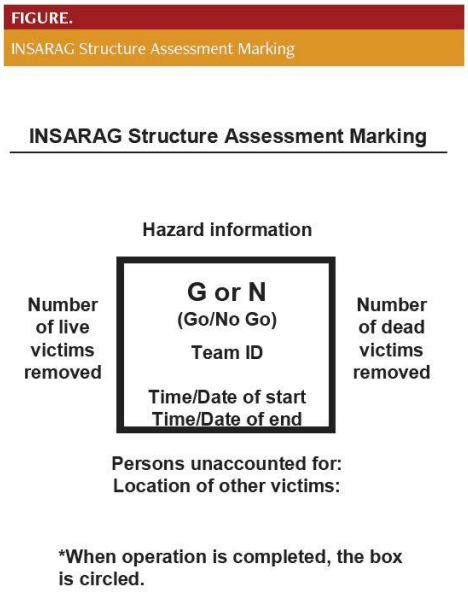
(Rogers, Arshad, & Lenz)

Figure 2



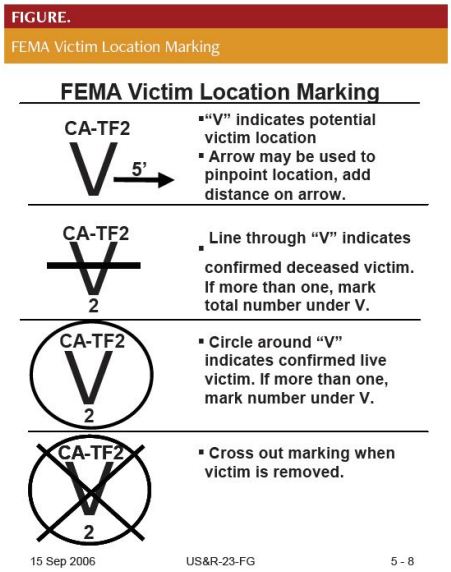
(Rogers, et.al.)

Figure 3



(Rogers, et.al.)

Figure 4



(Rogers, Arshad, & Lenz)

Time is a valuable resource that can not be wasted, so the marking system helps prioritize the scene.

> Urban search and rescue use the concept of "the golden day." The chance of extricating a casualty alive drop dramatically after 24 hours. However, there are reports of casualties surviving after being entrapped for 6 days and longer. Efforts should not be delayed or abandoned after 24 hours. (30 minutes 91.0% survive, 1 day 81.0% survive, 2 days 36.7% survive, 3 days 33.7% survive, 4 days 19.0% survive, 5 days 7.4% survive) (Rogers et al., n.d., para.7)

The window for success is a rapidly fading one and can not afford missteps or mistakes. Once an individual is found and rescued then they are treated for their injuries by onsite medical personnel if they sustained non-life threating injuries. Those in critical condition are attended to first and prepped for relocation to a nearby medical facility treatment. The onsite medical personnel are then to stabilize as many people as possible, so the techniques used are to stim bleeding and reduce pain or swelling. At the minimum someone will receive gauze wrapping and some minor stitching if necessary. Others may require different treatment methods, so medical personnel carry oxygen tanks, crude splints, and IVs. They may also carry defibrillators, but because of the urgency of the situation they may not have the time to try and revive someone.

Fall Prevention

In workplace there are a number of different hazards that are more obvious than others due to the use of safety signs to indicate what and where the hazards are. A hazard that is often over looked by its harmless demeanor is a fall. When looked at in terms of safety priority, fall prevention typically is viewed by all as any safety measure that insures that workers at higher elevations do not fall, but as a fall prevention in the safety field is not so narrowed. The most common type of workplace hazard is a slip, trip, or fall and because this can happen at any elevation any worker can fall victim to it.

> Universal slip, trip and fall culprits include unattended spills, wet floors, exposed cords, unstable work surfaces, uneven floors, loose rugs and cluttered areas. Inclement weather conditions, such as rain, snow and ice, create outdoor slip hazards on exterior steps, ramps, walkways, entry and exit areas, and parking lots, and indoor hazards when wet floors are not cleaned up promptly (Maurer, 2019, paras.4-5).

Due to the variety of hazards that could cause someone to fall and the number of fatalities or injuries caused by falling incidents, OSHA acted and created Subpart M in 29 CFR 1926.500 through 1926.503 to make standards for fall prevention. Under these standards employers are to reach a conclusion on whether the "walking or working surfaces have the necessary strength and structural integrity to safely support the workers" before work can begin (The U.S. Department of Labor, 2015, p.2). The decision lies with the employer on what safety systems are to be implemented for their workers. Failure to properly equip the workers with the appropriate systems before starting the work can result in fines, that will vary depending on the severity of the number of systems neglected, and in the worst cases injury or death of workers. The purpose of fall prevention systems is to prevent workers from falling, to catch or halt those who have fallen, or to slow their descent.

Fall prevention systems must be implemented in working conditions "6 feet or greater above a lower level and at heights of less than 6 feet when working near dangerous equipment, for example, working over machinery with open drive belts, pulleys or gears or open vats of degreasing agents or acid" according to The U.S. Department of Labor. Some general safety systems put in place are guardrails, safety nets, and personal fall arrest systems. These systems can be implemented separately or used all together depending on the discretion of the employer. Guardrails are designed to keep workers from falling over the edge of the working surface. The

best use of guardrails are on surfaces where there are definitive walking spaces, that are level, for workers to use. An example of this would be catwalks. 29 CFR 1926.502(b) describes the appropriate layout for how the rails are to look and function. Samples of the specifications include 29 CFR 1926.502(b)(1), which defines that the top rails are to be forty-two inches, plus or minus three inches, above the walking or working level. According to Roser et al. (2013), the average male height is 171 centimeters, or about five foot six inches tall, and women are about 159.5 centimeters, or about five foot two inches tall. Since the guardrails are required to be forty-two inches tall, that would mean they are slightly taller than the average man's hips, making it difficult to simply fall over the rail unless assisted by another force. The structural integrity and height of guardrails makes them ideal for fall prevention, but if someone does fall then there would need to be another safety system in place.

Safety nets are used to catch personnel or light pieces of equipment and materials that happen to fall off the edge of the working surface. According to 29 CFR 1926.502(c) (1-3) proper installation safety nets include that they should be no more than thirty feet under walking or working surfaces, if the net is under a bridge then it should be unobstructed, and the net should have sufficient clearance beneath the it to prevent a falling body from striking something beneath the net. This insures that the person falling will not be harmed while falling into the net or when caught by the net. The only function of the net is to safely catch individuals who have fallen off the working platform or surface, and thus need to be well maintained and tested before use as a safety device. A drop test is required for all newly installed nets to ensure that installation was done properly and that the net is rated to handle the force a falling person.

OSHA regulations 29 1926.502(c)(4)(i) states that safety nets and safety net installations shall be drop-tested at the jobsite after initial installation and before being used as a fall

> protection system, whenever relocated, after major repair, and at 6-month intervals if left in one place. The drop-test shall consist of a 400-pound (180 kg) bag of sand 30 + or - 2 inches (76 + or - 5 cm) in diameter dropped into the net from the highest walking/working surface at which employees are exposed to fall hazards, but not from less than 42 inches (1.1 m) above that level. (Department of Labor, n.d., para. 29)

There is one exception to this rule and that is if the employer or a competent minded person can demonstrate that a drop test is implausible to perform and that the installation of the net and the net itself adhere to the standards and regulations set forth by OSHA. Checking for damage or deterioration at least once a week and removing any tools, materials, and other foreign bodies from the net as soon as possible preserves the nets status as a safety device.

The final conventional system used to protect a worker form a fall is the personal fall arrest system. Unlike the previous methods, this method is meant to be used on a single personal only and is meant to act as a safety line. The device has multiple components meant to keep the worker from falling by tethering the worker to an anchor point that is study and structurally stable enough to hold the weight of the individual. The components required are anchorage, connectors, and a body harness, but can also include a lanyard, deceleration device, and lifeline. This is also known as the ABCs of the personal fall arrest systems, Anchorage, Body harness, and Connection points. Under no circumstances are body belts, or safety belts, to be used as part of the fall arrest system as stated in Subpart M. Safety belts do not provide the same protection that body harnesses do. When someone falls while using the fall arrest system, the weight of their body is distributed with the body harness whereas the safety belt offers one point of contact that will absorb the force of the fall, causing more bodily harm than needed. Safety belts can however be used in tandem with a positioning device in certain circumstances.

Positioning devices are used to suspend personnel at certain elevations so that they can work without limiting themselves by having to hold themselves in position. There are certain parameters that must be met by personnel that are attempting to use positioning devices. Examples of this, according to 29 CFR 1926.502(e)(1) and 29 CFR 1926.502(e)(2), are that these systems are to allow personnel to fall no further than two feet and must be able to withstand and support at least twice the potential impact load of a workers fall or three thousand pounds of force. “In determining this force, consideration should be given to site-specific factors such as the force generated by a person (including his/her tools, equipment, and materials) walking, slipping, tripping, leaning, or sliding along the work surface” (The U.S. Department of Labor, 2015, p. 14).

In addition to the fall protection systems in place there are warning line systems, controlled access zones, and safety monitoring systems. These systems are involved with keeping personnel away from high hazard areas of the worksite so they do not need to follow the standards listed previously. The systems keep untrained or under equipped personnel from ever coming close to the restricted sections of the jobsite. How this is achieved is by erecting barriers that are designed to be highly visible and distinguishable from all other surrounding items. These barriers are set up six feet away from the edge of the roof or other fall hazard and usually made from rope, chains, or wire that hold signs that warn personnel that beyond that point there are potential fall hazards. The guidelines are covered by 29 CFR 1926.502(f)(1-2). The idea is to give ample and obvious warning to personnel entering the area in case they unaware of the danger areas of the jobsite. Beneath the worksite canopies must be erected if there is a risk of falling objects on passersby. This is similar to the safety nets but are not designed to catch heavy objects. The canopy is strictly to stop smaller objects that fall through the safety net from hitting

anyone below. It can be made of anything as long as it is able to stop objects from passing through it. The most common materials used are fine mesh nets and metal or wood roofing.

Conclusion

In the competitive workforce there are any number of ways employers can take to ensure that they rise and stay at the top. Cutting corners on safety features to increase profits are not one of the ways to achieve this goal. Implementing certain standards can indeed slow production with their tedious nature and their constant need for testing and training, but the rewards far outweigh the losses. The employees are the backbone of the company and without them there would be little to no amenities that people enjoy today. For this reason, safety concerns should be at the forefront of all industry heads. Upholding safety standards and regulations for handling and transporting hazardous chemicals, ensuring that employees have been trained and equipped with the proper devices to manage emergencies until first responders arrive, and training them to detect potential hazards are all important aspects to safeguarding employee health. Proper management of safety standards means no loss of life and efficiency in the workplace. Whether a fire occurs, employees are tasked with handling hazardous chemicals or biological agents, or first responders are reacting to the scene to help the afflicted area and evacuate people to safety, all individuals involved are prepared for whatever the situation may be. Employers and personnel are there for one another to deal with any physical or mental threats that may be present. As the times change and technology advances so to will the standards of safety, because however the times may change an individual’s well-being should never and will never be out-weighed by greed or laziness. New procedures and technologies will be developed to maintain the pace of the ever growing and rapidly advancing world.

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