An Analysis of Employee Perception of Industrial Hygiene Equipment at Company XYZ

By

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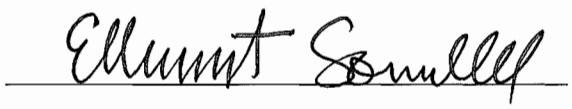

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ABSTRACT

The purpose of this study was to analyze employee perception of industrial hygiene equipment at Company XYZ. The study focused on the wet-bulb globe temperature monitor and multi-gas detector. Both of these instruments were commonly used by employees at the facility at the center of this study. The scope of this study included identifying the factors affecting perception of the instruments and potential methods of improving that perception.

A review of literature indicated the potential for the concepts of risk communication, risk perception, organizational development, and safety culture/climate to influence perception of these instruments. A written survey was distributed to employees in work groups who commonly used the two instruments. The survey

included a section on the wet-bulb globe temperature monitor, multi-gas detector, and safety culture/climate.

The data collected through the employee survey revealed that employee perception of these instruments was influenced by personal experience, knowledge of a heat stress or confined-space entry event happening to a peer, or a lack of knowledge related to how the instruments functioned. Many employees felt that their perception of the instruments would be improved through additional training. Several recommendations were developed based on the data collected through the employee survey.

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Chapter I: Introduction

Risk is the probability or the possibility of loss (Adams and Smith, 2001). It is often described as the product of the severity of the expected loss and the probability of that loss occurring. Organizations often attempt to mitigate the effects of risk through a risk management system. Risk management systems are concerned with identifying and treating risk across the areas of personnel, property, and liability. Risks involving personnel include occupational injuries and illnesses. Property risks involve the material goods, equipment, products, and real estate belonging to an organization. Risks of liability arise from the possibility of an organization being held responsible for its actions or lack thereof. All organizations face risk in the course of conducting business; however the risks faced may be different for all organizations. Many organizations use risk control or risk financing techniques to limit the impact of events on the organizations profitability and ability to survive. Aspects of these techniques require careful communication of information in order to achieve the desired affect.

Risk communication is the exchange of knowledge and ideas about hazards between those that make decisions and those affected by those decisions (Lundgren & McMakin, 1998). For various reasons organizations often communicate known risks to their employees and contractors. In industry, risk communication is used to inform employees about safety and health risks present in the workplace. This communication is done to align employee behaviors with established standards with the goal of preventing losses. Some risk communication is required by laws such as the Comprehensive Environmental Response, Compensation, and Liability Act or the Occupational Safety

and Health Administration Hazard Communication Standard. This type of communication is known as direct communication (Geller, 2001). Risk communication also takes an indirect form in signs, posters, and management actions (Lundgren & McMakin, 1998). Risk communication can be divided into the categories of care communication, consensus communication, and crisis communication. Care communication involves the dissemination of information to employees concerning known hazards and established standards. Consensus communication is used in the safety planning and decision making process. Finally, crisis communication occurs during an incident such as a large chemical spill.

Risk communication can affect the perception of risk and behaviors associated with that risk (Gerrard, Gibbons & Reis-Bergan, 1999). At the same time, this perception can be affected by a number of other factors including knowledge, experience, personality, position within the organization and several perception biases (Cutter, 1993). These biases include the optimistic bias, availability bias, compression bias, and miscalibration bias (Adams & Smith, 2001). Perception biases tend to lower an individual's estimate of risk associated with an event. On the other hand, an individual's estimate of risk can be increased by the factors of attitude and emotional response (Finucane, Peters, & Slovic, 2003 as cited by Pauley et al., 2008) or a lack of familiarity with or feeling of dread toward and event (Slovic, Fischhoff, & Lichtenstein, 2000 as cited by Pauley et al., 2008). In addition, the characteristics of risk itself can produce an elevated estimate of risk (Adams & Smith, 2001). The characteristics having the most impact are frequency, severity, controllability, and timing.

Studies have shown that experts in a particular field tend to perceive hazards as less risky than non-experts (Wright, Pearman & Yardley, 2000; de Rhodes, 1994). Gaps between expert and non-expert perception of risk may lead to decreased level of trust between the two parties (de Rodes, 1994). This is common in the relationship between the scientific community and the general public. However, this can occur within an organization when employees do not fully understand the information used to assess risks. For example, employees may not understand the analysis of industrial hygiene sampling that allows for an acceptable exposure dose of various industrial chemicals.

In organizations, this decreased level of trust can have a negative effect on the organizations culture and climate related to safety (Harvey et al., 2002). The trust of employees can also be lost during times of organizational change. This change often occurs as a result of organizational development efforts (Wheatley et al., 2003). Employee trust in an organization has been linked to total business performance, including but not limited to safety performance (Barfield, 2005). A reduced level of trust can limit the effectiveness of risk communication (Lundgren & McMakin, 1998). Burns et al. (2006) described trust as a central component of safety culture. Safety culture is deeply engrained set of values and beliefs (Mearns & Flin, 1999). Safety climate on the other hand, is a current picture of an organizations state of safety.

Industrial hygiene is the science of measuring, evaluating, and controlling environmental factors in the workplace that have the potential to cause injury or illness (Plog & Quinlan, 2002). At Company XYZ, employees and contractors often perform their own industrial hygiene monitoring during the task planning stage, directly prior to the task, and while performing the task. Two common industrial hygiene monitoring

tasks at Company XYZ are heat stress and confined-space air analysis. Heat stress monitoring is performed using a Wet-bulb Globe Temperature (WBGT) Monitor. This system was developed by the United States Army in the 1950's and is considered the standard way to measure heat stress environments. The WBGT monitor is capable of measuring the air temperature with a dry-bulb thermometer and a wet-bulb thermometer, sources of radiant heat with a globe thermometer, and relative humidity (Plog & Quinlan, 2002). It is designed to estimate the effects of temperature, humidity, air movement, and radiant heat sources on humans. The wet-bulb globe temperature is equal to:

Outdoors = 0.7 wet-bulb + 0.2 globe thermometer + 0.1 dry bulb

Indoors = 0.7 wet-bulb + 0.3 globe thermometer

Air monitoring is conducted as part of the confined-space entry procedure of Company XYZ. This sampling is performed using a Multi-gas Detector (MGD) capable of detecting the presence of carbon monoxide, hydrogen sulfide, oxygen, and a variety of flammable gases (Hagg, 2006). Carbon monoxide and hydrogen sulfide are toxic chemicals that can cause severe illness or death. Reduce oxygen levels may affect mental function and can be fatal. Increased oxygen levels and the presence of elevated levels of flammable gases increase the risk of a fire or an explosion. Employees receive training on the use of the MGD as part of confined-space entry training. Training related to the use of the WBGT monitor is more limited and is generally done on an as-needed basis.

Measurements conducted using the WBGT monitor and MGD, reveal the condition of the work environment. It is important that employees have confidence in these instruments and trust the measurements provided by them. The WBGT monitor helps employees establish a stay-time/recovery-time pattern that will minimize the

possibility of heat-related illnesses. At Company XYZ this pattern is based on recommendations by the American Conference of Governmental Industrial Hygienists. The MGD is used to determine whether it is safe for an employee to enter a confined-space. Unacceptable readings of carbon monoxide, hydrogen sulfide, oxygen, or flammable gases require the use of a forced-air ventilation system and additional monitoring before entry into the space. Once in the confined-space, the MGD will alarm if conditions change. It is vital that employees trust the MGD and respond to the alarm immediately.

Statement of the Problem

Job tasks at Company XYZ require frequent use of a wet-bulb globe temperature monitor and portable multi-gas detector by employees and supervisors. The measurements provided by these devices are vital to performing these tasks in a safe manner, yet many employees have a reduced level of confidence in the equipment and the measurements they provide.

Purpose of the Study

The purpose of this study was to determine the underlying issues and concerns of employees of Company XYZ related to industrial hygiene instrumentation and the measurements provided by it. A survey of employees examined attitudes and perceptions related to the WBGT monitor and MGD. The scope of this study focused on ways to improve employee confidence in this equipment.

Research Questions

The study answered the following questions:

1. What factors affected employee perception in industrial hygiene instruments at Company XYZ?
2. How was the perception of these instruments formed?
3. In what ways is this perception linked to the organizational or safety climate?
4. How can employee perception of the WBGT monitor and MGD be improved?

Importance of the Study

This study is important because it may:

1. Improve employee confidence in industrial hygiene instrumentation. This can reduce an employee's level of job-related stress and influence risk perception.
2. Improve the compliance of procedures related to confined-space entry and working in heat-stress environments at Company XYZ. Compliance with established procedures minimizes the potential for an injury or illness to occur.
3. Demonstrate the need for additional research in the area of employee confidence in industrial hygiene instrumentation. This study may also identify a need for further investigation into specific aspects of Company XYZ.

Limitations of the Study

The limitations of this study are:

1. The scope of this study included only employees and contractors of one facility owned and operated by Company XYZ. The applicability of these finding to other facilities or companies is unknown.
2. The survey focused on those employees and contractors who have used the WBGT monitor and/or MGD to determine safe work conditions or have worked under the recommendations of another employee, contractor, or supervisor based

on instrument readings. These employees were concentrated into a handful of occupational groups.

3. The results of the survey may require further research at Company XYZ. A clear picture of the factors affecting employee confidence in these instruments may not be established.

Definition of Terms

Availability Bias – The tendency of people to overestimate those risks that are easily remembered. (Adams & Smith, 2001)

Compression Bias – the tendency to "overestimate rare risks and underestimate common ones." (Adams & Smith, 2001, p. 747)

Industrial Hygiene – The science of measuring, evaluating, and controlling environmental factors in the workplace that have the potential to cause injury or illness. (Plog & Quinlan, 2002)

Industrial Hygiene Monitoring – The act of measuring and evaluating environmental factors in the workplace that have the potential to cause injury or illness. (Plog & Quinlan, 2002)

Miscalibration Bias – The tendency of people to overestimate size and correctness of their own knowledge. (Adams & Smith, 2001)

Optimistic Bias – The tendency of people to underestimate the likelihood of being personally involved in a hazardous event or developing a condition. (Avis, Smith & McKinlay, 1989)

Risk Communication – Conveyance of information related to environmental, safety, and health sources of possible loss. (Lundgren & McMakin, 1998)

Safety Culture – A set of "values, beliefs, legends, rituals, mission, goals, performance measures…that translate into a system of expected behavior" related to safety and health. (Manuele, 2000, p. 18)

Chapter II: Literature Review

The purpose of this study was to identify the factors influencing employee perception of industrial hygiene instrumentation. Once identified, knowledge of these influencing factors may improve confidence in these instruments. These improvements should reduce job-related stress, improve compliance with related procedures, and improve the safety culture at Company XYZ.

This section will introduce concepts related to employee perception of risk and industrial hygiene instruments and their measurements. Those concepts include risk communication, perception of risks and hazards, biases that influence perception of risk, organizational development, employee trust in organizations, and safety culture/climate. Several of these concepts are related and often influence one another.

Risk Communication

Risk communication is the exchange of knowledge and ideas about hazards between those that make decisions and those affected by those decisions (Lundgren & McMakin, 1998). Risk communication occurs in several different forms across the areas of environmental, safety, and health. Lundgren and McMakin (1998) divide risk communication into the categories of care, consensus, and crisis communication. In industrial settings care communication involves informing employees about safety and health risks in the workplace. Consensus communication is part of the decision making process surrounding risks. This type of communication occurs when organizations develop new safety standards and involve employees in the process. This form of communication involves a greater amount of stakeholder participation than care communication. Finally, crisis communication occurs during an accident or dangerous

event. In an industrial setting, crisis communication could involve information provided to employees during and after a large catastrophic event such as a chemical spill. These events often involve all employees in evacuation or emergency response procedures. Crisis communication informs employees of the action they are expected to take during and after the event.

Purpose. The purpose of communicating risks to employees can vary. Communication related to risks and hazards is often required by law. The Community Right to Know Act requires companies that use hazardous chemicals to inform local residents about the chemicals in their community as well as establish an emergency plan (Emergency Planning and Community Right to Know Act, 1986). The Hazard Communication Standard of the Occupational Safety and Health Act requires an employer to inform its employees about chemical and physical risks in the workplace (Hazard Communication: Foundation of Workplace Chemical Safety Programs, 2009). In 2006, OSHA released an advanced notice of proposed rulemaking indicating the agency's intent to move the Hazard Communication Standard into closer alignment with what is known as the Globally Harmonized System. The Globally Harmonized System of Classification and Labeling of Chemicals was adopted by the United Nations in 2003. The system created uniform rules for chemical hazard classification, labeling, and material safety data sheets. The purpose of the system was to create consistency in a global market place to improve communication of chemical hazards. Some states have individual programs that include additional hazard communication requirements and suggestions. For example, Minnesota has the "A Workplace Accident and Injury Reduction" Program, better known as AWAIR (An Employer's Guide to Developing a

Workplace Accident and Injury Reduction Program, 2009). Under the AWAIR Program, employers must establish a plan to identify, analyze, and control existing and future hazards in the workplace. Employers must also effectively communicate to hazards to employees. The AWAIR Program encourages employers to communicate safety and health issues to employees at the beginning of a new job assignment, when a change within the facility has occurred, and when the employer observes substandard work practices.

Organizations often communicate risk and provide safety related training for the purpose of influencing employee behavior in a positive way or affecting an employee's perception of hazards. Vecchio-Sadus (2007), found that risk messages have the ability to improve employee knowledge and influence behaviors. According to Adams and Smith, (2001) the main purpose of informing individuals about risk is to encourage a change in behavior that limits exposure to hazards. Weinstein found that risk communication had the ability to alter the perception of risk (as cited by Gerrard, Gibsons, & Reis-Bergan, 1999). These concepts are common to programs such as behavior-based safety.

Behavior-based safety. Behavior-based safety programs attempt to minimize accidents and incidents by centering attention on the actions of employees within an organization (Geller, 2001). This focus is justified by the fact that human behavior is an underlying cause of most accidents and incidents. This concept grew out of the early work of H.W. Heihrich (as cited by McKinnon, 2000). After studying accident records while working for a large insurance company, Heinrich concluded that 88% of all industrial accidents were caused by unsafe acts. Similar research by Du Pont has

concluded that 96% of all injuries were caused by unsafe acts (McKinnon, 2000). Krause et al, (1990) claimed that 80% to 95% of accidents are a result of a person's behavior. The authors describe behaviors as the "final common pathway" for incidents to occur (p. 12). Many substandard acts or substandard conditions lead up to almost every accident, but behaviors are the pathway those factors take to combine and produce an incident. Under the system proposed by Krause, measurement of critical safety behaviors through observation leads to a change in behavior and attitude, and creates predictability within an organization's safety management system (Krause et al,. 1990).

Direct vs. indirect communication. Companies communicate risk to their employees both directly and indirectly. Classroom training is a highly formal, direct form of communication. Other methods of direct communication include safety meetings, company newsletters, department meetings, pre-job briefs, and site-wide emails. Indirectly, organizations communicate matters of risk and safety though the safety artifacts such as signs and banners. A study by Luria and Rafaeli (2008) found that employees interpret safety signs as having both a functional and a symbolic meaning. The functional meaning is often a literal interpretation of the signs symbols and text. A sign that reads "Safety Glasses Must Be Worn in This Area" means that employees are required to wear safety glasses while working in the area delineated by the sign. The study (Luria & Rafaeli) demonstrated that the employee's understanding of the symbolic meaning of safety signs fell into one of two categories. First, some employees felt the signs were only in place because they were required by occupational safety and health laws. Second, the remaining employees felt that the signs were in place because the company was fully committed to the safety of employees. Not surprisingly, the

researchers concluded that the department in which employees interpreted signs as a commitment to safety also had a better safety culture/climate based on survey questions.

Organizations also communicate indirectly to their employees in non-verbal ways, through actions (Geller, 2001). The unwritten rules of an organization, the treatment of near-miss incidents, and even safety incentive programs demonstrate the level of organizational commitment to safety. Employee perception of this commitment is a major factor in safety culture and climate. In a study of construction workers, incentive programs were generally seen as not promoting safety (Gillen et al., 2004). Participants in the same study noted feeling pressure from implicit messages and non-verbal communication. In this case the messages were generally viewed as an emphasis on production and a lack of commitment to safety. One company that is particular effective at demonstrating its commitment to safety through actions is United Parcel Service (Trebswether, 2003). The company investigates incidents and near-misses with the intention of improving the processes without placing blame on an individual. The organizations incentive program recognizes long-term excellence among its drivers. Finally, the company demonstrates its commitment to safety by actively responding to employee safety concerns.

Limitations. Risk communication is often limited by an audience's opinion of the communicator, the risk message, and the risk assessment (Lundgren & McMakin, 1998). Risk messages often lose effectiveness because the communicator or organization is not viewed as credible. This happens often in the relationship between the scientific community and the general public. These messages may be downgraded further when audience view the risk assessment related to the message as too positive. Lundgren &

McMakin (1998) suggest that the concerns of an audience must be met before effective risk communication can take place.

Risk Perception

Human perception involves use of sensory information to recognize and interpret information. Perception of risk is more complicated than perception in general. People interpret risk along a spectrum that lies between the concepts of total risk avoidance and the weighing of risks and benefits (Mills, Reyna, & Estrada, 2008). Risk perception uses the same sensory information as general perception, but it is influenced by a person's experiences, cultural background, ethnicity, gender, proximity to the risk, and several perception biases (Cutter, 1993). An individual's estimation of the risks inherent to a given situation can be either higher or lower than that of an expert. Biases tend to create a lowered estimation of risk, while other factors can cause an increased estimation of risk. According to Finucane, Peters, & Slovic (2003) a person's attitude, emotional response can produce an elevated estimation of risk (as cited by Pauley et al., 2008). Similarly, Slovic, Fischhoff, & Lichtenstein (2000) showed a relationship between a lack of familiarity with and a feeling of dread toward a given situation and an elevated estimation of risk (as cited by Pauley et al., 2008).

A bias is a preference that influences perception or judgment. Bazerman (1994) describes biases as a "situation in which a heuristic is inappropriately applied by an individual in reaching a decision" (p. 12). Biases common to the perception of risk include the availability, compression, miscalibration, and representative biases (Adams & Smith, 2001). The availability bias occurs when people overestimate the probability of risks that are easily remembered. Bazerman (1994) has termed this bias, the ease of

recall. He also relates the bias of presumed associations to the availability bias. The bias of presumed associations occurs when individuals judge the probability of two events occurring at the same time based on the co-occurrence of those events in memories. The compression bias according to Adams and Smith (2001) is the tendency to "overestimate rare risks and underestimate common ones" (p. 747). In other words, people have difficulty in understanding risk across a range of probabilities. The miscalibration bias, explains the tendency of people to overestimate the size and correctness of their knowledge. Unfortunately, this can lead to a desensitization of individuals toward particular hazards. The representative bias or optimistic bias is the tendency of people to underestimate the likelihood of being personally involved in a hazardous event or developing a certain condition (Avis, Smith & McKinlay, 1989). This bias can produce an unrealistic estimation of probability and a reduced level of caution toward a hazardous event or behavior (Adams & Smith, 2001). Weinstein (1980), proposed that the amount of the optimistic bias applied to a given situation would vary according the characteristics of the event (as cited by Harris, Griffin, & Murray, 2008). The main characteristics named by Weinstein were the degree of dread, the estimated probability, the estimated controllability, and the ease of recalling a stereotypical sufferer of the event's consequences.

While biases generally cause people to judge objects or events as being less hazardous, other factors can cause people to judge them as more hazardous than an expert. A study by Hellesoy, Gronhaug, and Kvitastein (1998) investigated one facility and identified a group of people they termed "high hazard perceivers". The authors found high hazard perception to be connected to negative feelings and emotional states.

Harris, Griffin, & Murray (2008) also found that the estimation of personal risk was affected by differences between individuals. People who demonstrated higher anxiety or were easily threatened had higher estimates of their personal risk of being involved in a given event. High hazard perception is correlated to lower job satisfaction, higher burnout, anxiety, and depression (Hellesoy, Gronhaug, & Kvitastein, 1998). Harvey, et al. (2002), also found lower job satisfaction to be related to a higher perception of risk.

Beyond individual differences, the characteristics of risk may lead to an elevated estimation of personal risk (Harris, Griffin, & Murray, 2008). This can be driven by a reduced application of the optimistic bias. Harris, Griffin, and Murrary found that the perception of risk was most affected by the characteristics of frequency, severity, and controllability. Adams and Smith (2001) found a connection between risk perception and the same three factors as well as the characteristic of risk timing. Probability is simply the likelihood of an event occurring. Severity is more difficult to define, but is related to the impacts of event on organization or individuals. Risk assessment techniques attempt to assign a value to severity. Organization can sometimes define the severity of an accident or incident in terms of financial consequence or lost production. In general the definition of severity is subjective and can vary between organizations and cultures. People tend to be more afraid of events with high severity and low frequency than event with low severity and high frequency (Adams & Smith, 2001). The concept of controllability refers to a preference for risks that can be managed through actions. Having a choice in the matter affects the perception of hazards. Slovic described risks in which people feel they have no control as dread risks (as cited by de Rodes, 1994). These dread risks are usually associated with involuntary exposures. Timing refers to the

point at which adverse consequences of an event occur (Adams and Smith, 2001). Occupational injuries such as a broken bone have an immediate consequence, while occupational illnesses such as those related to chemical exposures often have a delayed consequence. Events with a more immediate consequence are perceived as having a greater severity. Finally, the work environment itself has also been linked to the perception of risk (Gyekye, 2006). In a comparison between mine workers and factory workers, mine workers perceived their work environment as more risky and hazardous.

Experts in a particular field tend to perceive risks differently than lay people (Wright, Pearman, & Yardley, 2000). In many cases, experts view hazards within their area of study as less risky than members of the public. Experts in general use more information and objective measures than lay people, who perceive risks more subjectively. A major issue in the expert vs. layperson debate is that laypeople have difficulty in understanding concepts of probability (Adams & Smith, 2001). In general, people understand verbal presentation of probability more than numerical ones. However, verbal presentations of probability are often open to some interpretation.

Organizational Development

Organizational development is the improvement of or increase in an organizations capacity to achieve its goals and objectives (Housden, 2000). It is a technique implemented within companies to manage change, reach goals, and initiate strategies (Wheatley et al., 2003). The practice of organizational development is based on "social psychology, group dynamics, industrial/organizational psychology, participative management theory, organizational behavior, sociology, and even psychotherapy" (Waclawski & Church, 2002; p. 7) If a system does not involve change, increase

effectiveness, and build capacity, then it is most likely another form of human resource management, not organizational development. The activities of encouraging innovation, motivating employees, and developing corporate strategy are all a part of OD (Housden, 2000). According to Housden, an analysis of OD strategies must consider the mission of the organization, the environment in which the organization functions, and the existing ability of the organization to accomplish its mission. Organizational development involves change within the organization (Wheatley et al., 2003). Often this change will affect the level of employee trust within an organization (Reina & Reina, 2004). Caudron (2003) also described the management of change as a major driver of employee trust in organizations. This has the potential to influence employee perception as well through the involvement of job satisfaction and burnout (Hellesoy, Gronhaug, & Kvitastein, 1998).

Employee trust. Employee trust involves a reliance on the actions and intentions of an organization by employees. Reina and Reina (2004) describe employee trust as the "key ingredient for organizational success". Employee trust in an organization affects the performance of that organization in the area of safety and beyond (Barfield, 2005). Reina and Reina (2004) proposed that employee trust requires conveying honest information to employees, especially during times of change. This requires clear and timely communication. Not only is trust driven by communication (Caudron, 2003), but trust in an organization affects an audiences acceptance of risk-related messages (Cutter, 1993).

Trust is a central component of safety culture (Burns, Mearns, & McGeorge, 2006). Reason described trust as a foundation of the subcomponents of safety culture (as cited by Burns, Mearns, & McGeorge, 2006). He proposed that a safety culture could be

developed by improving the subcomponents of a reporting culture, a just culture, and a learning culture. A reporting culture is an environment in which employees freely report errors and near misses without the fear of repercussions. In a just culture, clear distinction between acceptable and unacceptable actions and the appropriate consequence for unacceptable behavior have been established. An organization with an effective learning culture has the ability to use safety information correctly and the willingness to make changes based on safety information. These three subcomponents can only be maximized when employees trust the people and the systems of an organization.

Safety culture and climate. Safety culture is a subset of organizational culture. According to Manuele (2000),

> An organization's culture consists of its values, beliefs, legends, rituals, mission, goals, performance measures, and sense of responsibility to its employees, customers, and community, all of which are translated into a system of expected behavior (p. 18).

Safety culture is a complex and deeply engrained attribute of an organization (Mearns & Flin, 1999). Safety climate, on the other hand, can be described as a picture of a company's current state of safety. It identifies employee's attitudes, perceptions, and beliefs related to safety. Safety climate is apt to change more frequently than safety culture. The line between the concepts of safety culture and safety climate is often blurred (Mearns & Flin, 1999). Research into safety culture often measures attitudes and practices that are more easily attributed to safety climate.

According to Cullen (2000), safety culture is driven by corporate culture, objectives, and values. High quality safety cultures often share several common

attributes. The first is the attribute of management support for safety efforts. A study by Brown and Holmes, concluded that employee's perception of management attitudes and actions were vitally important to safety climate (as cited by, Mearns & Flin, 1999). This involved the perception of management concern for employee safety and activities related to responding to issues raised by employees. A quality safety culture should include a shared responsibility for safety across all levels of the company (Cullen, 2000). Employees must take personal responsibility for safety and not be afraid to coach their co-workers on safety issues. Next, a safety culture should feature open communication. According to Vecchio-Sadus (2007), "clear and constructive communication provides the mechanism by which knowledge and understanding can be improved to prevent at-risk behaviors and to enhance safety culture" (p. 9). It should be a two-way street in which employees can offer suggestions and report incidents without repercussions and are able to accept suggestions from supervisors and fellow employees (Cullen, 2000). Employees from all departments should actively participate in the safety program. Safety should be viewed as important to success of the organization. Finally, safety should be integrated into business as a whole. It should be seen as a function that is equally as important as productivity, quality, or customer service.

The E. I. DuPont de Nemours and Company has developed a safety philosophy that has allowed the company's facilities to enjoy high quality safety cultures and achieve an overall incident rate well below the industry average (Cullen, 2000). The DuPont safety philosophy includes the following ten principles:

1. Every injury is preventable
2. Management is responsible for preventing injuries

3. Exposures that have the potential to cause loss can be controlled
4. Employees have the responsibility to work safely
5. An effective safety program must include training
6. Audit should be use to determine the success of the safety program
7. Issues discovered during audits must be corrected as soon as possible
8. A total safety effort should include off-the-job safety
9. A quality safety program is a competitive advantage
10. People are the most important part of the safety program

Safety culture can vary between individuals groups within an organization (Harvey et al., 2002). In studies, the difference has been especially prevalent between line employees and management, although it has been noted between individual departments on the same employee grade. A study by Ibarra and Andrews, found that an employee's informal network of fellow employees affects his or her perception of the organization (as cited by Meyer, 1994). These informal networks include friendships, networks for the exchange of advice, and networks for consultation. Harvey et al. (2002) also concluded that a difference in perception often existed between line employees and management.

Gas Detection in the Work Environment

Confined space entry often involves the use of a multi-gas detector to sample the air in a work environment (Haag, 2006). Most multi-gas detectors measure four compounds – oxygen, carbon dioxide, hydrogen sulfide, and flammable gases. These gases are measured using electrochemical sensors with a catalyst, operation voltage, and filter combination designed to target the specific gas. The detector alarms when pre-

determined levels of air concentration are reached for one or more of the target gases in the work environment.

Gas detection began in the mining industry where the threat of methane, nitrogen dioxide, and carbon monoxide was common (Smith, 2005). The first gas detection devices were live canaries carried into the mine. Unusual behavior or the death of the canary signaled the presence of a hazardous atmosphere in the mine. In 1815, workers began using flame safety lamps to test the atmosphere of mines. The lamps were capable of detecting flammable gases and low oxygen levels.

Recent developments in gas detection include the use of photo-ionization detectors (PID) to measure gas concentrations (Haag, 2006). These detectors are capable of measuring a much wider range of compounds than electrochemical sensors. Photo-ionization detectors are especially useful for measuring volatile organic compounds. Another important innovation is the use of wireless transmitters to link multi-gas detectors to central computer systems. These systems save time and money.

Heat Stress

Heat stress refers to a set of conditions resulting from an exposure to elevated temperatures. In 2007 the Bureau of Labor Statistics report 30 deaths resulting from employee exposure to heat environments (Illnesses, Injuries, and Fatalities, 2007). Individual heat stress conditions consist of heat stroke, heat cramps, heat exhaustion, heat syncope, and heat rash (Heat Stress, 2009). Heat stroke occurs when the body loses its ability to control body temperature and it is the most serious heat stress condition. Heat cramps and heat exhaustion are related to excessive sweating and the resulting loss of body fluids and electrolytes. Heat syncope is a fainting episode related to heat exposure.

Heat rash is irritation of the skin due to prolonged sweating. An individual's response to heat stress environments can vary according to age, physical health, medications, hydration level, and acclimation to heat stress environments.

Measurement of heat stress environments must correlate to changes in core body temperature and other observable responses to heat stress (Wet-bulb Globe Temperature Index, 2008). Heat stress environments can be measured using a WBGT monitor or physiological monitoring of employees. It can also be estimated using metabolic rate tables based on activity level and clothing load or heat index tables (MacDonald, Shanks, & Fragu, 2008). Metabolic rate tables connect work rates to empirically established metabolic rates (Wet-bulb Globe Temperature Index, 2008). Heat index tables combine dry bulb temperature and humidity to provide an indication of thermal stress (MacDonald, Shanks, & Fragu, 2008). Physiological monitoring of employees measures an individual employee's core body temperature, heat rate, and rate of sweat production. Physiological monitoring is more invasive than measuring using a WBGT monitor or estimating the metabolic rate, but it provides an instantaneous picture of an employee's condition.

The WBGT monitor is the most used technique for measuring heat stress environments (Wet-bulb Globe Temperature Index, 2008). The WBGT monitor is capable of measuring the air temperature with a dry-bulb thermometer and a wet-bulb thermometer, sources of radiant heat with a globe thermometer, and relative humidity (Plog & Quinlan, 2002). It is designed to estimate the effects of temperature, humidity, air movement, and radiant heat sources on a person's response to the environment. The wet-bulb globe temperature is equal to:

Outdoors = 0.7 wet-bulb + 0.2 globe thermometer + 0.1 dry bulb

Indoors = 0.7 wet-bulb + 0.3 globe thermometer

The American Conference of Industrial Hygienists has established guidelines for working in heat stress environments based on WBGT readings (2009 TLVs and BEIs, 2009). The guidelines are designed to prevent the core body temperature of healthy workers who follow the guidelines from exceeding 100 degrees Fahrenheit.

Summary

A review of relevant literature suggests that employee perception of industrial hygiene equipment may be affected by risk communication, perception biases, employee trust, organizational development, and safety climate. Risk communication within an organization involves the delivery of risk-related messages to employees. Companies communicate risk to their employees both directly through verbal communication and indirectly through safety signs and posters. Indirect communication also occurs through the actions of management in handling issues of safety and risk. An individual's perception of risk can be higher or lower than the actual risk. Risk perception is increased by emotional state, attitude, and certain risk characteristics. The factors of severity, probability, timing, and controllability can directly impact risk perception. On the other hand perception of risk can be decreased by several biases and personal experience. These biases include the optimistic, availability, miscalculation, and representative biases.

Organizational development is an effort to increase the capacity of an organization to meet its objectives. These efforts involve some form of change that can affect employee trust. Employee trust has been described as a central component of safety

culture. Reason described trust as the foundation of the subcomponents of the safety culture. Safety culture is a part of an organizations values and mission, while safety climate is a current picture of employee perceptions, attitudes, and beliefs related to safety.

In many ways the concepts presented in this chapter are interrelated. Safety climate and employee trust influence the acceptance of risk messages communicated to employees. Perception biases influence an employee's judgment of risks and related messages. Managers should consider the affects of perception biases and tailor risk communication messages accordingly (Harris, Griffin, & Murray, 2008). Risk messages have the ability to change perception and influence behavior (Vecchio-Sadus, 2007), while changes in behavior have the ability to influence attitudes and improve safety culture (Krause, 1990). Organizational development is linked to safety culture through the importance of employee involvement conveyed in both systems. Finally, all of these concepts involve the people within an organization. The ideas of organizational development, behavior-based safety, and risk perception are centered on the behaviors and beliefs of people. Communication attempts to influence the actions and understanding of employees within an organization.

Chapter III: Methodology

The purpose of this study was to analyze the factors affecting employee perception of industrial hygiene equipment at Company XYZ. This study specifically investigated the WGBT monitor and MGD used by employees prior to and during job tasks. The scope of this study focused on identifying those factors affecting perception the most with the intention of determining methods for improving that perception. The goals of this study were to:

1. Determine employee perception of the WBGT monitor and MGD and the measurements these instruments provide.
2. Identify the factors leading to a negative perception of these instruments or the measurements provided.
3. Determine a method to improve employee perception of these instruments and the measurements provided.

This chapter will describe the methods and procedures used to conduct this study. A review of literature revealed the possibility of the factors of risk communication, risk perception, employee trust and safety culture/climate having an impact on employee perception of these instruments. Findings from the literature review were used to form the survey instrument. Included in this chapter is a description of the survey instrument, selection of subjects, data collection procedure, data analysis, and limitations.

Survey Instrument

The survey instrument used in this study was created in an attempt to answer the research questions proposed and gain perspective on employee perception of these instruments. The exact questionnaire can be found in Appendix A. The questions within

the instrument were developed after the review of literature. The instrument consisted of three main sections; Wet-Bulb Globe Temperature Monitor, Multi-Gas Detector, and Safety Climate, with a space provided for additional comments at the end of the questionnaire. Questions sought information related to employee perception of these instruments, the source of the perception, the communication of risk associated with these instruments, and aspects of safety climate.

Selection of Subjects

The sample population of the study was limited to one facility of Company XYZ. The population was further reduced to individual work groups within the facility based on the frequency of work group members using the WBGT monitor or MGD. Individual members of the work groups selected used the WBGT monitor weekly during the peak summer period and the MGD weekly throughout the year. The work groups included in the study population were radiation protection, mechanical maintenance, electrical, construction, laborers, chemistry, and operations.

Data Collection Procedures

Data was collected using a written questionnaire. Participants were given a copy of the written questionnaire and a consent form. The consent form described the purpose of the study, possible risks and benefits of the study, and informed participants that his or her involvement in the research was voluntary. Complete of the questionnaire implied consent to participate in the research project. The majority of the questionnaires were completed by employees during department meetings with the balance completed by individuals in the safety office of Company XYZ. Questionnaires completed during department meetings were distributed and collected by a member of the site's safety

department. Questionnaires completed in the safety office were also distributed and collected by the safety department when an employee who had not previously participated, checked out a WBGT monitor or MGD.

Data Analysis

Data collected through the use of a written questionnaire was analyzed for trends and correlations. The data was examined for potential correlation between a negative perception of one or both of the industrial hygiene instruments and the factors of:

- Risk communication related to the WBGT monitor and MGD
- Past experiences related to the WBGT monitor and MGD and associated job tasks
- Perception biases
- Safety culture or climate

Additional analysis of the data investigated the frequency of certain responses to selected questions. This technique was most utilized with questions from the safety climate section. Comments made by participants in the comment section were placed into categories and analyzed for patterns and similarities. Responses to individual questions, comments, and the review of literature were compared to identify ways to improve employee perception of the WBGT monitor and MGD.

Limitations

The results of this study are limited to one facility of Company XYZ. Validity of these findings to employees of other facilities or other companies cannot be determined without further research. Although the questionnaire was designed to extract the information needed to correctly answer the research questions proposed and a space was

provided for additional comments, the questionnaire may not have truly determined employee's perception of these instruments or the factors affecting that perception.

Chapter IV: Results

The purpose of this study was to measure employee perception of industrial hygiene equipment at Company XYZ. The study focused on a Wet-Bulb Globe Temperature Monitor and Multi-gas Detector used by employees on a regular basis. The research questions proposed for this study were:

1. What factors affected employee perception of industrial hygiene equipment at Company XYZ?
2. How was the perception of these instruments formed?
3. In what ways is this perception linked to the organizations safety culture/climate?
4. How can employee perception of the WBGT monitor and MGD be improved?

In an attempt to answer the research questions proposed, the methodology of this study included a review of literature and a written questionnaire. The questionnaire sampled the employee population of Company XYZ that had the most frequent contact with these two instruments. This chapter includes the data collected through the written employee questionnaire. The instrument featured 30 questions divided into the areas of WBGT monitor, MGD, and safety culture/climate.

Presentation of Collected Data

Data in this section is presented according to the research question proposed. Each section begins with a research question followed by a summary of survey results that address each research question.

Research Question #1: What factors affected employee perception of industrial hygiene equipment at Company XYZ?

Data collected through the survey instrument revealed that 67.9% of participants had used the WBGT monitor and 85.7% of participants had used the MGD either personally or under the guidance of a supervisor or peer. The vast majority of these employees indicated that they trust the measurements provided by these instruments.

Table 1

Do you trust the measurement provided by the WBGT monitor?

Response	Frequency (N=19)	Percentage
Yes	17	89.5%
No	2	10.5%

Table 2

Do you trust the measurements provided by the MGD?

Response	Frequency (N=24)	Percentage
Yes	24	100%
No	0	0%

In the WBGT monitor section, nearly half of all participants indicated that the wet-bulb thermometer was the component of the instrument that affected their perception of the instrument the most. On that same question, a significant number of the remaining participants indicated the internal calculations of WBGT temperature affected their perception of the instrument the most. In the MGD section, participants selected the daily calibration of the instrument and the instrument's individual gas sensors as the two aspects of the detector affecting their perception the most. Two participants selected the

answer of "other" and wrote in that the length of hose used to enter certain confined spaces was their biggest concern. Perception of the instrument in general was affected somewhat equally by the factors of the nature of the confined-space entry, training related to the MGD, hearing about confined-space accidents at other sites, and personal or peer experience, with a slight edge toward the factor of the nature of confined-space entry.

Participants in this study were generally very confident in these two instruments. Nearly all of the employees surveyed indicated they were either "mostly confident" or "totally confident" that the MGD would accurately measure the work environment or provide warnings to the user at the proper time. More than half of participants were either "mostly confident" or "totally confident" that the WBGT monitor work provide an accurate representation of the work environment. However, nearly half of those who answered the same question were either "neutral", "mostly unconfident", or "totally unconfident".

Table 3

What level of confidence do you have that the WBGT monitor will provide an accurate representation of the work environment?

Response	Frequency (N=19)	Percentage
Totally Confident	5	26.3%
Mostly Confident	6	31.6%
Neutral	4	21.1%
Mostly Unconfident	3	15.8%
Totally Unconfident	1	5.2%

Table 4

What level of confidence do you have that the MGD will accurately measure the work environment?

Response	Frequency (N=24)	Percentage
Totally Confident	9	37.5%
Mostly Confident	13	54.2%
Neutral	1	4.2%
Mostly Unconfident	0	0.0%
Totally Unconfident	1	4.2%

Several employees who participated in the survey admitted to often feeling burned out at work. Only 21.4% of employees answered disagree or strongly disagree to the question related to feeling burned out. Matching the answer of employees who often felt burned out at work with an answer of neutral, disagree, or strongly disagree to the question provided in Table 3, produced a correlation of 0.369.

Research Question #2: How was the perception of these instruments formed?

The majority of the employees who participated in this study had worked at the facility for five years or more. Many of the participants in the study were aware of a heat stress illness occurring at the facility. Not surprisingly, 42.1% of respondents selected the factor of having personally experienced or know someone who has personally experience heat stress to the question of what factor influenced perception of the WBGT monitor the most.

Two-thirds of participants indicated that the use of the WBGT monitor had been communicated to them in some manner, yet a significant number of participants felt that they had not been adequately trained to use the instrument.

Table 5

Do you feel you have been adequately trained to use the WBGT monitor?

Response	Frequency (N=19)	Percentage
Yes	5	26.3%
No	14	73.7%

Participants who felt they were not adequately trained to use the WBGT monitor had almost exclusively receive no formal training on the instrument. A total of 42.9% of those responded as having not been adequately trained to use the instrument had received no training, while 50.0% of those same respondents had received communication about the instrument from a supervisor or peer.

A far greater percentage of participants indicated that they had received some form of training on the MGD and felt that they were adequately trained to use the instrument. Of those who felt they were not adequately trained to use the MGD only 33.3% had received formal classroom training while remainder had received no training or were trained by a supervisor or peer. Training was select by several employees as the factor that affected their perception of the MGD the most. At the same time an equal number of employees selected the factor of personal experience or the experience of a peer and slightly fewer employees indicated that hearing about confined-space entry

accidents at other sites as the factor influencing their perception of the instrument the most.

Table 6

What factor in general influences your perception of the MGD the most?

Response	Frequency (N=24)	Percentage
The nature of confined space entry	9	37.5%
Training related to the MGD	5	20.8%
Hearing about confined space accidents at other work sites	3	12.5%
Personal experience or the experience of my peers	5	20.8%
Other	2	8.3%

Research Question #3: In what ways is this perception linked to the organizations safety culture/climate?

In general, the results of the safety culture/climate section of the employee survey indicated a positive safety culture/climate at the Company XYZ facility studied. Over 85% of all employees surveyed felt that the site valued safety, they were comfortable raising safety concerns, safety issues were communicated openly, and they were comfortable coaching their peers on a safety related issue. On the other hand, only 60% of those surveyed felt that safety-related posters showed management commitment to safety or that safety issues were addressed quickly.

Table 7

Safety posters at this site show a management commitment to safety.

Response	Frequency (N=28)	Percentage
Strongly Agree	5	17.9%
Agree	12	42.9%
Neutral	10	35.7%
Disagree	1	3.6%
Strongly Disagree	0	0.0%

All employees who entered neutral or disagree to the statement of being satisfied with their job, also selected an answer of strongly agree, agree, or neutral to the statement related to feeling burned out at work. Among those same employees, 75% were either neutral or disagreed with the statement that safety issues were handled quickly at the facility. A total of 54.5% of employees who were neutral or disagreed with the idea that safety posters represented a management commitment to safety were also neutral or disagreed with the statement that safety messages are communicated effectively.

One employee commented that management displayed the appearance of being committed to safety, but felt that they were just going through the motions of safety. The employee went on to say that he or she perceived management as believing that accidents were the fault of the employee since the company was meeting the requirements of all safety and health regulations. Another employee indicated that he or she was comfortable raising safety concerns, but felt that safety issues that required modifying the facility or equipment were rarely followed through on.

Research Question #4: How can employee perception of the WBGT monitor and MGD be improved?

Most employees indicated that their perception of the instrument would be improved through additional training. Nearly 90% of participants felt that their perception of the WBGT monitor would improved by training related to either how the instrument measures the work environment or how the wet-bulb globe temperature is calculated. Some participants even selected both of these choices.

Table 8

How could your trust in the WBGT monitor be improved?

Response	Frequency	Percentage
Training related to how the monitor measures the work environment	11	57.9%
Training related to how the monitor calculates the WBGT temperature used to determine stay times	11	57.9%
A standard thermometer to take to the job site	3	15.8%
A different WBGT monitor	2	10.5%

Fewer employees felt that their perception of the MGD would be improved by training related to the instrument. However, as noted earlier, a greater percentage of these employees had received training and felt that they were adequately trained to use the instrument. Several employees indicated that their perception of the instrument would be improved through the use of a bump-box that was capable of testing the MGD

to determine if it would alarm at the proper time under a given set of conditions. One third of employees felt that they did not have enough experience with the MGD to completely understand their perception of it. One participant mentioned that his or her perception would be improved by using the instrument more and gaining more experience with it.

Summary

Data for this study was collected through the use of a written questionnaire given to employees who frequently use the WBGT monitor or MGD. Almost all participants in the study revealed that they trust the measurements provided by these instruments. Perception of the WBGT monitor was most affected by the wet-bulb thermometer, the unit's internal calculation, and the employee having experienced or know someone who had experienced heat stress. The perception of the MGD was most affected by the daily calibration of the unit and the nature of confined space entry.

Employees felt that their perception of the WBGT monitor would be improved through additional training. Employees indicated that their perception of the MGD would be improved through training or the use of a bump-box to demonstrate that the unit would alarm at the proper time. However, several employees indicated that they had limited experience with the MGD and would understand their own perception better by gaining additional experience.

The overall safety culture/climate of the organization was rated highly by most employees. The two areas rated the worst by employees were the idea that safety posters demonstrated a management commitment to safety and that safety issues where addressed quickly. Many employees noted often feeling burned out at work. There was

a strong correlation noted between a lack of job satisfaction and a feeling of burn-out. Among the group of employees who indicated a lack of job satisfaction and a feeling of burn-out, most disagreed with the idea that safety issues were handled quickly at the facility.

Chapter V: Summary, Conclusions, and Recommendations

This study measured employee perception of industrial hygiene equipment at one facility of Company XYZ. The study focused on factors affecting perception of industrial hygiene equipment for the purpose of improving employee perception of and confidence in the wet-bulb globe temperature monitor (WBGT) and multi-gas detector (MGD). This chapter will provide a summary of the entire study, a sample of major finds, conclusions drawn from research findings, recommendations based on those conclusions, and recommendations for further research in this area.

Statement of the Problem

Job tasks at Company XYZ require frequent use of a wet-bulb globe temperature monitor and portable multi-gas detector by employees and supervisors. The measurements provided by these devices are vital to performing these tasks in a safe manner, yet many employees have a reduced level of confidence in the equipment and the measurements they provide.

Methods and Procedures

A written survey instrument was used to gauge employee perception of the WBGT monitor and MGD. The survey was developed following a review of literature that indicated that the concepts of risk communication, risk perception, organizational development, and safety culture/climate may have influenced the perception of these instruments. The instrument was distributed to members of several work groups at the facility who regularly use the WBGT monitor or MGD. The data collected through the survey instrument and a review of literature answered the following research questions:

1. What factors affected employee perception of industrial hygiene equipment at Company XYZ?
2. How was the perception of these instruments formed?
3. In what ways is this perception linked to the organizations safety culture/climate?
4. How can employee perception of the WBGT monitor and MGD be improved?

Major Findings

The following section lists majors finding of the study. Findings are based on data collected through a written survey instrument.

Research Question #1. What factors affected employee perception of industrial hygiene equipment at Company XYZ?

- Employee perception of the WBGT monitor was most affected by the wet-bulb thermometer and the employee having experienced or known a peer who had experienced heat stress.
- Employee perception of the MGD was most affected by the daily calibration of the unit and the nature of confined-space entry.

Research Question #2. How was the perception of these instruments formed?

- Perception of these instruments was formed through communication and training related to the instruments and the experiences of employees.

Research Question #3. In what ways is this perception linked to the organizations safety culture/climate?

- The overall safety culture of the organization is strong
- Employees tended to disagree with the idea that safety posters demonstrated a management commitment to safety or that safety issues were handled quickly at

Company XYZ. However, a clear link between perception of these instruments and the organizations safety culture/climate was not identified.

- The majority of employees who were not satisfied with their job and often felt burned out at work also indicated that safety issues were not handled quickly.

Research Question #4. How can employee perception of the WBGT monitor and MGD be improved?

- Most employees indicated that their perception of the WBGT monitor and MGD would be improved through additional training related to these instruments.
- Some employees felt that their perception of the MGD would be improved through the use of a bump-box system to demonstrate that the instrument is sampling the work environment correctly and providing warnings at the proper time.

Conclusions

Based on the data collected through the use of written survey instrument the following can be concluded about employee perception of the WBGT monitor and MGD at Company XYZ:

Research Question #1. What factors affected employee perception of industrial hygiene equipment at Company XYZ?

- The vast majority of study participants trust the measurements provided by these two instruments. Employees were generally confident that these instruments would accurately measure what they were intended to measure.
- Employees who use these instruments may not understand how the individual components function, the calibration of the instruments, or how these devices use

the measurements collected by individual components to produce a reading of the work environment.

- Employees have concerns about these instruments that are not being addressed. Two employees commented on the survey that they were apprehensive about the length of the hose used to sample certain confined-spaces before entry.

Research Question #2. How was the perception of these instruments formed?

- Perception of the WBGT monitor in general was most affected by the employee experiencing heat stress or knowing a peer who had experienced heat stress.
- Perception of the MGD in general was also influenced by personal experience or the experience of peers, but was equally influenced by training related to the instrument, and even more influenced by the nature of confined-space entry.
- Training and communication related to the WBGT monitor has been incomplete and ineffective. Training and communication related to MGD has been more complete and effective than that related to the WBGT monitor, but some employees still feel they have not been adequately trained to use the MGD.

Research Question #3. In what ways is this perception linked to the organizations safety culture/climate?

- The safety culture/climate of the facility is strong based on the survey results.
- A link was identified between a lack of job satisfaction and a feeling of being burned out at work. The segment of the population that reported both ideas also scored the safety culture lower in other areas.

Research Question #4. How can employee perception of the WBGT monitor and MGD be improved?

- Additional training would improve employee perception of the WBGT monitor and MGD. Perception of the MGD would also be improved through the use of a bump-box system to demonstrate to employees that the monitor is correctly sampling the work environment and providing warnings at the proper time.

Recommendations

The following recommendations should improve employee perception of the WBGT monitor and MGD at Company XYZ:

- A training program should be developed for all users of the WBGT monitor. The training could utilize the organizations computer-based training system and should be required annually before the use of the monitor each year. This would be consistent with other training programs in place at Company XYZ. All employees who use the monitor would be required to complete the training. The curriculum should include proper use of the instrument, how the individual components of the instrument measure the work environment, how the instrument calculates a wet-bulb globe temperature from the components, and why the WBGT system is used to approximate the effects of work environment temperature on the human body.
- An analysis of the heat stress incidents that have occurred at the facility should be conducted. The analysis should investigate each incident and the effectiveness of controls that are in place to minimize heat stress environments. The investigation should also include the stay time schedule used for the task associated with the heat stress incident and the availability of water or electrolyte drinks at that time. The results of the analysis may improve the effectiveness of engineering and

administrative controls related to heat stress environments at the facility. This information should be clearly communicated to the employees of Company XYZ. The information may improve employee understanding of the risk associated with heat stress environments.

- Qualified medical staff should regularly monitor employees working under recommended stay times of 30 minutes or less. This will ensure that employees working under the most severe heat stress conditions are monitored for signs and symptoms of heat stress.
- The formula used to calculate wet-bulb globe temperature should be posted on the unit itself and near the charts displaying recommended stay-time based on wet-bulb globe temperature. This will remind employees that it is expected that the monitor's reading will be different than the air temperature.
- The training program for the MGD should be modified to include information related to how the instrument measures the work environment and how the unit's alarm system works. This training should include a discussion of the risk of entering a confined-space so those employees develop and accurate perception of confined-space entry risk. A computer-based system for signing out MGD should be developed to ensure that the employees using the detectors have been properly trained.
- The training related to the WBGT monitor and MGD should be assessed on a regular basis to ensure the objectives of the training are being met. The assessment should include a written exam similar to other training programs at the facility. The training could be further assessed through observation of employees

using the instruments. Any change in employee perception of these instruments following the training program could be determined through the use of a follow-up perception survey similar to the one used in this study.

- Employee concerns such as the use of relatively long sampling hose should be addressed. This could happen by displaying the question or concern along with the appropriate answer on the safety department's bulletin board or website.
- Management should identify the needs of those employees who lack job satisfaction or feel burned out at work. Risk communication directed toward these employees will be more effective if their needs are met first.
- Determine the extent of the gap between management commitment to safety and health and the perception of that commitment among employees. The existence of this gap was noted in the written comments on a few employee surveys. The analysis should try to determine the source of that perception so that the gap can be improved over time.
- Conduct regular drills using the MGD to provide employees with more experience to improve their comfort level with the instrument.

Areas of Further Study

- Expand the number of surveys distributed and/or the method of distribution in an attempt to reach more employees in a wider variety of work groups.
- Conduct more in-depth investigation in the organizations safety culture/climate through a site-wide survey and employee interviews. This study could attempt to identify a link between the organizations safety culture/climate and the perception of the WBGT monitor and MGD.

- Re-evaluate employee perception of these instruments following the implementation of a new training program and other recommended controls.

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Appendix A: Survey Instrument

This research has been approved by the UW-Stout IRB as required by the Code of Federal Regulations Title 45 Part 46.

Survey: Employee perception of industrial hygiene equipment

Instructions: Please circle the most appropriate answer to the questions below.

1. What category best describes the department you work in?
   a. Chemistry
   b. Construction/Laborer
   c. Electrical
   d. Mechanical Maintenance
   e. Operations
   f. Radiation Protection
   g. Other, please list _____

2. What is your age?
   a. 18-20
   b. 21-25
   c. 26-30
   d. 31-35
   e. 36-40
   f. 41-45
   g. 46-50
   h. 51-55
   i. 56-60
   j. 61-65
   k. 66+
   l. Prefer not to answer

3. How long have you worked at this site?
   a. Less than 5 years
   b. 5 to 10 years
   c. 11 to 15 years
   d. 16 to 20 years
   e. 21 to 25 years
   f. More than 25 years

Wet-Bulb Globe Temperature Monitor

4. Have you ever used the wet-bulb globe temperature (WBGT) monitor to determine stay times for a job task, or worked under the recommend stay times determined by a peer or supervisor?
    a. Yes, I have used the WBGT monitor
    b. Yes, I have worked under the recommendation of a peer or supervisor
    c. Yes, to both
    d. No, I have not used the monitor or worked under the recommendation of a peer or supervisor

If no, skip to question #13.

5. How has the use of the WBGT monitor been communicated to you? Circle all that apply.
    a. Formal classroom training
    b. Department safety meetings
    c. By a Supervisor or peer
    d. By the Safety department
    e. No training
    f. Other, explain _____

6. Do you feel you have been adequately trained to use the WBGT monitor?
    a. Yes
    b. No

7. What level of confidence do you have that the WBGT monitor will provide an accurate representation of the work environment?
    a. Totally confident
    b. Mostly confident
    c. Neutral
    d. Mostly unconfident
    e. Totally unconfident

8. Do you trust the measurements provided by the WBGT monitor?
    a. Yes

b. No

9. What aspect or function of the WBGT monitor do you trust the least?
    a. Dry-bulb temperature
    b. Wet-bulb temperature
    c. Globe temperature
    d. The internal calculation of the WBGT temperature used to determine stay times
    e. Other, explain _____

10. What factor(s) in general influence your perception of the WBGT monitor the most?
    a. Training related to heat stress environments
    b. I have personally experienced or know someone who experienced heat stress
    c. The device is very complicated
    d. The monitor does not seem to provide an accurate picture of the work environment
    e. Other, explain _____

11. How could your trust in the WBGT monitor be improved? Circle all that apply.
    a. Training related to how the monitor measures the work environment
    b. Training related to how the monitor calculates the WBGT temperature used to determine stay times
    c. A standard thermometer to take to the job site
    d. A different WBGT monitor

12. Are you aware of heat stress illnesses occurring at this site?
    a. Yes
    b. No

Multi-gas Detector

13. Have you ever used the multi-gas detector as part of job task or performed a job task with a peer or supervisor who was using the multi-gas detector?
    a. Yes, I have used the multi-gas detector
    b. Yes, I have performed a job task with a peer or supervisor who was using the multi-gas detector
    c. Yes, to both
    d. No, I have not used the multi-gas detector or performed a job task while the multi-gas detector was in use

If no, skip to question #22.

14. How has the use of the multi-gas detector been communicated to you? Circle all that apply.
    a. Formal classroom training
    b. Department safety meetings
    c. By a Supervisor or peer
    d. By the Safety department
    e. No training
    f. Other, explain _____

15. Do you feel you have been adequately trained to use the MGD?
    a. Yes
    b. No

16. What level of confidence do you have that the multi-gas detector will accurately measure the work environment?
    a. Totally confident
    b. Mostly confident
    c. Neutral
    d. Mostly unconfident
    e. Totally unconfident

17. Do you trust the measurements provided by the MGD?
    a. Yes
    b. No

18. What level of confidence do you have that the multi-gas detector will provide warnings at the proper time?
    a. Totally confident
    b. Mostly confident
    c. Neutral
    d. Mostly unconfident
    e. Totally unconfident

19. What aspect or function of the multi-gas detector influences your perception of the multi-gas detector the most?
    a. The air pump

b. The daily calibration
c. The individual gas sensors
d. The unit's warning system
e. The battery system
f. Other, explain _____

20. What factor in general influences your perception of the multi-gas detector the most?
    a. The nature of confined-space entry
    b. Training related to the multi-gas detector
    c. Hearing about confined-space accidents at other work sites
    d. Personal experience or the experiences of my peers
    e. Other, explain _____

21. How could your perception of the multi-gas detector be improved? Check all that apply.
    a. Training related to how the unit measures gases in the air
    b. Training related to the units warning systems
    c. A "bump-box" to show that the unit alarms when it should
    d. A different multi-gas detector
    e. Other, explain _____

Safety Climate

Instructions: Please indicate your answer by checking one box for each statement below.

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
22. This site values safety					
23. Safety-related messages are communicated effectively at this site					
24. Safety posters at this site show management commitment to safety					
25. I feel comfortable in raising safety concerns and making safety suggestions to management					
26. Safety issues are communicated openly at this site					
27. Safety concerns are addressed quickly at this site					

28. I feel comfortable in coaching my peers on safety-related issues					
29. I am satisfied with my job					
30. I often feel burned out at work					

Please provide any additional comments in the space provided.

End of Survey

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Date: April 10, 2009

To: Trent Noecker

CC: Elbert Sorrell

Susan Foxwell

From: Sue Foxwell, Research Administrator and Human Protections Administrator, UW-Stout Institutional Review Board for the Protection of Human Subjects in Research (IRB)

Subject: **Protection of Human Subjects**

Your project, "*Factors Affecting Employee Confidence in Industrial Hygiene Equipment,*" has been approved by the IRB through the expedited review process. The measures you have taken to protect human subjects are adequate to protect everyone involved, including subjects and researchers.

Please copy and paste the following message to the top of your survey/interview form before dissemination:

This research has been approved by the UW-Stout IRB as required by the Code of Federal Regulations Title 45 Part 46.

If you are conducting an **online** survey/interview, please copy and paste the following message to the top of the form:

"This research has been approved by the UW-Stout IRB as required by the Code of Federal regulations Title 45 Part 46."

This project is approved through **April 6, 2010**. Modifications to this approved protocol need to be approved by the IRB. Research not completed by this date must be submitted again outlining changes, expansions, etc. Federal guidelines require annual review and approval by the IRB.

Thank you for your cooperation with the IRB and best wishes with your project.

***NOTE: This is the only notice you will receive – no paper copy will be sent.**