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MANUFACTURING PRACTICE SPECIALTY

Safely MADE

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For a complete Table of Contents, see page 3

Duration & Energy of Hydrocarbon Flash Fire

BY SCOTT MARGOLIN

Over the past 2 decades, there have been some reasonable debates and some less reasonable marketing on the duration and energy of hydrocarbon flash fires, despite the fact that existing North American standards were clear on the subject. NFPA and Canadian General Standards Board (CGSB) both defined flash fire with identical technical language: the main factors being diffuse fuel in air, an ignition source, a rapidly moving flame front and a consequent duration of 3 seconds or less. NFPA 2112 requires a manikin test duration of 3 seconds precisely because it is viewed as the practical upper limit of a flash fire. Groundbreaking research was recently conducted to answer the debate and vet the standards.

The short duration is what makes these events survivable without respiratory protection and a single layer of flame-resistant clothing.

The key differentiator between a fire and a flash fire is the fuel. In a

*continued on page **8***

ADMINISTRATOR'S MESSAGE

Safety & Health Management in Manufacturing

The late Dan Petersen is generally credited with coining the phrase, "If you have a safety problem, you have a management problem." I first met Dan at a safety conference in Tucson, AZ, in June 1980 when I started graduate school at the University of Arizona in the Masters of Safety Management program. I had 6 years' safety experience with OSHA in North Carolina and had spent all of that time on the standards side of safety. With the help of Professors Cliff Crutchfield and Mark Van Ert, I came to understand much better what Dan meant.

David F. Coble

The safety profession lost another icon late last year—Ray Boylston, CSP. Ray was ASSE president from 1988-89. Ray learned the importance of management's commitment and leadership to safety while working with DuPont from the 1950s to 1973. Ray was on the DuPont team that developed the Central Safety and Health Committee/Task Group safety management system that has made DuPont so successful in managing safety and health. Ray was the safety manager at the DuPont Kinston North Carolina plant that set the world safety record in the late 1960s of 63 million hours without a lost-time incident. Ray had his own catchphrase and taught that if you have a safety problem, you have a safety management systems problem. Dan and Ray thought alike.

According to the Bureau of Labor Statistics, the U.S. manufacturing industry experienced 111.9 lost-time injuries per 10,000 full-time employees in 2011. On average, this is as if you went into your plant and picked 1 person out of every 100 to have a lost-time injury. However, if your site has the right management systems in place and those systems are mature and fully functioning, it is feasible that you will have no lost-time injuries. Serious incidents should be quite rare.

Every manufacturing plant should consider implementing a joint management/labor safety and health steering committee. This committee is one of the elements of a 21st-century management system. Populate that committee with top management, top union leadership and others who are peer leaders among the workforce. When a safety and health issue comes up, you have management readily available to address the issue.

Do your board of directors and top management understand the proper management systems needed? Do they understand that injuries and illnesses are not a normal part of doing business? Do they understand that it is reasonable to expect a workplace without serious injuries? If they do not, Dan would say you have a management problem, and Ray would say you have a management systems problem.

To help managers with "problems," the Manufacturing Practice Specialty is preparing a whitepaper containing best practices in safety and health management in manufacturing. If you would like to contribute examples of best practices, please send them to me.

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Manufacturing Practice Specialty

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CONTENTS

Volume 4 • Number 3

CONNECTION KEY

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V Video W Website P PDF L Hot Link AD Ad Link D Direct Link

Welcome New Members

We want to thank everyone who has remained a loyal member of the Manufacturing Practice Specialty (MPS) and welcome the following members who recently joined. We currently have more than 800 members. If you have any colleagues who might be interested in joining MPS, please direct them to **www.asse.org/ps** for more information.

Rakesh Agrawal, Piping Technology & Products
James Barfield, Corning Inc.
Kozzette Bennett, AceCo Precision Manufacturing
James Boschuetz, Rockwell Automation
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Derrick Hellinga, Tyson
Terry Hill, Resource Optimization & Innovation
Harold Holloman, Honda Manufacturing of Alabama
Stacy Huelsman, Kellogg Co.
John Johnson, JMP & Associates
Grant Kerr, Coca Cola Bottling Co.
Michael Kurkowski, RCS Group
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George Mackie, Dogfish Head Craft Brewery
Charles Mignoli, The Estee Lauder Cos.
Michael Miller, Trinity Structural Towers Inc.
Matt Monteith, Goodyear Tire & Rubber Co.
Ann Mulvaney, Deere & Co.
Mark Paulson, Avnet
Robyn Pearce, Pinova Inc.
Joseph Plata, Wm. Wrigley Jr. Co.
Benjamin Preston, MAHLE Behr Industry America
Christy Pryga, Michelin North America
Matthew Rouse, Louisiana Pacific Corp.
Marla Ryan, Deere & Co.
Elizabeth Sawyer, CooperVision
Jessica Siron, Multisorb Technologies Inc.
Timothy Spicer, First Quality Baby Products LLC
Kevin Stanton, L'Oreal USA
Ryan Tamm, Boeing Co.
Norman Umberger, American Woodmark
Barry Ward, Leigh Fibers Inc.

Manufacturing Sector Morbidity & Disability

All U.S. Workers

From 1997-2007, 196,924 U.S. workers age 18 years and older (representing an estimated 126,898,030 U.S. workers annually) participated in a probability sampling of the entire noninstitutionalized U.S. population **(Table 1)**. Of the U.S. workers, there were approximately equal percentages of men (54.0%) and women (46.0%) during this time period. The majority of the U.S. workers self-identified as White (83.0%) with 11.1% Black and 5.9% "Other" races, while 11.8% were Hispanic and 88.2% Non-Hispanic. The majority (83.5%) of U.S. workers were in the 25- to 64-year-old age group with 13.4% in the 18- 24-year-old age group and 3.1% in the 65 years and older group. The majority (59.4%) of U.S. workers had more than a high school education, with 11.7% having less than a high school education and 28.4% having completed high school. Although 83.8% of U.S. workers reported having health insurance, 16% did not have health insurance.

Manufacturing

From 1997-2007, an estimated 17,581,652 U.S. workers age 18 years and older worked annually in the Manufacturing sector **(Table 1)**. Of the total U.S. workforce, approximately 13.9% worked in the manufacturing sector. In this sector, the majority of workers were men (70%) with only 30% women during this time period. The majority of the workers self-identified as White (84%), with 9.7% Black and 6.4% "Other" races; 12.6% self-identified as Hispanic and 87.4% Non-Hispanic. The majority (89.3%) of workers were in the 25- to 64-year-old age group, with 9% in the 18- to 24-year-old age group and 1.7% in the 65 years and older group. In this sector, 47.7% of workers had more than a high school education, with 15.4% having less than a high school education and 36.3% having completed high school. Although 89.5% of workers in this sector reported having health insurance, 10.4% did not have health insurance.

The following summary statements on population, disability and morbidity measures are based on data found in **Table 1** and **Table 2**.

Health Status

An estimated 5.4% or about 950,000 National Occupational Research Agenda (NORA) manufacturing

sector workers reported their health status was worse when compared with 12 months prior.

An estimated 5.7% or about 1.0 million NORA manufacturing sector workers reported their health status in general was fair to poor.

NORA manufacturing sector workers reported an estimated mean of 1.7 bed disability days during the past 12 months; 22.6% or about 4.0 million workers reported 2 or more bed disability days.

NORA manufacturing sector workers reported an estimated mean of 4.1 work loss days during the past 12 months; 10.8% or about 1.9 million workers reported 6 or more work loss days.

Physical Activity Limitations

An estimated 1.3% or about 229,000 NORA manufacturing sector workers reported having a health problem that required the use of special equipment.

An estimated 20.7% or about 3.6 million NORA manufacturing sector workers reported experiencing any functional limitations in any of 12 activities.

An estimated 15.0% or about 2.6 million NORA manufacturing sector workers reported some degree of hearing impairment.

An estimated 6.6% or about 1.2 million NORA manufacturing sector workers reported some degree of visual impairment.

Health & Chronic Conditions

An estimated 3.3% or about 580,000 NORA manufacturing sector workers reported being told by a doctor or other health professional that they had cancer or a malignancy of any kind.

An estimated 19.2% or about 3.4 million NORA manufacturing sector workers reported being told by a doctor or other health professional that they had ever had hypertension.

An estimated 6.7% or about 1.2 million NORA manufacturing sector workers reported being told by a doctor or other health professional that they had had heart disease (including coronary heart disease, angina, heart attack or any kind of heart condition or heart disease).

An estimated 7.8% or about 1.4 million NORA manufacturing sector workers reported being told by a doctor or other health professional that they had asthma.

An estimated 4% or about 703,000 NORA manufacturing sector workers reported being told by a doctor or other health professional that they had diabetes (or sugar diabetes).

An estimated 0.5% or about 88,000 NORA manufacturing sector workers reported experiencing in the previous 30 days symptoms of severe psychological distress.

Healthcare Utilization

An estimated 32.6% or about 5.7 million NORA manufacturing sector workers reported not having seen a primary healthcare provider during the past 12 months.

An estimated 35.8% or about 6.3 million NORA manufacturing sector workers reported not having seen or talked to a dentist during the past 12 months.

An estimated 10.2% or about 1.8 million NORA manufacturing sector workers reported having surgery or other surgical procedures as an inpatient or outpatient during the past 12 months.

An estimated 16.8% or about 3.0 million NORA manufacturing sector workers reported having made one or more hospital emergency room visits during the past 12 months.

Health Risk Factors or Behaviors

An estimated 27.2% or about 4.8 million NORA manufacturing sector workers reported being current smokers.

An estimated 70.2% or about 12.3 million NORA manufacturing sector workers reported being current alcohol drinkers.

An estimated 24.3% or about 4.3 million NORA manufacturing sector workers reported a combination of height and weight consistent with obesity.

An estimated 70.2% or about 12.3 million NORA manufacturing sector workers reportedly did not achieve CDC-recommended leisure time levels of physical activity.

An estimated 32.3 or about 5.7 million NORA manufacturing sector workers reported ever being tested for HIV.

An estimated 79.1% or about 14 million NORA manufacturing sector workers reported not receiving an influenza vaccination during the past 12 months.

An estimated 78.7% or 764,000 million NORA manufacturing sector workers 60 years and older reported never receiving a pneumococcal vaccination.

Visit **www.cdc.gov/niosh** for more information. ⊙

Duration & Energy of Hydrocarbon Flash Fire
*continued from page **1***

fire, the fuel is concentrated (pool fires, jet fires, etc.) and thus is not a significant limiting factor in duration; it will burn for minutes, hours or even days if not actively extinguished. Conversely, in a flash fire, the fuel is diffused in air (gas leak, vapor cloud, combustible dust, etc.), meaning it will be consumed quickly once ignited, as the flame front moves rapidly from the ignition point to the source and/or to the limit of the cloud and goes out. Thus, the duration of heat levels sufficient to ignite flammable clothing or cause second-degree burns to exposed skin is brief in any single location within the flash.

This short duration is what makes these events survivable without respiratory protection, and with a single layer of flame-resistant (FR) clothing, as opposed to self-contained breathing apparatuses and turnout gear worn by firefighters (FR clothing will not ignite and continue to burn, but single-layer, breathable FR does not provide sufficient insulation against protracted fire exposures).

While the science and standards seem clear, the sales and marketing of FR clothing sometimes does not. Some companies merely report that they pass the NFPA 2112 manikin test (less than 50% total second- and third-degree body burn at a 3-second test duration), while others report the exact percentage with which they pass. Few spend the time and the money to conduct complete research and publish graphs that fully characterize body burn from inception of burn through the fabric to, or beyond, failure (>50% burn). The manikin test required by NFPA 2112 uses the ASTM International F1930 standard test method; ASTM F1930 features a full-size manikin, wearing a standardized coverall, in a burn chamber with propane torches capable of fully engulfing it. The manikin has more than 100 thermocouples evenly distributed over its surface to predict the extent, severity and location of body burn.

Further complicating matters, three ASTM F1930 manikin chambers are in North America, two of which are independent university labs; the other is owned and operated by a company with commercial interest in FR clothing. Data can vary marginally from lab to lab but should not vary significantly when testing is performed in compliance with the standards. Thus, decision-makers are faced with performance data that can be presented as a "pass," a number or a graph and can see different data on the same product from different labs. This environment has understandably caused confusion and disagreement about what is correct and what is relevant. It has also fostered significant leeway in the marketing of performance comparisons; some products prefer to show end users a particular niche in the performance spectrum because that is the only place they record an advantage.

The two primary points of contention have been duration and heat flux. NFPA 2113 historically defined flash fire duration as "3 seconds or less" predicated on the science of a flame front moving rapidly through a diffuse fuel. As noted, NFPA 2112 accordingly set the pass/fail performance test at 3 seconds to characterize performance in a worst-case scenario. Heat flux measures the rate of heat energy transfer per unit area per unit time and is typically expressed as calories/square centimeter second (kilowatts per square meter); it is important to understand that because heat "flows," what matters is average heat flux over the course of a single event. Average heat flux of diffuse hydrocarbons burning in air was known to be about 2 cal/cm^2*sec (84 kW/m^2), so the standard selected propane fuel and a 2 cal/cm^2*sec heat flux. However, when results of this standardized testing are less than favorable to the commercial interests of a fabric, data have been presented at longer or shorter durations, and arguments have been made about higher or lower heat flux.

Many things are theoretically possible, but standardized testing focuses on what is probable. Independent consensus standards organizations like NFPA and CGSB attempt to quantify and protect the greatest number of people from the most prevalent hazards based on real-world conditions and experience. Given the frequency

Manufacturing Meeting & Networking Event

Monday, June 24th, 6pm, Las Vegas Convention Center, Room N120

MPS Sponsored Sessions

- Understanding NFPA 70E and the Arc Flash Hazard (Session 642)
- Safety Training Activities for Manufacturing (Session 643)
- ANSI B11 & Machine Safeguarding Risk Assessment: Achieving Acceptable Risk (Session 667)
- The Synergy of Environmental Health and Safety and Sustainability (Session 715)
- Key Issue Roundtable: Best Practices for Fork Truck Operator Training (Session 769)

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and scope of the debate, it was time to quantify the duration and heat flux of actual outdoor flash fires and to confirm whether the standards were on target.

The first two challenges in initiating such testing would be finding or creating enough field-deployable sensors and a facility capable of reliably, repeatedly and safely creating the flash fires. The University of Alberta is one of only two independent facilities in North America with an ASTM F1930 flash fire manikin lab. Professor Mark Ackerman was responsible for the flash fire manikin lab at the University of Alberta and developed portable versions of the same thermal sensors used in the Protective Clothing and Environmental Research Facility (PCERF) manikin to create 3D models of wildfires. These sensors proved perfect for the research.

Data can vary marginally from lab to lab but should not vary significantly when testing is performed in compliance with the standards.

With equipment capable of quantifying the answers in hand, what was still needed was an outdoor full-scale fire field. After an exhaustive search, Texas Engineering Extension Service (TEEX) (part of Texas A&M University in College Station, TX) was selected. TEEX's Brayton Fire Training Field is the largest industrial fire training facility in the U.S., with 279 acres on which are dozens of rigs, pipelines, industrial plant structures, tankers, railcars, etc. (called "props"), all designed to intentionally create huge fires, allowing firefighters and other emergency personnel to train under real conditions. The Brayton Fire Field is designed to train industrial firefighters, not conduct research, but TEEX personnel immediately realized the value of the work and agreed to participate.

The ideal experimental design would feature a large, open outdoor area with a centrally located pipe to release hydrocarbon vapor; 360° of unimpeded space to allow natural vapor cloud movement in all wind conditions; externally operable ignition sources to create the flash; mounting surfaces adaptable to thermocouples and data loggers, good sightlines for HD cameras; and independent university labs and personnel. During a scouting trip to the TEEX Fire Field, Prop 66 proved to be nearly perfect and was selected for the experiments.

The center of the prop features a large-diameter vertical pipe that releases propane, two rings of piping 10 ft. and 25 ft. from the propane release point and an outer ring of torches 40 ft. away. The experimental design focused on three concentric rings around the fuel source pipe: an inner ring of double sensors at 10 ft. facing both out toward an oncoming flash and in toward the fuel leak; a second ring of single sensors at 25 ft. facing out toward an oncoming flash; and the outermost ring of torches, which would initiate combustion of the hydrocarbon vapor cloud. The sensors were placed in rings to allow for changes in prevailing wind speed and direction and remained stationary for the duration of the experiments. There were also three cube arrays, each of which has five sensors, one per cube face, on a cube 6 in. square; the sixth side of the cube houses an adjustable stand to deploy the array. These cubes are mobile and were placed downwind to ensure maximum exposure to the each flash. HD cameras were positioned perpendicular to wind direction to best capture movement of the flame front and were adjusted as conditions dictated.

Heat flux is fluid; fires move and swirl and heat ebbs and flows, so each sensor was placed at upper-torso height of an average adult to optimize data capture in the area most relevant to a worker caught in a flash fire. Thirty-one sensors were deployed in each flash, and more than 60 flashes were created over several days. Each sensor measured heat every tenth of a second, which was recorded by a dedicated data logger for each unit. Ackerman then uploaded the data into a computer, which plotted precise flash duration as well as peak and average heat flux.

The intentional release of huge quantities of propane outdoors can be a dangerous and intimidating process, especially with timing and location of ignition entirely determined by prevailing environmental conditions. TEEX personnel were in control of decisions and procedures at all times and did an outstanding job of successfully creating real flash fires and keeping everyone safe.

The research had three main goals: quantify duration, average heat flux and confirm that flash fires are a rapidly moving flame front. The concept of a moving flame front is central to understanding the brief duration of a flash fire; the length of time flame is visible overall when a flash traverses a significant distance is longer, and often much longer, than the duration at any single location within the flash path (where a worker is standing). When a flash fire is initiated by an ignition source, the flame front will propagate from that source until it reaches the limits of the vapor and/or the source of the vapor. As the flame front moves, it quickly consumes all the diffuse fuel behind it. The net effect is that by the time further reaches of the cloud are on fire, the original area is extinguished. Thus, the fire moves like a wave through the cloud. And like a wave at the beach, the total duration is longer than the amount of time it affects a single person standing still in the surf.

HD video cameras and high-speed still cameras are a good start to showing this phenomenon, but they only record the visible light energy of the fire. The cube arrays are outstanding in this capacity. While a camera is certainly capable of proving a flame front moves, it does not capture nonvisible energy, such as radiant heat, that can bracket the flame front and pose a hazard to people. The sensors do, and multiple sensors in the same location, one facing the flash and one facing away in the "shadow" of the unit, were able to quantify the directional nature of flash fire.

Normally, scientific experimentation strives to control or limit all variables other than the one(s) examined. This is necessary to repeatability of the results, which is central to the scientific process. However, this research was specifically intended to replicate real-world flashes as closely as possible, so some variability in conditions was both inevitable and desirable. An experiment can compensate for higher variability with a higher volume of tests. Normal flash fire laboratory protocol for University of Alberta and other laboratories is to run three exposures and average the results; due to the real-world design of this research and the variability of the weather conditions, Ackerman conducted in excess of 60 replications. Environmental conditions fluctuated over a fairly wide range of temperature, wind speed, wind direction and humidity, just as they do in unplanned flash fires.

Wind speed in particular is challenging. Little or no wind allowed more propane to be released prior to ignition, causing larger flash fires, while too much wind or too much rapid variation in direction made it more difficult to get the right concentration in the right place to ignite. However, once ignition occurred, neither had any significant effect on duration.

Once all data were uploaded and assimilated, the results were presented as graphs for each individual sensor in each individual flash fire. The vertical axis tracks heat flux, and the horizontal axis tracks time. Thus, the typical look for an exposure is an upside-down letter V, where the peak at the top represents maximum heat flux, and the width of the opening at the bottom represents duration of the event at that location in the flash. With so many thermocouples in so many locations through so many flash fires across so many environmental conditions, the data are compelling. No single sensor recorded a flash fire duration of 3 or more seconds. This was true regardless of position in the flash path, wind speed or direction, amount of propane released, etc. The vast majority of exposures were 2 to 2.25 seconds.

The duration results can be evaluated in two ways. The most conservative way, which yields the longest duration, is to count all time the sensor records heat above ambient conditions, which was the protocol for this work. A second alternative is to approach the data from a perspective closer to the lab flash fire and arc flash analysis, which are predicated on avoiding or minimizing second-degree burn and worse. This can be done by looking at the total time each exposure spends above 1.2 cal/cm^2*sec (50 kW/m^2), which is threshold for second-degree burn. This will typically yield a slightly lower duration and represents the amount of time that flash was directly hazardous to exposed human skin. We chose to examine and present the data from the more conservative perspective, but the two approaches generally yield data that differ by only fractions of a second.

Heat flux averages are discernible within a single location in a single exposure, across multiple locations in a single exposure and across all exposures. The individual peak data showed somewhat greater variability than duration data, but average heat flux within an exposure and across all exposures were consistent. Heat flux averaged 2 cal/cm^2*sec (84 kW/m^2).

The pictures and video clearly showed that a flash fire is a moving flame front, comprised of two or three sections. At ignition, there is a portion that is burning and a portion that has not yet ignited; then, as the flame front moves into an area of fresh fuel, it becomes a three-phase event. Behind the flame front is an area where the fuel has been consumed and the fire is out, then an area of flame and ahead an area of unignited fuel into which the flame is moving. The cube array sensors were able to confirm this observation.

A moving flame front is by definition directional. That is, if it is moving toward your face rapidly and self-extinguishing as it moves by consuming all of the fuel, then you would not predict burns to your back. If you are sprayed with a fire hose for a second or two while standing still, one side of you will be wet and one side of you will be dry. Similarly, if a flash fire is a moving flame front, it is directional and would be predicted to show a high heat flux on the sensor surface facing the flash and a low heat flux on the surface on the back of the cube, in the "shadow" of the unit. This is exactly what the data showed. In each case, the side of the cube facing the oncoming flash fire recorded elevated heat flux consistent with the single-sensor units, but the side of the cube facing away from the flash (a mere 6 in. from the high-heat sensor) recorded little or no elevated heat flux.

NFPA and CGSB each created standards to address the flash fire hazard in the mid and late 1990s. These standards committees were staffed by subject matter experts and highly experienced industry personnel, resulting in noncommercial guidance and test protocol. The parameters of that testing were based on the best available science and accident investigations. They intended to require passing performance against a worst-case flash fire, which they defined as a rapidly moving flame front lasting typically 3 seconds or less. They set the heat flux at 2 cal/cm^2*sec (84 kW/m^2) because that is the average for hydrocarbon flash fire in air.

The research discussed here was driven by marketing, which has created a climate of confusion vs. these standards. The experiments were designed and executed by personnel from University of Alberta's PCERF at the Texas A&M Brayton Fire Field, and the conclusions are clear. Hydrocarbon flash fires are moving flame fronts, with average heat flux of about 2 cal/cm^2*sec (84 kW/m^2), and durations below 3 seconds. The standards are correct. ✪

Scott Margolin *is a technical director at Westex.*

INTERVIEW

Semiotics in the Workplace

Q&A With Geoffrey Peckham, CEO of Clarion Safety Systems

Geoffrey Peckham is CEO and director of research and development at Clarion Safety Systems, a company that designs and manufactures safety signs and labels. In this interview, Peckham explains how safety signs and symbols will change in light of OSHA's final rule to revise its hazard communication standard and discusses the importance of semiotics in the workplace.

MPS: ***Please provide a brief description of your professional background and of your position as CEO of Clarion Safety Systems, LLC.***

GP: I started Clarion 22 years ago to provide companies with warnings, primarily on-product warnings for capital equipment, so that people who transport, install, use, service and decommission equipment could be better protected from harm.

Prior to forming Clarion, it was my time spent studying art and philosophy at Cambridge and Oxford Universities that gave me an intense interest in visual communication. I put myself through college by working in the printing/graphic reproduction industry, in both the production and management sides of the business. So it is with all of these things combined that brought Clarion, and me personally, to where we are today.

MPS: ***OSHA has issued a final rule to revise its hazard communication standard (HCS) (29 CFR 1910.1200) to align with the United Nations' (UN) Globally Harmonized System of Classification and Labeling of Chemicals (GHS). Why is this global consistency so important when it comes to safety signs, symbols and markings?***

GP: Global consistency is important to safety communications for the simple reason that we live in an increasingly interconnected world. Our economies are inextricably linked. Many companies are global in scale; the markets for their products and/or their workforces and facilities extend beyond the borders of one country. Safety communication is only effective if it can convey the intended message to the intended audience. So whether your intended audience is the general public, your local employees or an international workforce, the methods you use to convey safety information should now be designed in a manner that is consistent with global standards, not provincial national standards.

The UN certainly understood this principle when it began the development of GHS. Although it has taken years to complete, OSHA's recent adoption of GHS is, in my opinion, a brilliant move. Not only does it signal to the world that the U.S. is on board with the idea that safety matters, but it also begins the process of accepting internationally standardized graphical symbols as the means to improve the communication of critically important safety information.

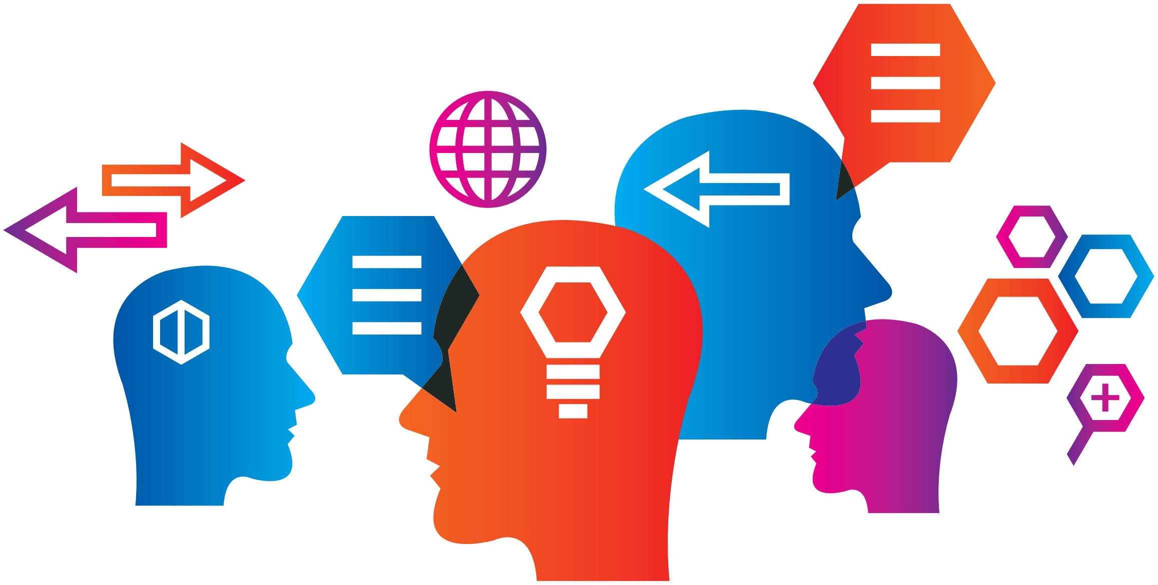
MPS: ***In light of OSHA's final rule, how is Clarion advising its clients when it comes to indicating chemical hazards on product safety labels or facility safety signs?***

GP: GHS was meant to provide chemical manufacturers with a fixed set of pictograms and word messages to be used on safety labels that would appear on their chemical products' packaging. But our recommendation to our clients is this: Anytime you need to sign or label to warn about a chemical hazard, whether it is on a facility safety sign or on an equipment safety label, use one of the nine pictograms that are part of GHS if it applies to what you are trying to communicate.

A good example of the usefulness of GHS pictograms is the new construction-oriented safety sign we created for a company that does demolition and renovation. The sign warns about asbestos (Figure 1). First, notice that our sign's message is not a simple, generic "DANGER—Asbestos," as shown in Figure 2.

Instead, the content of the new sign is more detailed. This is becoming the norm, not the exception. In almost every situation we encounter when we are designing safety signs that are compliant with the latest standards, the messaging is much more specific so the viewer can better understand and avoid the potential hazard. The new sign, then, goes one step further. To reinforce the word message, symbols were added. And not just any symbols. Since the inhalation of asbestos fibers was the problem, the GHS symbol for "Health Hazard" was perfect for the job of pictorializing the hazard. The "No Access for Unauthorized Persons" symbol was then added to pictorialize the primary avoidance message.

Using the GHS symbols on your facility signs and equipment safety labeling will help reinforce the understanding of the pictograms



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wherever they are used. When it comes to establishing a symbol-based system for globally recognizing hazards, part of the equation is training people on the symbols' meaning. Using these GHS pictograms when you need to communicate chemical hazards will help achieve the goal of global comprehension for these symbols.

MPS: ***You mentioned that GHS is just the beginning of a new way to better communicate safety. What did you mean by this?***

GP: OSHA's acceptance of GHS was the start of a process that recognizes the fact that the latest standards having to do with safety signs and labels give safety professionals a valuable tool to better communicate risk and reduce it. You need only compare one of the old-style signs you typically find in U.S. workplaces today with one of the new ANSI/ISO standards-based signs to see and understand the difference.

Seeing—that is the first objective of every safety sign, that it be seen! The old 1941-era ASA Z35.1 signs you might still be purchasing for your facility today are not only outdated in terms of their formats and oversimplified content, but they lack symbols. All three of these components not only better convey a sign's message across language barriers, but help the sign achieve its first goal, that of being noticed.

Truly, a picture is worth a thousand words here. Although in the case of safety signs, the picture is worth more than words—it can be worth a person's life. The graphics used on safety signs play an integral role in getting your message across. The fact is the old word-message-only signs are rapidly going by the wayside and in their place are new signs that use the new symbol-based communication technology. We see this here in the U.S. and in nearly every country in the world where safety communication is valued.

MPS: ***What is semiotics and how does it relate to safety signs and symbols?***

GP: Semiotics is the science behind how signs and symbols communicate messages. The field of semiotics was invented by Charles Pierce in the early 1900s. Although he died in relative obscurity, Pierce is now recognized as having been one of America's greatest thinkers. Ironically, Pierce lived and worked out of his home located half a mile down the road from Clarion's world headquarters in Milford, PA.

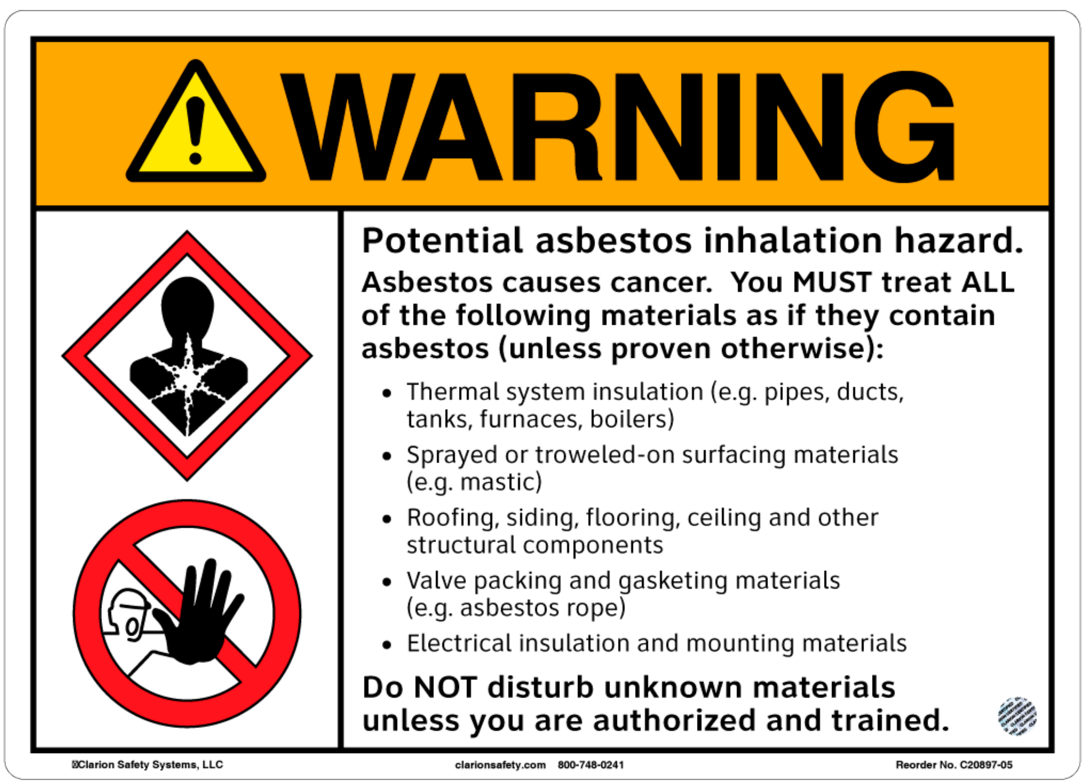
If I were to condense semiotics down to a few words, it works like this. In the material world, everything we perceive as communication is made known to us through our senses—sight, touch, hearing, etc. In the visual realm, we see colors and shapes and these things have meaning to them. The words you are reading right now are made up of letters, each of which has a shape that, when put in context with other letters, make up words that have meanings. But the vehicle of transmitting these meanings starts with seeing them and associating what you see with a meaning, a meaning that has been learned. At Clarion, we apply this theory of knowledge communication to the field of safety signs and labels. Colors, shapes, symbols and words become signal colors, safety symbols and coherent text messages all aimed at reducing risk and protecting people. It is fascinating work.

MPS: ***Can you provide some examples of where semiotics proved successful in the workplace?***

GP: First, many people doubt the effectiveness of warnings and say that you can never prove whether or not a safety sign has done its job of preventing accidents. I challenge this assumption with this fact: At this point in time, Clarion has more than 46 million safety signs and labels installed in over 180 industries, and we have yet to hear of a single instance where one of our clients was sued for "inadequate warnings" or "failure to warn." Since these are the

Figure 1 New ANSI-Style Asbestos Safety Sign

(©Clarion Safety Systems)



two leading allegations in product liability lawsuits today in the U.S., and these allegations are increasingly found in premises liability litigation, the fact that we are using semiotics to successfully communicate safety speaks for itself.

To illustrate this point, compare the signs shown in Figure 3. The signs on the left served as the starting point for deviation to create new signs on the right that are, first and foremost, compliant with the latest ANSI Z535 standards (the standards that set the benchmark for safety signs, colors, labels, tags, symbols and safety information in manuals in the U.S.). Second, the new signs not only describe the hazard, but they include information on the possible consequences of interaction with the hazard and how to avoid the hazard. This increased degree of content is in line with the expectations our society has today for knowledge and information, especially when it comes to safety.

Over the years, U.S. court cases have defined and redefined what constitutes an "adequate warning," and it is on this understanding, combined with human factors research, that the ANSI Z535 standards were built. At Clarion, we infuse our safety sign design experience and knowledge into each sign we design. The standards and the experience in having applied the standards to address so many needs make the signs on the right more effective than those on the left. The communication that is possible with the new sign systems is light years beyond where it used to be.

MPS: ***Is semiotics often used in settings where workers speak multiple languages?***

GP: Yes. The new sign systems we are designing for multilingual workplaces incorporate standards-based color-coding and symbols, as well as text messages that are often translated into the various languages spoken in the specific facility. By using the latest digital print production technology, we are able to cost-effectively produce these sign systems, tailoring them to the specific needs of every client. Old generic signage was practical back in its day because customized signs were prohibitively difficult and costly to make. That has all changed thanks to digital imaging and today's high-tech materials that do not compromise quality and longevity. Safety professionals need to know these tools exist and that they can be used effectively to reinforce their safety training programs. It is possible, now, to achieve the goal of improved safety communication precisely because all of the tools and motivators have come together—the standards, graphical symbols, global consistency, safety training reinforcement and digital print production technology.

MPS: ***You are the new chair of the ANSI Z535 standards committee, which writes standards that govern the characteristics of visual safety markings used to warn about hazards and prevent accidents. How do you think the ANSI Z535 standards will be further developed or revised from this point forward, and how do these standards mesh with OSHA's current regulations?***

GP: As with all ANSI standards, the Z535 series is on a 5-year revision cycle, which means the 2011 standards will be revised and published again in 2016. It is a great committee. I have been on it now for 20 years, and unlike many standards committees where everyone comes from the same industry, the Z535 members come from a diverse range of industries, backgrounds and expertise.

For instance, just the manufacturers on the committee make the following products: heavy off-road equipment, hand power tools, consumer products, batteries, firearms, home appliances, furniture and industrial machinery, to name a few. Add to that people from the insurance industry, the legal profession, the Consumer Product Safety Commission and human factors experts and you have a wide range of perspectives on how warnings are designed and used in real life.

What works and what does not work in the ANSI Z535 standards has been sorted out over the years. Now new issues present themselves that will cause these standards to be further refined. It is clear that graphical symbols are playing an increasingly important role on safety signs, labels and tags. The ANSI Z535.3 standard, Criteria for Safety Symbols, will probably change considerably in its next version. Right now, the standard gives some general guidance on symbol design and describes how to test symbols for comprehension. I can see the Z535.3 standard giving more practical advice on how and where to use symbols, with many examples of illustrative techniques. This would be done in an informative annex so the examples would not be misinterpreted as the only way to do things. They would just be

Figure 2 Old OSHA-Style Safety Sign

examples of how to apply some of the design concepts described in the standard. Such changes would make the standard more useful to those who design warnings and would help keep it relevant in a world becoming increasingly dependent on symbols.

As for the relationship between the ANSI Z535 standards and OSHA regulations, I will paraphrase David Michaels, assistant secretary of labor, as he spoke at ASSE's Safety 2012: "If you are looking to implement best practices, do not turn to OSHA's regulations, they are out of date… look to ANSI standards, they represent the current state of the art."

In so many areas, OSHA regulations have not been revised since their initial creation, and the references to safety sign, color and tag standards that OSHA makes are to the 1967 versions of what are now the ANSI Z535 series of standards. OSHA accepts compliance with the Z535 standards through the "de minimus" rule that allows one to use the latest version of the basis document that OSHA used to make its regulations. It is not a pretty way of doing things, but short of OSHA overcoming its own politically charged process of rulemaking; it is the best way to justify doing the right thing.

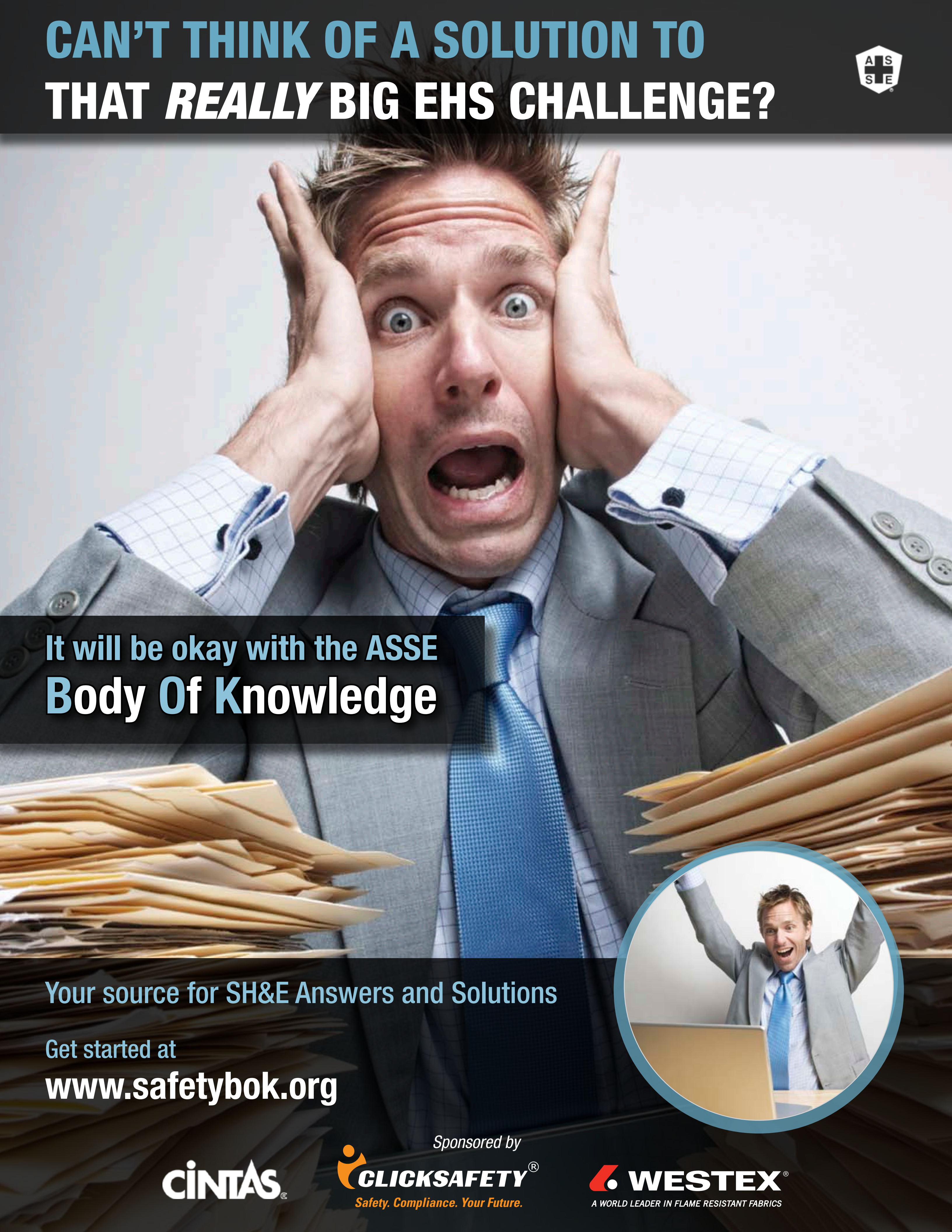
MPS: ***How does your experience as CEO of Clarion help you in your position as ANSI Z535 chair?***

GP: My role at Clarion involves working directly with clients to develop safety sign systems for their products, factories and environments. It is the experience of having practically implemented the concepts found in the ANSI Z535 standards that I bring to the standards-making table. Over the past several revision cycles, many of my change proposals have been accepted by the committee and written into the standards, and every one of these changes began as a means to better meet a client's need to communicate safety. As chair of the committee, I hope to continue to see that future revisions to the standards are valuable to those who need to implement them, all in the effort to keep people from harm. This goal of protecting people is a worthwhile endeavor and one that every safety professional recognizes as vitally important. I take great satisfaction in working with these people to create better and safer work environments for their companies to thrive in. ✪

Geoffrey Peckham *is a longtime member of ASSE and CEO and director of research and development at Clarion Safety Systems. He is chair of both the ANSI Z535 Committee and the U.S. Technical Advisory Group to ISO Technical Committee 145—Graphical Symbols. Over the past two decades, he has played a role in the harmonization of U.S. and international standards pertaining to safety signs, colors, formats and symbols.*

Figure 3 Comparing Old to New

(Best practice signs ©Clarion Safety Systems)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KEY ISSUE

By Peg Zenk

Tightening the Food Chain

Twenty years ago, few people beyond food manufacturers talked about food safety. But today, food safety is a key issue in the minds of consumers, whose awareness of foodborne illnesses has been heightened by attention swirling around recent food recalls.

It is not that there has been an increase in the number of food contamination cases in the past few years, but advancements in science allow safety concerns to be more quickly detected and tracked to their sources, says Joe Swedberg, chair of the Minnesota Agri-Growth Council.

"The U.S. has the safest food system in the world," says Swedberg, vice president of legislative affairs for Hormel Foods Corp. "But there are ways to make our food system even safer, including helping everyone do a better job of troubleshooting for potential problems all along the food chain."

A recent survey revealed that the most memorable 2009 food news stories were those that dealt with food safety issues.

Ray Rauenhorst, a southern Minnesota producer, says that concern goes all the way to the start of the food chain: the farm.

"Most of us take pride in creating a quality product, whether that is grain or meat or milk. But we also need to be concerned about what happens to what we produce after it leaves our farm," explains the Easton, MN, corn and soybean grower. "We should care about food safety because when things go wrong, that can have an impact on our image, even when growers are not directly involved."

Rauenhorst does not view more attention to food safety as a threat to producers. "It is a chance for us to become more involved in monitoring our food supply and providing input on how to make the system better. If we do not help in making those changes, someone will do it for us, and we may not like those results."

Consumer Concerns

A recent survey revealed that the most memorable 2009 food news stories for Americans were those that dealt with food safety issues, including serious foodborne illness stemming from consumption of peanuts.

"Consumers may have become more aware of food safety in recent years, but it is something we have always been focused on," says Michael Considine, general manager of CHS Protein Foods Group in Hutchinson, KS. "When you are in this business, you cannot afford to slip up."

The plant Considine manages produces textured soy protein (TSP), which is sold to makers of frozen pizzas, chilis, dry soups and Mexican foods. "Chances are if you have prepared a frozen pizza with a beef or sausage topping, you have eaten our product," says Considine.

"We are fortunate in the types of products we make and handle," he adds. "The TSP that we produce is essentially made with just water and soy flour we buy from the CHS plant at Mankato, MN. The mixture is heated and extruded using steam."

"The product basically is sterile as it comes out of the extruder, and we need to make sure it stays that way through the packaging process," explains Charlie Fox, quality control manager for CHS Protein Foods. "The dry product goes into a variety of package sizes, from 25-pound bags to 900-pound totes, and is shipped to food manufacturers all around the country."

But accountability does not end there, notes Considine. "The Food and Drug Administration (FDA) now requires that we track all products, down to each ingredient and its source, within 24 hours if a problem arises. That is why we label every package with a lot number that allows us to quickly trace when it was made and where each ingredient came from."

Stepping Up Oversight

Over the past few years, the publicity about several serious foodborne illness outbreaks has contributed to increased public pressure on government agencies and legislators. They are being asked to step up regulations and to require better systems for tracking foods and the ingredients used to produce them, from the farm to the dinner table. Several bills now in Congress would increase oversight of food production and processing.

"It is likely we will see action on one of these bills soon," says Swedberg. "The main intent is to provide more resources for FDA so it can better standardize and modernize the oversight process, as well as help companies do a better job of troubleshooting their own food manufacturing and handling. The industry needs to stay on the offensive and to work hard to prevent problems, not just react to them."

One way FDA works proactively is by engaging food production and processing industries to help find ways to more successfully prevent contamination. A new position has even been created, sometimes called the "food czar," to help producers and food processors set up workable standards. Identifying potential contamination hazards, finding ways to minimize them and then documenting what has been done are expected to be part of on-farm standards.

Food manufacturers already have tools that help ensure food safety, notes Fox. Hazard Analysis & Critical Control Points (HAACP) is a management system originally created in 1959 to help the National Aeronautics and Space Administration ensure safety of foods consumed in space. In the 1970s, FDA adapted and modified HAACP to help companies along the food processing chain identify points in the chain where contamination is most likely to occur, then find ways to reduce the contamination risk. "HAACP is really the backbone of a quality control system," he explains. "It helps us identify critical areas where more control or oversight is needed."

"For instance, using HAACP, we have developed more than 200 written procedures regarding how equipment cleaning and other procedures need to be done," Fox says. "Every step must be followed every time. We cannot afford to take shortcuts."

Thorough, regular employee training is a critical component in an effective quality assurance program, notes Considine. "It is an ongoing process to keep employees trained and focused on food safety and to bring any new people up to speed quickly."

Setting Global Standards

The food industry is also working to standardize safety and checking procedures in food processing within the U.S. and beyond. The Safe Quality Food (SQF) program is one way food manufacturers, including Ventura Foods, a CHS joint venture company, are certifying that their plants use best practices to make safe products that meet the highest quality standards.

"Our plants each go through as many as 15 safety audits a year, conducted by independent agencies and customers," says Ed Wellmeyer, vice president, quality assurance for Ventura Foods.

"Standardizing this process is helping put all food companies on more even footing, streamline audit procedures and reduce costs for our customers."

The eleven Ventura Foods plants, which produce prepared foods, including Marie's® salad dressings and Dean's® dips, are now SQF-certified up to the second of three program levels, he notes. "We are working toward attaining Level 3 certification now."

The global aspect of the SQF program is also important to Ventura Foods facilities, including the plant in Albert Lea, MN, which is one of the country's largest producers of oils, shortenings and margarines.

"We export lard to Mexico and ship margarine to Puerto Rico and Panama. And China and Japan are growing markets for us. We need to know our products will meet the standards of customers all around the world," says plant quality assurance manager Joan Weber.

"Going through the SQF program has helped everyone here take a broader view of what we do and why food safety is so important," she says. "When employees understand all the steps in the manufacturing process—what comes before them and what comes after them—they can do a better job of troubleshooting potential problems."

Congress Debates Greater Food Safety

Several new pieces of food safety legislation are under debate in the U.S. House of Representatives and the U.S. Senate:

•Food Safety Modernization Act of 2009: The act would establish a new Food Safety Administration within the Department of Health and Human Services to prevent foodborne illness, improve research on contaminants that lead to foodborne illness and help protect food from intentional contamination.

•Food Safety Enhancement Act of 2009: The bill would amend the Food, Drug and Cosmetic Act to improve safety of food in the global market, requiring federal registration of all food facilities.

•Processed Food Safety Act of 2009: The bill would amend the Poultry Products Inspection Act, the Federal Meat Inspection Act and the Food, Drug and Cosmetic Act to require processors to certify that their products are not adulterated.

Ventura Foods plants go through up to 15 routine safety audits each year, conducted by independent agencies and customers.

Cost of Foodborne Illness

Foodborne illnesses are a burden on public health and contribute significantly to healthcare costs, as shown by these statistics from FDA and the U.S. Department of Agriculture's Food Safety and Inspection Service.

•From 1988 to 1992, reported U.S. foodborne disease outbreaks caused illness affecting an average of more than 15,000 people each year.

•When unreported cases are taken into account, microorganisms in food are associated with an estimated 76 million illnesses, 325,000 hospitalizations and 5,000 deaths annually.

•Hospitalizations due to foodborne illnesses cost an estimated $3 billion each year.

•Lost productivity from foodborne illnesses costs an estimated $20 billion to $40 billion every year.

Clean Hands

CHS trainers educate food handlers about keeping consumers safe.

A Michigan State University Food Safety Policy Center study revealed that about two-thirds of surveyed consumers worry about the safety of their food, particularly when they eat away from home.

To address those concerns, CHS Energy provides food safety training for employees at Cenex®-branded convenience stores and other retail locations. "We are protecting consumers and the Cenex brand," says Bob Gumatz, manager of retail support for CHS.

The experience and expertise CHS trainers have gained over the years are now available to other food-handling businesses. "If we are offering training for Cenex convenience stores in Minot, ND, for example, why not make it available to other area businesses working with food?"

CHS convenience store trainers use the industry-recognized ServSafe Food Safety program with training and certification provided by the National Restaurant Association. CHS ServSafe training is offered to kitchen staff and supervisors at hotels, bars, restaurants, schools, daycare centers, nursing homes and fast-food operations. The CHS team trains personnel for businesses in Iowa, Minnesota, North Dakota, South Dakota and Wisconsin.

Wisconsin, South Dakota and Minnesota are among the states that require this type of training for foodservice workers. Food handlers in other states, including Iowa and North Dakota, do not need certification, although some cities and counties within their borders require it. Mandatory or not, the training has been well received in all five states, says Gumatz.

Steve Haase and other CHS convenience store trainers use workbooks, presentations, videos and other visual aids to drive home their safety message.

They also conduct exercises using an ultraviolet black light to expose unseen grime and other impurities, both before and after volunteers wash their hands. ✪

Peg Zenk *is a professional writer for CHS Inc.*

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By Jerome E. Spear, CSP, CIH

Improving Contractor Safety Performance

Contractors are hired for their technical competency and skill to complete a project that has been conceptualized by the project owner and designed by the owner's architect(s) and engineer(s). However, since the project occurs on the owner's site, the owner is potentially exposed to additional liability (i.e., OSHA fines and tort liability) that must be considered. In general, a "hands-off" approach or a "hands-on" approach is used to address such potential liabilities.

Liability is a complex issue. Some case law gives an incentive to owners to keep contractors "at arm's length," while other case law appears to require owner involvement that gives rise to additional liability (Yohay & Sapper, 1998). However, preventing an injury is ultimately the best way to prevent a lawsuit. Contractor SH&E performance can be improved by integrating SH&E activities into the contracting process, which includes the following:

•prequalification and contractor selection;
•designing and planning for safety;
•work-in-progress assessment and verification;
•post-work performance evaluation.

Prequalification & Contractor Safety

A formal prequalification process is an important initial step in establishing an effective contractor SH&E program. Although SH&E personnel are not typically in control of the contractor prequalification or selection process, opportunities exist to provide input on the SH&E performance of prospective contractors during the prequalification process.

The prequalification process typically involves the prospective contractor providing the owner with a completed prequalification questionnaire (PQQ) and supporting documents and programs. The PQQ's purpose is to identify those contracting organizations with effective safety management systems with proactive cultures. The completed PQQ should be evaluated by a review panel comprising a variety of experts from various departments within the company. Areas of expertise represented on the review panel should include the following (Farrow, 1999):

•SH&E issues: look at culture, safety management systems, regulatory compliance and safety performance.

•Technical issues: review organizational structure, discipline/trade skills, ability and experience in similar projects.

•Quality issues: evaluate the contracting organization's ability to ensure the integrity and quality of the service.

•Financial issues: ensure that resources are available to meet the demands, performance standards and costs.

Prequalification Criteria

The effectiveness of the contractor's risk reduction practices should be the basis for contractor safety prequalification criteria. Commonly used contractor SH&E performance criteria include the following:

•Experience modification rate (EMR): It is common practice for owners who have a formal contractor SH&E program to require contractors to have an EMR of 1 or less.

•Injury frequency and severity rates: Specific target injury rates are typically company-specific and are often revised (i.e., lowered) periodically by the owner based on the owner's contractor safety goals.

•SH&E program evaluations: SH&E program evaluations are time-consuming and more subjective than reviewing injury statistics, but the evaluator should base his/her judgment on the presence or absence of specific management system elements.

•Integration of SH&E on current projects: The most effective means of evaluating a contractor's SH&E capabilities is to visit a jobsite to evaluate their performance (Hislop, 1999). Interview the prospective contractor to assess their corporate safety culture, SH&E knowledge, management skills and philosophy.

•OSHA and EPA citation history: A contractor that is subject to regular scrutiny by OSHA should be avoided since the presence of that contractor would increase the likelihood of OSHA inspections performed at the owner's site. OSHA inspection records are public records and may be obtained by conducting a company search of the OSHA inspection database.

•References from previous customers: The owner should talk with previous customers and should determine whether or not previous customers were satisfied with the contractor's SH&E performance.

SH&E Contract Requirements

Prudent contractors usually include the cost of supplying safety equipment and employee training in their bids (Nwaelele, 1996). Consequently, their bids may be higher, causing owners to look elsewhere. In other words, some effective SH&E programs go unrewarded. Owners can change this by making SH&E considerations an integral part of project management. Many owners have well-written contractor SH&E programs and incorporating their standards as specific contract requirements

should be considered. The more specifically the SH&E requirements are stated in the contract, the greater the owner's ability to ensure that the work is conducted in a safe manner (Hislop, 1999). SH&E requirements should also be objectively stated to avoid ambiguity and interpretation issues. The project team should work with legal and contract specialists to formulate project safety specifications. Although SH&E contract specifications vary from company to company and often from project to project, the following should be considered when developing SH&E project requirements (MacCollum, 1995):

- name the person who will be responsible for overseeing contractors' performance and ensuring that the work is performed in a safe manner;
- require all contractors to prepare and submit an acceptable SH&E plan that defines supervisory and employee safety training prior to the start of their particular work;
- list specific published SH&E standards and hazard prevention requirements;
- list special SH&E requirements to be followed for unique hazards not adequately defined in provisions contained in published SH&E standards;
- list qualifying requirements for eligible contractors to ensure that bidders are restricted to those contractors whose past SH&E performance indicates that they are competent and safe contractors and include an assessment of the contractor's current SH&E capabilities.

Designing & Planning for Safety

Considering SH&E issues while designing the project and during preplanning of the project could have a dramatic impact in reducing injuries that may occur during the project's work phase. SH&E considerations not addressed during the initial design phase often costs significantly more to retrofit or otherwise correct after the project is completed or even during the project's work phase.

The owner's project team should include a safety engineer who analyzes conceptual project designs and predicts hazards that may evolve (Nwaelele, 1996). Performing formal SH&E assessments and reviews during the designing and planning phases can identify and assess hazards early on so that the project team can eliminate them or provide engineering solutions to efficiently control hazards during the work phase. Some specific examples of how SH&E issues may be addressed during the design and planning phase include specifying temporary decking to be installed as soon as possible to prevent injury from falling, designing permanent stairways and walkways to be constructed first so that the use of temporary scaffolding is minimized and removing or relocating utilities.

Work-In-Progress Assessment & Verification

A monitoring program typically includes SH&E performance reporting, inspections (by owners and contractors) and incident reporting. Owners often require periodic (i.e., at least monthly) reports to be submitted to the owner to track the contractor's SH&E performance. Consideration should be given to measure and track both results-based metrics (such as injuries and incidents) and activity-based metrics (e.g., inspections, audits, job safety analyses completed, toolbox safety meetings, number of corrective actions implemented, behavior observations and feedback, etc.).

Once the contractor is on site, the owner should periodically monitor the contractor's work practices. If improper SH&E practices are observed, the owner needs to take action to ensure that the responsible contractor(s) correct the situation. The frequency of monitoring should depend on the level of risk associated with the work the contractor is performing. The contractor should conduct internal SH&E inspections according to their procedures. The contractor's self-inspection reports may be submitted to the owner or be available to review upon request. A formal system should be established to review the audit findings with the contractor(s) that reflect corrective actions needed, person(s) responsible for implementing the corrective action and due dates to ensure that deficiencies are corrected in a timely manner.

Post-Work Performance Evaluation

After completion of the project, a post-work evaluation of the contractor's performance should be conducted. The SH&E portion of this evaluation should incorporate data from the contractor's monthly reports, audit findings and observations. This comprehensive report can be used to build a database of contractors for future projects (Nwaelele, 1996). Furthermore, both company and contractor management teams should complete contract closeout reports that detail the positive and negative aspects of the contract and the recommendations for similar contracts in the future. If the contractor does not meet the owner's expectations and requirements, a meeting may provide the contractor an opportunity to discuss the issues and to develop a corrective action plan. In some cases (consistent with contracting provisions), the owner may determine that the contractor should be removed from the approved contractor list.

In summary, successful contracting management requires the involvement of various owner and contractor representatives. The key to improving SH&E performance is through the integration of SH&E into the contracting process, which includes establishing formal prequalification and contractor selection criteria and incorporating SH&E requirements into the contract. Since designing and planning with contractor safety in mind provides the greatest opportunity to minimize incidents in the field, formal SH&E reviews should be performed during the designing and planning phases of the project. Finally, the contractor's performance should be evaluated both during and upon completion of the project to not only provide feedback to the contractor so they can work to improve their performance, but also to determine if the contractor should be considered for future projects. ✪

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