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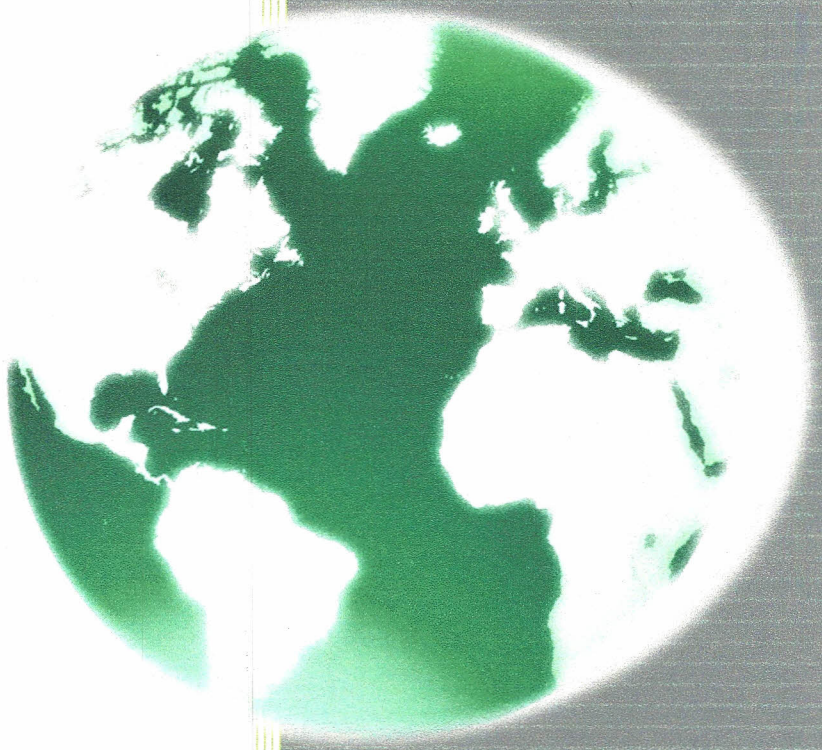
ESP-Enhanced Safety Principles



In This Issue

- Letter to the Editor: Gaining Commitment to Good Occupational Health and Safety
- International Solutions for Improving Community Health and Workplace Safety
- Safety Auditing
- Contractors Benefit from Safety and Environmental Audits
- Considering Cognitive Ergonomic Factors to Prevent Accidents

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Article Submission

Articles for inclusion in this journal will be accepted at any time; however, there can be no guarantee that the article will appear in the following journal issue.

All articles shall be written in concise English and typed with a minimum font size of 12 point. Articles should have an abstract of not more than 200 words. Articles shall be submitted as Times New Roman print and presented in the form the writer wants published. On a separate page, the author should supply the author's name, contact details, professional qualifications, and current employment position. This should be submitted with the article.

Writers should include all references and acknowledgments. Authors are responsible for ensuring that their works do not infringe on any copyright. Failure to do so can result in the writer being accountable for breach of copyright. The accuracy of the references is the author's responsibility.

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Updated 09/17/2014

World Safety Organization (WSO)

World Safety Organization Profile

The WSO was founded in 1975 in Manila, The Republic of the Philippines, as a result of a gather of over 1,000 representatives of safety professionals from all continents at the First World Safety and Accident Prevention Congress. The WSO World Management Center was established in the United States of America in 1987 to be responsible for all WSO activities, the liaison with the United Nations, the co-operation with numerous Safety Councils, professional safety/environmental (and allied areas) organizations, WSO International Chapters/Offices, Member Corporations, companies, groups, societies, etc. The WSO is a not-for-profit corporation, non-sectarian, non-political movement to **"Make Safety a Way of Life…Worldwide."**

World Safety Organization Activities

The WSO publishes WSO Newsletters, World Safety Journal-ESP, and WSO Conference Proceedings.

The WSO provides a network program linking various areas of professional expertise needed in today's international community.

The WSO develops and accredits educational programs essential to national and international safety and establishes centers to support these programs.

The WSO presents annual awards: the James K. Williams Award, Glenn E. Hudson International Award, J. Peter Cunliffe Transportation Award, WSO Concerned Citizen, WSO Concerned Professional, WSO Concerned Company/Corporation, WSO Concerned Organization, Educational Award, WSO Chapter/National Office of the Year, and Award for Achievement in Scientific Research and Development.

The WSO provides recognition for safety publications, films, videos, and other training and media materials that meet the WSO required educational standards.

The WSO receives proposals from professional safety groups/societies for review and, if applicable, submits them to the United Nations for adoption.

The WSO establishes and supports divisions and committees to assist members in maintaining and updating their professional qualifications and expertise.

The WSO has Chapters and National/International Offices located throughout the world, providing contact with local communities, educational institutions, and industrial entities.

The WSO organizes and provides professional support for international and national groups of experts on all continents who are available to provide expertise and immediate help in times of emergencies.

Benefits of Membership

The WSO publishes the "WSO Consultants Directory" as a service to its Members and to the Professional Community. Only Certified Members may be listed.

The WSO collects data on the professional skills, expertise, and experience of its Members in the WSO Expertise Bank for a reference when a request is received for professional expertise, skill, or experience.

The WSO provides a network system to its Members whereby professional assistance may be requested by an individual, organization, state, or country or a personal basis. Members needing assistance may write to the WSO with a specific request, and the WSO, through its Membership and other professional resources, will try to link the requester with a person, organization, or other resource which may be of assistance.

The WSO provides all Members with a Membership Certificate for display on their office wall and with a WSO Membership Identification Card.

The WSO awards a Certificate of Honorary Membership to the corporations, companies, and other entities paying the WSO Membership and/or WSO Certification fees for their employees.

Members have access to WSO Newsletters and other membership publications of the WSO on the WSO website, and may request hard copies by contacting the WSO World Management Center. Subscription fees apply to certain publications.

Members are entitled to reduced fees at seminars, conferences, and classes given by the WSO. This includes local, regional, and international programs. When Continuing Education Units (CEUs) are applicable, an appropriate certificate is issued.

Members who attend conferences, seminars, and classes receive a Certificate of Attendance from the WSO. For individuals attending courses sponsored by the WSO, a Certificate of Completion is issued upon completion of each course.

Members receive special hotel rates when attending safety programs, conferences, etc., sponsored by the WSO.

Membership

The World Safety Organization has members who are full time professionals, executives, directors, etc., working in the safety and accident prevention fields, including university professors, private consultants, expert witnesses, researchers, safety managers, directors of training, etc. They are employees of multi-national corporations, local industries, private enterprises, governments, and educational institutions. Membership in the World Safety Organization is open to all individuals and entities involved in the safety and accident prevention field, regardless of race, color, creed, ideology, religion, social status, sex, or political beliefs.

Membership Categories

Associate Membership: Individuals connected with safety and accident prevention in their work or individuals interested in the safety field, including students, interested citizens, etc. **Affiliate Membership**: Safety, hazard, risk, loss, and accident prevention practitioners working as full time practitioners in the safety field. Only Affiliate Members are eligible for the WSO Certification and Registration Programs. **Institutional Membership**: Organizations, corporations, agencies, and other entities directly or indirectly involved in safety activities and other related fields.

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[ ]	Associate Membership	$55.00 USD
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PLEASE specify your area of professional expertise. This information will be entered into the WSO "Bank of Professional Skills," which serves as a pool of information when a request for a consultant/information/expertise in a specific area of the profession is requested.

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"Safety Across Multi-Disciplined Organizations with Global Lessons to Inspire Local Actions"

The Symposium presentations this year will focus on multi-disciplined cooperation between different organizations and cross-disciplinary research that addresses safety promotion and injury prevention. This important theme of the 2014 Symposium is how we learn from one another's experiences in different organizations and countries. The Symposium will focus on how to build connections and research partnerships between these different sectors.

The 27th Annual Symposium will provide a unique opportunity for the WSO members from the USA to meet members from other countries where the WSO is represented through the WSO National Offices, WSO Chapters, and individual members. Participation in the Symposium will provide a forum for information exchange, networking, professional contact with other members, safety professionals, but most of all, learning about new programs and professional knowledge at sessions, panels and workshops presented during the Symposium. The Symposium format consists of presentations, lectures, panels, workshops and plenary sessions. As a part of the program symposium attendees are invited to participate in the "WSO Global Safety Round-table" discussion where the suggestions, comments, resolutions, etc., will be formatted for submission to governmental legislation and Missions of the United Nations, International Labor Organization, World Health Organization, and similar rule-making groups on the local, national and international levels.

Detailed information and a downloadable registration form are available on the WSO website: www.worldsafety.org.

International Solutions for Improving Community Health and Workplace Safety

WSO Global Safety Round Table Report for the United Nations' Economic and Social Council

By **Dr. Janis Jansz**. RN, RM, Dip. Tch., BSc. Grad. Dip. OHS, MPH, PhD Curtin University, Faculty of Health Science; Edith Cowan University, School of Business; **Robert V. Trapani**, WSO-CSS/CHME, CET, CIT, Environmental Engineer; B.A. Arizona State University; Engineering Management, California Institute of Technology, Arizona Department of Transportation; **Robert Brandys**, PhD, MPH, PE, CIH, CSP, OEHCS, Inc., Hinsdale, Illinois; and **Gail Brandys**, MS, CSP, OEHCS, Inc., Hinsdale, Illinois.

Abstract

Community and workplace safety improvements are an important concern for the United Nations Economic and Social Council. At the 26th World Safety Organization International Environmental and Occupational Safety and Health Symposium focus group research was conducted with participants from twelve countries to identify international emerging issues in community and workplace safety and to develop risk control recommendation for these concerns. This article describes the outcomes of the focus group findings which were that health and safety education should be taught to children in pre-school, improvements were required for sports safety, there was a need to involve everyone in the organization in workplace

Key words: Pre-school education. Sports safety. Health. Safety. Environmental management. Indoor air quality. Occupational exposure limits.

Introduction

World Safety Organization has Consultative Status to the United Nations Economic and Social Council. At the 26th World Safety Organization International Environmental and Occupational Safety and Health Symposium held at the Hilton Hotel in Mission Valley, San Diego, California, USA, on the 9th of September 2013, a Round Table discussion was held to provide advice to this United Nations Council on international solutions for improving community health and workplace safety. At this Round Table focus group discussion there were over 70 participants who came from the following countries: Australia, Canada, Lebanon, Malaysia, Nigeria, Panama, Philippines, Qatar, Saudi Arabia, Taiwan, United Arab Emirates and the United States of America.

From this focus group four main discussion themes emerged:

- Health and Safety Education to be provided for Pre-School Children
- Sports Safety
- Involving Everyone in the Organization in Workplace Safety and Health Management
- Workplace Environmental Management

Health and Safety Education to Be Provided for Pre-School Children

Findings of the focus group participants were that much of what people learn begins in early childhood, so this is where health and safety needs to begin. Pre-school children often take infections home to other members of their family. For this reason for children in all countries in the world an important skill that should be taught in pre-school is how children need to correctly wash their hands, and when children need to wash their hands to prevent the spread of infections. Pre-school children also need to be taught to drink water from a clean cup, not a drinking fountain, as many children using a common drinking fountain assist with the spread of throat infections, particularly those caused by streptococcus. Using simple hygiene measures can reduce community mortality rate from 60% to 2.2% (*Simkin, 2012*).

Children can also have a positive effect on improving health-related behaviors of their parents. An example of this is when children encouraging their parents not to smoke cigarettes. Children that learn early in life about the ill health effects of cigarette smoking are likely to tell their parents to cease smoking as they want their parents to be healthy, but also because they do not want their own health harmed by side-stream smoke (second hand smoke). Having their child disapprove of their actions may encourage parents who smoke cigarettes to stop smoking. Today, smoking is not allowed in public buildings and workplaces in many countries.

Educating children in pre-school about health and safety will enable the children to bring their knowledge to encourage their parents and other family members to have a high standard of health and safety practices in their home and community. Also if a young child learns to consider health and safety in everything the child does, when they do go to a workplace for their employment, they will be in the habit of automatically finding the safest and healthiest way to perform work tasks. This will have long-term benefits of decreasing workplace injuries, work-related ill health and payments for workers compensation.

Sports Safety

While parents may consider health and safety for many aspects of their children's life, this does not always extend to when their children play sports. This may be due to the competitive nature of the activities and the desire to see their child win. Some examples of child sports injuries include repetitive strain injury when the same sets of muscles are used repetitively, such as when a child spends a long period of time as a pitcher at a baseball game. To minimize the occurrence of repetitive strain injuries, children should be taught to play in a variety of positions on a sports team, particularly when they are young, and should perform no one-muscle action for more than 30 minutes without a rest or change of required muscle actions. Other problems related to playing sports that may affect the players' safety and health are environmental factors such as playing sports outdoors when the weather is very hot, or playing sports when lightning is crackling in the sky. Casa, et al., (*2012, p.96*) has recorded that the 10 most common causes of sudden death in sports are:

- Asthma
- Catastrophic brain injuries
- Diabetes
- Exertional heat stroke

- Exertional hyponatremia
- Exertional sickling
- Head-down contact in football
- Lightening
- Sudden cardiac arrest

Harmon, et al. (*2011*) identified that between January 2004 and December 2008 there were 273 sudden deaths of participants during sporting activities in Members of the National Collegiate Athletics Association in the United States of America (USA). Mathews, et al., (*2012*) examined the statistics for marathon runners' deaths in the USA for the period 2000 to 2009 and identified that for the 6 women and 22 men (a total of 28 deaths in 10 years) who died due to participation in a marathon run the most common cause of death was a cardiac arrest.

To maintain good health and safety, before training or a sports game commences, a risk assessment should be conducted that considers sports participant's health, environmental factors, the work processes that are part of the sport, and the skills and abilities of individual players. For example, in certain parts of the world children ride sheep or bulls for sport. In animal riding sports, environmental factors that should be considered include the temperature (ensure the weather is not too hot or cold); the ground, if there is snow or uneven ground, soft or hard ground; any obstacles or barriers on the ground. If the rider could fall from the animal they are riding, then the rider should be wearing personal protective equipment in the way of clothing and should also wear a helmet to protect their head. In some parts of America this is a problem as the parents believe that this is un-American not to take risks and wearing a helmet. For this reason, education in sports safety and the consequences of not using good health and safety practices needs to be provided at the beginning of primary school to children, so that they do not have future health problems due to childhood sports injuries.

If environmental consideration are not assessed heat related illnesses and deaths during sporting activities can occur as children's bodies have a higher surface area ratio than adults; they have a lower perspiration rate and their metabolic rate is higher than adults at the same rate of activity so children produce more body heat when participating in sporting activities and loose this heat at a slower rate (*Marshall, 2010*). Another important aspect of risk assessment is the need for more complete physical exams of athletes before engaging in rigorous sports. An inordinate number of soccer field and football field deaths occur with youngsters and teens who have unknown, underlying heart conditions. Many of these conditions can be identified with a more complete physical exam, but few school districts perform them.

A problem with some athletics is that they are proud of having sporting injuries and encourage the next generation to take the same risks as they took, in the name of sports' excitement. People have to value their health and safety, and that of their children before changes can be made. There is an old saying that a person cannot be helped until they understand that they need help, and that it takes a village community to raise an alcoholic. In other words, what society values is what will be enforced for people's acceptable behavior, so starting the young in learning good health and safety practices is very important.

Another example of pride interfering with good health and safety is the connection between repeated concussions during sports such as football and physical and mental health later in life. For example Lehman, Hein, Baron & Gersic (*2012*) conducted research to evaluate the incidences of neuro-degenerate deaths in a cohort of 3,439 ex USA National Football League players. This research identified that, due to recurrent mild traumatic brain injuries (concussions) the neurodegenerative mortality of this cohort was 3 times higher than for the general USA population. Many athletes feel the need to get back in the game after they have sustained a concussion. Concussion awareness training, proper fitting equipment, better medical treatment, longer recuperation time, and closer monitoring of illegal moves on the field can help minimize the lifelong, life changing problems of chronic pain and mental deficits (*Lehman, Hein, Baron & Gersic, 2012*). Thomas et al. (*2011*) evaluated the US National Registry of Sudden Deaths in Young Athletes (*1980-2009*) and identified that of the 1,827 deaths of people under 21 years old who died while participating in sports activities the largest number of deaths (148) occurred while the athlete was playing football.

Involving Everyone in the Organization in Workplace Safety and Health Management

Just as it is important for everyone in the community to be involved in good health and safety practices, it is important for everyone in a workplace to do this. In a workplace, the person with the most power to affect the work environment, work processes, equipment and products used and the actions of employees, is the employer or Chief Executive Officer (CEO). For this reason, to be effective, the Safety and Health Professional should attend social activities as well as work activities at which the CEO will be present, to keep up to date with what is happening in the consideration and implementation of good occupational safety and health practices.

Having good occupational safety, health and environmental management must be company values to promote a positive culture in the workplace in relation to these values. Priorities change, but values remain.

Often company CEOs think that they know all about safety in relation to their company, but they do not. Workplace health and safety advisors are usually needed to keep everyone in the company up to date with current occupational safety and health knowledge.

CEOs do not always know everything that occurs in their company. Often they only know what they are told by other company managers. For example when the Deepwater Horizon oil rig exploded with the loss of life of 9 platform workers and 2 engineers, 4 of the 6 BP employees who were on board this oil rig were there to congratulate senior Deepwater Horizon staff on having 7 years of operation without a single loss time injury (*Roach, Harris & Williamson, 2010; Deepwater Horizon Study Group, 2011*). The CEO of BP, Mr. Tony Hayward, thought that health and safety was well managed on the Deepwater Horizon, but unfortunately cost cutting measures of several million dollars that ignored safety concerns (Waxman, 2010) resulted in an explosion that produced an oil spill of 4.9 million barrels of crude oil that was released into the Gulf of Mexico producing an oil slick that covered 6,500 km^2 and polluted hundreds of kilometers of beaches, wetlands and estuaries on the Gulf of Mexico Coast (*Kostka et al, 2011; Rico-Martinez, Snell & Shearer, 2013*). Sav-

ing money by not ensuring safety had, by 2013, cost BP US$14 billion in clean-up costs, payments of US$11,003 million to the USA Federal and State Governments, to individuals and businesses and a fine of US$4 billion for the death of the 11 people killed in the Deepwater Horizon explosion (*Ramseur & Hagerty, 2013*). BP also had over 100,000 private claims made against it in relation the Deepwater Horizon explosion and resulting oil spill which in 2013 were being settled with a limit of US$2.3 billion for seafood compensation and the remainder of the claims being expected to be settled for approximately US$7.8 billion (*Ramseur & Hagerty, 2013*). In part this is an example of the cost of the CEO not understanding the importance of workplace safety and promoting a culture of safety at BP.

To enable CEOs to have a better understanding of what is happening in their company it is also necessary to have employees who are doing the hands on work elect employees from their work group. Countries that have ratified the International Labour Organization (ILO) Convention ISS calls these elected employees Safety and Health Representatives. In all these workplaces, as well as having safety representatives, there is usually a workplace health and safety committee composed of an equal number of health and safety representatives and workplace managers who include the CEO. Through the information provided to, and provided by this committee, good occupational safety and health practices can become a normal part of work for everyone in the company.

It is very important to enable good workplace health and safety practices in the role of the supervision since the supervisor usually organizes employees' daily work, provides education on safety work practices, and observes employees' work to ensure the work is performed correctly. The pressure that comes from managers above the workplace Supervisor can affect the Supervisor's decisions. If the company values are production at all costs without considerations of employee health and safety, then this value can affect the Supervisor's decisions. If workplace health and safety as well as production is a value and the supervisor has this assessed as part of their performance management, then the supervisor is more likely to consider and implement best work practices.

The workplace health and safety advisor also has a role to play in letting the CEO, and other people who are business decision makers, know the cost of including safety and health work practices, and the cost of not having these, as businesses need to make a profit to remain financially viable. It is also important for companies to measure positive performance indicators, such as having good safety management plans and systems, as these show where the company is going with their occupational safety and health management and using positive performance indicators can decrease company insurance premiums, reduce worker's compensation costs and improve employee productivity. Log indicators, such as loss time injuries, show where the company has been with its safety management and can identify opportunities for improvement in the company's safety and health management.

Experienced workplace health and safety advisors have much knowledge to offer not only to the people in their workplace, but also to the next generation of health, safety and environmental management advisors. Organizations, including World Safety Organization, need to encourage their experienced workplace health and safety advisors to be the peer mentors for the next generation as much learning is achieved when working in industry as well as from classroom learning. Professional organizations need to have links to colleges and universities where workplace health, safety and environmental management is taught to provide these students with practical workplace experience and peer mentoring.

Some states in the USA require that asbestos building inspectors work under a mentor for one year after completing their inspector coursework. This is particularly useful since a three-day classroom experience is not sufficient to address all the issues that an asbestos inspector will encounter in the real world.

Workplace Environmental Management

Part of good workplace safety and health is environmental management. In the modern world, workers are exposed to hundreds if not thousands of potentially-hazardous chemicals every day. These chemicals come from the outdoor environment and indoor environments both at home and in the workplace. With recent efforts for Global Harmonization of chemical information in the occupational arena, it seems appropriate to also share information between countries on occupational exposure levels. For example, US OSHA has occupational exposure limits for about 600 chemicals, whereas globally, the various industrialized developed countries have occupational exposure limits for over 6,000 chemicals. This information includes occupational exposure limits for 8-hour industrial exposures as well as long-term exposure limits for indoor air quality. This is valuable information that safety and health professionals can use to better evaluate and control chemical exposures in all indoor environments.

The adoption of the Global Harmonization System for chemical hazard identification is a wonderful first step in standardizing chemical hazard information worldwide. Countries should be encouraged to share the wealth of their knowledge of workplace chemical and biological exposure standards so that all workers can benefit from the most comprehensive knowledge available on protection from chemical and biological exposures.

Reduction of Harmful Microbial Contamination in Work Places

Microbial contamination of the work environment is a relatively new concern in the area of worker health. This has taken on even more importance with the development generic engineering technologies that allow the mutation of both mold and bacterial species. It is important that the potential risks to worker health be both recognized as well as managed by competent and adequately trained individuals. Training materials on this subject area are woefully lacking on a global basis. The UN should consider developing training materials that can be used by both developed and developing countries.

Indoor air quality can also be significantly affected by microbial contamination (*Jansz, 2011b*). Management decisions to reduce energy use can result in a serious reduction in outside air delivered to a building and consequential increases in the indoor microbial levels (*Jansz, 2011a*). Many new building today contain an indoor "green" area with numerous plant species. At the same

time, these plants and the soil supporting their growth contain high levels of microbial species. When outside air is reduced in these building areas, the building essential operates as a green house, exposing office workers to "green-house" workers' health risks which are well documented in the literature. This presents a serious health risk, especially at night when many "energy efficient" building turn off ventilation systems. Subsequently, workers entering the building at the start of the workday can be exposed to unhealthy levels of mold, bacteria and endotoxins. Unfortunately, this indoor air quality health risk is not well recognized or even considered by building owners (*Jansz, 2011c*). This health risks in buildings with internal "green" areas need to be made a priority since this is an expanding area of new building design and construction.

An Environmental Workplace Management Recognition and Incentive Program

An example of best practice in environmental management comes from the State of Arizona Department of Transportation (ADOT) which, in 2008, implemented effective environmental workplace management recognition and incentive program called the "Environmental Green Shop Award Program." The goal was to "Go Green" at the 22 equipment repair shops located throughout the State of Arizona. This was accomplished and has evolved beyond what was originally anticipated.

The program started with a focus on the proven principles of Reuse, Reduce and Recycle. It quickly expanded to emphasize the conservation of energy, water, consumables and petroleum fuel, while at the same time reducing and minimizing source waste. ADOT's commitment to 'green initiatives' and 'zero waste' is part of the culture and is the mission of the Agency with core values aimed at improving environmental impact and sustainability in order to achieve a competitive value-added business advantage through sustainable business approaches. One of the results of this program was improved efficiencies resulting from a cleaner shop and structured work practices. As a result of this program the repair shops have realized savings on chemical purchases; disposal costs; regulatory monitoring, reporting and permit fees; water, electricity and sewer use charges. The success of the Green Shop Program comes from the basic principles of ownership and accountability.

Ownership

The Environmental Green Shop Award Program was initiated to help reduce waste and improve sustainability based on the simple fact that the equipment repair shops, their workers and the environment would all benefit. The Program provided an opportunity to apply best management practices to equipment repair shop operations and thus reduce the cost, carbon footprint and energy consumption of the workplace infrastructure state wide. At the core of the program was the Best Management Practice Manual (BMP Manual). The BMP Manual was written to provide documented guidance in order to reduce pollution, improve and enhance operational capabilities in an environmentally sensitive manner. Most regulations document what has to be done to be in compliance; but they don't explain how to do it. That's where 'best management practice' comes into play on the shop floor. BMPs are proven guidelines and methods that help companies and their employees become compliant and remain compliant.

Most of the efforts to make the repair shops 'green' came from implementing best management practices in the equipment repair shops. The manual was made readily accessible to all technicians on the shop floor and was included on all company desktop computers. It provides guidelines and procedures for employees to follow. From its inception the Program has empowered employees to go 'above and beyond' to make a meaningful difference by engaging workers as 'Green Shop Teams' to implement and improve environmental sustainability, which is both good for business and the planet. Each year the best new ideas, from the shops are incorporated into the Best Management Practice Manual making the program not only a living document but one that is created from employee innovations discovered in the field.

Self-audit checklists are used for various types of tasks and repair shop procedures to ensure shops followed the BMPs, complied with regulations, protect the health of employees and the quality of the environment. The self-audit checklist was required in order to certify a shop green, bridge the gap between the goal and the reality of environmental accountability as well as attest to the successful efforts of the shop supervisor. Each shop completed a self-audit inspection using the checklist twice a year and submitted it to the Environment Engineering Manager for review. The Self-audit checklist was used to review shop activities in order to identify and select best practice for those activities with the potential to cause spills or releases of pollutants like oil, grease and/or fuel, to identify inlet and discharge points and to identify any illegal connections. The Checklist was not used for a 'gotcha,' but as a tool to help identify some of the things that might be done in a better manner.

The Self-audit checklist is divided into four parts:

- Environmental Compliance. Ensures environmental compliance at the shops.
- Quest for a Green Shop. Identifies shop practices that impact environmental sustainability, moves the repair shops beyond compliance and towards a more 'green' environmental footprint.
- Action Plan. Creates a plan of action for everyone to continue to move each repair shop towards a more 'green' workplace.
- Personal Effects of Going Green. Identifies the per-sonal program benefits.

Accountability and Rewards

Unannounced audits are performed annually. These audits provide a method of extensive data collection, reviews, validation, documentation, communication and reporting. Checklists are scored and equipment shops must obtain a minimum score for compliance certification. A scoring metric was developed and is used to evaluate and rate the quality of implementation of BMPs in the equipment repair shops. This numerical rating system indicates overall implementation of BMPs including consistency of the Self-Audit Checklist with an actual onsite evaluation. Green Shop Award recipients are chosen based on their score after reviewing their second Checklist and unannounced site inspection. The shop with the highest score is the winner. Winning shops receive a Green Shop Flag for the shop front, a Green Shop Banner to hang inside their shop, a handsome award plaque, a Star Performer Award and Green Shop embroidered uniform patches for all shop personnel. The winning shop team gets a day off

work with pay. The ceremony includes the State of Arizona Department of Transportation Director presenting awards and words of gratitude to the winning team members.

Winning shops are also judged on the following:

- Environmentally friendly new procedures or systems developed;
- Implementation of a variety of best practice measures to reduce the amount of chemicals stored;
- Effectiveness and safety of hazardous materials management, waste management and hazardous materials storage;
- The hazards of the chemicals used. (Is the least toxic chemical fit for the purpose used?);
- Amount of hazardous waste generated while minimizing the employee exposure and lessening environmental impact;
- Number of reported spills or releases within the past year;
- Use of environmental friendly equipment and new procedures or new systems developed;
- Level of compliance with all environmental regulations (no Notice of Violations or fines by regulatory agencies);
- Personal housekeeping;
- Overall shop cleanliness;
- Contributions made to advance environmental leadership;
- Maintenance and improvement of environment programs at the shop;
- Timely submittals of the shop Self-Audit Checklists;
- Consistency of checklist findings with unannounced onsite evaluations;
- Commitment to continue complying with pertinent regulations and implementing the measures chosen from the Checklist;
- BMPs manual requirements implemented and manuals maintained in good condition;
- Implemented measures contribution to sustainability;
- Commitment to continue demonstrated initiatives (reporting a problems, prompt clean-up);
- Other achievements related to shop work practices made to improve environmental management and sustainability.

The green initiatives that Shops have put into practice have significantly reduced the amount of waste generated and has sometime eliminated waste production. This can be attributed to the process of recycling thousands of used tires, lead-acid batteries and filters along with tons of scrap metal and thousands of gallons of motor oils and other fluids. There are recycling bins in all shops and at fuel islands to recycle paper, cardboard, plastics, and aluminum cans. Shops have implemented additional green measures to conserve water and improve energy efficiency.

The Environmental Green Shop Award Program has supported each shop in exceeding national environmental compliance standards and encourages each shop to move beyond compliance in their own way. The Program continues to encourage a long-lasting, sustainable commitment to protecting public health and improving and preserving Arizona's beautiful natural surroundings. The Program sends a clear message about the importance of being environmental stewards and strives each day to make a positive impact to the environment, customers and to the citizens of Arizona. The State of Arizona Department of Transportation actions and policies make a difference! More information about this program can be obtained from Mr. Robert V. Trapani, CET, CIT, WSO-CSS/CHME, Environmental Engineering Specialist, phone (602) 712-6177 or email: rtrapani@azdot.gov or contact at the Arizona Department of Transportation, 2225 S. 22nd Ave., Phoenix, Arizona, 85009 USA.

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Safety Auditing [1]

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Abstract

Safety Auditing is required to ensure that all workplace hazards are identified and the risk of hazards causing harm is either eliminated, or risks of identified hazards causing harm are reduced to as low as practical. This article is the first in a series of four articles on safety auditing. It identifies the arrangements required for safety auditing, the major elements required to be included in a safety audit and includes case studies on safety auditing.

Key words: Safety audits. Accident prevention. Hazard identification. Risk control.

Introduction

Safety auditing has been playing a significantly increased role in the prevention of accidents and ill health at work over the last 20 years or so. A variety of measures have been used to evaluate and measure the organizational performance in this field. Most of these measures and relevant quantitative indices are reactive and calculated on the basis of the consequences, i.e. , the accidents and occupational disorders we have not been able to prevent. Examples include lost time injuries, first aid injuries, or medical treatment injuries, as well as restricted duty injuries.

The system safety approach involves concentrating on the preventive measures before occupational accidents and diseases occur. This is connected with the effort to develop predictive measures of the occupational safety and health performance. One of these predictive measures, and a very powerful one, is auditing of the critical range of the accident prevention processes. For some organizations this includes not only safety but also other loss prevention measures.

Safety Auditing

In order to be an effective predictive technique, auditing must address not only the physical working environment, but also all management processes managing the physical working environment, i.e., all relevant aspects of human factors. Therefore, auditing will give a reasonable indication of how well an organization's occupational safety and health program is working in all its aspects, e.g.:

- how hazards are being identified
- how hazards are being controlled
- how accidents are being avoided

In the US a number of large companies, which were noted for profitability as well as good safety records, were convinced that effective safety and loss prevention programs were essential for a company's prosperity and accepted as an integral part of a good business (Safety Audit- A guide for the chemical industry, 1986). One requirement of such programs was that efficiency should be checked by the introduction of safety audits to ensure that the company's assets were effectively safe-guarded.

Based on the experience of large industrial companies, safety auditing has become an integral part of occupational safety and health across the board, including e.g. universities (University of Wollongong, 2013).

The potential for injury, occupational disease and material loss in the mining and mineral processing operations is enormous. Examples would include fires, explosions, ground fall accidents in underground mines, accidents related to operation of machinery and to machinery failure, transport accidents occupational lung disorders and many others. Injury to the people would be only one side of the coin. The other side of the coin would be heavy financial losses as a consequence of even a minor accident, which may lead to lengthy downtime.

The major objective of safety auditing is to determine the effectiveness of the company's occupational safety and health management system. Detailed objectives should cover the examination and assessment of all safety aspects of every occupational activity. These activities should include, among others:

- design and commissioning of the equipment
- technical operations
- operating procedures
- maintenance
- permit-to-work system
- personnel selection and placement
- job descriptions and job safety analysis
- emergency procedures
- investigation of accidents and near misses
- management and employee training
- purchasing
- housekeeping
- monitoring the work environment

Safety audits should involve a systematic, critical appraisal of all potential hazards involving personnel, machinery and equipment, operations and services including management and first line supervisors. The audits need to ensure that a company's occupational safety and health systems, as a minimum, fully satisfy the relevant legal requirements.

Another essential requirement of a safety audit system is that it should originate with the policy-making chief executive who, together with other levels of management, has to be fully committed. They also must be prepared to adjust on their own safety and health activities in accordance with the results and recommendations of the audits. It is also essential that all relevant senior managers are directly involved in the review of audit reports, design and implementation of an action plan and in subsequent reviews of progress of such plan.

Since all company's activities should be subject to audit, auditing should involve individual employees at all levels not only as a manifestation of management's interest and concern, but also to encourage comments and suggestions relating to safety and health matters. Such close cooperation between management and workers encourages the discovery process of factors and conditions which need modification and improvement, to be brought up to a desired level.

Detailed arrangements for safety auditing depend on the size of a company, and the range of its activities. Every good safety auditing system should contain five main elements:

a) identification of possible loss-producing situations;
b) assessment of potential losses associated with these risks;
c) selection of measures to minimise losses;
d) implementation of these measures within the organization;
e) monitoring of the changes.

Organizational aspects of safety auditing generally vary from one company to another one. Western Mining Corporation (WMC, 2004) has developed audit protocols for most of their activities and operations. Western Australian Department of Mines and Petroleum (Resources Safety, 2010) has developed protocols for High Impact Function audits which examine the way in which certain functions with a high hazard potential are performed within an organization. The Queensland mining sector has been recently increasing the frequency of audits on the safety and health management systems and induction programs (McCartney and Lee, 2012).

Several safety auditing systems, which have been successfully used in Australia over the last 20 or so years, are discussed below and in following papers in this series.

Safety Auditing – Lessons Learned from Alcoa's Experience

Russel Williams in his paper delivered at a Minesafe conference in 1993 described the developments of the safety auditing system of Alcoa of Australia.

Alcoa of Australia, one of the world leaders in occupational safety and health, was one of the first large companies in Western Australia to develop the safety-auditing program. The initial stage of this development concentrated on the elements forming the basis of an excellent safety and health program. For these elements the set of standards defining the level of performance as regards those topics were developed. The standards for the excellent criteria were also downgraded to the minimum acceptable levels so that a scoring process could be used to judge the variation between different levels of safety performance for each of these elements.

A series of protocols were developed to assist the auditors in various aspects, e.g., where the relevant information would be available in the individual departments or operations and who would be the best contacts for obtaining such information. For the company to enjoy maximum benefits from the cross-pollination of ideas of the safety personnel and the line managers, the decision was made to carry out safety auditing by the teams compromising safety and operations personnel from various operations. The company has also developed a relevant training program of three days' duration, and has trained several hundred safety auditors from its worldwide operations.

Safety Audit – Major Elements

The major occupational safety and health elements typically reviewed in safety auditing included:

- Management and involvement in the safety and health program and the level of commitment to occupational safety and health across the organization;
- Organization and arrangements for the safety and health program, and the assessment of the effectiveness of the program across the entire workforce;
- Accident investigation procedures;
- Accident prevention programs;
- Occupational hygiene programs;
- Operational procedures;
- Safety training and education;
- Human factors at work, with the emphasis on the motivation to develop safe work practices.

Safety Audit – Assessment

According to Williams (1993) the above major elements were further broken down to 54 different subjects covered within the safety audit process. The company has been using four descriptors – excellent, good, fair and poor – for each subject being reviewed. The assessment guides have been developed in order to minimise the potential for personal bias or subjectivity of individual auditors. The ratings have been developed on the basis of the following:

- World class program or the one which can be described as a benchmark, is usually rated as EXCELLENT.
- The program with no deficiencies and where the compliance with the legislation fully exists, is usually rated as GOOD.
- Some program deficiencies exist, or where there are some legal compliance, usually rated as FAIR.
- If many program deficiencies exist, or there are greater legal compliance deficiencies, POOR rating is applicable.

Safety Audit – Preparation and Protocols

The safety audit process actually proceeds in two parts. The first part is an assessment of whether the department or the plant has the appropriate systems in place to meet the relevant safety and health requirements. The second part of the safety audit process centers on the verification that those systems are really being adhered to by the plant personnel.

Sometime before the safety audit is scheduled to take place, the safety audit team, carries out a familiarisation visit to a department or plant to be audited. During this familiarisation visit, relevant safety and health documentation is identified as audit prereading materials. These materials should be related to both company safety and health programs, and to relevant legislation including local regulations.

After that, the audit protocols can be developed, or the existing audit protocols can be modified for the forthcoming safety audit. The protocols should assist the auditors in their task of assessing how well the plant or department is performing the particular activity under review.

The protocols should:

- Outline the intent of each step of the safety audit (e.g., what contacts to use in the process assessment: verification)
- Establish the minimum actions needed
- Guide the safety auditors, efforts
- Guide understanding, then assessment and verification
- Recommend observations and testing to increase the auditors' confidence in their findings
- Be tailored to suit the local legislation framework

Just before the safety auditors' visit, all necessary documentation related to the occupational safety and health program, as well as related to the legislation must be available. During the safety audit commencement, the auditing team needs to acquaint themselves with the technology, processes and operations in the plant under review. Then the auditors need to meet, in a structured manner, as many people as possible, to discuss various elements of the safety and health program the auditors believe exist in the plant under review, and to what extent this program is adhered to. The auditors' team works in this way systematically through the entire program elements that have been selected for the audit process, and arrives at the scores for each of the elements.

During the feedback session the review includes how well the plant or department has done, what scores it has achieved for various elements under review, and also some relevant comments and observations by the auditing team of inadequacies observed during the process. Recommendations can also be made on how to make improvements where poor or fair scores have been identified.

Then the detailed confidential report covering all aspects of the department's or plants safety and health performance in the elements under review is submitted to the manager of plant under review. According to Williams, Alcoa has derived a number benefits from the safety auditing process, in particular significantly better understanding of safety and health practices. They have learned a lot more about what makes people tick, how some programs can be successful and how some can fall into a heap due to inappropriate direction or lack of support. From a plant perspective it is clear that it helps the plant to identify the weaknesses and it also gives the plant significant kudos when excellent programs are identified and publicised across the company. The plant management can establish where the plant is at that point of time as regards its safety program, so that two or three years later having actioned the results of the audit report they can look back to see what progress has been made.

Safety Auditing – Developments in Some SE Asian Countries

Under the ILO (International Labour Organization) auspices, the author of this paper has coordinated the developments of safety auditing in a number of SE Asian countries. The first safety auditing in this program took place in the chemical industry in Thailand during late 1980s. Major developmental work took place in early 1990s in Indonesia, where it centred on mineral processing operations, as well as on chemical and petrochemical industries.

Safety auditing has been developed as one of the tools for major hazard control (Nedved, 1987; Toohey, Borthwick and Archer, 2005). A number of training programs have been developed and tested by the Western Australian team. At a later date, research and development work in the area of safety auditing included a series of training programs in Malaysia. Whilst these training programs were designed to cater for the needs of accomplished, experienced senior occupational safety and health practitioners (such as safety engineers, occupational physicians, occupational hygienists and others), experience has shown that a successful safety audit training program has to review a number of other topics from the occupational safety and health field.

The training program needs to start with the review of the latest concepts of accident prevention (Nedved, 1987; Tweeddale, 2003), paying adequate attention to economics of accident prevention systems (Nedved, 1993). The principles of occupational hygiene follow in the sequence (Chesson, 1994). Current "hot" issues in occupational safety and health deserve and receive special attention in the training program. These include the management of hazardous chemicals in the workplace (Chesson, 1995), and major hazard control (Nedved, 1993; WMC, 2004).

Workshops and syndicate exercises within the training course centre on the developmental of industrial hygiene audits and the development of safety audits (Nedved, 1994). The development of safety audit protocols, and of relevant checklists in small groups prior to a full day safety audit of an industrial company gives the course participants the "real life" taste of safety auditing. They also receive the guidelines on how to write up a useful report for the plant management. In such reports, ratings given for each element of the program under review need to be accomplished by extensive supportive comments, and followed by the recommendations – usually what steps should be taken in order to achieve the rating a level higher than the one determined during the safety audit.

Conclusions

An organization as a whole, and also its smaller entities (plants, departments, operations, etc.) can derive extensive benefits from the safety auditing process.

Safety auditing identifies both strengths and weaknesses and therefore identifies the opportunities for improvement. It also identifies best practices, and encourages the transfer of occupational safety and health excellence within the organization. Safety auditing provides an organization with independent assessment, and makes recommendations for continuous improvement. It also provides a very valuable learning opportunity, and a snapshot of occupational safety and health management system performance.

The next paper in this series will deal in detail with the developments of audit protocols, and of checklists for pre-audit survey and for the actual safety audit.

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Contractors Benefit from Safety and Environmental Audits

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Abstract

Safety is a management function. As such workplace managers have a responsibility to ensure that contractors working for the company have a high standard of workplace safety practices. This article describes the purpose of contractor safety audits, types of audits and how contractors can benefit from safety audits.

Key Words: Contractor safety management. Safety auditing. Accident prevention.

Safety as a Management Function

Safety, risk assessment and environmental protection are management functions. Is your company in full compliance with all government safety, health and environmental regulations? Companies must increasingly rely on contractors and outside labor as technology expands, and downsizing coupled with corporate reengineering continues. The impact on the bottom line of identifying and eliminating hazards will increase accordingly. One frequently-overlooked aspect of occupational safety, health, and environmental management is safety, health and environmental audits and inspections. These audits and inspections are the formal process of evaluating contractors, subcontractors, and labor leasing companies for safety, health, and environmental risks associated with "equipment, materials, processes, or activities." (*Kohn, Friend, and Winterberger 1996*).

A common practice in some industries has been to furnish a contractor or subcontractor with a questionnaire before work is begun. The form may be a simple checklist verifying the requisite license(s), appropriate liability and workers' compensation insurance, an acceptable EMR rate. The process should also evaluate a formal safety and environmental program, complete with employee training, a system for investigating incidents, identifying hazards and providing suitable personal protective equipment. The contractor checks the boxes "yes," signs the form, and the company contracting for services places the questionnaire in the project file.

"We assumed we had done our part of the job, when the contractor self-audit checklist was completed and signed," said the general manager of the Los Angeles branch of a national company, which recently settled out of court for an undisclosed amount (reputedly eight figures), in the permanent disability of an employee caused by a contractor working on site. Further investigation revealed the contractor lacked a functional safety program, and had history of high-frequency, high-severity accidents. Also, it was not uncommon for the company to bid jobs, hire contractors, and then have them complete the self-audit questionnaire the day the contractor began work.

Contractors Benefit from Safety Audits

Recently, more organizations which use contractors have established formal auditing programs. "Improving financial performance is certainly one of the most important factors firms consider when deciding whether or not to develop and implement an auditing program" (*Nastri, 1996*). Financial performance is enhanced by fewer injuries, increased productivity and reduced exposure to liability for tortious acts. The bottom line benefits by eliminating accidents and clean-up costs from hazardous waste, as well as ruling out litigation and stiff fines from regulatory agencies.

However, actions like those of the Georgia construction company which caused a worker to be buried in eight feet of clay, paying a $26,000 OSHA fine, demonstrate regulation alone has failed to deter non-compliance. "Passage of criminal penalties has made local prosecutors equal partners with the regulatory agencies that had been primarily responsible for enforcement" (*Hammet and Epstein, 1993*).

The Environmental Crimes/OSHA Division of the Los Angeles County District Attorney's Office heads a Strike Force consisting of the Hazardous Materials Control Program of the LA County Fire Department, the California Highway Patrol, the Los Angeles Police Department, as well as the DA's office. Together these agencies form a powerful team capable of acting quickly and decisively to criminally prosecute and indict serious safety violators and environmental polluters.

Another Jury Speaks: Contractor Ordered to Pay $22.5 Million

The "corporate veil," legal barriers traditionally protecting corporate officers and directors from liability, has gradually been worn away over the past several years according to Gary Swain and Andre Weinstock, writing in "For the Defense," the monthly journal of the 18,000 member Defense Research Institute. Also, plaintiff awards have dramatically increased. A 40-year-old construction worker for general contractor Tutor Saliba Corporation at the Los Angeles Memorial Coliseum was awarded $22.5 million in damages after being rendered a quadriplegic as a result of a job site fall in 1994 (*Francois v. Tutor Saliba Corp., Calif SuperCt. No. BC 130677, 8/1/96*) as reported by The Bureau of National Affairs, Inc. (*8/21/96*). The company was found negligent in its obligation to provide a safe workplace for its employee, Michael Francois. Francois was installing fencing for a subcontractor, Alcorn Fence Company, when he fell almost 14 feet from an unsecured plank.

No one can prove a strong self-audit program alone, or coupled with audits by outside consultants would have prevented this incident. However, auditing programs do identify unsafe conditions, unsafe acts, and poor attitudes. Such unsafe conditions invariably lead to unplanned releases of energy or hazardous materials, ultimately resulting in fatalities, injuries, damage to the environment, and property losses. Identifying unsafe acts or unsafe conditions can prevent accidents and eliminate unsafe conditions.

Purpose of Safety, Health and Environmental Audits

An audit is generally regarded as a methodical or systematic analysis of management, systems, and operations to verify compliance with safety, health and environmental regulations, as well as accepted industry standards and technology. Here the term "audit" is used to refer to a detailed examination and verification of written, documented policies and procedures. "Inspection" refers to a physical site visit and safety inspection. Written safety policies and procedures should include: management support for an effective safety, health and environmental program, documentation of regular safety meetings and management communication regarding safety, health and environmental issues, hazard evaluation and control, incident investigation, training, safety committee meetings and environmental management systems (EMS), as well as procedures for safe work practices.

Stage One of an audit deals with pre-qualification. A "pre-qualification audit" form may be used prior to actually auditing a contractor, subcontractor, or labor-leasing company. To become a qualified contractor (eligible for inclusion on bid lists) a contractor must answer basic questions relating to their EMS, insurance and workers' compensation rates, and furnish copies of insurance policies and workers' compensation reports. If there is a deficiency at this stage (such as inadequate liability insurance) the contractor is removed from qualified status, and asked to comply. Once pre-qualification criteria have been met, Stage Two of the audit begins. The contractor completes an audit questionnaire, then meets with an auditor or audit team experienced and trained in safety, health and environmental auditing. If the contractor meets the criteria of Stage Two, then Stage Three proceeds. Stage Three is a physical site inspection of the contractor at work.

Types of Audits

Audits can be described as comprehensive, limited, formal, and informal (*Kavianian and Wentz, 1990*). A comprehensive audit reviews all aspects of the organization's safety, health and EMS program (policy, responsibility, regulatory compliance, training, and so on). A comprehensive contractor audit is recommended before hiring a contractor for the first time, and when the audit process of currently-used contractors is begun. It may be repeated annually or every other year, as determined by need and company policy.

You may choose to perform the audit using your own employees, but many contractors prefer an outside consultant for several reasons. An outside safety consultant may be more familiar with changing government regulations, and is objective about identifying safety violations or deficiencies. Also, an experienced, well-credentialed consultant brings the prospective of myriad programs and processes from a wide variety of industries. This diversity adds a dimension in-house audit can provide.

A limited audit examines a specific area, program, or problem area, such as data for emissions or lockout/tagout policy and practice. A formal audit focuses on a structured evaluation system, using a detailed checklist designed to identify particular safety and EMS problems or deficiencies within an organization. Often contractor audits fall within this category. An informal audit is characteristic of examining a recognized deficiency, or following-up a prior audit of a particular area.
So an audit can be relatively simple, with a specific problem in mind, or it can be a complete review of the safety program by the safety staff and numerous collaborating personnel" (*Kohn, Friend and Winterberger, 1996*). However, documentary evidence (simply stated, proof) is required for all types of contractor and subcontractor audits. An auditor should not accept: "Oh, we're working on an enforcement policy for trenching and shoring, and a facility compliance plan, but we haven't finalized them yet." Either a policy exists or it does not. If not, there is a deficiency, subject to an informal or follow-up audit before the contractor or subcontractor can be approved.

From an organizational stand point, every manager, project manager and supervisor must understand the rationale, concept and techniques of safety and environmental audits. Audits provide valuable information about how effectively an organization is utilizing equipment, materials, personnel, and processes. While safety and environmental audits are applicable to all types of organizations, they are particularly appropriate to engineering contractors, given the potential for costly damage to people, the environment, equipment, and property. Audits can be viewed as a nuisance and given cursory attention, or they can be integrated into the total management matrix to increase profits. It's up to you.

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Considering Cognitive Ergonomic Factors to Prevent Accidents

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Abstract

This paper examines the role of cognitive ergonomic factors in accident prevention through the use of case study examples and includes recommended risk control strategies. From this analysis a model including consideration of cognitive ergonomic factors in accident prevention is developed.

Key words: Cognitive ergonomics. Perception. Design. Attention. Education. Memory. Decision making. Accident prevention.

Introduction

One of the first people to consider ergonomic factors in accident prevention was Wojciech Jastrzebowski. In 1857 Professor Wojciech Jastrzebowski, in Nature and Industry, (which was a weekly newspaper published in Pozan in Poland), had an article published which was titled: An outline of Ergonomics, or the Science of Work. Based on truths taken from the natural science. He published a series of four articles on this topic. Polish people claim that Wojciech Jastrzebowski "was the first in the world to use and define the concept of ergonomics" (*Karwoski & Koradecka, 1997, p. 6*). The term ergonomics was used to define the Science of Work and the Science of Needs which together Wojciech claimed formed the Science of Life. Wojciech used the Greek words 'ergon' which means 'work' and 'nomos' which means 'natural laws' to define his new science. Ergonomics is applying natural laws to the work done by humans.

Wojciech Jastrzebowski was not the first person to consider "the science of matching the job to the worker and the product to the user" (*Pheasant, 1994, p.4*). Archaeological evidence has identified that the ancient Egyptians used ergonomic principles when making household equipment and work tools. The Greek civilization, in the 5th century BC, added to this knowledge by not only using ergonomic principles to design tool but also when designing workplaces and work processes (*Marmaras, Poulakakis & Papakostopoulos, 1999*).

Other researchers have added to Wojciech Jastrzebowski's ideas to make considering ergonomic factors an important part of maintaining a safe and healthy workplace environment, having safe work processes and in assisting people to be able to make safe work related decisions. For example, Alphonse Chapanis (1917-2002) looked at the fact that many aircraft accidents occurred on take-off and landing. He identified that a cause of most of these accidents was that pilots became confused with the cockpit controls for take-off and landing as the controls for the flaps and the landing gear looked the same and were close to each other. Alphonse Chapanis asked aircraft designers to attach a wheel to the end of the landing gear control and a triangle to the end of the flaps control to enable each control to be easily distinguished by touch alone. After this design was included in aircraft cockpit controls there were no further accidents due to pilots mistaking the wrong control for the landing gear and the flaps controls. This design is included in every aircraft today (*Vicente, 2004*).

In the 1920s in the United States of America (USA), particularly in the military, there were included human consideration in "the design of machines, machine systems, work methods and environmental design to take into account safety, comfort, and productiveness of human users" (*Encycolpedia Britanica, 2012, p.1*). This branch of science was called Human Factors. In 1957 the Human Factors Society was formed in the USA. In Britain the Ergonomic Society was formed in 1952 (*Cornell University, 2012*). In essence these two professional organizations were concerned with the fit between the person, their equipment, the person's work environment and with ensuring that the person's capabilities and the limitations of their ability were taken into account when designing equipment, work tasks, work environments and when providing information. In the USA this science is still called Human Factors but outside the USA it is called ergonomics.

The Aims of Ergonomics are to:

- Make it possible for an individual to perform tasks without undue physical or mental fatigue.
- Make performing tasks within an individual's capabilities.
- Make the product and work environment fit the user.
- Identify hazards and implement risk control measures to prevent harm occurring to people.
- Provide people with the knowledge to perform tasks safely.
- Prevent accidents happening.

The science of ergonomics is further divided into Physical Ergonomics, Organizational Ergonomics, Social Ergonomics, Environmental Ergonomics and Cognitive Ergonomics as all of these factors affect people at work.

Physical Ergonomics is concerned with human anatomical, anthropometric (height, reach, width of a person), physiological & biomechanical characteristics as they relate to physical activity. It includes considering working postures, materials handling, movements, work-related musculoskeletal disorders, workplace layout, safety and health.

Social Ergonomics considers people's social needs at work as well as human potential and limitations. It includes group work, stress, hours of work and meeting people's work related social needs.

Environmental Ergonomics is concerned with environmental factors like having enough light to be able to see what you are doing clearly, having enough ventilation to be able to breath comfortably, not having too much noise or too little of appropriate noise and having a comfortable environmental temperature.

Organizational Ergonomics is the way work is designed to meet the physical, cognitive and social requirements of people doing the work and the requirements for the organization for products

and/or service outputs. It includes work design, job tasks and characteristics, job redesign, job rotation, vertical and horizontal job enlargement, job enrichment, work characteristics, job satisfaction and management.

Cognitive Ergonomics is the way people detect and process information.

Ergonomics is about making work and products fit people's ability. Part of cognitive ergonomics is making sure that people do not have too much information at once to process. If too much information is given at once either verbally, or in writing, or on a control panel, or if information is provided in a form that is not easily understood, or if too many alarms ring at once, it is easy to forget something, or not see or hear something that is important.

Why do Humans Make Errors!

When considering cognitive ergonomic factors some of the reasons that humans make errors are due to incorrect perception, the design of what they see is not logical, their attention is not focused, they have a lack of education on what needs to be done to perform their work safely, they have too much to remember or they make poor decisions, often due to not having all of the information required to make the best decision. This paper examines at each of these factors as a cause of accidents using accident case studies and reports. It describes how the use of cognitive ergonomic factors in the design stage of the equipment, work process or work environment would have prevented the accident.

Perception

Surry (1974) developed the following accident sequence model based on cognitive ergonomic factors.

The danger in this model can be the work environment, equipment, chemicals, work processes, the actions of people or due to other causes. Accidents are often the result of a chain of more than one event. The first cycle of Jean Surry's model commences by asking if there is a warning of danger build up. If the person answers "yes" to all of the questions in this part of the cycle then Surry (1974) states that there is no risk of the hazard causing harm to the person. The follow on cycle begins by asking if there is a warning of danger release. Both cycles of this model ask if

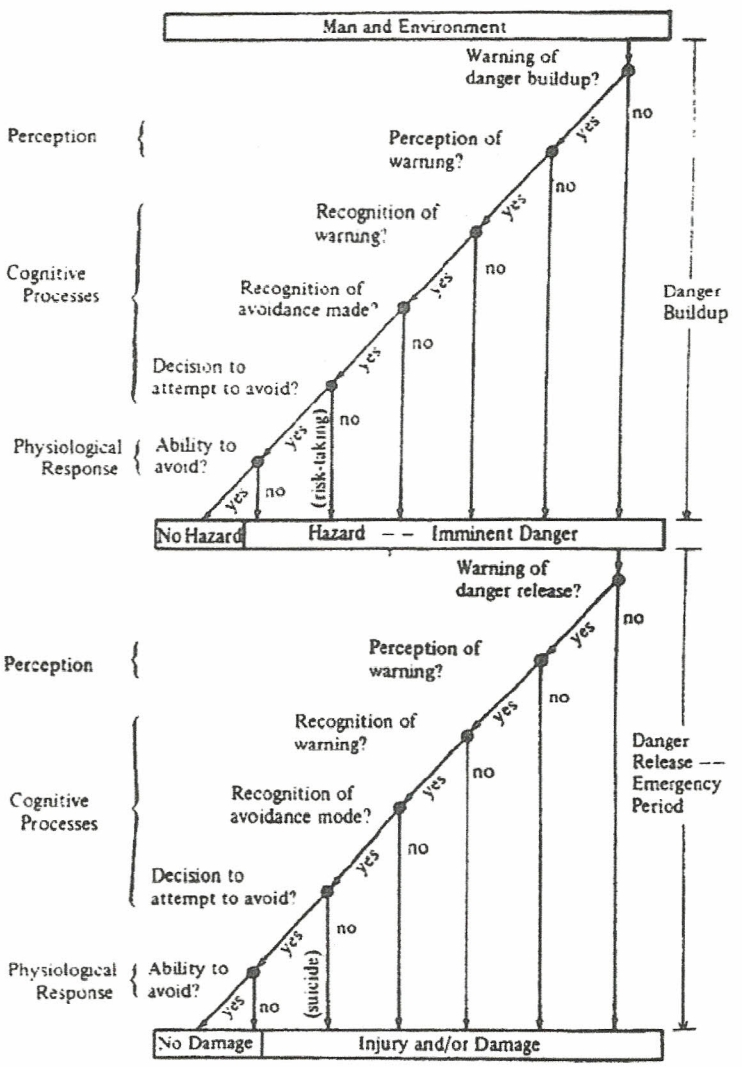

Figure 1. A decision model of the accident process. (*Surry, 1974, p. 36*)

the person is able to perceive the danger warning, recognize the warning, knows how to avoid the danger, decides to avoid the danger and uses their ability to avoid the danger. If the answer to all of the questions in this model is "yes" then an accident does not occur. If the answer is "no" to any of the questions in the second cycle, then there is the possibility of an accident occurring that results in injury, damage or even death.

Perception is how people see a situation or an object. Perception is influenced by sight, hearing, taste, touch, information provided, education that promotes understanding and past experiences. This case study from the mining industry illustrates the importance of perception and factors that influence perception in avoiding accidents. Mine Safety significant incident report number 153 documents that a female haul truck operator was found dead on the ground directly below the access ladder to the driver's deck of a Caterpillar 777D haul truck that was parked in a designated park up area. An investigation into this accident found that the structure of the deck plates and ladder access to the driver's platform on the truck left an open area over the ladder stairwell. The access ladder top rung was lower than the level of the truck deck. The hand rail around the deck did not extend the full length of the ladder access and truck windscreen but there was a flexible safety chain from the grab rail across the stair well access. If the employee did not see this safety chain it could be a trip hazard. If the employee tripped over this chain the employee would have fallen backwards to the ground. As no one saw this accident this is what was presumed to have occurred. Contributing factors to this accident were the fact that there were no written procedures for the employee to follow to clean the windscreen on this large high truck. "The other trucks in the mining fleet were Caterpillar 789 and 793 haul trucks, which have an enclosed walkway around the driver's cabin and an enclosed stairway for access to the truck" (*Resource Safety, 2009 p.1*).

In this case study there was no warning of danger build up or release if the employee did not see the safety chain. Other factors that could have affected this employee's perception of how to clean a truck window could have been that this truck had a different structure around the deck that needed to be walked and stood on to clean the truck window to the other trucks at this work site which had a safer structure to walk on for window cleaning. Not having documented procedures for cleaning the windscreen of this vehicle, which included a job safety analysis, meant that the employee did not have a clear method to use to perform this work task that included all safety factors to be considered. Having a clear method to perform this task would have enabled this employee to recognize the danger of the position of the safety chain and to be able to make a decision to avoid getting caught in it. As the employee was not educated on how to clean the windows on this truck she did not perceive the safety chain as being a trip hazard.

The importance of perception is also illustrated in the following accident case study. On the 8 January 1989 the British Midland Flight BD 92, a Boeing 737–400, crashed onto the embankment of the M1 motorway near Kegworth, Leicestershire, in England. The aircraft was attempting to conduct an emergency landing at East Midlands Airport. Of the 126 people aboard, 39 were killed on impact, 8 died due to their injuries and a further 74 people, who included seven members of the flight crew, sustained serious injuries.

Cooper (1991) reported that the British Midland 737-400 aircraft was on a scheduled flight from London Heathrow Airport to Belfast, Northern Ireland, having already flown from Heathrow to Belfast and back that day. This plane was 3 months old. The Pilots had not been given adequate training to be able to deal with engine problems in this new type of plane. After taking off from Heathrow at 7:52 pm, Flight 92 was climbing through 28,300 feet to reach its cruising altitude of 35,000 feet when a blade detached from the fan of the port engine. The pilots did not know the source of the problem, but a pounding noise was suddenly heard, accompanied by severe vibrations. Smoke poured into the cabin through the ventilation system and a smell of burning entered the plane. Several cabin staff and passengers noticed that the left engine had a stream of unburnt fuel igniting in the jet exhaust, but this information was not passed to the pilots because the passengers and cabin staff assumed the pilots were aware that the left engine was malfunctioning. The flight was diverted to nearby East Midlands Airport at the suggestion of British Midland Airways Operations.

After the initial blade fracture, Captain Kevin Hunt had disengaged the plane's autopilot. When Kevin Hunt asked First Officer David McClelland which engine was malfunctioning, McClelland replied: "It's the left one. No, the right one" (*BBC, 1991*). This is where the cognitive ergonomic factor of perception comes in. In previous versions of the 737, the left air conditioning pack, fed with compressor bleed air from the left (number 1) engine, supplied air to the flight deck, while the right air conditioning pack, fed from the right (number 2) engine supplied air to the cabin. On the 737-400 this division of air is blurred; the left pack feeds the flight deck but also feeds the aft cabin zone, while the right feeds the forward cabin. The pilots had been used to the older version of the aircraft and did not realize that this aircraft was different. The smoke in the cabin led them to assume the fault was in the right engine so the working right engine was shut down instead of the malfunctioning left engine. Pilots had no way of visually checking the engines from the cockpit. There were no external cameras or mirrors to be able to see which engine was on fire so the Pilots had to trial shutting down each engine to see which engine had a problem. When the pilots shut down the right engine, they could no longer smell the smoke, which led them to believe that they had correctly dealt with the problem. When the auto-throttle was disengaged to shut down the right engine, the fuel flow to the left engine was reduced, and the excess fuel which had been igniting in the jet exhaust disappeared so that the ongoing damage was reduced, the smoke smell ceased and the vibration was reduced.

The dial on the two vibration gauges (one for each engine) were small and the LED needle went around the outside of the dial as opposed to the inside of the dial as in the previous 737 series aircraft. The pilots had received no simulator training on how to fly the new model as no simulator for the 737-400 existed in the United Kingdom. At that time vibration indicators were known for being unreliable (and in fact were normally ignored by pilots) but, unknown to the pilots, this was one of the first aircraft at the time to have a very accurate vibration readout.

During the final approach to the East Midlands Airport, more fuel was pumped into the damaged engine to maintain speed, which caused it to cease operating and burst into flames. The flight crew attempted to restart the right engine by windmilling, using the air flowing through the engine to rotate the turbine blades and start the engine, but the aircraft was by now flying at 185 km/h, which was too slow for this. Just before crossing the M1 motorway, the tail slammed onto the ground, the aircraft bounced back into the air and over the motorway before crashing on the opposite embankment and breaking into three sections. The aircraft was approximately 519 yards away from the runway's paved surface. The last 2 people to touch the plane got it wrong due to having an incorrect perception of which engine was on fire. Part of the cognitive ergonomic factor of perception is logic in design where people actually see what they expect to see.

Design Not Logical

A cause of errors that can lead to accidents is when what a person sees, or hears, or smells, or touches is not what they expect. A group of workers who need to be considered are migrant workers, as what is logical (the "normal" way to operate) in one country may not be so in another country. In part logic is taught by past education and experiences. For example car drivers in Europe drive on the right hand side of the road while in the United Kingdom (Britain) they drive on the left hand side of the road. Bridger (2009) reports that the road accident rate for British car drivers in the United Kingdom is one of the lowest in the world. In Europe the same British car drivers have one of the highest accident rates. This is not due to differences in driving skills, but to the British drivers being unfamiliar with left-hand drive vehicles and driving on the right-hand side of the road.

James Reason (2005) told the following story to illustrate why it is important to have logic in design to minimize the risk of errors occurring.

"The incident. During a syringe change-over, a nurse incorrectly re-calibrated a syringe pump delivering a morphine infusion to a patient with stomach cancer, resulting in a fatal overdose.

The response. Institution suspended the nurse pending an investigation. She was subsequently given a formal written warning, reinstated, and retrained in the use of syringe pumps.

Incident investigation. Showed that a Grasby MS26 syringe driver was being used. Whereas this pump is calibrated in mm per hour, a second widely used pump, the Grasby MS16A, is calibrated in mm per day. During the syringe change-over, the nurse applied the calibration principles for the MS16A pump to a MS26 pump.

Early warning signs. Two similar errors had recently been reported. Both errors were detected before harm was done.

Recommendation. Chief Pharmacist and two consultants wrote to management requesting that a single pump be used throughout the Trust.

Management response. Suggestion rejected because cost would make it impossible for the institution to stay within the budget limits set by the regional health authority.

Recurrent system problem. In all 3 cases nurses had been working on under-staffed wards. Sisters had complained about not having enough staff to be able to provide a safe level of patient care, but management accepted this as a "sad fact of life" and did not act.

Key situational factors. Equipment design, workloads, etc, were not thought relevant. Sole focus was on nurses involved: naming, blaming, retraining" (pp 12-13).

"Fallibility is part of the human condition. We are not going to change the human condition, but we can change the conditions under which people work" (*Reason, 2005, p. 20*). To increase human reliability it is important to understand how the average person thinks. If the Chief Pharmacist's recommendation to have a single pump had been implemented there would not have been confusion in how to calibrate the pump, and the patient would have been given the correct dose of medication.

A lesson to be learnt from this case study is that where ever possible it is important to have consistent equipment that employees are trained to use for set tasks in the workplace. To ensure that errors are not made it is important that the person concentrates all of their attention on the task that they are doing, particularly if the risk of all hazards causing harm is not controlled.

Attention Not Focused

Pedley (1998) wrote about how the Devon County Council's Road Safety Department aimed to improve car driver's skills. He commenced with a story about Rosanna who stated that "I was driving my Ford Orion through Sidmouth one Saturday afternoon. I glanced to one side for just one or two seconds – and ploughed right into the car in front" (p.43).

In Devon, instead of fining drivers or giving them demerit points for making an error, drivers who have an accident are required, by the Devon County Council's Road Safety Department, to attend a week end course (that costs 85 pounds) to discuss, in front of other drivers who have had road accidents, their errors and to devise risk control measures to make them better car drivers. As part of this course the participants spend a lot of the weekend behind the wheel of a car with other offending motorist looking at their driving from the back seat of the car and making recommendations for improvements in driving. In this course vehicle drivers are encouraged to reflect why they had an accident and to devise strategies that, for them, will improve their concentration when driving. Factors such as road and car design are not considered as in this course; all of the emphasis is placed on making the actions of people safe.

It is not only when they are driving cars that people are not always fully focused on what they are doing. In many work situations it is necessary to be vigilant. Vigilance is sustained alertness. It is the ability to maintain a given level of alertness over a long period of time. Vigilance is affected by:

- Anticipation (which shortens observation detection time);
- Movement (time taken to do an activity);
- Distractions which can be noise, heat, humidity or sleep deprivation;

- Limits of mental load which can be too much information at once to process, information provided too fast for easy detection, work being boring (so that concentration is not maintained) and the person being expected to concentrate on a task for more than 30 minutes (Grandjean, 1988).

A good example of an accident that occurred as a result of employees being expected to be vigilant when they did not have the mental capacity to do this is the accident that occurred at Longford in 1998. At the Gas Plant at Longford operators worked a 12 hour shift. "On one occasion an incident occurred which led ESSO incident investigators to count the number of alarms. The figure for a 12 hour shift was 8,500 or 12 alarms every 60 seconds!" "All alarms had to be responded to by silencing the audible alarm and switching the visual alarm from flashing mode to steady state. The visual alarm would then remain illuminated until the process had returned to normal. Many of these visual alarms were located on a computer screen which could only contain a certain number of alarm signals. Once that number was exceeded, existing alarms would be hidden by a new page of alarms and earlier ones could only be accessed by scrolling backwards" (*Hopkins, 2000, p.42*).

The operators did not have time to scroll backwards. As a consequence of not being able to cope with the volume of signals received the operators routinely allowed the plant to operate in alarm mode as the plant operators were expected to keep production going. Through lack of sustained alertness (vigilance) an operator allowed the plant to continue production with the condensate liquid above 100%. This caused the warm oil pumps to shut down. It took several hours for these pumps to be started during which time the metal heat exchanger became very cold (-50^{D} C). When the warm oil was introduced there was brittle metal fracture and the gas explosion that killed 2 men, injured 8 other people and cut off Melbourne's gas supply for 2 weeks.

Part of the cause of the accident at Longford was that the Engineers, who knew about "brittle metal fracture", had been relocated from the Longford plant to the head office in Melbourne. The Royal Commission, which was held to investigate this accident, found that the control room operator was not to blame for this accident as neither he, nor anyone else at this workplace, understood what caused brittle metal fracture. When hundreds of liters of fluid began flowing on the ground the operators thought that the bolts just needed tightening. Maintenance men were called to re-tension the bolts, but they found that no adjustment was required. ESSO insisted that they had trained the employees about aspects of operating the gas plant. When tested on what they had learnt some of the employees had ticked the right answer without understanding what their answer meant. For example, an employee had ticked "thermal stress" as a correct answer because that is what the book said was the correct answer. When questioned in the Commission investigation, this employee said he had no idea what "thermal stress" meant. Not understanding what thermal stress was contributed to the employee's decision to re-introduce warn oil into cold pipes, which was a cause of the pipes rupturing.

At Longford the work needed to be reorganized so that only safety critical tasks had alarms. Job rotation, hours of work and effective employee education were all required to prevent future accidents due to the same or similar causes.

Lack of Education

In the case study of the Longford gas plant explosion a contributing factor to this accident was that the employees doing the work at Longford had not received enough work related education about the causes of brittle metal fracture. Lack of education about work processes safety factors was also one of the causes of another accident in which not only were employees' lives lost, but which killed many people in the surrounding community.

On the night of 2 to the 3 of December in 1984, at the Union Carbide India Ltd pesticide plant in Bhopal, a leak of methyl isocyanate gas (MIG) and other chemicals from the plant resulted in the immediate death of 3,787 people. A further 3,000 people died within a week (official government figures. Other estimations were that 30,000 people died within a week). The Indian Government has recorded that 47,787 people have subsequently died as a result of their exposure to the toxic gasses released by the Union Carbide India Ltd pesticide plant in Bhopal and that 558,125 people were injured with, in some cases, severe and disabling injuries.

The cause of this disaster was, amongst other factors, a lack of education for Supervisors and operational employees about how the plant worked. After the Technical Experts from the United States of America left this Union Carbide Plant in India, operational and maintenance staff were reduced to half their normal number, senior people left this company to work in more profitable companies and safety was neglected as the plant was not making a profit. The local Indian employees did not have the technical expertise to maintain safety. A cause of this accident was that the plant operator at Bhopal had no prior experience working in a hazardous facility and was not educated on how to perform the work safely.

On the 26th November + the 2nd of December the Methyl isocyanate tank 601 could not be pressurized even though nitrogen was reported to be flowing into the tank. There was no investigation as to why. An inexperienced Supervisor ordered that the tank pipelines be washed to ensure that this was not the cause of the blockage. A slip blind was not inserted by the operator to stop water getting into holding tank 610 to prevent a violent chemical reaction between water and Methyl isocyanate. There was failure to recognize the source of the leak of toxic gas when it started to flow due to lack of employee experience and education. When the pressure in the Methyl isocyanate tank 601 increased from 2 to 10 psig the shift operator for this tank did not communicate this information to his Supervisor, or to the next shift operator. The empty tank 619 was not used when tank 610 showed a sharp rise in pressure due to the plant operators not knowing what to do and being stressed. At 1am the toxic gas alarm sounded, but an employee switched this alarm off immediately. On hearing the alarm the local police contacted the plant and were told that nothing abnormal had happened. Between 2am and 2.30am the safety valve was resealed, but by this time 40 to 45 tons of Methyl isocyanate gas (MIG) had escaped (*Bowonder & Miyake, 1988*).

Learning is gaining knowledge, or skills, by study, experience, or being taught. Learning is a lifelong experience. Up to 70% of

skills are learned from experience (*Trautman, 2007*). Before the American experienced plant operators left the Union Carbide India Ltd pesticide plant in Bhopal there should have been buddying of inexperienced staff with experienced staff for on the job learning. Bowonder & Miyake, (1988) reported that many of the employee errors at the Union Carbide India Ltd pesticide plant in Bhopal arose due to lack of employee training, lack of employee skill development, having work procedures that were not written in a language that employees could understand (procedures were written in Technical English rather than the local language), there were no emergency procedures or previous emergency management practices and the person in charge of the plant that night lacked experience in handling such a situation. In an emergency situation employees can become very stressed if they have too much to do and remember.

Too Much to Remember

Memory is the process of storing incoming information in the brain. There are two types of memory, short term and long term memory. Short term memory is recent information. It is what a person sees, hears, tastes or touches. Most information in short term memory is quickly forgotten to prevent information overload. For long term memory it is necessary to supply meaning to the information and to relate it to information already stored in long term memory. This is why effective learning builds on people's existing knowledge and adds new information to it.

Memory comes from the sub systems of sensory storage; including visual (iconic) storage and auditory (echonic) storage. Information in sensory storage needs to be transferred to working memory. Information in working memory is transferred to long term memory by semantically coding it. That is, supplying meaning to the information and relating it to information already stored in long term memory. For example, when an adult hears the word dog, they can code it phonetically into the letters DOG and this word can conjure up a picture of a dog that the person has seen before. Effective ways to transfer information is to analyze the information, compare it with other information available, organize the information into meaningful chunks, use mnemonics, or draw pictures of what is required to be remembered. Transferring information into long term memory is assisted by doing practical activities and by teaching other people. Glasser, cited in Oliver, (2006, p2-3) wrote that people learn:

10% of what they read,
20% of what they hear,
30% of what they see,
50% of what they see and hear,
70% of what they discuss with others,
80% of what they experience personally, and
95% of what they teach someone else.

Information needs to be presented in meaningful and distinct chunks for people to remember it. People can only remember 5-9 chunks of information at a time (*Saunders & McCormick, 1993*) so work processes should not involve employees being required to remember more than 5 pieces of information at a time.

The control room operators at Longford in 1988 had too much to remember to act effectively on all of the alarms that they observed. Pape, Wiegmann & Shappell (2001) analysed 110 accidents and 69 incidents involving Air Traffic Controllers that occurred between January 1995 and December 1997 in the United States of America. Of these accidents and reported incidences 82% (147) were due to a break down in the attention or memory processes of Controllers. Air Traffic Controllers often work 12 hour shifts and are required to be very focused on preventing the collision of planes coming into, or leaving, the airport. What has helped to decrease the number of accidents has been that most commercial aircraft are operated by 2 highly skilled pilots who share the "see-and-avoid" responsibilities with the Air Traffic Controller. This highlights the importance of having a good checking mechanism to assist with critical work related decision making.

Poor Decision Making & Problem Solving

A good illustration of the importance of making good work related decisions comes from an analysis of the Moura Mine disaster in which just before midnight on 7 August 1994 the first of two explosions ripped through an underground coal mine at Moura in outback Queensland. Twenty-one miners were working there at the time. Ten managed to make their way through the dust and heat to the surface more than a mile away, but 11 did not. The dangerous conditions frustrated all attempts to enter the mine and rescue any survivors or recover the victims. The mine was later sealed. The cause of the initial explosion was most likely triggered when a pocket of burning coal came into contact with combustible methane gas in a section known as panel 512. This was the third disaster from underground explosions in the area - 13 miners died at nearby Kianga in 1975 and 12 at Moura No. 4 in 1986.

In the book, 'Managing major hazards. The lessons of the Moura Mine disaster' by Hopkins (1999), there is a very good chapter on decision making. The under manager in charge of the Moura Mine had the information that the methane gas would enter the explosive range sometime after 11.30pm that day. A new shift started underground at 10.30pm. This information about the expected time of explosive range of methane gas was not communicated to the Deputy in charge of the shift that was commencing at 10.30pm. The information on the expected time that the methane gas would be in the explosive range was not easily available for the Deputy to have access to it, although the registered mine manager, the shift under manager and the under manager in charge had this information. The decision to send the miners underground when the mine Methane gas was in an explosive range was made by the Shift Deputy. Hopkins theorizes that the Deputy made this decision because he was told by the shift under manager that the mine "was so safe that he would go underground and 'kiss the seals' if necessary" (*Hopkins, 1999, p. 59*). The sealing of this area of the mine meant that it would no longer be ventilated. The area was sealed to prevent oxygen entering as heat could ignite the methane gas, as if there was not enough oxygen in the mine air a fire would not be sustained. The sealing of this area of the mine also meant that the concentration of methane gas in this area of the mine would build up and enter the calculated explosive range at about 11.30pm that night.

Other factors that may have affected this Deputy's decision making were that, besides not being told that the methane gas in the mine was going into an explosive range during his work shift, if the Deputy did not take his team to work in the mine that night

the Deputy would be called a wimp and the mine would not have met its production target. The mine did not have a policy stating when Deputies could refuse to take their work crew underground due to safety concerns. The Deputy was expected to make a non-programmed decision with insufficient relevant information. This story highlights the importance of people being given enough information to be able to make informed decisions about safety, that peer pressure can influence decision making and that not having a clear policy about when it was safe for mine workers to work underground cost the life of 11 men when the mine exploded at 11.35pm that night.

There are two major ways that decisions are made in a workplace. One is programmed decisions. Programmed decisions are based on documented organization rules, documented standard operating procedures and in allowing the organizational structure (from workplace supervisor to Chief Executive Officer depending on the importance of the decision and level of knowledge required to make the decision) to be used to handle problems. To make programmed decisions employees need to follow organizational rules.

The second type of decision is an un-programmed decision that there are no rules for and for which judgment, intuition and creativity must to be used to make the decision. Many errors occur when employees must make un-programmed decisions, particularly if there is inadequate information available to make this decision, as happened in the Moura Mine disaster. Cognitive Ergonomics is the way people detect & process information. Decision making and problem solving are part of processing information.

Accident prevention by considering cognitive ergonomic factors

The following is a model of accident prevention strategies that consider cognitive ergonomic factors. This model includes employee perceptions, attention, considering the equipment to be used, the workplace, work processes, education, memory and decision making.

If cognitive ergonomic factors are considered in the workplace design stage, everything in the workplace is logical, there are warnings of danger and risks are controlled this will eliminate the cause of many accidents.

When examining accident case studies many accidents are noted to be due to people being new to a workplace or to work processes or to being unfamiliar with using equipment. Education and supervision are very important in these situations. People need an orientation to their workplace, work processes and the equipment that they will be required to use. A good way to provide supervision is to buddy inexperienced employees with experienced employees. Le Goubin (2009) recommends that inexperienced employees be given a peer mentor to help them learn what to do safely in the workplace. Peer mentoring is one of the best ways to not only provide employees with adequate supervision but also to develop the education and skills of the person who is the mentor (Oliver, 2006).

In both the Bhopal and the Moura Mine disasters there was inadequate handover of information for decision making and problem solving. To prevent accidents occurring there must be both good oral and written communication at the start of the work shift, during the shift and at the end of the shift so that the incoming workers have all necessary information to make good decisions. Employees must be give adequate information and education to be able to make safe decisions.

Having the information available to make programmed decisions is important, but there are times when employees need to think critically and make un-programmed decisions. For example, in the Piper Alpha disaster Appleton, (1993) wrote that when there was an explosion and a fire developed on the Piper Alpha gas platform all employees had been trained to go the accommodation block if an emergency occurred as the normal method of transport to and from this gas platform was by helicopter and the landing platform for the helicopter was on top of the accommodation block. It should have been apparent to the people on this gas platform, within a few minutes of the oil fire developing, and

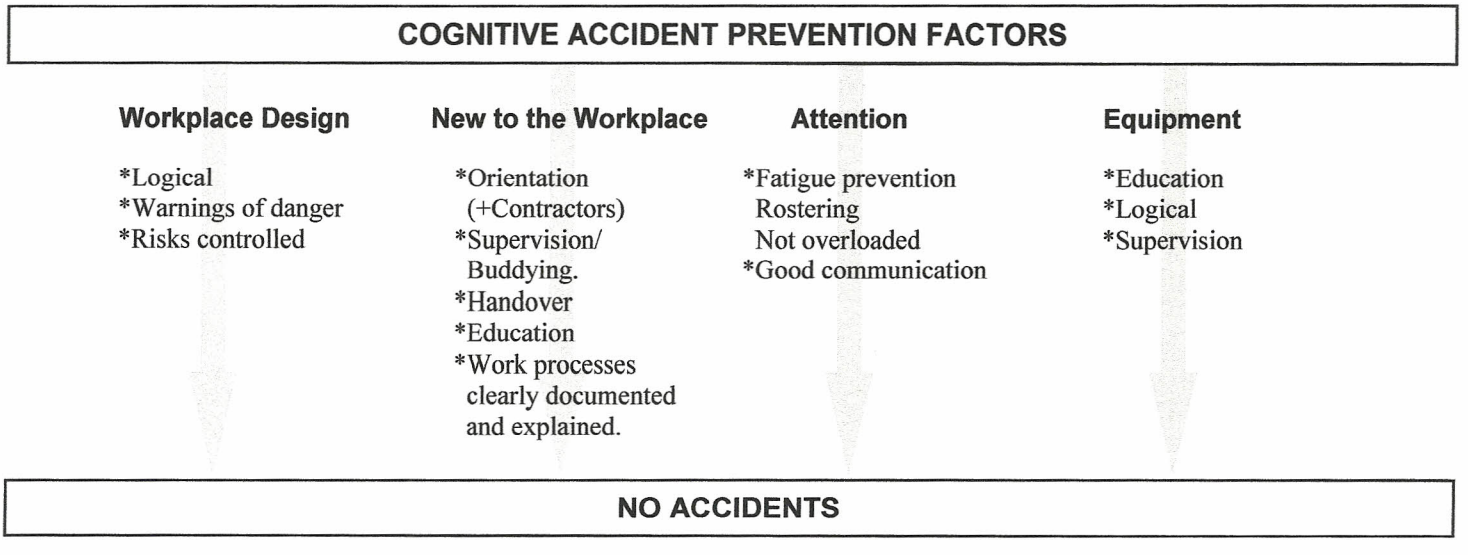

Figure 2. Consideration of cognitive ergonomic factors in accident prevention.

certainly once the gas fire enveloped the platform, that there was no possibility of a helicopter being able to land due to the smoke and flames. Employees only chance of survival was to fight their way through the smoke and flames, jump into the sea and hope to be picked up immediately by one of the ships which had come to help. There were no orders to do this from any of the senior personnel on board this platform. One hundred and sixty seven men died from following a programmed decision. Sixty two men lived as they evaluated the situation and made an un-programmed decision to jump into the sea where they were picked up by rescue boats.

Several of the accident case studies in this paper are related to the unsafe use of equipment. To prevent accident, for any new equipment, or for any equipment that an employee is unfamiliar with using, there should be education and supervision until the employee is competent in using the equipment. For example, in the syringe driver case, if the dose of medicine had been checked by 2 people the error may have been prevented. If the pilots for Flight 92 had been trained in a simulator on how to fly the 737-400 air craft then 47 passengers would not have been killed. If the employees at Bhopal had been educated to include a slip blind to prevent water entering the Methyl isocyanate holding tank then over 5,000 people would not have died due to gas poisoning. Considering cognitive ergonomic factors is very important in preventing accidents from occurring.

Summary

Cognitive Ergonomics is the way people think, perceive and interpret information. It includes people's way of learning, their motivation, memory ability and matching what people see and do to their cognitive expectations so that they can work more safely and more productively.

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