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The Journal
- Aims to serve as a forum for the sharing of research findings and information across broad areas in occupational safety and health.
- Publishes original research reports, topical article reviews, book reviews, case reports, short communications, invited editorials and letters to editor.
- Welcomes articles in occupational safety and health related fields.
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Introducing the Journal of Occupational Safety and Health

The National Institute of Occupational Safety and Health (NIOSH) is delighted to announce the publication of *Journal of Occupational Safety and Health* (*JOSH*). Beginning in January 2004, the new journal will start with Volume 1, Issue 1.

*JOSH* is devoted to enhancing the knowledge and practice of occupational safety and health by widely disseminating research articles and applied studies of highest quality.

*JOSH* provides a solid base to bridge the issues and concerns related to occupational safety and health. *JOSH* offers scholarly, peer-reviewed articles, including correspondence, regular papers, articles and short reports, announcements and etc.

It is intended that this journal should serve the OSH community, practitioners, students and public while providing vital information for the promotion of workplace health and safety.

Apart from that *JOSH* aims:
- To promote debate and discussion on practical and theoretical aspects of OSH
- To encourage authors to comment critically on current OSH practices and discuss new concepts and emerging theories in OSH
- To inform OSH practitioners and students of current issues

*JOSH* is poised to become an essential resource in our efforts to promote and protect the safety and health of workers.

From the Editor in Chief

Workplace safety is a priority. Much needs to be done to encourage employees, employers and industries to put occupational safety and health at the top of their agenda. The most important thing is our commitment in taking action; our commitment to make the necessary changes to ensure that safety is at the forefront of everyone’s thinking.

The Journal of Occupational Safety and Health, (*JOSH*), the first to be published in Malaysia, aims to boost awareness on safety and health in the workplace.

It is no longer sufficient to simply identifying the hazards and assessing the risks. We aim to increase understanding on the OSH management system. We aim to strengthen commitment to workplace safety and better working conditions. We believe these aims can be achieved through participations and involvement from every industry.

We hope the contents of the journal will be read and reviewed by a wider audience hence it will have a broader academic base, and there should be an increased cumulative experience to draw on for debate and comment within the journal.

It is our hope that the journal will benefit all readers, as our purpose is to serve the interest of everybody from all industries. Prime Focus will be on issues that are of direct relevance to our day-to-day practices.

I would personally like to take this opportunity to welcome all our readers and contributors to the first issue of the journal. I look forward to receive contributions from the OSH community in Malaysia and elsewhere for our next issues.

*Ir. Hj. Abu Bakar Che’ Man*

Editor-in-chief
Emergency Response Programme in a Petrochemical Company in Malaysia

Jefferelli Shamsul Bahrain, Mohamad Husain Sajahan, Mohd. Nazri Hamad

BASF PETRONAS Chemicals Sdn. Bhd.

Abstract

Malaysia is blessed with oil and gas resources, which form raw materials for the petrochemical industry. The petrochemical industry creates added value to this resource and is an important contributor to the national economy. The petrochemical industry however also creates hazards of which fire or explosions and chemical release are of special concern. These hazards pose a risk not only to workers but also to the surrounding population and environment. To ensure industry is prepared to cope with emergencies, a comprehensive emergency response programme is necessary. This is inline with both the Malaysian Occupational Safety and Health (Control of Industrial Major Accident Hazards) Regulations 1996 and the Responsible Care initiative of the chemical industry. This paper describes elements to be considered in an emergency response programme for industry such as the concept of emergency management, organisation, duties and responsibilities, emergency system, training and mutual aid plans and agreements. We shall provide related examples based on a multinational petrochemical company practice.

Impact on industry: Educate industry of need and contents of a comprehensive emergency response plan.

Key words: Petrochemical, Emergency, Response

The Petrochemical Industry in Malaysia

Malaysia offers two great advantages to the petrochemical industry. Firstly, the raw materials for the petrochemical industry - oil and gas are present naturally in abundance off the shores of Malaysia. Secondly the Malaysian government has invested in petrochemical related infrastructure in specially designated zones to support such an industry. The three petrochemical industry zones are Gebeng and Kertih on the east coast of Peninsular Malaysia and Tanjung Langsat in the south of Peninsular Malaysia. Currently there are 27 petrochemicals plants throughout the country producing 38 different types of petrochemicals. Petrochemicals are used to create value added products in the agriculture, food, clothing, housing and transportation industry (Malaysian Petrochemicals Association, 2003). Although the petrochemical industry stimulates economic growth, it also creates new hazards to the environment it operates in. Fire, explosions and chemical release are of special concern. These hazards have potential to cause damage not only to workers and structures within the plant area but also to the surrounding population and environment. An emergency response programme is necessary to mitigate potential consequences of such an event.

Creating an Emergency Response Programme

An emergency is defined as a situation or state characterised by a clear and marked reduction in ability of people to sustain their normal living conditions with resulting damage risks to health, life and livelihoods (Wisner B, Adams. J, 2002). Another definition is an unexpected condition requiring specific action plans to normalise (i.e. fire, explosion, leak of products or gas, loss of containment or threats) (BASF-PETRONAS Site
The process of creating a programme begins with a needs and resource assessment. The needs and resources available to different industries vary and thus the need to customize programmes to suit a particular industry. In Malaysia, there are specific laws, regulations and guidelines published related to Emergency Response. Some plants are also required to adhere to their own corporate guidelines or publications on emergency response programmes. There are also many books commercially market on this subjects which form a useful source of information.

Knowledge of the company operations background as well as internal resources available such finances, manpower and equipment are also vital in developing a comprehensive emergency response program. Information on external resources such as distance to from nearest fire brigade and their incident management capability are important. Also important is to know the distance from nearest medical service (Department of Occupational Safety and Health, 1996), specialty service offered and their ability to manage mass casualties (BASF Occupational Medicine and Health Protection Department, 2003). In this paper we shall share our experience in creating and executing our own emergency response programme. We believe this paper will form a useful guide to other industries in particular petrochemical companies in developing their own emergency response programme.

BASF PETRONAS Chemicals (BPC) Sdn. Bhd.

BASF-PETRONAS is a joint venture Petrochemical Company between BASF Aktiengesellschaft of Germany and Petroliam Nasional Berhad (PETRONAS) of Malaysia on a 60: 40 basis, involving an initial investment of RM 3.4 billion. The production complex consists of 12 plants, which are located in Gebeng, Pahang. The main products are acrylic monomers, oxo products and butanediol product. The total work force is around 840 employees. The plant runs 24 hours a day, seven days a week and thus there are a significant amount of workers who work on shift. There are a total of four different shift groups whereby each shift period lasts for 12 hours. A shift worker generally works 4 shifts per week. A Managing Director, who is assisted by 4 directors from the Operations and Technical, Marketing and Logistics, Human Resource and Administration, and Corporate Functions division, manages the company (BASF-PETRONAS Corporate Information, 2003).
Emergency Response Related Laws in Malaysia

The Malaysia government has recognised the need to regulate activities with potential to cause major hazards. The Occupational Safety and Health (Control of Industrial major Hazards Installation) Regulations 1996 states the need for such industries to create their own emergency response programmes. The Fire Services Act 1988 states the need for premises to obtain a fire certificate of which the details required to obtain this certificate are listed in the Fire Services (Fire Certificate) Regulations 2001. The elements required to obtain a fire certificate are those related to personal safety facility, fire prevention, fire protection, fire fighting facilities, special needs and fire fighting team on site.

Although there is no specific mention in the Fire Services (Fire Certificate) Regulations 2001 on the need of an emergency response programme, all the provisions mentioned are in fact elements within such a programme. The Uniform Building By-Laws, 1984 state the need for fire alarms, fire detection, fire extinguishment and fire fighting access. These items are also elements of an emergency response system. The National Security Council Directive No 20 is another important piece of legislation which clearly states that industrial accidents such as explosions, fire, pollution and leaks of hazardous material from plants are incidents covered under the directive. This directive also defines the levels of disaster and how the disaster and aid should be managed.

Emergency Response Related Guidelines

In 2001, the Fire and Rescue Department came up with guidelines (Jabatan Bomba dan Penyelamat Malaysia, 2001) on how to create an emergency response programme (ERP), which incorporates the Incident Command System (ICS). The emergency response plan needs to incorporate the ICS and the Incident Action Plan (IAP) both on site and offsite. The ERP report must contain information on the management organisation for the building or industry, process/operation flow chart, risk assessment and hazard identification for process and storage areas as well as transport. Other areas covered in this guidelines are procedures, strategy and tactics, training and exercise, mutual aid arrangements, creation of predesignated facilities, fire fighting, rescue and hazmat equipment, ERP demonstration and exercise, the need for preparation of ERP by trained individuals, the need to submit ERP/ICS to the Malaysia Fire and Rescue Department, responsibility to audit, implementation training and need for ERP to be a living document.

Commercially available programmes such as ChemWatch as well as Chemical Safety Data Sheets obtained from companies producing chemicals form a valuable source of information on such material. The document contains information on physicochemical properties of the chemical and also that on First Aid measures, antidotes if available as well as toxic effect of chemicals to the environment. Some Multinationals produce their own guidelines for handling chemical emergencies. BASF is one such company. Their Occupational Medicine and Health Department created a guideline on Medical Management (BASF Occupational Medicine and Health Protection Department, 2002) of exposure to 20 chemicals of concern produced by the BASF group. It contains advice, which has been tailored for first responders, paramedics, doctors at site and doctors at hospital as well as the patient in managing chemical exposures. Since BASF-PETRONAS is partly owned by BASF we have access to this useful resource document.

Emergency Response Human Resource in BPC

A Manager who heads the Health and Safety department, reports to the Operations Director. The Chief of the Fire Department responsible for responding to fire and chemical incidents reports to the Health, Safety and Environment Manager. The Fire Department consists of 15 full time Fire professionals. The team is led by a fire officer and assisted by 6 fire marshals. Two fire marshals work office hours whereas the other 4 work on shift. These 15 individuals are employed full time at the fire department. For every shift there are also 2 fire fighters on duty. The company has created an emergency response team,
which consists of shift plant employees who are trained to assist the fire department during emergencies (BASF-PETRONAS Site HSE Manual, 2003).

The Occupational Health Physician who is responsible for the emergency medical service reports to the Director of Human Resource. The emergency medical service is led by the Occupational Health Physician and assisted by 5 paramedics and 1 occupational health nurse. The lead paramedic and occupational health nurse work office hours, whereas the other 4 paramedics work shifts (BASF-PETRONAS Site HSE Manual, 2003). The company has also created an advance first aider team, which mainly consists of shift plant employees who are trained to assist the paramedics during emergencies. There will always be at least between 7-8 advanced first aiders on duty every shift. The first aiders are trained in basic life support, how to assist paramedics and some plant specific concerns such as handling chemical emergencies. These group of specially trained first aiders are known as Advanced First Responders (AFR) (Jefferelli SB, Husain MSJ, Nasrudin S, 2003). Although reporting to different superiors, the fire and medical service work closely together in planning and executing the emergency response programme in the plant.

Emergency Response Equipment and Facility Resource in BPC

Structurally, a building known as the Response Centre was built to house emergency personnel and equipment. Within this building is located the emergency treatment room as well as the call center which is open 24 hours a day, 7 days a week. The call centre shall respond to any offsite or onsite incidents. All calls are recorded and relayed through an integrated messaging system. The fire officer on duty shall activate the relevant personnel to respond and provide specialised advice to the caller on managing the incident. The emergency response system includes heat, smoke, fire and gas detection devices and alarm systems, air horns, fire fighting systems and a messaging network system. A dry chemical foam truck and Hazmat foam truck are available to facilitate fire fighting and containment of chemical leaks and spills (BASF-PETRONAS Site HSE Manual, 2003). Emergency showers are constructed near work areas to allow rapid decontamination. First aid boxes are also available at strategic locations. Medical facilities for emergencies available at the clinic include a fully equipped ambulance and emergency room and emergency shower facilities. Among the equipment available are assessment tools such as stethoscopes and vital signs monitor, respiratory management equipment such as oxygen, intubation set, suction pumps and ventilators, circulatory management equipment such as intravenous drips, defibrillator, immobilisers such as splints and cervical collars, transport equipment such as stretchers and scoop stretchers and bleeding arrestors such as suture sets and bandage (Jefferelli SB, Husain MSJ, Nasrudin S, 2003).

Emergency Response Resources from Neighbouring Industries

BASF PETRONAS Chemicals is located in the Gebeng Industrial Zone. In 1999, BASF PETRONAS signed an agreement to be part of the area mutual assistance program in cases of emergency. This understanding is known as Gebeng Emergency Mutual Aid (GEMA) agreement. It helps enlarge the pool of resources and is especially beneficial for the smaller industries that may be less well equipped to cope with major incidents. To enhance emergency preparedness and cooperation, a yearly drill is conducted at one of the facilities during which emergency response team members from neighbouring plants will come and assist. Site visits are also conducted among members to the different plans to get a better idea of their operations and how to best respond in an emergency.

Emergency Response Plans in BPC

The BPC Emergency Response Plan is documented in it’s emergency response manual as well as the site emergency medical service procedure. This plan outlines the organisation, system and procedures to be followed in an emergency. The contents of the emergency response manual include definitions, emergency management concepts, organisation, duties and
responsibilities, emergency systems, training and mutual aid plans. There are three types of teams involved in execution, which are the emergency response team (ERT), plant emergency management team (PEMT) and site emergency management team (SEMT). The emergency response team is led by the fire marshal and advised by the shift supervisor of the affected plant. Among the duties of the fire marshal is to lead the emergency response team, inform the PEMT of developments, determine level of emergency, seek plant specific advice and inform the local fire authorities (BOMBA). The advisor (shift supervisor) shall provide plant specific advice, is responsible for shutting down and securing plant, activating the PEMT and announcing the emergency on the PA system. Other ERT members assist the fire department in specific activities such as fire fighting and containing chemical release. The PEMT is activated in level two emergencies whereby the incident can no longer be contained by internal resources. The complex General Manager leads this team. His duty is to develop a strategy for handling the emergency, obtain resources needed to handle emergency such as food, manpower, service, equipment and logistics, recommends activation of SEMT and informs them of development. In level 3 emergencies the SEMT is activated. The Operations and Technical Director who is also known as the Kuantan Site Director leads the team. The document also details roles of other personnel. Areas where primary and secondary triage is carried out namely the medical command post and clinic are defined. The tagging system used is similar to international standards using tags coloured green, yellow, red and white to indicate the severity of injury and urgency of treatment. The emergency response manual also provides emergency organization structures and incident flowcharts. The manual also lists the available emergency systems and information on training methods, training sessions and drills. An Incident Action Plan, which prepares for every possible hazard scenario on site is also available. This plan shall determine the incident scenarios for the drills to be carried out (BASF-PETRONAS Site HSE Manual, 2003).

The site emergency medical service procedure (BASF-PETRONAS Site HSE Manual, 2003) defines the personnel involved and their duties, specific work areas, victim tagging system, phases of medical emergencies and flow chart. The personnel involved are divided into occupational health physician (OHP), lead paramedic, paramedic on duty, paramedic on call, occupational health nurse, GEMA members and AFRs. The first health personnel to respond in an emergency will be the paramedic on duty. His duties are to respond to call for assistance, anticipate number of victims, type of injury and need to call for support, establish Medical Command post and perform triage, provide first aid and initial treatment, stabilize victim prior to transport to clinic, coordinate AFR on duty, updates OHP and lead paramedic on the situation and report writing and record keeping. The document also details roles of other personnel.

In phase 2, the medical situation can be controlled and coordinated internally but external assistance is required from GEMA members. In phase 3, assistance is required from external bodies other than GEMA members. In phase 4, the situation can no longer be coordinated by the Medical Emergency team but needs to be managed by the government medical authorities. The flow chart further illustrates the chain of events and responsibilities.

The Importance of Drills

An emergency response plan itself does not assure preparedness and ability to respond successfully to an incident. An important element in an emergency response program is training. This will help ensure all equipment is in order, personnel respond accordingly and that the system used is understood and works. Among the weakness we have identified from drills conducted include delay in arrival of rescue team at site, delay in donning full protective gear, lack of air or gas monitoring,
activation of wrong alarm, failure to decontaminate victim, poor communication, failure to setup medical command post, failure to establish a safe zone and failure to request for medical backup. Similar weaknesses were identified during drills conducted in BASF, Germany (Andreas Zober, 2003). The lessons learnt form every drill is conveyed to the stakeholders and remedial action is taken to avoid the same mistakes repeating itself.

Conclusion

Petrochemical industries are a major hazard. Steps can be taken to reduce the risk of incidents occurring as well as reducing the impact of such incident should it occur. A comprehensive emergency response programme is instrumental in the latter. The programme must not only look good on paper but must be practical. The roles of every party must be clear and drills to identify weaknesses in the system need to be conducted regularly. A good Emergency Response Programme is like good insurance. You want to be well covered but hope you will never have to use it.

Acknowledgments

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The Missing Element of OHSMS and Safety Programmes
- Calculating and Evaluating Risk

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Abstract

How realistically and reliably can an OHSMS or safety programme be meaningfully constructed and interpreted without an objective basis for risk calculation and evaluation? Does the descriptor ‘at risk’ have any useful meaning? Don’t we all know that all actions involve some risk ? All behaviours are ‘at risk’.

To be confident that employees at all levels need to understand and may possibly want to change their risk taking behaviours at work, we need to be confident that they can understand & evaluate the risks adequately,

AND to be confident that they can understand & evaluate the risks adequately,

we need to be confident that they can perceive the risks adequately,

AND to be confident that they can perceive the risks adequately,

we need to be confident that they can assess the risks adequately

AND to be confident that they can assess the risk adequately,

we need to be confident that they can calculate the risks adequately.

Nearly all OHSMS and safety programmes don’t recognise the need, and don’t provide any adequate process, for adherence to all of the logic chain above. Breaking any single link of the chain breaks the logic of the chain itself and continues the frustration of current programmes the on-going confusion and lack of agreement of what is ‘at risk’. This paper describes how successful safety systems and programmes need to provide all stakeholders with at least one method calculating risk and hence provide an objective basis for understanding, prioritisation and assessment of workplace risks. Currently, the term ‘at risk’ in “at-risk behaviour” has no more practical meaning than ‘unsafe’, the old traditional term it replaced. There is still just as much argument, confusion and inconsistency with the term because it has no objective basis and worse no objective criteria for evaluating and agreeing on risk tolerability. Unless all stakeholders are given both a method for calculating risk levels, and a framework of criteria for agreeing on tolerability, then the programmes do not advance beyond the perennial confusion and lack of agreement of what is “unsafe”. Nothing is being achieved in getting closer to removing the problems associated with the persistent and subjective assumption that we all innately agree on what is “safe” i.e. we all share the same risk tolerability levels (the myth of ‘safety is common sense’). Without a basis for calculating risk levels, current programs lack an objective basis for selecting and prioritising, which behaviours are ‘at risk’. This paper describes the necessary risk management philosophy and components of a successful OHSMS or safety programme by providing the missing risk management links. The processes will be described in details and explanations of the importance of integration of risk management philosophies and methods with safety programmes will be provided.

The Role of Risk Management in Safety Systems and Programmes

Shifting the “zero risk-absolute safety” paradigm

Just as important as the methods of risk calculation and evaluation, there is an essential need to shift the safety culture from the non-existent “zero risk-absolute safety” paradigm to that of “risk tolerability” - whereby no injuries and illnesses are ever “acceptable” and only risks fully managed to ALARP are “tolerable”. (ALARP = As Low As Reasonably Practicable). (Fig 1)

For once and for all, employees are encouraged to recognise the difference between the intellectually-dishonest concept of “a safety threshold or zero risk threshold” and the workable, realistic but more demanding concept of
“a spectrum or range of risk with possible zero injuries and illnesses”, (Figure 2) Managers and Employees see for the first time the real significant differences between ‘zero risk’ and ‘zero injuries’.

The former is the concept that has held the safety profession back because it is seen and known as unreal, while the latter involves the more demanding recognition of the futile belief in a non-existent safety threshold that separates absolutely ‘safe’ from absolutely ‘unsafe’. No risk to ‘at risk’. Just substituting the words ‘at risk’ for ‘unsafe’ is not incorporating the essential risk management concepts that are needed in any realistic safety behaviour-based culture/programme.

**Tolerable’ is a better term than ‘Acceptable’**

Implicit in the paradigm shift is the need to recognise that ‘acceptable’ is a passive, defeatist almost fatalist term, whereas ‘tolerable’ is an active, dynamic, term that indicates that we have not accepted nor given up but are still actively interested and working hard to control our work risks better. A new safety culture based on risk management always substitutes tolerable for acceptable, tolerate for accept, tolerability for acceptability.

The philosophy at the heart of this belief is fundamentally important. Many organizations can adopt a realistic and rewarding Safety Vision based on this philosophic framework expressed in ways similar to :- “We will never accept any injuries/illnesses anywhere anytime AND we will What is an intolerable risk? Need not and should not be a qualitative subjective question. Tolerable can and must be objectively quantified. Agreed quantitative tolerable risk levels (lines in the sand) need to replace meaningless ‘unsafe’ or ‘at risk’ descriptors. The vertical axis in Figure 1 can be assigned quantitative values representing the 2 boundaries of ALARP. The author’s paper at ASSE 2001 covered how “tolerability can be quantified” and hence minimise uncertainty and confusion on what is tolerable?

**Figure 1: Two lines in the sand**
- Deciding a risk above which is “intolerable”
- another risk level below which is “broadly tolerable” even “negligible”
- and the in-between risks are only tolerable if assured that they are being managed to as low as reasonably practicable ALARP

**Figure 2: There is no threshold that separates risk from no-risk or “safe”- rather there is always a continuum or spectrum of risk**
The Absolute Link Between Risk Perception And Behaviour

We need to emphasise the importance of focussing on the absolute link between risk perception and behaviour. We need to recognise that ‘managed risk’ is achievable while ‘zero-risk’ is not. The term managed risk-taking behaviour is used to refer to any behaviour that is required to minimise risk to health and safety. Examples include following Agreed Standard Work Procedures (ASWPs), e.g. wearing PPE, reporting hazards and incidents, using appropriate manual handling techniques, and so on. There are obviously many factors that influence, initiate, activate and control human behaviour. All safety programs need to recognise the importance of risk perception in the Activator A component of the ABC Model of explaining behaviour. (Figures 3A, 3B, 3C and 3D)

The ABC model has combined the best of the 2 models - the Cognitive model and the Behaviourist model. Risk perception is seen as the powerful if not ultimate prompt, cue, stimulus, or activator A for behavioural choice at a conscious level and also as a powerful reinforcer of past experiences or consequences of past behaviours at an automated conditioned response form of behaviour B. It is always important to remember that what risk level (chances of positive outcomes and chances and of negative outcomes) are perceived are real to the person involved. Perception is reality! If we believe/perceive that a certain line of action has a higher chance of providing a good outcome for us than the chances of providing a negative outcome, then we take that line of action or behaviour.

By definition, rational behaviour is always taken ‘for good reasons’

No one takes risks for the chance of harm or loss-rather they take them for the perceived or real chance of good outcomes, profit or gain for themselves or their organisation. No one is stupid or careless or. If you dig deep enough, you usually find well-motivated employees taking actions for very good reasons. Saving time or taking short cuts is one of the best reasons anyone can find because it meets all the prominent business imperatives!!
We should never criticise each other for finding short cuts but we should do so if we take them before doing a comparative risk assessment with the currently agreed way.

**Factors Influencing Risk Perception**

*When and how do we agree when a Risk is not a Risk?*

As an aside, it is worth remembering that no one wants to be completely risk averse. “Telling an investor there is no hope of beating the averages is like telling a six-year-old there is no Santa Claus. It takes the zing out of life,” Malkiel writes. (Krause, 1984).

People’s perceptions of the level of risk are not determined solely by quantitative, numerical data but are also strongly influenced by many other subjective factors. The accurate perception of risk by all employees within an organization of what the organization regards as “tolerable” and “intolerable” is important for effective risk management. “Common sense” cannot be assumed as automatic without considerable effort in discussion and argument in achieving commonality and agreement on those risks which are “tolerable/acceptable” and those which are not. This is why the phase of discussion/interpretation of safety sampling or risk sampling is important and valuable. A common position can be achieved but not assumed. Employees’ risk perceptions are subjective risk estimates which usually differ from objective risk data in a number of ways. (Table 1) It is important that organizations are aware of the biases.

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**Figure 3A: The ABC Model of Human Behavior**

**Figure 3B: Examples of Activators - Note the prominence of “risk perception”**

**Figure 3C: Examples of Consequences - experiential re-inforcers of risk perception**

**Figure 3D: Exercises to demonstrate the feedback loop from consequences to Activators and 3 qualities of re-inforcers of risk perception - positivity, immediacy, and certainty**
in employees’ subjective assessments of risk, so they can develop mechanisms to reduce the impact of these biases. Biases in risk perception can affect the accuracy of task risk assessment, including the identification, assessment of the likelihood and consequences, and the selection/implementation of the risk control measures.

**Biases in employees’ risk perceptions**

Employees tend to underestimate the risk from tasks that they perform frequently. This bias has been called ‘risk habituation’, It appears to be due to people becoming accustomed to being exposed to the hazards, therefore underestimating the risk and becoming complacent about the hazards. This complacency may be due to the fact that they have performed the tasks very often and have never experienced an accident - a case of familiarity breeding apathy. As it is based on a vigorous on-going discussion of safety or risk sampling results, the “good” reasons for SSPs including biases in risk perception are more readily exposed.

Employees can become more aware of their biases in risk perceptions. Work group discussions need to be very direct, relevant, and specific to the hazards that employees are exposed to most frequently, and use actual SSPs to highlight the potential consequences.

On the other hand there is evidence to suggest that employees overestimate the risk from tasks that are notoriously dangerous, operations that they perform infrequently or hazards that produce a feeling of ‘dread’ or that they perceive as ‘unknown’. Employees appear to overestimate the risk when they focus too much on the vivid, or gruesome consequences and not enough on the likelihood of the event occurring. They focus on the consequences and therefore overestimate the risk.

Overestimation of risk can be just as worrying as underestimation. If employees are concerned about one risk factor or hazard in an operation, they may not pay sufficient attention to other risk factors or hazards. This phenomenon reinforces the need for giving employees a method for objective estimation or calculation of risk levels to reduce the effects of biases. In order to minimise overestimation bias, organisations need to develop processes to ensure that employees consider all aspects of risks posed by all the kinds of exposures associated with an operation.

<table>
<thead>
<tr>
<th>A potentially exposed person’s views/perceptions of to lerability of a risk are influenced by: Is the risk ...?</th>
<th>Perceived as ‘more tolerable’</th>
<th>Perceived as ‘less tolerable’</th>
</tr>
</thead>
<tbody>
<tr>
<td>voluntary / internal / free choice</td>
<td>externally imposed</td>
<td>controlled others</td>
</tr>
<tr>
<td>under an individual’s control</td>
<td>little or no obvious benefit</td>
<td>synthetic / artificial</td>
</tr>
<tr>
<td>clearly beneficial to exposed person</td>
<td>Effects statistically uncertain</td>
<td>negative effects immediate</td>
</tr>
<tr>
<td>natural components</td>
<td>unusual, exotic</td>
<td>inequitable, unfairly distributed</td>
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<tr>
<td>effects apparently statistically certain</td>
<td>catastrophic consequences</td>
<td>generated by non-trusted source</td>
</tr>
<tr>
<td>negative effects delayed</td>
<td>targets children</td>
<td>targets adults</td>
</tr>
<tr>
<td>familiar characteristics</td>
<td>associated with ‘dread’ words</td>
<td>associated with benign words</td>
</tr>
<tr>
<td>equitable, fairly distributed</td>
<td>generated by a trusted source</td>
<td>natural components</td>
</tr>
<tr>
<td>minor consequences</td>
<td>effects apparently statistically certain</td>
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<tr>
<td>associated with benign words</td>
<td>natural components</td>
<td>effects apparently statistically certain</td>
</tr>
</tbody>
</table>

Table 1: Risk Characteristics which influence Risk Perception and Tolerability Adapted from “Acceptable Risk” by Baruch Fischoff, et al NY: Cambridge University Press 1981
Aside: Always consider the 3 terms - hazard, exposure and risk together. Risk analysts can forget the value of the term exposure in clarifying the difference between hazard and risk - eg. A hazard can only be a risk if there is exposure!

Providing information on a risk assessment proforma, to prompt employees to consider common hazards such as tripping hazards - that might be omitted from the assessment, can reduce the impact of this bias. Examples of previous accidents where an inaccurate risk judgement was a causal factor will be useful. The more practical knowledge an individual has about an activity, the more likely he is to be able to identify all the hazards and have accurate perceptions about the characteristics of the exposure and hence the risk. So it is essential that those performing risk assessments have the relevant practical experience of performing the tasks being assessed.

Supervisors can be more likely to under-estimate risk than front-line employees. It can be argued that supervisors tend to underestimate risk because for them, the risk-benefit trade-off for the risk taking activity is biased towards productivity and this can lead them to underestimate the risk. Involving all team/work group members in the risk assessment process can counter-balance the supervisors’ underestimation of risk and may reduce the impact of this bias.

Mechanisms to reduce the impact of risk perception biases.

Adapted from Anon (1999)
1) Are risk assessments performed by an individual or a team with the following skills:
   -Practical knowledge of the operation being assessed?
   -Knowledge of risk assessment techniques?
   -Overview of other factors (such as operations) that may influence the risk?
2) Do risk assessment training courses provide skills training to reduce perception biases?
3) Are the employees who are going to perform the operation involved in the risk assessment?
4) Is the accuracy of risk assessments performed by frontline employees monitored?
5) Was the way employees think about risk considered when risk assessments processes, procedures, and documents were being designed?
6) Do risk assessment procedures ensure that task-specific risk assessment are performed early enough to ensure that sufficient time is available to implement the control measures and are not pressured to allow work to proceed?
7) Are task risk assessments performed by people who have the authority and resources required to implement additional risk control measures they feel are required?
8) Do risk communication campaigns address biases in risk perception in order to combat complacency about operations frequently performed?

Sub Standard Practices, Conditions and Errors

The immediate causes of an incident are divided into categories: substandard practices (SSPs), substandard conditions (SSCs), and errors. Often the traditional terms unsafe acts (or ‘at-risk’ behaviours) and unsafe conditions are used instead. However, “substandard” is preferable as it implies measurement against an agreed standard (set by legislature, professional bodies, companies or joint risk assessments with supervisors and employees). The term “unsafe” requires a large degree of arguable, subjective judgement. Safety is relative not absolute. Safer means lower risk and are achievable. Safe means zero risk and is not achievable at all times in all places under all circumstances.

Safety is NOT zero risk taking rather it is taking only necessary risks and only after they are fully assessed and managed. SSPs are the behaviours that we are interested from the point of view of understanding and changing intolerable risk-taking behaviour. A SSP can be defined as any practice that deviates from an agreed tolerable (quantitative) standard (i.e. the Agreed Standard practice, or ASP). Examples include using an improper tool or method, using hazardous substances without the prescribed precautions, lifting a small compact article from floor height with straight knees, choosing not to use or defeating the protective safeguards provided on a machine.
Similarly, a SSC can be defined as a condition that deviates from an agreed tolerable (quantitative) standard. Examples include defective tools, lack of machine guarding, objects placed in access lanes. The interactions between SSPs and SSCs are important. SSPs can lead to SSCs, and vice versa. For example the SSP of placing or leaving an article in a passageway leads to a SSC. The SSC of insufficient lighting may lead to the SSP of not using safety glasses when doing a precise job with a grinder or a VDU operator using wrong screen settings. Consequently the distinction between SSPs and SSCs is not absolute. Therefore, although it is primarily concerned with minimising the frequency of use of SSPs, the process also will help to minimise the occurrence of SSCs as well as Errors.

Human Error

Errors should always be seen as Consequences NOT Causes!

The 2 main categories of human performance difficulties ‘errors’ - (with no intent and due to ergonomic mismatches between person, task and environment) and ‘sub-standard practices’ (SSPs) (intentional acts for ‘good reasons’ which replace the old ‘unsafe acts’ or ‘at risk behaviours’). (Figure 4)

The most common good reason in the case of taking SSPs is to take a perceived short-cut to save perceived time, money and effort. We should never criticize people for finding shortcuts because that is the perennial smart, necessary business, commercial imperative i.e. to find smarter, better, more efficient, more productive ways of doing things. To criticize finding short cuts is duplicitous. All our other spoken, written communications in our workplaces favour and encourage the finding of short cuts, BUT we must recognise the difference between finding a short cut and using it only after a risk assessment is performed to justify it replacing the currently Agreed Standard Work Procedure (ASWP). As with SSPs, there are always very good reasons for errors. (usually ergonomic mismatches).

“Human error” as part of Human Performance Difficulties is a term that has many different definitions. Extending Rasmussen’s work, Reason (1988) proposed a definition that has gained a great deal of acceptance: error embraces all those occasions in which a planned series of mental or physical activities fail to achieve the intended outcome, and when these failures cannot be attributed to the intervention of some chance agency. Behavioural scientists use very negative words such as human failures and violations. The preferred neutral term is Human Performance Difficulties which can be “errors” or SSPs. It is important to note that error refers to unintentional difficulties only.

Many human “failures” - I prefer “performance difficulties” - are performed with some degree of intention, i.e. very 'good' reasons. Errors are always associated with ergonomic mismatches between the human, the work and/or work environment. Humans often have difficulty doing what they want or need to do because there are incompatible work tasks or work environments.

To account for intentional ‘failures’, Reason uses another term, “violation”, defined as deviations from those practices deemed necessary (by designers, managers and regulatory agencies) to maintain the safe operation of a potentially hazardous system. As we can see, these “violations” can be regarded as the same as “substandard practice” SSPs. The term “substandard practice” is more appropriate.
however as it does not imply blame to the same extent as the term “violation” can.

Errors are unintentional types of SSPs. They are not performed with intentional disregard of the Agreed Standard to be used. For example, pressing the incorrect switch or button or key, not wearing hearing protection may be an honest or unknowing mistake. Errors can also lead to SSCs (eg. forgetting to replace a guard on a machine after doing a maintenance task will lead to a SSC). Errors can also occur in management decisions and supervisory performance as well as in employee actions. Directly focusing on SSPs which involve some degree of choice or intent, without assuming or implying that the person has any wilful intent of harm or damage, is not directly concerned with Errors. The risks due to SSCs and Errors need to be addressed fully by other parts of your HSE programs. There is no suggestion of misguided emphasis on human behaviour in our choice of SSPs. Rather the emphasis is on the principle that there are always “good” reasons for people choosing SSPs. The goal is for workgroups in a program to identify and analyse what are the “good” reasons which lead us to use SSPs.

It is also essential that we remember that all rational behaviour is risk taking for “good” positive reasons, i.e. expecting benefits and gains. Risk taking is always speculative, i.e. for the perceived gain, but with recognition of the chance of loss or harm as well. No one takes a risk for the chance of loss. The types of behaviours of interest to are SSPs which involve some degree of choice or intent.

**Root causes**

SSPs, SSCs and Errors can be regarded as immediate “causes” of incidents - they are the events that are most closely associated with the incident itself. However, these immediate causes can be regarded as symptoms of the root or more basic causes. All incidents can be regarded as results of breakdowns in one or more aspects of the management system of control.

Root causes include:

- **management safety policy and decisions** (eg. inadequate policy and programs, inadequate program standards, failure to comply with Agreed Standards), supervisory performance (eg. inadequate instruction, non-enforcement of rules, safety not included in job instruction, scheduling issues, fatigue),
- **personal factors** (eg. lack of knowledge, unsuitable physical or psychological conditions, tiredness, fatigue, lack of vigilance), and
- **job/ environmental factors** (eg. inadequate and non-agreed work standards, inadequate design or maintenance of equipment, speed, ie ergonomic mismatches). It is easy to see how root causes can lead to SSPs and SSCs. Thus, it would seem that we should focus on these root causes in an effort to control health and safety risk rather than on SSPs and SSCs.

Although the focus is on specific behaviours (and thus immediate causes), the implementation will necessarily involve a detailed examination of the root causes that result in SSPs, and the identification and development of appropriate solutions to overcome these root causes. Focuses are on specific behaviours because of the effectiveness and many advantages associated with this approach.

**The role of SSPs in incident causation**

Some studies have reported statistics on the relative roles of SSPs and SSCs in incident causation. Heinrich’s (1959) study of 75 000 incidents is the most well known. For each accident, he isolated one major immediate cause or significant contributory factor.

Aside: There is never 1 and only 1 “cause” of an incident. He found that 88% of the incidents had a SSP as the major immediate cause, and 10% of the incidents had a SSC as the major immediate cause.

Other studies have usually allowed more than one immediate cause or contributory factor to be used for each incident. These studies have usually found a similar number of incidents have SSPs and SSCs as immediate causes, with usually 70- 90% of incidents involving SSPs and 70-90%
involving SSCs. The National Occupational Health and Safety Commission NOHSC (Worksafe Australia) researchers conducted a study of 1020 work related fatalities that have occurred in Australia (Feyer and Williamson, 1990). Their results were that 91\% of the fatal incidents had behavioural factors involved in their causation. The statement that most incidents are caused by SSPs is wrong and inappropriate. Many factors combine to produce an incident. A SSP may be one of many reasons why an incident occurred, but it is unlikely to be one of the many underlying root causes. Similarly, the use of the term “cause” can imply blame to the individual responsible for the SSP.

There are always good reasons why behaviours occur, and connotations of blame should be avoided. Studies investigating the role of SSPs in incident causation often do not distinguish between the relative role of intentional SSPs and unintentional (errors). Both are certainly important.

The studies have also used different methods and classification systems. There is a need for more effective management of the behavioural side of incident causation. However, it is the conditions side of the incident causation model that appears to have received more attention in the past. Critics of behaviour-based safety wrongly claim that SSCs and their physical risk control solutions are ignored. Legal and logical imperatives such as the risk control hierarchy dictate that physical and engineering aspects of incident causation and risk control must take precedence over behavioural aspects but cannot do so exclusively. It is just as illogical to rely solely on engineering and physical solutions as it would be to rely on ISO 9001. It is equally wrong to assume that physical and engineering controls are the complete answers. The common principle called KISS (Keep It Simple Stupid) reinforces this harmful and incorrect approach.

While having some value in ensuring corrective actions or risk control options are kept as uncomplicated as possible, it assumes that a work environment can be engineered to be ‘idiot proof’ or ‘fool proof’ i.e. it assumes that we can make work so safe that even an idiot couldn’t get hurt. This belief gives a dangerous and wrong comfort zone, because as is proven in all incident studies, there are always aspects of SSPs where people (Infinitely clever, motivated and innovative humans) choose to vary or defeat or circumvent even the best safeguards/controls for a perceived gain or benefit. Often the perceived gain or benefit is corporate rather than personal. A well-motivated human can defeat everything which an imaginative engineer can invent!

Aside: Maybe we should recognise the need to replace the KISS Principle, Keep It Simple Stupid by the MIST Principle. Make It Safer Sunshine.

Types of Positive Behaviours of Interest to Safety Systems and Programs

The aim of OHSMS and safety programs is ultimately about creating a system designed to increase the use of certain agreed SPs and hence decrease the use of certain SSPs. Most discussions regarding the management of risk-taking behaviour emphasise the need to decrease the use of SSPs. In contrast, we must emphasise the importance of increasing the use of SPs. Focusing on desired positive behaviour, and reinforcing such behaviour, is a very important principle of effective behaviour management. However, increasing the use of SPs and decreasing the use of SSPs are complementary aims. We need to focus on SPs as this positive approach is more effective for changing behaviour, but we need to focus on SSPs initially in order to understand why they occur and how to best increase the frequency of SPs.

SSPs can be divided into those that are routine and those that are exceptional. Routine or habitual SSPs appear to be shaped by two main factors: the natural human tendency to take the path of least effort, and an environment that is relatively indifferent or forgiving (Reason, 1988). We need to orient our safety programmes to decreasing the occurrence of both routine and exceptional SSPs. Table 3 lists many of the common SSPs of concern in industry. The reader is encouraged to rewrite them as positive SPs. SPs can be divided into those that are formally defined (i.e. specified in ASWPs, safety rules or by other similar means), and those associated with initiative (eg. checking the suitability of another individual’s machine guarding if something does not appear to be right).
Table 2: Brief List of Error Types

<table>
<thead>
<tr>
<th>Brief List of Error Types</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Actions</strong></td>
</tr>
<tr>
<td>- too early / too late</td>
</tr>
<tr>
<td>- too much / too little</td>
</tr>
<tr>
<td>- too long / too short</td>
</tr>
<tr>
<td>- in wrong direction</td>
</tr>
<tr>
<td>- on wrong object</td>
</tr>
<tr>
<td>- wrong action on right object</td>
</tr>
<tr>
<td>- in wrong sequence</td>
</tr>
<tr>
<td>- omitted</td>
</tr>
<tr>
<td><strong>Decision Making</strong></td>
</tr>
<tr>
<td>- forming an incorrect diagnosis</td>
</tr>
<tr>
<td>- not supported by available information</td>
</tr>
<tr>
<td><strong>Checking</strong></td>
</tr>
<tr>
<td>- omitted</td>
</tr>
<tr>
<td>- on wrong object</td>
</tr>
<tr>
<td>- wrong check on right object</td>
</tr>
<tr>
<td>- check mistimed</td>
</tr>
<tr>
<td><strong>Information</strong></td>
</tr>
<tr>
<td>- not obtained</td>
</tr>
<tr>
<td>- wrong information obtained</td>
</tr>
<tr>
<td><strong>Communication</strong></td>
</tr>
<tr>
<td>- incomplete / confusing</td>
</tr>
<tr>
<td>- wrong / inaccurate</td>
</tr>
<tr>
<td>- too late / not timely</td>
</tr>
<tr>
<td><strong>Misalignment</strong></td>
</tr>
<tr>
<td>- of controls, tools, equipment</td>
</tr>
</tbody>
</table>

The Value of Employee-Owned & Agree Standard Work Procedures (ASWPs)

The SPs required for a certain task or activity need to be formally defined and agreed by the interested parties by a formal process. This formal definition is required to ensure that the appropriate behaviour is known, agreed and will be consistently used. If the required behaviour is not formally defined, then we are relying on “common sense” or the initiative of the relevant individuals to guess if their perceptions of appropriate (tolerable risk) behaviour match the perceptions of others. As we all know, this approach does not work because “common sense” cannot be assumed and is not common until commonality is achieved by formal discussion and agreement. SPs can be defined in terms of safety rules, applicable to a certain work area or several tasks, and the ASWPs for specific tasks. These safety rules and ASWPs need to be developed by the involved employees, after they thoroughly analyse what behaviour is required and reasonable to expect of the individuals concerned. Consequently, a Job Safety Analysis (JSA), leading to writing of the procedure used to set up a ASWP, is a very important and essential component of any approach to managing risk-taking behaviour.

Such an integrated analysis needs to lead to 1 and only 1 Agreed Standard Work Procedure (ASWP); Not a safe way, not a quality way, not an environmental way, not the productivity way but simply your organization’s or workgroup’s agreed standard way of doing each and every job as well as you need and can do! All risk discussions and consultations need to be based on the 7 principles - adapted from Corvello:

- Accept and involve all personnel as necessary consultative ‘partners’
- Plan carefully what is to be said and/or written and evaluate your efforts
- Listen to all your employees’ individual and specific concerns.
- Be honest, frank, and open.
- Coordinate and collaborate with other credible sources.
- Meet the needs of internal and external media.
- Speak/write clearly and with empathy and compassion.

Risk Perception and the Shift of Safety Culture to a Risk Management Paradigm

The ultimate influence on, or Activator A of, a person’s behaviour is the individual’s perception of the level of risk associated with a given situation and the use of certain types of behaviour. This perception of risk is a function of:

1. The extent to which the person believes he/she is personally exposed and susceptible to a given outcome (i.e. injury or illness); (“It won’t happen to me”)
2. The extent to which the person believes the outcome is serious; and
3. The extent to which the person believes that preventative action would be effective.
Table 3: Typical Sub Standard Practices SSPs - This is obviously only a representative - not an exhaustive list. The reader is encouraged to rewrite these as positive SPs - no 'nots', or 'don’ts'.

1. Not following specified Agreed Standard Work Procedures.
2. Using unsuitable manual handling techniques (eg. lifting with the load not as close to the body as possible; moving heavy items with large degree of spinal twisting or sudden jerking movements).
3. Not storing or disposing of articles appropriately (ie. poor housekeeping) (eg. free-standing gas cylinders; placing or leaving articles in passageways; not cleaning up liquid spills).
4. Not reporting hazards or incidents observed, or injuries sustained.
5. Unsuitable placement of body in relation to task (et. Standing too close to a machine, standing with back to a main passageway).
6. Operating machines or tools with methods other than that recommended (eg. at faster speeds than recommended, for different purposes than recommended).
7. Not using the protective guards of a machine, or by passing/defeating safety devices or procedures.
8. Not using designated access lanes/passageways when moving around a workplace.
9. Not using appropriate lockout/tag out procedures (eg. not turning equipment off before starting maintenance).
10. Using unsuitable working postures (eg. sitting slouched for long periods, not varying posture regularly).
11. Not wearing (and maintaining) required PPE in appropriate ways.
12. Wearing inappropriate clothing or other items (eg. loose, long hair or loose clothing around revolving machinery; gloves while grinding).
14. Not reporting near hits
15. Not discussing appropriate work methods with fellow employees
16. Not completing agreed number of risk analyses
17. Not completing agreed number of hazard/risk audits
18. Not reviewing agreed number of Standard Work Procedures - Practices

Although risk perception is the ultimate determinant of behaviour, it is again a belief or attitude, and consequently it is difficult to observe, measure or change by directly focusing on the internal state itself. Perception of risk is strongly influenced by personal experience with the situation or task and observation of others in the same situation. Short of actually having an incident (or even simulating incidents), there is often little that can be done to directly influence this perception of risk when there are other motives in the situation (eg. benefits for working quickly or taking short-cuts).

An individual’s or workgroup’s tolerability of risk is an extremely complex concept that depends on personal, individual, corporate and social values. In the workplace OHS context, the ultimate arbiter of what is tolerable is usually a regulator or judge who is often called upon to decide whether the risk I benefit tolerability equation was evaluated according to the community’s prevailing legal and moral standards.

On a day-to-day basis, the risk takers and the risk makers are the appropriate risk managers. However, this principle assumes that the risk takers and the risk makers know and fully appreciate all positive and negative dimensions of the risk.
Risk Level Estimation by Risk Score Calculation

All employees and managers need to be active, committed participants in safety systems and programs. Hence they all need to given the knowledge and skills to calculate risk. This process need not be time-consuming nor complex. The author can teach an employee how to reliably and consistently calculate risk in as little as 1 hour.

The Risk Analysis phase of Risk Management consists of 3 alternative or sequential levels of analysis. (See AS/NZS 4360: Risk Management: 1999*)

(* becoming the defector ISO world standard for risk management.)

The 3 levels of risk analysis are:
- qualitative
- semi-quantitative
- quantitative ORA

Qualitative risk analysis is the fastest assessment involving simple judgement of whether the risk is capable of being classified by verbal descriptors such as “high/low” OR “high/moderate/low”.

Semi-quantitative risk analysis involves the numerical assessment of the components of risk separately then compounding them into an overall estimation of the risk level by a numerical score.

There are 2 common alternative forms of semi-quantitative risk analysis:

The Matrix Method - 2 components of Risk (R) - Consequence (C) and Likelihood (L) (Figure 5) and,

The Tie-Line Method - 3 components of Risk (R) - Consequences (C) Exposure(E) Probability (P) (Figure 6)

If a scale of 1 to 6 is chosen for each of the sizes of the components (See Tables 4 and 5), then the compounded risk score level ranges from 2 to 12.

Notes:
1) For convenience only, the term likelihood is reserved for the Matrix or LC method and the term probability is used in the Tie-Line/CEP method.
2) The 2 semi-Q methods are consistent and the Tie-Line or CEP Method is essentially the same as the Matrix method except that (L) likelihood of the whole risk scenario has been broken into 2 components - (E) exposure (duration/frequency of the critical breakdown event) and (P) the probability of the whole risk scenario proceeding in its entirety as specified.
3) The Matrix/LC method is usually chosen because it can be faster than the Tie-Line/CEP method but its results can be less reliable and inconsistent.
4) Risk Scores provide the (often missing) objective basis for prioritising target behaviours and compiling the traditional Critical behaviour lists, or similar, used for safety or risk sampling.
5) The objective Risk Score settle the debates about tolerability:

11-12 Intolerable
5-10 ALARP
1-4 Broadly Tolerable / Negligible

Quantitative Risk Analysis QRA involves detailed specification of the risk scenario with a given Consequence and all the risk factors/frequencies/probabilities for each of the events in a combination of logic trees such as Event and Fault Trees. The ORA method yields a risk evaluation with an expression similar to: “the risk of the ..scenario VVV.. leading to a consequence of ZZZ is 1 chance in 10000 per annum” OR “the probability of ...VVV...with consequence ZZZ occurring is 0.0001 per annum”.

With QRA, the Consequence and Probability are not compounded as in semi-Q analysis methods. Safety systems and program often can choose the “middle-of-road” semi-Q method as a reasonable workable compromise of:
- Ease of learning
- time-to-perform, and
- accuracy/reliability/consistency of risk scoring results.

The semi-Q method of risk scoring can be assisted by the use of Z-CARD™ pocket cards which replicate the Matrix or Tie-Lines of Figures 5 and 6 as well as Tables 4 and 5. Their pocket portability maximises accessibility at the workplace.

**Conclusion**

Everyone involved in safety systems and programs need the knowledge and skills associated with Risk Management otherwise there will continue to be confusion and argument about what is an “at risk” behaviour and what is not. “The term “at risk” is no more helpful than the old term “unsafe act”. The pocket cards constitute a decision support system which can reduce the impact of biases in risk perception by providing front-line employees with a formal method to make probability and consequence/severity estimates. The results of generic risk analyses can support employees performing task-specific assessments. The development of programs/processes that heighten employees’ awareness of the importance of low consequence but high likelihood hazards when performing a risk assessment will also be worthwhile.

But the over-riding success of safety systems and programs depends vitally on the availability and understanding of tools to make selection of target behaviours and meaningful discussion of the results of safety or risk sampling. Stakeholders not having the knowledge or skill to do risk calculation is the “missing link” in most safety programmes and processes.

**Philosophy Platform for Improved Safety Performance:** “When all employees are fully involved and participating in:
- identifying their risks,
- assessing them,
- choosing risk control options, and
- self-sampling
their own agreed standard practices, then they will “own” and tolerate those standard practices as coping with the residual risk that always remains after physical, engineering, risk control measures have been implemented”
The Missing Element of OHSMS and Safety Programmes - Calculating and Evaluating Risk

Table 4: Risk Analysis Likelihood Table (for use with the Matrix Method)

<table>
<thead>
<tr>
<th>Category</th>
<th>Rating</th>
<th>Description</th>
</tr>
</thead>
</table>
| Certain  | 6      | - Very high likelihood of the complete chosen risk scenario happening. (eg. more than once a month.)  
|          |        | - Very high probability that it will occur in operations of this type. Guide: expected frequency greater than 2 p.a. |
| Likely   | 5      | - High likelihood of the complete chosen risk scenario happening (eg. several times within the next 10 years.)  
|          |        | - Has occurred within the last two years.  
|          |        | - High probability that it will occur in operations of this type. Guide: expected frequency greater than 0.1 p.a. |
| Probable | 4      | - Probably could occur (eg. more than once within the next 10 years.)  
|          |        | - Likelihood of occurrence is increased due to limit of control through external influence.  
|          |        | - History of occurrence with the defined consequence level within the industry. Guide: expected frequency of between 0.1 and 1 p.a. i.e. once per 1 to 10 years. |
| Possible | 3      | - Has occurred sometime in industry with the defined consequence.  
|          |        | - Would not be surprising if it occurred. Guide: expected frequency between 0.07 and 0.1 p.a. i.e. once per 10 to 100 years. |
| Unlikely | 2      | - Low probability that the situation resulting in the defined consequence will occur. Could occur but it is considered unlikely.  
|          |        | - Causal events have occurred but effects have been controlled so that the defined consequence has not resulted.  
|          |        | - No history of a base situation which results in the possibility consequence level defined in the railway industry. Guide: expected frequency between 0.001 and 0.01p.a., i.e. once per 1000 to 10,000 years. |
| Improbable| 1      | - Possible but very unlikely that the complete chosen risk scenario resulting in the defined consequence will occur.  
|          |        | - Sequence of causal events have occurred within the industry but this is not easily and effective to control and such controls are in place. Guide: expected frequency < or = 0.001 p.a., i.e. less than or equal to 1 per 1000 years. |

Table 5: Risk Analysis Consequence Table (for use with all Methods)

<table>
<thead>
<tr>
<th>Consequence</th>
<th>Safety related</th>
<th>Legal Liability</th>
<th>Public Perception</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 Multiple fatalities</td>
<td>&gt; $100 Million</td>
<td>Office closed, Corporate fine $10M. Multiple third party claims totaling $100M</td>
<td>Hostility down of major installation or curtailment of operations</td>
</tr>
<tr>
<td>5 Single fatality</td>
<td>$1M - $10M</td>
<td>Corporate fine $1M - $5M. Multiple third party claims totaling $1M - $5M</td>
<td>Limited national/ international adverse media campaign. Government inquiry</td>
</tr>
<tr>
<td>4 Multiple serious injuries</td>
<td>$50K - $1M</td>
<td>Corporate fine $50K - $1M. Third party claims $50K - $1M</td>
<td>Adequate national media coverage</td>
</tr>
<tr>
<td>3 Casual injuries (hospitalized)</td>
<td>$5K - $50K</td>
<td>Corporate fine $5K - $50K. Third party claims $5K - $50K</td>
<td>Adequate capital (claim) coverage</td>
</tr>
<tr>
<td>2 Medical (sick)</td>
<td>$10K - $100K</td>
<td>Third party claim &lt; $100K</td>
<td>Local media coverage: Public (complaint) complaints</td>
</tr>
<tr>
<td>1 First aid treatment or no treatment</td>
<td>&lt; $10K</td>
<td>Third party claim &lt; $10K</td>
<td>Publicly normally unknown</td>
</tr>
</tbody>
</table>
Reference

IEC 61508-5: Functional safety of elect or programmable electronic safety-related systems - Part 5

Colour Vision of Workers in the Plastics Industry

Sharanjeet-Kaur, Mursyid A. and Ariffin A.E.
Faculty of Allied Health Sciences, Universiti Kebangsaan Malaysia

Abstract

A study was undertaken to determine the effect of polyethylene and polystyrene used in the manufacture of plastic items on colour perception. Colour vision was assessed using the Ishihara plates, panel 015 test and the Farnsworth Munsell 100-Hue test. Two factories were chosen at random. One factory (referred here as factory A) used virgin resin in pellet form (polyethylene) in the manufacturing of plastic containers to store consumer edible oil. The other factory (referred as factory B) used polystyrene to make plastic bags. A total of 39 healthy employees from factory A (mean age 26.4 ± 8.2 years) and 40 healthy employees from factory B (mean age 26.8 ± 9.6 years) were recruited in this study. A control group of 27 normal healthy subjects (mean age 27.4 ± 4.3 years) who were employees of UKM with no occupational involvement with petroleum derivatives were also recruited in this study and they performed the same colour vision tests. All subjects passed the Ishihara plates test showing that none of the subjects (employees of factory A and B, and control subjects) had a congenital red-green defect. All control subjects passed all of the colour vision tests whilst some employees of factories A and B failed the 015 and FM100 Hue tests. For employees from factory A results from the 015 test showed that 7 (17.9%) had a tritan (blue-yellow) type of defect and 1 (2.6%) had a complex type of defect. The FM 100 Hue results of factory A employees showed that 51.3% (n=20) had a complex type of defect. Total error scores (TES) calculated from the FM 100 Hue test revealed that employees from factory A had a statistically significant higher mean TES of 65.13 ± 48.31 compared to that of control subjects with a mean TES of 31.26 ± 14.93. For employees in factory B, 10 employees (25.0%) had a tritan (blue-yellow) type of defect and 2 (5.0%) had a complex type of defect. Results of the FM 100 Hue test showed that 4 employees (1.0%) had a tritan type of defect whereas 22 (55.0%) had a complex type of defect. Mean total error scores (TES) calculated from the FM 100 Hue test revealed that employees from factory B had a statistically significant higher mean TES of 71.54 ± 54.63 compared with that of control subjects with a mean TES of 31.26 ± 14.93

The above results show that employees of the plastic factories studies are associated with a higher risk of acquiring colour vision defects as compared to normal subjects who are not engaged in the plastic manufacturing industry. This may have an implication towards the future retinal health of employees in petrochemical-based industries.

Key words: polyethylene, polystyrene, colour vision

Introduction

Interest in the colour perception of workers exposed to neurotoxic chemicals is relatively recent with very little research having addressed the topic. However, during the 1999 International Symposium on Neurobehavioral Methods and Effects in Occupational and Environmental Health, it was revealed that the number of chemicals affecting visual function was progressively increasing (Gobba 2000).

It has been shown that chemical-related colour vision impairment is an early effect that can generally be detected at low exposure levels if the method used to test colour vision is sensitive enough, provided that the results are evaluated by adequate methods, and that an appropriately selected control group is compared with (Gobba 2000).

The petrochemical industry is a large industry producing basic plastic materials. Plastics and resins make up about 60% of the petrochemical end-product. The petrochemical industry produces basic raw materials such as ethylene, propylene and vinyl chloride. Further derivates include basic plastics, such as
polyethylene, polypropylene and polyvinyl chloride. Three quarters of the total consumption of plastics are targeted at basic plastics where Western Europe, USA and Japan use 64% of the total polyethylene produced (http://www.itcilo.itlenglish/actrav/telearn/ash/kemi/ctm9.htm). It is the largest volume petrochemical product in the world.

One of the most widely studied plastics is styrene. It is part of the family of polymers and is produced from ethylene gas. Studies (Campagna et al. 1995, 1996; Chia et al. 1994; Eguchi et al. 1995; Fallas et al. 1992; Gobba 2000; Gobba & Cavalleri 1993a; Gobba & Cavalleri 2000; Gobba et al. 1991; Kishi et al. 2001) have shown that styrene can affect colour vision, even at lower exposure levels than the current Threshold Limit Value (TLV) proposed by the American Conference of Governmental Industrial Hygienists (ACGIH) (ACGIH 1997).

However, other plastics like polyethylene have not been much studied. One study (Gos et al. 1999) showed that lacrimation disorders could result as a consequence of present workplace, number of hours of work per day, number of days worked per week, previous workplace and type of work involved, duration of work at previous workplace, history of colour vision problems presently or in the past, history of colour vision problems in other family members, medical problems such as diabetes, hypertension, heart disease, etc, consumption of drugs, medications, traditional foods or medications, alcohol, history of cigarette or tobacco smoking (if yes, then number of cigarettes or cigars smoked per day) and exposure to it. Another study (Zdzięszyska & Gos 1995) showed that exposure to petroleum derivatives in the petrochemical industry could result in colour vision defects. The objective of the present study was to evaluate the status of colour vision of workers employed in the making of plastic products from polyethylene and polystyrene using standard clinical colour vision tests.

**Material and Methods**

A cross sectional study was carried out on seventy-nine healthy individuals aged between 21 years and 35 years who worked in a plastic product manufacturing environment.

**Place of study**

Two factories were randomly chosen. One factory (referred to here as factory A) used virgin resin in pellet form (i.e. polyethylene) to make plastic containers to store consumer edible oil. The other factory (referred as factory B) used polystyrene to make plastic bags. All tests for the factory employees were conducted in a room provided by the management at the factory site.

**Subjects**

A total of 39 healthy employees (mean age 26.4 ± 8.2 years) from factory A and 40 healthy employees (mean age 26.8 ± 9.6 years) from factory B were recruited in this study. A control group of 27 normal healthy subjects (mean age 27.4 ± 4.3 years) who were employees of UKM with no occupational involvement with petroleum derivatives were also recruited in this study and they performed the same colour vision tests as the factory employees. The control subjects were tested at the Optometry Clinic in UKM.

**Tests conducted**

a. **Questionnaire**

Employees who volunteered to participate in this study first filled in a questionnaire. The questionnaire consisted of demographic data of the subjects: duration of work at present workplace, number of hours of work per day, number of days worked per week, previous workplace and type of work involved, duration of work at previous workplace, history of colour vision problems presently or in the past, history of colour vision problems in other family members, medical problems such as diabetes, hypertension, heart disease, etc, consumption of drugs, medications, traditional foods or medications, alcohol, history of cigarette or tobacco smoking (if yes, then number of cigarettes or cigars smoked per day) and exposure to it. Another study (Zdzięszyska & Gos 1995) showed that exposure to petroleum derivatives in the petrochemical industry could result in colour vision defects. The objective of the present study was to evaluate the status of colour vision of workers employed in the making of plastic products from polyethylene and polystyrene using standard clinical colour vision tests.

b. **Preliminary tests**

Visual acuity was measured for distance using the Snellen chart and at near using a reading chart. Only subjects with best corrected distance visual acuity of 6/6 or better and best corrected near acuity of N6 at 40 cm or better were included in the study. Subjects with any systemic, ocular and neurological disease were excluded from the study. Direct ophthalmoscopy was also done to screen for any ocular pathology.
c. Colour vision tests

Colour vision was assessed using the Ishihara plates, panel 015 test and the Farnsworth Munsell 100-Hue (FM 100-Hue) test. The Ishihara plates were used as a screening test for red-green congenital defects. The 015 test FM100 Hue tests were mainly used as clinical tests for determining the presence of acquired colour vision defects. Testing was done under daylight conditions. Subject wore their best correction whilst doing both tests at a distance of 35 to 40 cm. The testing conditions were similar for all three groups.

Results

a. Demographic data

The demographic data of the subjects is shown in table 1. The study group (employees from factories A and B) comprised predominantly of males. Most of the workers were foreigners, that is Bangladeshis. They had been working at their respective factories for periods between 2 to 3 years. They worked almost 12 hours per day, and 7 days per week. They reported of no medical or ocular problems. There were also some employees who consumed alcohol and who smoked cigarettes. The mean age of the employees in factory A was 26.4 ± 8.2 years, in factory B it was 26.8 ± 9.6 years and that of the controls was 27.4 ± 4.3 years. There were no statistically significant differences in the mean ages of the three groups [ANOVA p > 0.05]. As a whole one or two persons, all women, were either taking a traditional herbal remedy called Jamu or multivitamins.

b. Preliminary tests

All subjects had a distance visual acuity (VA) of 6/16 or better when tested with the Snellen chart and a near acuity of N6 or better when tested with a reading chart. Ophthalmoscopy did not show any fundus abnormality in any of the subjects.

c. Colour vision tests.

Table 2 shows the number and percentage of subjects having errors and therefore having colour vision defects on testing with the Ishihara plates, panel 015 test and the FM100 Hue test. It can be seen that all subjects passed the Ishihara plates test. However, the factory workers were found to have colour vision defects when tested with the 015 and FM100 Hue tests. Eight (20.5%) and 20 (51.3%) employees from factory A had colour vision defects with the 015 and FM100 Hue tests respectively. Twelve (30.0%) and 26 (65.0%) employees from factory B had colour vision defects with the 015 and FM100 Hue tests respectively. All control subjects showed no defects when tested with the Ishihara plates, panel 015 and FM100 Hue test.

<table>
<thead>
<tr>
<th>Data</th>
<th>Factory A</th>
<th>Factory B</th>
<th>Factory C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Subjects</td>
<td>39</td>
<td>40</td>
<td>27</td>
</tr>
<tr>
<td>Gender: Males</td>
<td>31 (79.5%)</td>
<td>29 (72.5%)</td>
<td>7 (25.9%)</td>
</tr>
<tr>
<td>Females</td>
<td>8 (20.5%)</td>
<td>11 (27.5%)</td>
<td>20 (74.1%)</td>
</tr>
<tr>
<td>Race: Malays</td>
<td>8 (20.5%)</td>
<td>10 (25.0%)</td>
<td>21 (77.8%)</td>
</tr>
<tr>
<td>Chinese</td>
<td>3 (7.7%)</td>
<td>2 (5.0%)</td>
<td>5 (18.5%)</td>
</tr>
<tr>
<td>Indians</td>
<td>8 (20.5%)</td>
<td>10 (25.0%)</td>
<td>1 (3.7%)</td>
</tr>
<tr>
<td>Others</td>
<td>20 (51.3%)</td>
<td>18 (45.0%)</td>
<td></td>
</tr>
<tr>
<td>Duration of Work (Years)</td>
<td>2.1 ± 2.8</td>
<td>2.8 ± 3.1</td>
<td>8.4 ± 5.4</td>
</tr>
<tr>
<td>Duration of Work Per Day (Hours)</td>
<td>11.28 ± 1.50</td>
<td>11.36 ± 1.50</td>
<td>8.11 ± 1.20</td>
</tr>
<tr>
<td>Duration of Work Per Week (Days)</td>
<td>6.6 ± 0.5</td>
<td>6.7 ± 0.5</td>
<td>Not relevant</td>
</tr>
<tr>
<td>General &amp; Ocular Health</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Traditional Remedies Taken</td>
<td>1 person taking Jamu</td>
<td>Jamu (2.5%)</td>
<td>5 persons taking multivitamins (18.5%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcohol Consumed</td>
<td>3 (7.7%)</td>
<td>4 (10.0%)</td>
<td>0</td>
</tr>
<tr>
<td>Cigarettes Smoked</td>
<td>9 (23.1%)</td>
<td>12 (30.0%)</td>
<td>1 (3.7%)</td>
</tr>
<tr>
<td>Mean Age</td>
<td>26.4 ± 8.2</td>
<td>26.8 ± 9.6</td>
<td>27.4 ± 4.3</td>
</tr>
</tbody>
</table>

Table 1: Demographic data of all subjects.

Table 2: Number (%) of subjects showing colour vision defects.
The type of colour vision defect obtained was also analysed using the method devised by Vingrys & King-Smith (1988). It can be seen from table 3 that colour vision testing with panel 015 test showed that 7 (17.9%) employees from factory A and 10 (25.0%) employees from factory B had a tritan or blue-yellow type of colour vision defect. A further 1 (2.6%) employee from factory A showed a complex or non-polar type of colour defect. On the other hand, testing with the FM100 Hue test showed that 20 (51.3%) employees from factory A had a complex or non-polar type of defect whereas 4 (1%) employees from factory B showed a tritan or blue-yellow type of colour vision defect whilst a complex or non-polar type of defect was demonstrated by 22 (55.0%).

Table 3: Types of colour defects found.

<table>
<thead>
<tr>
<th>Factory</th>
<th>D15 Test</th>
<th>FM100 Hue Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>RG defect: 0</td>
<td>RG defect: 0</td>
</tr>
<tr>
<td></td>
<td>BY defect: 7 (17.9%)</td>
<td>BY defect: 0</td>
</tr>
<tr>
<td></td>
<td>Complete: 1 (2.6%)</td>
<td>Complete: 20 (51.3%)</td>
</tr>
<tr>
<td>B</td>
<td>RG defect: 0</td>
<td>RG defect: 0</td>
</tr>
<tr>
<td></td>
<td>BY defect: 10 (25%)</td>
<td>BY defect: 4 (1%)</td>
</tr>
<tr>
<td></td>
<td>Complete: 2 (5%)</td>
<td>Complete: 22 (55%)</td>
</tr>
</tbody>
</table>

Total Error scores (TES) were also calculated from the FM100 Hue test results. The mean TES for the three groups are shown in table 4. There was a statistically significant difference in mean TES between the two study groups and the controls (ANOVA, p<0.05). There was however no difference in mean TES between the two study groups.

Table 4: Mean TES of all subjects calculated from the FM100 Hue test.

<table>
<thead>
<tr>
<th>Groups</th>
<th>TES</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factory A</td>
<td>65.1</td>
<td>48.3</td>
</tr>
<tr>
<td>Factory B</td>
<td>71.5</td>
<td>54.6</td>
</tr>
<tr>
<td>Controls</td>
<td>31.3</td>
<td>14.9</td>
</tr>
</tbody>
</table>

Discussion and Conclusion

The factory workers in the present study were found to have colour vision defects when tested with both the 015 and FM100 Hue tests. 20.5% (n=8) and 51.3% (n=20) of employees from factory A had colour vision defects with the 015 and FM100 Hue tests respectively. And 30.0% (n=12) and 65.0% (n=26) of employees from factory B had colour vision defects with the 015 and FM100 Hue tests respectively. The higher percentage of colour defective detected with the FM 100 Hue test is testimony of the established fact that it is a more sensitive test for detecting acquired colour vision defects (Fletcher & Voke 1985). All control subjects showed no defects when tested with the Ishihara plates. 015 and FM100 Hue tests.

As for the type of acquired colour vision defect, the 015 test showed that 17.9% (n=7) of employees from factory A and 25% (n=10) of employees from factory B had a tritan or blue-yellow type of defect. Another 2.6% (n=1) of employees from factory A showed a complex or non-polar type of defect, while 5% of employees from factory B had a complex defect. On the other hand, colour vision testing with the FM100 Hue test showed most employees to have the complex type of defect as opposed to a tritan defect per se. 51.3% (n=20) of employees from factory A had a complex defect and 55.0% (n=22) of factory B employees showed a complex or non-polar type of arrangement of defect, signifying appreciable reclassification of the nature of colour vision defect within the employees as a whole. By the same token the percentages of tritan defects revealed with the FM100 Hue test was expectedly reduced dramatically in both groups, i.e. from 17.9% to none for factory A employees and from 25% to 1% for factory B employees.

Whatever the exact nature of the type of defect present, these results show that working in an environment involved with the manufacturing of plastic products is associated with the presence of an acquired type of colour vision defects.
The nature of colour vision testing allows some flexibility in the diagnosis of type because different clinical tests probe into different aspects of colour perception (Aspinall 1974). Notwithstanding, taking the FM100 Hue test on its own, the fact that more subjects had a defect with non-polar arrangement could be interpreted as a deterioration of whatever tritan defects that was originally present. Bresnick et al. (1987) has shown in his diabetic series that tritan defects could become complex and show non-polar arrangement due to progressive deteriorations from the outer retinal layers towards the optic nerve. Thus, the observation of non-polar defect could reflect a similar trend of progression in the severity of the acquired colour vision defect, taking into account of the 015 test results that there was in the beginning a tritan defect present. Total Error Scores (TES) calculated from the FM100 Hue test showed that there was a statistically significant difference in mean TES between the control and factory employee groups (ANOVA, p<0.05). There was however no significant difference in mean TES between the two factory employee groups. The employees from factory A had a mean TES of 65.1 ± 48.3, employees from factory B had a mean TES of 71.5 ± 54.6 whereas the controls had a mean TES of 31.3 ± 14.9. This corroborates the earlier results presented. No correlation between TES and duration of work at the factories could be found. As the number of subjects studied in the two study groups was small and the duration of work was around 2 to 3 years only, no significant correlation could be established.

The mean age of the employees in factory A was 26.4 ± 8.2 years, in factory B was 26.8 ± 9.6 years and that of the controls was 27.4 ± 4.3 years. There was no statistically significant difference in the mean ages of the three groups (ANOVA p > 0.05). This meant that any colour vision defect seen in the employees of the plastic product manufacturing factory were most probably due to their smoking activity. Ophthalmoscopy also did not show any fundus abnormality in any of the subjects in both groups. The crystalline lens of all subjects did not show any significant sclerosis either to account for the defects found. This indicates that the acquired colour vision defects seen in the factory employees are most likely due to problems within the visual pathway, presumably parts associated with the central or peripheral nervous systems. None of the subjects had a congenital colour vision defect as shown by passes on the Ishihara test by all subjects.

As a whole, it can be seen that 51% to 65% employees working in an environment where plastic products are manufactured show an abnormal colour perception, with 1% having a blue-yellow or tritan type of defect and 51% to 55% having a complex non-polar colour vision defect. It appears that being in the environment where plastics products are being manufactured posts a risk to having an effect on colour vision.

One may speculate how the chemicals could have entered the body, with the respiratory tract being high on the list. As neurotoxins have been shown to affect colour vision (Baelum et al. 1990; Campagna et al. 1995, 1996; Cavalleri et al. 1994; Chia et al. 1994; Eguchi et al. 1995; Fallas et al. 1992; Gobba 2000; Gobba & Cavalleri 1993a; Gobba & Cavalleri 2000; Gobba et al. 1991, 1993b, 1998, 1999b; Gonzalez et al. 1998; Kishi et al. 2001; Muttray et al. 1999; Nakatsuka et al. 1992; Raitta et al. 1978, 1981; Vanhoorne et al. 1996), it is not impossible that plastics manufacturing chemicals could do likewise in as far as affecting the nervous system.

The very fact that this could be shown, presumably, at a very early stage by deterioration of the colour vision function is a significant indicator indeed for any corrective or precautionary measures to be initiated. Subclinical it may well be, but acquired colour vision defects have unfailingly been shown before to signify serious underlying central and peripheral nervous system disorders (Foster 1991); the results of the present study suggest that polyethylene and polystyrene are capable of similar insults.

References


Hearing Loss in Walkman Users

Sofia Jaffer, Mohd Shakil Razi

Department of Audiology and Speech Sciences, Universiti Kebangsaan Malaysia

Abstract

This retrospective study was conducted at the audiology clinic of UKM in the year 2000. It was intended to detect the effect of walkman on the hearing system of its users and to investigate whether distortion product otoacoustic emission test can provide an early and reliable sign of cochlear damage or not. Distortion product otoacoustic emission test helps to determine the function of outer hair cell. Outer hair cells get damaged with exposure to loud sound, drugs and aging. Thirty subjects (20 in the study group and 10 in the control group), between the ages of 19-25 years, who fulfilled all the criteria of selection, were investigated. There were two sets of criteria (general and specific). Anyone, in the control or study group, failing in any of these criteria was excluded from the study. According to the general criteria, it was essential for all the subjects to have clean ear canals, normal hearing at all the frequencies (250Hz-8000Hz), normal middle ear function (Type A tympanogram), no middle ear problem, not used/using any ototoxic medicine, no family history of hearing loss, no history of ear surgery, not exposed to any form of loud noise like disco, concert, F1 racing or gun shooting. According to the special criteria it was essential for the subjects in the control group to have never used a walkman and those in the study group must have been using a walkman for at least 6 months.

Comparison of distortion product emission levels between control and study groups revealed that emissions were significantly lower in the study group, across all the frequencies, suggesting outer hair cell damage in the walkman users. These differences reached level of statistical significance (p<0.05) at 2, 4, 6 and 8kHz. Using walkman at an intensity unsafe for hearing and a duration longer than recommended is suspected for the outer hair cell damage in our study group. Those using walkman for longer duration and higher intensity manifested much lower emission levels. Our study supports the literature that distortion product emission test is a much sensitive test than pure-tone audiometry, as it can detect cochlear damage long before it appears in an audiogram. It is recommended that people who are exposed to loud noise regularly should be monitored with distortion product emission test. It is suggested that the use of walkman

Introduction

Our hearing system is facing the assault and bearing the consequence of the sound around us at all times (Table-1). It tends to manifest the effect of noise in the form of tinnitus with a bang and hearing loss, insidiously. The damaging effect of noise on our hearing (noise induced hearing loss) is not apparent during the early stages of exposure. Initially, the noise induced hearing loss may be temporary, with hearing being recovered some time after the noise exposure has stopped. But with repeated exposure to loud noise, hearing loss eventually becomes permanent. The hearing loss tends to start in the higher frequencies and spreads gradually with further exposure (Taylor et al., 1965).

Some of the noise we are exposed to (road traffic noise, noise at the construction sites, blowing horn of a car or noise of a bike without silencer), are unavoidable. There are many others (walkman, rock concerts, F1 racing, orchestra, disco music, and gun shooting etc.), we deliberately expose ourselves to without even thinking or realizing about their effect on our hearing system. The level of noise we are exposed to (Table 1) and NIOSH’s recommended exposure limit (Table 2) provides a clue about the damaging effects of noise on our hearing system.

Walkman is a popular gadget used by people during leisure time, exercise, reading, while at work, walking on the road or waiting for bus, taxi or a train. It is used by people of various age and of different background. It is
relatively more common amongst the teenagers and young adults for recreational and educational purposes. Regular walkman users use it to enjoy music, to block off background noise while studying or performing work or to drown out background noise.

<table>
<thead>
<tr>
<th>Noise Levels Around Us</th>
<th>dBA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Children’s toy weapons</td>
<td>153</td>
</tr>
<tr>
<td>Jet engine (near)</td>
<td>140</td>
</tr>
<tr>
<td>Shortgun, Jet take off (100-200 ft)</td>
<td>130</td>
</tr>
<tr>
<td>Firecrackers</td>
<td>125-156</td>
</tr>
<tr>
<td>Discotheque</td>
<td>120</td>
</tr>
<tr>
<td>Symphonic music peak</td>
<td>120-137</td>
</tr>
<tr>
<td>Rock music band</td>
<td>110-150</td>
</tr>
<tr>
<td>Power saw</td>
<td>110</td>
</tr>
<tr>
<td>Pneumatic drill</td>
<td>110</td>
</tr>
<tr>
<td>Garbage truck</td>
<td>100</td>
</tr>
<tr>
<td>Subway, Motorcycle, Lawnmower</td>
<td>90</td>
</tr>
<tr>
<td>Walkman, Portable cassette player</td>
<td>85-100</td>
</tr>
<tr>
<td>Telephone tone</td>
<td>85</td>
</tr>
<tr>
<td>Electric shaver</td>
<td>85</td>
</tr>
<tr>
<td>Industries / Factories</td>
<td>85</td>
</tr>
<tr>
<td>Flute</td>
<td>85-111</td>
</tr>
<tr>
<td>Violin</td>
<td>85-103</td>
</tr>
<tr>
<td>Average city traffic noise</td>
<td>85</td>
</tr>
<tr>
<td>Vacuum cleaner, Hair dryer, Inside car</td>
<td>70</td>
</tr>
<tr>
<td>Normal piano practice</td>
<td>70</td>
</tr>
<tr>
<td>Normal Conversation</td>
<td>60</td>
</tr>
</tbody>
</table>

Table 1: Noise Levels Around Us

<table>
<thead>
<tr>
<th>Noise Level (dBA)</th>
<th>Recommended Exposure Limit (REL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>85</td>
<td>40 hours per week*</td>
</tr>
<tr>
<td>88</td>
<td>20 hours per week</td>
</tr>
<tr>
<td>91</td>
<td>10 hours per week</td>
</tr>
<tr>
<td>94</td>
<td>05 hours per week</td>
</tr>
<tr>
<td>97</td>
<td>2½ hours per week</td>
</tr>
<tr>
<td>100</td>
<td>1½ hours per week</td>
</tr>
</tbody>
</table>

* week of 5 working days

In other words, exposure to 85 dBA for 40 hours/week is the same as being exposed to,

<table>
<thead>
<tr>
<th>Noise Level (dBA)</th>
<th>Recommended Exposure Limit (REL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>88 dBA for</td>
<td>20 hours per week</td>
</tr>
<tr>
<td>91 dBA for</td>
<td>10 hours per week</td>
</tr>
<tr>
<td>94 dBA for</td>
<td>05 hours per week</td>
</tr>
<tr>
<td>97 dBA for</td>
<td>2½ hours per week</td>
</tr>
<tr>
<td>100 dBA for</td>
<td>1½ hours per week</td>
</tr>
</tbody>
</table>

Table 2: NIOSH’s Recommended Exposure Limit (REL)

Ever since its introduction, people have debated whether or not walkman has any damaging effect on hearing or not? To some it is a prime suspect because it can deliver music at loudness levels hazardous to our hearing (Airo et al, 1996; Bradley et al, 1987; Rice et al, 1987). Others, Turunen et al, (1991, a,b); Hellstrom, (1991); Hellstrom and Axelsson, (1988) believe that it not the case as the length of time that a person listens to a walkman is shorter than the length of time workers are exposed to industrial noise, so the risk of acquiring a permanent hearing loss from walkman use is comparatively small. This argument may be true if people are using it at a level considered safe for hearing. Airo et al, (1996) believes that its prolonged use at higher sound levels is harmful to hearing because, the louder the sound the lesser time it takes for the damages to occur (OSHA, 1995).

In view of the controversy, it was felt that there is a need to further investigate the effect of walkman on the hearing of its users.

Methods

This study was carried out in the year 2000 at the Audiology clinic of UKM, Jalan Temerloh, Kuala Lumpur. Students between the ages of 19 and 25 years volunteered to participate in this study. Information about them was collected through an interview and a short questionnaire. Only those who passed all the criteria of selection were selected for this study.

There were two sets of criteria. Anyone, in the control or study group, failing in any of these criteria was excluded from the study. According to the general criteria, it was essential for all the subjects to have clean ear canals, normal hearing at all the frequencies (250Hz-8000Hz), normal middle ear function (Type A tympanogram), no middle ear problem, not used/using any ototoxic medicine, no family history of hearing loss, no history of ear surgery, not exposed to any form of loud noise like disco, concert, F1 racing or gun shooting. According to the special criteria it was essential for the subjects in the control group to have never used a walkman and those in the study group must have been using a walkman for at least 6 months. None of the subjects were smokers.
Medical history and history of noise exposure was obtained through a questionnaire and personal interview. Otoscopic examination was carried out to check the ear canal for wax, discharge, infection and tympanic membrane. Pure tone audiometry was carried out using Madsen diagnostic pure-tone audiometer and TDH-39 headphone. Tympanometry was carried out using GSI middle ear analyzer.

For distortion product otoacoustic emission test, following Bio-Logic equipments were used. Scout distortion product otoacoustic emission software, AuDX Scout Sport machine, connected to the software through a computer was used to deliver the stimuli and record the responses. Bio-Logic probe ear tips (Adult foam tips). Technical details: distortion product otoacoustic emission testing was carried out using the 750Hz-8000Hz diagnostic protocol. Analysis was made at 750Hz, 1kHz, 1.5kHz, 2kHz, 3kHz, 4kHz, 6kHz, and 8kHz. Pure-tone stimuli were presented at frequency f1 and f2. Intensity of stimulus, L1 and L2 was kept constant at 65 and 55dBSPL respectively. The f2/ f1 ratio was 1.2-1.3. Iso-f2/f1 Paradigm was used in this research. In this paradigm, f2/f1 ratio is kept constant (at 1.2) and f1 and f2 frequencies are varied in such a way as to produce well-spaced logarithmic frequency scale equal to the geometric mean of f1 and f2. The response collected from this paradigm is called “DP-Gram or DPE audiogram”. Response pattern of emission are expected to mirror the frequency configuration of the hearing seen in the pure-tone audiogram.

To determine the effect of intensity of sound on distortion product oto-acoustic emission, intensity level at which our walkman users would have been using their walkman was calculated on the basis of the reported findings on the following elements. Good speech to noise (S/N) ratio, noise reduction rating (NRR) of walkman headsets, intensity at different volumes, noise levels of sound around us, purpose of using walkman by the students, exchange rate and NIOSH’s recommended exposure limit (REL). Considering all the factors mentioned above, the possible intensity level at which our subjects were using their walkman was at least between 90-100 dB.

Based on NIOSH’s recommended exposure limit (REL), the safe exposure duration for walkman for those using it at 90 dB level would be around 10 hours per week or 90 minutes per day and for those using it at 100 dB would be 1º hours per week or 11 minutes per day. Most of the subjects involved in our study were using walkman for time longer than REL. These timings would change if we take 85 dB as the safe limit or alter the trading relationship from 5 dB to 3 dB or vice versa.

If the sound level of the walkman is constant over the entire period it is used, the daily noise dose D can be calculated by D = 100 C/T where C is the total length of time (in hours) walkman is being used in a day, and T is the permissible duration of exposure for the corresponding sound level (OSHA guidelines). As single-number compound descriptor “daily noise dose” incorporate a time-weighted average, therefore, it was used. In the case of daily noise dose, the time weighting is according to the 5 dB time/intensity trade dictated by OSHA regulation.

As a composite sound exposure descriptor, Lw (equivalent level) can also be used. Leq is a time-weighted energy average experienced over a given period of time as if the sound was unvarying. Calculation of Leq values is based on an equation derived from an integral calculus equation. 

\[ Leq = Li + 10 \log x \]

Where, Li is the level experienced for a period of time and xi is the proportion of time Li occurs with respect to total time. Unlike, daily noise dose, Leq uses 3 dB trading relationship.

To check the reliability of our test results, subjects were tested again after two weeks. Result was analyzed using independent t-test and Wilcox-Signed Ranked tests.

**Result**

The result is based on 30 subjects who fulfilled all the selection criteria. Twenty of them qualified for the study group and ten for control group. Sample consisted of 26 boys and 4 girls. The mean age of subjects in the control group was 22 years (SD = 1.7), and in the study group it was 21.5 years (SD = 1.8). The t-test showed no significant difference. All the cases had normal hearing (Figure 1) and type A tympanogram suggesting normal middle ear function. Use of walkman varied from 1-5 hours a day (between 6-30 hours a week). The daily noise dose was therefore between 12.5% (if walkman was used for one hour
Hearing Loss in Walkman Users

A day at 90 dB) and 300% if walkman was used for 6 hour a day at 100 dB). This means, increase in the intensity level and duration of walkman use exposes its users to more sound than is permissible. This therefore increases the risk of auditory damage.

Distortion product otoacoustic emission amplitude levels were measured as a function of frequency. Mean distortion product otoacoustic emission levels of control group were compared with walkman users to analyze the difference. DP-gram of the control group was used as reference data. The mean distortion product otoacoustic emission values obtained from the control and study group along with those using walkman for different length of time (Table 3).

<table>
<thead>
<tr>
<th>Frequency in Hz</th>
<th>Mean DPOAE Amplitude in Control Group</th>
<th>Mean DPOAE Amplitude in Study Group</th>
<th>Mean DPOAE Amplitude in Walkman Users</th>
</tr>
</thead>
<tbody>
<tr>
<td>750</td>
<td>11.0</td>
<td>3.5</td>
<td>9.0</td>
</tr>
<tr>
<td>1000</td>
<td>12.0</td>
<td>4.2</td>
<td>8.0</td>
</tr>
<tr>
<td>1500</td>
<td>9.0</td>
<td>3.1</td>
<td>6.0</td>
</tr>
<tr>
<td>2000</td>
<td>7.0</td>
<td>-1.0</td>
<td>7.0</td>
</tr>
<tr>
<td>3000</td>
<td>6.0</td>
<td>-0.9</td>
<td>1.0</td>
</tr>
<tr>
<td>4000</td>
<td>8.0</td>
<td>-1.4</td>
<td>4.0</td>
</tr>
<tr>
<td>6000</td>
<td>5.0</td>
<td>-7.2</td>
<td>3.3</td>
</tr>
<tr>
<td>8000</td>
<td>3.0</td>
<td>-9.5</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Figure 2 shows that the DPOAE amplitude in the control group is much robust than in the walkman users, at all the frequencies. They reached the level of statistical significance at and above 2kHz, (p<0.05). This finding suggests that the walkman noise has affected the cochlear hair cells of its users. This damage is however not manifested in pure tone audiogram, yet.

In Figure 3, comparison of the distortion product otoacoustic emission levels of control group and those using walkman for different length of time is presented together. It is clear that, no matter what the duration of use of walkman is, the DPOAE level in its users is low at all the frequencies.

Figure 4, displays the finding between the control group and those using walkman for approximately 6 hours. It is evident that distortion product otoacoustic emission is stronger in the control group than those using walkman for approximately 6 hours. These differences were statistically significant at 3kHz.

Figure 5, compares the finding between the control group and those using walkman for >12 hours/week. Distortion product otoacoustic emission is stronger in the control group than in the walkman users. The differences in emission levels are statistically significant at 4, 6 & 8kHz.

Figure 6. Those using walkman >12 hours/week manifest widespread cochlear damage (manifested by greater reduction in cochlear emission level). These differences in emission levels reached the level of statistical significance at 2, 4, 6 and 8kHz.
Discussion

Most of us do not realize that our daily activities, whether occupational or recreational, can be potentially hazardous to hearing. Exposure to loud noise can damage the hearing mechanisms in our ears. With a short-term exposure to noise such as an occasional rock concert, hearing will most likely to recover within a day. However, if it is a regular feature then there is a high likelihood that over time some permanent hearing loss will develop. Other recreational activities that can be potentially damaging to hearing include snowmobiles, motorcycles, firearms (i.e. target shooting or hunting) etc. Listening to stereos or Walkman-type radios at loud levels is also suspected to cause hearing problem.

In our study, we have tried to establish the effect of walkman use on the outer hair cells of cochlea. We noted that the amplitude of distortion product oto-acoustic emission of walkman users was worse than those who were not using it. This finding is in line with that of West and Evans (1990), that loss of or damage to the outer hair cells reduces or abolishes the oto-acoustic emission level. We consider our finding very important because in none of our cases this cochlear damage was manifested in their audiogram. As a matter of fact, all the subjects included in this study (both groups) had absolutely normal hearing. It is interesting to note that hearing threshold of subjects in the study group was worse than their counterparts. It is true that not all the frequencies have shown the same level of damaging effect. This must not come as a blessing because the overall picture is quite consistent. Similarly, it should not be a matter of consolation that the damaging level in cochlea did not reach the level of statistical significance. On the basis of our finding, we believe that the notion “all is well if the audiogram is normal” is misleading. What appeared to be the hallmark of noise induced hearing loss (acoustic notch at 4kHz) should now be considered to be an outdated parameter in the diagnosis of noise induced hearing loss. In the light of what we have observed, it is appropriate to suggest that if distortion product oto-acoustic emission results indicate cochlear damage in people exposed to noise, there is no justification to wait for the appearance of the acoustic notch.
Our finding is important in the sense that it can help the audiologists and hearing conservationists to take action to prevent the occurrence of hearing loss long before it starts showing up in audiogram. As far as the walkman users in our study are concerned, manifestation of hearing loss in their audiogram is a matter of time if they do not take preventive measures. Our distortion product otoacoustic emission finding should in fact serve as a warning to them.

To substantiate that the cochlear damage we noted was in fact due to walkman use. We looked at two important elements “intensity and duration of use of walkman”. Both these are directly related to the damage to our hearing (Table 2).

First, we calculated the expected intensity level of walkman, hypothetically. This calculation was based on the sound level necessary to maintain S/N ratio of +15, NRR of walkman headsets, intensity provided by walkman and noise levels of sounds around us. We did not take into account the type of walkman used because volume control and loudness level produced by different types of walkman is different.

In the calculation of the intensity level, the objective of use of walkman (enjoying music, block off background noise while studying or performing work and to drown out background noise of rush hour traffic noise etc.) was also taken into account. Research has shown that the traffic noise (noise at bus stands, train stations and other places) is usually between 80-85 dBA. The walkman users need a loudness level of 90-100 dB to drown out the background noise and enable them to enjoy music. This, to the walkman user, may appear to a “comfortable loudness level” but it is beyond the recommended safe level of 85 dB. This means that the hearing system of our subjects is at risk.

Secondly, we looked at the effect of the duration of exposure to 90-100 dB sound. Using NIOSH’s recommended exposure limit (Table 2) and the exchange rate mechanism (which states that for every 3 dB increase in noise exposure the damage doubles, Table 2), the safe exposure duration for our subjects was calculated. It was concluded that the safe exposure duration for those using walkman at 90 dB level would be 90 minutes per day and for those using it at 100 dB level it would be 11 minutes per day. Our subjects are using walkman for much longer time. This means that they are causing an unseen damage to the outer hair cells of cochlea.

Finally, calculation of the daily noise dose supports the above findings. Use of walkman varied from 1-5 hours a day (between 6-30 hours a week). The daily noise dose was therefore between 12.5% (if walkman was used for one hour a day at 90 dB) and 300% (if walkman was used for 6 hour a day at 100 dB). This means, increase in the duration of walkman use by a subject exposes him/her to more sound than is permissible. This therefore increases the risk of auditory damage.

On the basis of what has been explained above, we believe that the weak emission noted in walkman users is the reflection of cochlear damage occurring due to unsafe loudness level and longer duration of walkman use.

We noted that the cochlear hair cell damage is directly proportional to the duration of the use of walkman, i.e., greater the use greater the hair cell damage. It is also noticed that there is a specific pattern of cochlear hair cell damage, “cone shaped spread”, i.e., less damage for short duration of exposure and more for the longer duration and more damage at higher frequencies.

**Conclusion**

Walkman can cause hair cell damage in cochlea, which if continued unabated (if intensity level and duration of use is not reduced) may eventually give rise to hearing impairment in its users. Distortion product otoacoustic emission test can detect cochlear damage well before it appears in a pure tone audiogram. Test-retest result indicates that DPOAE test can be used in clinical practice with high degree of reliability.

**Caution**

Even though the findings of our study are revealing and extremely useful. It is important to mention that because of small sample size, caution must be exercised in interpreting our findings. Considering the importance of this study, it is essential that a large-scale study is conducted to substantiate our findings.
It is suggested that, distortion product otoacoustic emission finding should not be ignored just because pure tone audiometry results are normal. Normal audiogram with abnormal distortion product otoacoustic emission suggests that the outer hair cells are damaged. Steps must be taken to protect hearing before damaged hair cells start to die due to continuous exposure to high level of noise and audiogram starts showing hearing loss.

**Rule of Thumb**

If a person sitting or standing nearby can hear the sound emitting from your walkman: the sound is too loud. Should this happen, the volume must be lowered.

**Suggestion**

People exposed to loud sound should have their hearing checked regularly with distortion product otoacoustic emission test. Distortion product otoacoustic emission test is less time consuming and more efficient in detecting cochlear damage. It is recommended that the intensity of sound and duration of use of walkman must be reduced to the level safe for hearing system.

**References**


Neuropathy due to Organic Solvent Exposure: Three Cases Reported From Pahang, Malaysia

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\textsuperscript{d} Department of Occupational Safety and Health

Abstract

Exposure to organic solvent during work activities has been known to be associated with significant clinical conditions such as peripheral neuropathy and neurobehavioral changes. Three reported cases of peripheral neuropathy most likely due to exposure to chronic organic solvent were reported recently in Bentong Malaysia. These cases showed a compatible clinical history, occupational history, examination and neurological study that link with peripheral neuropathy due to organic solvent poisoning. Proper education and training with review of engineering control measures are among preventive and corrective measures recommended. More comprehensive study in order to establish significant causal-effect relationship as documented evidence is recommended.

Keywords: Organic solvent, occupational exposure, neurological studies, neuropathy

Introduction

Adverse effects from chronic exposure to organic solvent have been documented in many developed countries. Based on the epidemiological studies, it has clearly shown that there is a relationship between organic solvent exposure and clinical complications such as peripheral neuropathy, fatigability, irritability and memory impairment (Costa and Manzo, 1998). In Malaysia, however there is no scientific evidence reported so far.

This report documents clinical evidence suggestive of chronic organic solvent exposure and its effect on the nervous system.

Methods

Malaysia’s Department of Occupational Safety and Health (DOSH) as a regulatory body is responsible to conduct inspection and enforcement activities under the Occupational Safety and Health Act 1994 (OSHA 1994). A few cases of neurological impairment in a company located in Pahang were reported to the department. DOSH and National Institute of Occupational Safety and Health (NIOSH), Malaysia in collaboration with JICA (Japan International Co-operation Agency) project team, initiated a detail investigation. The investigation included walk through survey, workers interview, clinical assessment on the suspected cases. Based on the initial investigations, there were three cases that presented with neurological problems.
All the three cases were further examined clinically and sent to NIOSH for neurological studies. The tests included the following:

<table>
<thead>
<tr>
<th>Test</th>
<th>Instruments used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grip test</td>
<td>Tracker C.H.E (J Tech Medical Industries, US)</td>
</tr>
<tr>
<td>Pinch Test</td>
<td>Tracker C.H.E (J Tech Medical Industries, US)</td>
</tr>
<tr>
<td>Balance test</td>
<td>Balance Master (Neuro Com System, US)</td>
</tr>
<tr>
<td>Nerve Conduction Velocity</td>
<td>Neuropack Sigma (Nihon Kohden Japan)</td>
</tr>
<tr>
<td>Brainstem auditory potential</td>
<td>Neuropack Sigma (Nihon Kohden Japan)</td>
</tr>
</tbody>
</table>

The tests were carried out under strict procedures and expert supervision (Colin et al., 1996)

**Background of the company**

The company, situated in Pahang Malaysia was established in 1989 and currently one of the world’s largest PVC floor manufacturer. Organic solvents used in the work process include MEK, MIBK and Toluene, which are mainly used in the printing section.

**Results**

**Case 1:**

A 33 year old Malay man, who had been working with the company since 1990 complained that he had numbness and weakness of both hands for 6 months. The problem actually began in 1999 when he started having lethargy and reduced effort tolerance after being posted to coating section where he had to dip his hand into *Methyl Ethyl Ketone* (MEK) solution without using proper personal protective equipment. Later on, he was posted to printing section (July 2001) which used high quantity of MEK, *Methyl Isobutyl Ketone* (MIBK), cyclohexanone and toluene. Since then, he started feeling numbness and weakness of the extremities.

Apart from the above complaints he also suffered heavy headedness, headache, dizziness on standing up, difficulty in concentrating, fatigability, abnormal thirst and palpitation. The symptoms were worst during the working hours. He perceived that the severity of the symptoms were associated with the intensity of exposure to organic solvent or duration of working hours. The symptoms were reduced after he left printing work in December 2001.

Subjective symptoms reported during the work process when exposed to organic solvents include smell of solvents, eye irritation, nasopharyngeal irritation, headache, drunken feeling, sleepiness and edematous face.

Clinical examination revealed a non distinct pattern of sensory loss over the upper extremities. Main muscles bulk, power and tone were found to be normal. Reflexes were also normal.

Nerve conduction velocity test revealed a slow velocity of the sural nerve i.e 45 m/sec (49 -65 m/sec) and brainstem evoke potential test showed a lengthened right cochlear nucleus response.

**Case 2:**

A 23 year old Malay man, had been working for the company since 1995. He was posted to printing section since 1997 where he had exposure to main organic solvents used namely MEK, MIBK, cyclohexanone and toluene. He complained of having weakness of the right hand. The symptom was also associated lethargic and insomnia.

He admitted that he had been having health problems since 1997 which is 2 years after he started the job in printing section. At that time he complained of having numbness over the extremities (glove and stocking distribution). It became more severe during work-days and improved after he left the printing section in 1999. Other symptoms that he experienced was headache, feel dizzy on standing up, difficulty to concentrate, anxiety, occasional fainting spell and palpitation.

Previously, he was also involved in manual handling activity of lifting heavy object i.e 40 - 50 kg, 20 times a day (4 days a week).

Subjective symptoms during work when exposed to the organic solvent were smell of
solvents, eye irritation, nasopharyngeal irritation, face blushing, headache, dizziness, drunken feeling and sleepy.

Clinical examination revealed a reduced gripping power of all digits in the right hands. No sensory loss was noted and other examination revealed normal.

Neurological tests revealed abnormal findings on pinch test (right palmar), slow conductivity of median (sensory) and sural (sensory) nerves while brainstem evocation potential test showed altered latencies in certain standard waves for both left and right sides.

Summary of the case

All the three cases showed the following characteristics:
1. Common symptoms namely heavy headedness, headache, dizziness, paraesthesia in extremities, numbness in extremities, reduced muscular strength, feel dizzy on standing up and palpitation.
2. Occupational history indicating that they were involved heavily with organic solvents namely MEK, MIBK, cyclohexanone and toluene.
3. Subjective symptoms suggestive to the impairment function of central and peripheral nervous systems.
4. Clinical findings of peripheral neuropathy.
5. Lab neurological tests of abnormal nerve conduction velocity and brain evoked potential tests.
6. The symptoms were prominent during working days and less during holidays. The changes in symptoms were consistent with the degree of exposure to organic solvents.
7. No history of alcohol or any other drugs abuse.

Discussion

Based on the results of interview, clinical examination and neurological studies, the cases showed evidences suggestive of organic solvent poisoning due to occupational activities. With extensive reviews from clinical and occupational points of view, there is a possibility that neuropathies reported in these cases are occupational in origin. Effects of other occupational hazards other than organic solvents were excluded during interviews. Past medical history, hereditary factors, personal habits such as smoking, alcohol or any drug effects were also ruled out. The temporal relationship between the
symptoms and organic solvents exposure i.e. the onset starts after the exposure and the severity of the symptom change with the intensity of exposure supports the diagnosis.

Clinical and laboratory findings support the evidence and though it is not definite, it is suggestive that organic solvents would be the main cause in all the three cases reported with subjective symptoms of both central and peripheral nervous system.

Proper education and training with review of engineering control measures are among preventive and corrective measures suggested. More comprehensive study in order to establish significant causal-effect relationship as documented evidence is recommended.

References

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