HUMAN ERROR AND ACCIDENT AT WORK: A CASE STUDY IN LAEM CHABANG PORT

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Abstract: This study is a Participatory Action Research carried out in one company in Laem Chabang Port, Chonburi. The study is to reveal causal factors of accidents at work especially due to human errors, and to set up safety measures approved by the company. All studied population were 77 male-workers with an average age of 28 years. Fifty percent of the studied workers had work periods during 1 – 5 years, and 96% of sampled workers had been trained on work procedures and safety at work.

The results of the study were found that most of the workers, 57% of the studied workers, complained about musculoskeletal disorders, and 71.4% of those complaints were low back pain. Subsequently, peptic ulcer was found to be a health problem among 27.2% of the studied workers. Concerning health behaviors, 47.4% of the studied group had sleep problems, 37.7% were smokers, and 83.1% were alcohol drinkers.

According to accidents at work, 64% of the studied workers had experiences on accidents due to work, and among those experienced workers, 65.2% understood that causal factors were their unsafe acts. Moreover, 50% of the studied workers had accidents during night shift, and 39.1% were during morning shift. From the analysis of accident investigation reports in the company, 78.2% of all accident causes were human errors, i.e., not follow Safe Work Procedures of the company. However, the evaluation of workers’ vision by using a Vision Tester showed that 13% of sampled workers had visions not appropriate to their works.

After the study results were presented to key persons of the company, namely; Professional safety officer, Personnel manager and Supervisors, recommendations were discussed and approved as follows:

Recommendations for management level:

1. Review and improve safety policy in order to fit the present situation of the company. Ensure to announce it to all members.
2. Set up positive safety measures:
   - Give incentives to workers who never experience accident at work in 1 year. Progressive rewards should be considered in consecutive years.
   - Campaign for reduction of drugs, alcohol and tobacco uses. Technical supports should be found from Provincial Health Office, and Provincial Welfare and Labor Protection Office.
   - Annual Safety week activities should be specified to each group of workers, i.e., Shift work and sleep, Safety for drivers and crane controllers, Alcohol and safety/health impacts, Tobacco and related diseases, Prevention of low back pain, Vision and safety at work, etc.
   - Set up health promotion activities related to workers’ health: Physical exercise, Nutrition, Prevention of low back pain, etc. Safety behaviors should be expected.
   - Health surveillance and environmental monitoring should be implemented continually.
   - Safety inspection should be performed regularly.
   - Put the right job to the right man, i.e., crane controller with appropriate vision.
   - Shift work should be planned with workers. Ensure shift workers to understand about sleep deprivation and safety effects.
3. Set up enforcement measures:
   - Screening test of alcohol level in body prior to shift. Penalty should be considered.
   - Inspection of work practice whether workers follow their Safe Work Procedures should be done in order to prevent accidents.
   - Punishment of workers who do not follow safety rules, then announce to public.
Recommendations for workers:

1. Employee participation should be strengthened to suggest safety measures. Incentives should be considered.
2. Safety training should be resulted in improvement of knowledge, attitude and practice.
3. Capacity building among workers should be supported to gain their own healthy life styles, both in physical and mental health.
4. Annual health check should be performed to all workers. In cases of ITV drivers and crane controller, vision test should be performed every year.

1. INTRODUCTION

Human performance is cited as a causal factor in the majority of accident at work. If the accident rate is to be decreased, Human Factors issues must be better understood and Human Factors knowledge more broadly and proactively applied. The human element is the most flexible, adaptable and valuable part of the work system, but it is also the most vulnerable to influences which can adversely affect its performance. Throughout the years, some 3 out of 4 accidents have resulted from less than optimum human performance made by healthy and properly certified individuals. This has commonly been classified as human error. The sources of some of these errors may be traced to poor equipment or procedure design or to inadequate training or operating instructions (ICAO, 1998). Moreover, three of the many factors which may influence the well-being of operational personnel are fatigue, body rhythm disturbance and sleep deprivation. Other factors affecting physiological or psychological well-being include temperature, noise, humidity, light, vibration, workstation design and seat comfort.

The increasing significance of human error was identified by Hollnagel (cited in ICAO, 1998). In the 1960s, when the problem first began to attract serious attention, the estimated contribution of human error to accidents was around 20%. In the 1990s, this figure has increased four-fold to 80%. There are many possible reasons for this dramatic increase:

- The reliability of mechanical and electronic components has increased markedly over the past thirty years. People have stayed the same.
- Mechanical and electronic components have become more complex. This may have reduced the burden on operators, but it has placed a greater demand on maintenance technicians.
- Increase mechanical system complexity creates the potential for organizational accidents in which latent procedural and technical failures combine with operational personnel errors and violations.

Human error rather than technical failures has the greatest potential to adversely affect contemporary aviation safety. A major manufacture recently analyzed 220 documented accidents and found the top 3 causal factors to be:

- Flight crews not adhering to procedures (70/220)
- Maintenance and inspection errors (34/220)
- Design defects (33/220)

A comprehensive study of road safety (Treat et al., 1977) found that human error was the sole cause in 57% of all accidents and was a contributing factor in over 90%. In contrast, only 2.4% were due solely to mechanical fault and only 4.7% were caused only by environmental factors.

The use of drugs such as hypnotics, sedatives (including antihistamines) and tranquilizers to induce sleep is usually inappropriate, as they have an adverse effect on performance when taken in therapeutic doses for up to 36 hours after administration. Alcohol is a depressant of the nervous system. It has a soporific effect, but it disturbs normal sleep patterns and entails poor quality of sleep. The effects persist after it has disappeared from the blood (“hangover”). Ingestion of hypnotics in combination with alcohol can have bizarre consequences. Caffeine in coffee, tea and various soft drinks increases alertness and normally reduces reaction times, but it is also likely to disturb sleep. Then, it is clearly understood that human error is the main causal factor of accident and loss at work. Control of human error can substantially reduce accident rate and national economic loss.

In this study, human error and accident at work in container movement is in concern because of its high accident record. In addition, maritime Transport Expansion to accommodate the steady and rapid increase of Thailand’s international seaborne trade over the past decade and into the future, the Port Authority of Thailand is implementing several major projects, particularly the expansion of Laem Chabang Port, Thailand’s most important international port. Therefore, to study accident causes and to find preventive measures for container movement at the port in the maritime transport enterprise are considered necessary.
1.1 Objectives of the study
This study aims:
- To study main causal factors of human error and accident at work in Laem Chabang Port,
- To compare human errors and accidents at work between morning and night shift, and
- To recommend preventive and control measures for management level and workers.

2. METHODS

This study was designed as a Participatory Action Research with participations of managers, workers and professional safety officer in one factory of Laem Chabang Port.

2.1 Sampled population
There were approximately 500 workers in this factory. Sampled population was computed by using Epi Info program with 95% confidential level, using expected frequency = 4.06% and worst expected frequency = 8%, then sample size became 81 workers.

Purpose sampling was applied to identify volunteers who work in transportation section such as crane controllers, ITV (Internal Transfer Vehicle) drivers etc., and 77 volunteers were the sample size in the study.

2.2 Equipment /questionnaire
a) Titmus Vision Tester including Job Standard for Use with the Titmus Vision Tester and Titmus Vision Tester Record,
b) Digital Flicker Value Tester and CFF Form
c) Lux meter for illumination measurement
d) Questionnaire separated into 2 parts:
   - general information: health behavior, welfare, experience in accident, etc.
   - subjective feelings in safety at work, satisfaction at work, and stress/boredom.

2.3 Implementation
- Literature review,
- Coordination with professional safety officer and management level of the participated factory,
- Observational walk through survey in the factory,
- Planning for field investigation,
- Prepare equipment / questionnaire,
- Preliminary survey by Cross-sectional study:
  - Implementing health check, vision test, visual fatigue test by using CFF (Critical Flicker/Fusion Frequency);
  - Study work process in the port;
  - Working environmental survey: lighting condition;
  - Adjust study plan according to preliminary survey data:
    - Implement vision test before work in the first day of work week;
    - Visual fatigue measurement in the second day of work week (2 measurements: before work and 1 hour before finishing work);
  - Illumination measurement at surface area of work;
  - Data collection, data analysis and conclusion,
  - Meeting with relevant personnel in the factory and set practical recommendations.

2.4 Data analysis
Statistical Package for Social Science (SPSS) and Epi Info program were applied in the study. Descriptive statistics was explained by using Mean and Percentage.

Records of accidents at work of the factory were also analyzed in this study in order to find main cause of accident and its preventive measures.
3. RESULTS

3.1 Results of the preliminary survey

The results of the preliminary survey carried out in December 2003 among 39 workers showed that:

Population data:

All 39 workers were male with average age of 28.5 years, 76.9% of workers had work duration less than 5 years, 61.5% had working hours more than 48 hours/week, 51.3% had extended work hour longer than 15 hours, and 51.3% work as ITV drivers.

Working condition:

Almost all workers had to work with static muscular effort at their hands and arms. High concentration at work is necessary among crane operators and ITV drivers. ITV drivers had their back rest during driving while crane operators had to work without back rest because they had to gaze downward with back bent during operating crane. Vibration was generally transmitted through direct contact between the body and the vibrating seat. Vibration may impair visual acuity, interfere with neuromuscular control and lead to fatigue. The nature of outdoor work causes heat stress, fatigue and glare at work.

Work-related musculo-skeletal disorders:

The preliminary survey revealed that the prevalence rate of musculo-skeletal disorders were 69.2%. The most symptom was found to be Low Back Pain (84.6% of those complaints) followed by neck and knee pain.

Visual Test and visual fatigue measurement:

Visual fatigue was found in 3 workers (8.3%) who were night shift workers. Symptoms of visual fatigue were found to be less severe than symptoms of muscular pain. The result of visual test revealed 5 workers with substandard vision that was inappropriate at work.

Health status and health behavior:

Among all 39 workers, 30.7% had problems in peptic ulcer, 42.1% had experience in accident at work relating to container transportation. For health behavior, 51.3% were smokers, 76.9% were alcohol drinkers, 63.2% had regular physical exercise, 65.8% had normal body mass index (BMI), and 64.1% had satisfaction at work.

![Figure 1. Container movement from ship by crane where a crane operator had to move forwards and backwards inside a control room.](image-url)
Figure 2. Container movement by ITV (Internal Transfer Vehicle) in the left, and by RTG (Rubber Tyre Gantry) in the right.

Work process and health hazards

<table>
<thead>
<tr>
<th>Container movement from ship</th>
<th>Health hazards</th>
</tr>
</thead>
<tbody>
<tr>
<td>Containers in ship</td>
<td>- working posture: sitting with back bending for downward gaze</td>
</tr>
<tr>
<td>Port crane operation (to pick up containers from ship)</td>
<td>- forceful hand effort, continuous long duration with high concentration requirement (mental stress)</td>
</tr>
<tr>
<td>(figure 1)</td>
<td>- low illumination at containers in ship</td>
</tr>
<tr>
<td>Move container to ITV</td>
<td>- unsafe working condition</td>
</tr>
<tr>
<td>(figure 2)</td>
<td></td>
</tr>
<tr>
<td>ITV driving (to transfer containers)</td>
<td>- heat stress</td>
</tr>
<tr>
<td>(figure 2)</td>
<td>- driving accident</td>
</tr>
<tr>
<td>RTG crane operation (to pick up containers from ITV)</td>
<td>- long duration of work</td>
</tr>
<tr>
<td>(figure 2)</td>
<td></td>
</tr>
<tr>
<td>Pile up containers in stockyard (waiting for customers)</td>
<td>- working posture: sitting with back bending for downward gaze</td>
</tr>
<tr>
<td></td>
<td>- forceful hand effort, continuous long duration with high concentration requirement (mental stress)</td>
</tr>
<tr>
<td></td>
<td>- unsafe working condition</td>
</tr>
<tr>
<td></td>
<td>- vibration</td>
</tr>
</tbody>
</table>

Work process and health hazards of container movement into ship were the same.
3.2 Results of the study

3.2.1 Descriptive data of studied population
All 77 studied workers were male with average age of 28.2 years. Most workers (50%) had work duration for 1-5 years, 39.5% had work duration less than one year. Almost all volunteers (96.1%) had been trained on their jobs. About half (50.7%) were married and lived together, and 83.6% of all volunteers had enough time for their family. Most workers were ITV drivers (45.3%) followed by port crane operators (41.3%).

For health status, 57.1% of workers had musculoskeletal complaints, followed by peptic ulcer (27.2%). Sleep deprivation was found among 47.4%. Smokers were 37.7% of all volunteers. However, alcohol drinkers were found to be very high number in this factory (83.1%).

For accident at work, 64% of all volunteers had experience in accidents in which causes were understood to be their own practice errors. Fifty percent of volunteers had accidents at night shift work, while 39.1% at morning shift work.

For preference of working time, 56.8% preferred work at day time while 43.2% preferred night shift work because of higher compensation and privacy. Moreover, 70.1% of all volunteers responded that they always followed safety rules while working.

3.2.2 Analysis of accident record in the studied factory
The accidents recorded by the professional safety officer were analyzed for 3 year data (from 2002-2004). The accident data were classified by working time, types of work and causes of accident which were divided into working condition, machine fault, and human error. It was found that there were increasing number of accidents in this factory, namely 52, 60 and 108 times of accidents in the year 2002 to 2004, respectively. However, accidents were found most frequently in the morning shift. ITV drivers were the most frequent accident group compared to other type of work. The record showed the common cause of accidents (78.2% of all accident causes) to be human error, i.e., not follow Safe Work Procedures (SWP) of the company. Examples of the reported unsafe practice that not follow SWP were as follows:
- no inspection of ITV before container movement,
- vehicle park without hand brake that caused backward movement and crash,
- break the safety rule by driving backwards,
- work and drive with too high speed,
- crane movement without informing stevedore that caused shock or surprised and crash,
- no adjustment of sling before container movement that caused swing and fall.

The reported accident data were analyzed and shown in table 1.

3.2.3 Evaluation of musculoskeletal disorders (MSDs)
The highest frequency and the most severe of MSDs were found to be low back pain (71.4%), followed by neck pain (44.2%) upper back pain (28.6%) and shoulder pain (28.6%).

3.2.4 Evaluation of psychological aspect
Safety attitude at work, work satisfaction, and stress at work were evaluated and found that 90.3% of all volunteers had safety attitude at very good level, 47.9% had work satisfaction at high and medium levels, 29.2% had stress at work at high level while 68.1% had stress at medium level.

3.2.5 Vision test and evaluation of visual fatigue
Only 13% of the studied population had their vision capacity inappropriate for their work. Among those with inappropriate vision, 53.8% had problems in far vision. Far vision is necessary for those who drive vehicles and control cranes.

For visual fatigue, CFF was evaluated before and after work within one day (shown in figure 3) and found that 11.8% had the decrease in CFF value after work. The decrease in CFF value implies an occurrence of visual fatigue. Only two ITV drivers and four RTG operators were found to have visual fatigue at work.
Table 1. Number of accidents classified by working time, types of work and causes of accident in the studied factory (from 2002-2004).

<table>
<thead>
<tr>
<th>Year</th>
<th>Working time</th>
<th>Types of work</th>
<th>Causes of accident</th>
<th>Times</th>
<th>Human error</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Maintenance</td>
<td>Pickup &amp; Van</td>
<td>Forklift</td>
<td>ITV</td>
</tr>
<tr>
<td>2002 (52 times)</td>
<td>Morning</td>
<td>1</td>
<td>2</td>
<td>-</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Morn./OT</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Evening</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Even./OT</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>2003 (60 times)</td>
<td>Morning</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td></td>
<td>Morn./OT</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Evening</td>
<td>1</td>
<td>1</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Even./OT</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>7</td>
</tr>
<tr>
<td>2004 (108 times)</td>
<td>Morning</td>
<td>12</td>
<td>5</td>
<td>-</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Morn./OT</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Evening</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>16</td>
</tr>
<tr>
<td></td>
<td>Even./OT</td>
<td>-</td>
<td>2</td>
<td>-</td>
<td>9</td>
</tr>
</tbody>
</table>

Note: * +2 means including accidents of Stevedore, ** +1 means including accident of tally worker inside port.
ITV = Internal Transfer Vehicle, RSD/SL = Reach Stacker, Side Loader inside/outside port, RTG = Rubber Tyre Gantry
3.2.6 Measurement of Lighting

Illumination levels in a control room of the port crane both during day shift and night shift were measured in the study. A control room where an operator had to look downwards through its glass floor all the time during crane control was covered by glass wall in major area. Layout of the control room of the port crane marked with points of illumination measurement is shown in figure 4.

The results of lighting measurement at crane operator in 3 port cranes during night shift (9 - 11 P.M.) were found to be only 2 - 4 lux. It was remarked that there was a lamp in the control room, however, the operator did not turn on the light because it might cause lighting contrast between inside and outside the control room.

For the lighting measurement in the control rooms of 3 port cranes during day shift (10 - 12 A.M.), the illumination levels were found to be 420 - 1,317 lux at spots A, B, and C (in figure 4) as shown in table 2.
Table 2. Illumination levels in 3 control rooms of port cranes during day shift.

<table>
<thead>
<tr>
<th>Control room</th>
<th>Spot measurement</th>
<th>Illumination level (LUX)</th>
<th>Standard (LUX)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Crane forward to ship</td>
<td></td>
</tr>
<tr>
<td>1.Crane N0.3</td>
<td>A</td>
<td>870</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>680</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>725</td>
<td>300</td>
</tr>
<tr>
<td>at 11.10 A.M.</td>
<td></td>
<td>1,135</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,030</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>1,180</td>
<td></td>
</tr>
<tr>
<td>2.Crane N0.1</td>
<td>A</td>
<td>668</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>806</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>1,317</td>
<td>300</td>
</tr>
<tr>
<td>at 11.30 A.M.</td>
<td></td>
<td>636</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>704</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>931</td>
<td></td>
</tr>
<tr>
<td>3.Crane N0.2</td>
<td>A</td>
<td>619</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>420</td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>C</td>
<td>431</td>
<td>300</td>
</tr>
<tr>
<td>at 11.50 A.M.</td>
<td></td>
<td>688</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>515</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>617</td>
<td></td>
</tr>
</tbody>
</table>

4. CONCLUSION AND DISCUSSION

The studied workers were 77 males with average age of 28.5 years. Fifty percent of those workers had work duration from 1-5 years, and 39.5% had their work duration less than 1 year. Work duration of workers in this factory was found very short. However, 96.1% of all studied group had been trained on their job procedures.

Concerning health status, 57.1% of all studied workers had musculo-skeletal problems, 71.4% of those problems were low back pain followed by neck pain among 44.2%. The other health problems were found to be peptic ulcer among 27.2% of studied population and sleep deprivation among 47.4%.

For health behavior of the workers, 37.7% were smokers and 83.1% were alcohol drinkers. It was considered in the study that campaign for reduction of alcohol drinkers was necessary because “Hangover” might be one of accident causes at work. Hangover occurred 8-12 hours after alcohol drinking with symptoms of headache and dizziness. Since alcohol depresses central nervous system, visual impairment can occur and decision making capacity decreases that increase risk at work, especially crane or vehicle control work (Wadsworth Health Sciences, 1983).

Illumination level within the crane control rooms during night shift was found very low at 2-4 lux because the crane operator did not turn on the light inside in order not to make illumination contrast between inside and outside the control room as stated before. However, illumination level in the control rooms during day shift during the period of measurement was found between 420 – 1,317 lux that was considered very high. The illumination level depends mostly on the weather of each day because the control room was made of glass in most area. The aged workers were considered inappropriate for crane controller especially during night shift work because of the limitation of lighting condition for their visual work. The aged workers had limitation in working under too low and too high illumination levels compared to the young age.

The results of vision test showed that 13% of all volunteers had their visions inappropriate for their jobs. Among this group, 53.8% had problem on far vision that is necessary for container movement job. However, visual fatigue measurement by comparing CFF values, at before and after work, showed only 11.8% had their CFF values decreased meaning that fatigue occurred after work. Actually, there was a limitation in CFF measurement in this field study because workers could not have the CFF measurement immediately after work. This limitation possibly influenced the CFF test results in the study.

Preference of shift work was also interviewed in the study. Since there were only 2 shifts in a day: day shift and night shift, the workers had to work in extended work hours, i.e., 12 hours per day. Among the studied group, 56.8% preferred day shift while 43.2% preferred night shift. The reasons for night shift preference were higher compensation and more privacy.

Most accidents at work reported in this factory were property damages. Questionnaire survey in the study showed 64% of the studied group had experiences in accident at work. Among the experienced group, 65.2% answered that the causes of accident were their unsafe acts. Fifty percent of the studied group had accidents at night shift while 39.1% had accidents at day shift. The analysis of accident report of the studied
factory from the years 2002-2004 revealed that there were increasing number of accidents each year, i.e., 52, 60 and 108 times consecutively. The highest accident rate was among ITV drivers. The reported accident causes were human error identified that 78.2% all accident causes were not following Safe Work Procedures (SWP) of the company. The response of questionnaire survey concerning the causes of accident was in contrast to the accident report. The survey showed that 70.1% of all volunteers responded that they always followed safety rules while working. However, the workers understood that the accident causes were due to their own practice errors.

5. REFERENCES


