EMERGENCY RESPONSE / OPERATING PROCEDURE COMPETENCY AND EVALUATION OF HUMAN ERROR POTENTIAL AT THE CHEMICAL LOADING BAY OF A BULK CHEMICAL FACILITY IN WESTPORT, PORT KLANG

By

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Project Paper Submitted in Partial Fulfilment of the Requirements for the Degree of Master of Science (Emergency Response and Planning) in the Faculty of Engineering
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ABSTRACT

Abstract of Research Project submitted to the Faculty of Engineering, Universiti Putra Malaysia in partial fulfilment of the requirements for the Degree of Master of Science (Emergency Response and Planning)

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A questionnaire survey and passive observation was conducted at a bulk terminal facility in Westport, Port Klang. The survey was conducted using a questionnaire consisting 44 elements that make up five categories, to assess the knowledge, training and skills of the operators and contract drivers, and four questions to determine the level of emergency equipment at their respective workplace or tanker truck. The observation was based on a structured checklist of procedures using the facility's operation procedures as well as NFPA standards.

The objective of this study is to evaluate the competencies of the facility operators and contract drivers who are involved in loading operations at the tanker loading stand area. This activity had been rated as having the highest risk compared to all other activities in the bulk terminal facility. The study also intends to determine the error rates for each of the procedural step involved in this operation.

It was found that operators on the average have failed to meet the minimum baseline score in all the five categories, namely; (i) knowledge of emergency response plan, (ii) level of training, (iii) familiarity with the emergency equipment, (iv) familiarity with the loading procedures, and (v) ability to respond during an emergency.

Contract drivers have been able to meet the minimum requirements of the last three categories mentioned above. This could be due to contract drivers having almost twice the experience in years in this type of work compared to facility operators.

The emergency equipment level for both facility operators' workplace and drivers' tankers all fell below the baseline requirement.

Error rates during loading operations were also found to be quite high, especially errors involving parking and positioning of the tanker (24.5%) where many incidents of the tankers brushing or hitting the overhead hoses were recorded. Next in frequency is the failure to attach the earth clamp according to procedures (i.e. before commencement of product loading) where 18.9% error was recorded. High errors involving product spills over the tanker were also recorded (between 17% and 19%)

especially during nozzle insertion into and withdrawal from the compartment. The above situations are considered critical as they could lead to an accident involving fire and explosion.

Poor compliance in terms of wearing of goggles and appropriate breathing masks when required were also recorded. During loading of acid, operators and drivers have completely ignored the requirement to wear full PVC chemical suit as well as full visors/breathing masks.

There was no correlation found between drivers' competencies and their ability to carry out procedures correctly. Observations suggest that this is due to the lack of enforcement and the lack of proper attitude in appreciating the safety and health procedures that were in place.

It is recommended that adequate and regular briefing and training should be provided to operators, and where possible to contract drivers as well. The areas to cover include:

1) Site emergency response plan.
2) Appropriate use of personal protective equipment during loading operation.
3) The correct usage of emergency response and personal protective equipment during an emergency, such as fire or spill.
4) Familiarity with evacuation procedures and location of all emergency equipment.

The facility management should ensure strict enforcement of all loading procedures to reduce the present error rate recorded. The enforcement will need to be facilitated by adequate training and familiarity with the procedures and risk exposures present at the loading stand area.

ABSTRAK

Abstrak Projek Penyelidikan yang dikemukakan kepada Fakulti Kejuruteraan, Universiti Putra Malaysia sebagai memenuhi sebahagian daripada keperluan untuk mendapatkan Ijazah Master Sains (Perancangan dan Respon Kecemasan).

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Satu tinjauan borang soal-balas and 'passive observation' telah dilaksanakan di suatu terminal pukal kimia yang bertempat di Westport, Pelabuhan Kelang. Survei ini dilaksanakan dengan mengunakan borang soal-balas yang mengandungi 44 elemen dan dibahagikan kepada lima kategori bagi menilai tahap pengetahuan, latihan dan kecekapan operator-operator and pemandu-pemandu. Empat soalan lagi adalah bagi menentukan kelengkapan alat-alat kecemasan di tempat kerja and kenderaan pengangkut masing-masing. 'Observation' pula berdasarkan senarai langkah-langkah berstruktur yang mengikut langkah-langkah operasi terminal yang sedia ada and juga piawaian NFPA.

Tujuan kajian ini adalah untuk menilai tahap kecekapan operator yang bekerja di terminal menyimpan bahan kimia dan juga pemandu-pemandu kontrek yang terlibat dalam operasi mengisi bahan kimia di bahagian pengisian pengangkut. Jika dibandingkan dengan bahagian-bahagian yang lain di terminal ini, bahagian pengisian pengangkut mempunyai risiko yang tertinggi. Kajian ini juga bertujuan menentukan kadar salahlaku (ataupun 'error rate') bagi setiap langkah operasi pengisian ini.

Daripada hasil kajian ini, kami mendapati bahawa operator-operator terminal tidak mencapai tahap minima dalam kesemua lima kategori yang ditinjaui, iaitu (i) tahap pengetahuan pelan tindakan kecemasan, (ii) tahap latihan, (iii) kebiasaan dengan alat-alat kecemasan, (iv) kebiasaan dengan langkah-langkah pengisian, dan (v) kebolehan bertindak dengan betul semasa berlaku kecemasan.

Pemandu-pemandu kontrek pula didapati telah mencapai tahap minima dalam tiga kategori yang terakhir seperti di atas. Ini mungkin kerana secara puratanya pemandu-pemandu mempunyai hampir dua kali lebih lama pengalaman dalam menjalankan kerja seperti ini jika dibandingkan dengan operator.

Kelengkapan alat-alat kecemasan di kedua-dua tempat kerja operator ataupun kenderaan pengangkut masing-masing adalah tidak memuaskan dan jatuh di bawah tahap minima.

Kadar salahlaku semasa operasi pengisian juga didapati tinggi, terutama sekali jika salahlaku itu melibatkan pengendalian and meletak kenderaan pengangkut (24.5%) di tempat pengisian bahan kimia. Kebanyakan salahlaku-salahlaku yang tercatit melibatkan bahagian atas kenderaan yang mengeres atau menghentak hos yang tergantung. Yang berikutnya ialah sebanyak 18.9% pemandu-pemandu tidak mengepit 'earth clamp' mengikut langkah-langkah pengisian yang ditetapkan (iaitu sebelum memulakan pengisian bahan merbahaya). Kadar salahlaku yang tinggi, iaitu tumpahan bahan kimia keatas kenderaan pengangkut juga dicatit (daripada 17% hingga 19%) dan ini kebanyakannya melibatkan langkah memasukkan nozzle ke dalam tangki ataupun langkah mengeluarkan nozzle. Keadaan-keadaan yang dinyatakan di atas adalah kritikal kerana mereka mungkin boleh melibatkan kebakaran atau letupan.

Pematuhan kepada langkah pemakaian 'goggles' dan juga alat penafasan seperti yang dikehendakinya adalah tidak memuaskan. Semasa pengisian bahan asid, kami mendapati bahawa kesemua operator and pemandu tidak memakai 'full chemical suit' dan juga 'full visors/breathing masks'.

Kami mendapati bahawa tiada sebarang kaitan ataupun 'correlation' wujud di antara kecekapan pemandu-pemandu dengan kebolehan mereka menjalankan operasi pengisian dengan baik. Penjelasan yang kami boleh berikan adalah langkah-langkah keselamatan itu tidak dikuatkuasakan dengan baik dan juga 'attitude' yang lemah terhadap langkah-langkah keselamatan dan kesihatan yang telah ditetapkan.

Kami mengesyorkan bahawa taklimat and latihan yang cukup dan kerap perlu diberi kepada operator-operator, dan jika boleh kepada pemandu-pemandu kontrek juga. Ia perlu merangkumi tajuk-tajuk seperti yang berikut:

1) Pelan tindakan kecemasan tapak.
2) Cara pengunaan alat pelindung peribadi yand sesuai semasa melakukan operasi pengisian.
3) Pengunaan secara betul alat tindakan kecemasan dan alat pelindung peribadi semasa berlaku kecemasan, seperti yang melibatkan kebakaran ataupun tumpahan bahan kimia.
4) Memastikan kebiasaan dan pengetahuan yang cukup mengenai langkah beredar dari tapak semasa kecemasan dan juga lokasi alat-alat kecemasan.

Pihak pengurusan terminal juga perlu memastikan bahawa kesemua langkah-langkah keselamatan dan pengisian yang betul diikuti atau dikuatkuasai bagi mengurangkan kadar salahlaku yang kini tercatit. Latihan yang cukup serta pengetahuan yang lengkap mengenai langkah-langkah keselamatan dan risiko di bahagian pengisian bahan kimia ini adalah perlu supaya penguatkuasaan ini boleh dilaksanakan.

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LIST OF ABBREVIATIONS

APELL	Awareness and Preparedness for Emergencies at Local Level
APR	Air-Purifying Respirators
CIMAH	Control of Industrial Major Hazard Accidents
DOSH	Department of Occupational Safety and Health
HEP	Human Error Probability
HER	Human Error Rates
HRA	Human Risk Analysis
IchemE	Institution of Chemical Engineers (UK)
ICS	Incident Command System
IDLH	Immediately Dangerous to Life and Health
LBT	Liquid Bulk Terminal
MHI	Major Hazard Installation
MSDS	Material Safety Data Sheet
MT	Metric tons
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Act
PPE	Personal Protective Equipment
PVC	Polyvinyl chloride
QRA	Quantitative Risk Assessment
SAR	Supplied-Air Respirators
SCBA	Self-Contained Breathing Apparatus
SCDI	Serious Chemical Distribution Incident
SOP	Standard Operating Procedures
THERP	Technique for Human Error Rate Prediction
TLV	Threshold Limit Value
TWA	Time Weighted Average (8 hours)
UK	United Kingdom
UN	United Nations
VAM	Vinyl Acetate Monomer

CHAPTER 1

INTRODUCTION

1.1 Accident History

The Institute of Chemical Engineers (UK) has recorded many accidents involving loading operations at loading stands. One significant event occurred in April 1967 [1] in the United Kingdom where the plant supervisor switched over operations to the manual position without realizing that a number of other manual valves were locked in the open position. This error was committed despite the switching cabinet being boldly marked stating to the effect that manual valves had to be closed before operating the switches. The result was about 2 m^3 per minute of product flowing out of each valve that were still open, resulting in the loading stand being immediately engulfed by fire and the fire swept across the stand and towards other buildings. It was reported that a diesel vehicle being left in gear started up on its own, crossed the yard and ended up blazing near some aboveground product pipelines. The explosion and fire destroyed the loading stand and 19 road tankers, resulting in a loss estimated at £5,000,000 (in 1967). Three drivers were killed and 11 others were injured in this accident.

In another accident in February 1979 [2], for some unknown reason the loading arm came out of the compartment and motor spirit continued to be delivered over the vehicle and onto the ground. It was thought that the spirit came in contact with the

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[1] IchemE's (Institute of Chemical Engineers, United Kingdom) Accident Database, reference 9151.
[2] IchemE's (Institute of Chemical Engineers, United Kingdom) Accident Database, reference 10034.

vehicle exhaust pipe or caused the battery to short resulting in the fire.

There were also many other accidents at loading stands recorded, some of them involved:

- The mistake of loading product into the wrong product tank resulting in a chemical reaction [3];
- The release of product due to valve operating sequence error [4]; or
- The removal of face hood (personal protective equipment) resulting in face being splashed with product (phenol) [5];

In Malaysia, the most serious bulk storage chemical fire occurred in May 1980 [6] in the Shell Chemical Plant in Port Kelang where a severe explosion and fire on the marine vessel from which product was being unloaded spread onshore and involved several storage tanks and drums stored in the open. The accident killed three persons and injured about 200 people in the surrounding area. The latest accident involved another bulk petrochemical storage and refinery facility in Bintulu in 1998 [7] where fire and explosion involving several large storage tanks resulted in one of the most expensive insurance claims in the Malaysian insurance industry, said to be several hundred million ringgit.

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[3] IchemE's (Institute of Chemical Engineers, United Kingdom) Accident Database, reference 8743.
[4] IchemE's (Institute of Chemical Engineers, United Kingdom) Accident Database, reference 8071.
[5] IchemE's (Institute of Chemical Engineers, United Kingdom) Accident Database, reference 7560.
[6] APELL (Awareness and Preparedness for Emergencies at Local Level) list of selected accidents.
[7] Foong H.W. / Yong P. (personal communication), 2000.

1.2 Problem Statement

Looking at the above accidents, the common problem areas identified are that the procedures may be inadequate or the operators have failed to comply with the established procedures.

So far, on checking with the Department of Occupational Safety & Health (DOSH), Malaysia, there is no local standard regulating loading procedures at dangerous chemical bulking and loading installations. Although such bulking and handling facilities would certainly fall under the CIMAH Regulations 1996 [8] Major Hazard Installation category, requiring the mandatory preparation and submission of a "Report on Industrial Activity and Preparation of Emergency Plan" to DOSH, the department has not adopted any standard approach on such procedures.

As such, chemical bulk storage and handling facilities would have to adopt industry codes or standards such as NFPA 30, Chapter 5 (Operations) [9] and NFPA 385 [10], or procedures established and practiced by their principals. Chapter 5 of NFPA 30 outlines the requirements for liquid handling, transfer and use, including loading and unloading operations involving tank vehicles, and fire prevention and control requirements. NFPA 385 outlines the requirements for tank vehicle design (not emphasized in this project report) as well as operations involving tank vehicles. One of the areas of investigation would be to compare the loading procedures and safety

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[8] Occupational Safety and Health (Control of Industrial Major Accident Hazards) Regulations 1996.

[9] NFPA 30 – Flammable and Combustible Liquids Code, 1990 edition.

[10] NFPA 385 – Tank Vehicles for Flammable and Combustible Liquids, 1990 edition.

precautions at the bulk storage terminal facility with the requirements stipulated in the above reference standards for their compliance.

For the bulk storage terminal facility under study in this project, initial observations conducted at the loading stands have indicated that tanker drivers and operators may have violated some of the standard operating procedures [11] as well as committed such acts that may endanger the unloading operation. However, the extent of errors and types of errors committed is not known. There was no comparative data available from other similar facilities to relate the observations.

Two earlier reports from two consultants, Rayvonne (1996) [12] and Rimac (1999) [13], have both indicated that the highest risk present involves the loading operations at the loading stands of this facility.

Loading operations at loading stand are carried out by the facility's operators and external tanker drivers. The level of knowledge and training on the emergency procedures and loading operation procedures are not fully understood or known. Moreover, there is also no knowledge on whether the standard operating procedures have been executed correctly or whether what errors or unsafe acts have been committed and at what degree of regularity.

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11 Bulking facility's Operation Procedure Manual (Section 2)

12 Quantitative Risk Assessment Study of the Pulau Indah Terminal (Final Report) prepared for "facility" by Rayvonne Sdn Bhd, author Runny Poh, June 1996.

13 Risk Management Inspection Report for "facility" by Rimac Consultants Sdn Bhd, author K.K. Ng, 1999.

1.3 Background of bulk storage terminal facility being studied

The name of the bulk storage terminal facility being studied for this project has been withheld for reasons of sensitivity and to protect the interests of the company.

The company is a liquid bulk storage service facility handling various dangerous cargoes solely for third party clients. Clients unload their products from marine vessels that call at the terminal, store them in the tank farm provided by the facility until they dispatch their tanker trucks to pick up the product in the quantities they require.

The company is a joint venture between a local listed company and an international cargo transport and storage operator with operations in many parts of the world. The majority of the facility's design and operating and emergency procedures were a result of the foreign partner's input.

1.4 Objectives of this study

The objectives of this study is as follows:

1. Evaluate the competency of operators and contract drivers on their knowledge on:
   - Emergency response procedures and equipment
   - Operating procedures

2. Audit the workplace and tanker trucks on their emergency and personal protective equipment.

3. Assess operating procedures compliance at the tanker loading stand, hence developing a sample error rate for the loading activities.

4. Provide recommendations to the facility for improvement.

The investigations will focus on the tanker loading stand operations of the facility.

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