The importance of Training on Engineering Control of Hazardous Materials Using Pilot Plant

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ABSTRACT- This study illustrates how Jubail Technical Institute successfully integrated different empowerment training principles into the teaching methods and curriculum of an Industrial safety training program. The 8 months follow-up survey involved local industries respondents, each representing a separate plant site, a group of trainees, staff members and graduates of the chemical skills department. The evaluation shows that 93.3% of the teaching staff believe that the competency based training method is one of the best ways to help the technician in how to control risk using pilot plant, compared to other well-known training methods. 75% of the graduates confirmed that training using pilot plant is the best method of training in engineering control of the risks of chemical processes compared to theoretical training or training using models. 93% of the trainees emphasized that the training in engineering control of the risks of chemical processes at the institute and before graduation helps to understand the risk control processes. 20% of the industrial sector confirms that the costs of training in engineering risk control in petrochemical plants are higher than other risk control methods. The data substantially supported the importance of Training in Engineering Control of Hazardous Materials Using Pilot Plant.

Keywords: *Hazard, Engineering Control, Petrochemical, Pilot Plant, Research Survey.*

المستخلص *– توضح هذه الدراسة كيف نجح معهد الجبيل التقني في دمج وتكامل مبادئ التدريب المختلفة في أساليب التدريب ومناهج برنامج التدريب على السلامة الصناعية. وتم تنفيذ هذه الدراسة عبر استبيان شمل متابعة استمرت ثمانية أشهر وشاركت فيه عينة من القطاع الصناعي تمثل كبريات الشركات الصناعية، حيث يمثل كل منهم موقع مصنع منفصل، كما شاركت مجموعة من المتدربين وأعضاء هيئة التدريس وخريجي قسم المهارات الكيميائية في هذه الدراسة. يظهر التقييم أن 93.3٪ من أعضاء هيئة التدريس يعتقدون أن طريقة التدريب القائمة على الكفاءة هي واحدة من أفضل الطرق لمساعدة الفنيين في كيفية السيطرة على المخاطر باستخدام التدريب على مصنع مصغر، وذلك مقارنة بطرق التدريب المعروفة الأخرى. أيضاً أكد 75٪ من الخريجين أن التدريب باستخدام المصنع المصغر هو أفضل طريقة للتدريب في مجال التحكم الهندسي في مخاطر العمليات الكيميائية مقارنة بالتدريب النظري أو التدريب باستخدام النماذج. أكد 93٪ من المتدربين أن التدريب في مجال التحكم الهندسي على مخاطر العمليات الكيميائية في المعهد وقبل التخرج سوف يساعد على فهم عمليات التحكم في المخاطر. ولقد أكد 20٪ من القطاع الصناعي أن تكاليف التدريب على التحكم الهندسي في السيطرة على المخاطر في مصانع البتروكيماويات أعلى من أساليب التحكم الأخرى في المخاطر. ولقد دعمت البيانات بشكل كبير أهمية التدريب في مجال التحكم الهندسي للمواد الخطرة باستخدام المصنع المصغر.*

INTRODUCTION

Engineering control one of the hierarchy controls of hazardous materials. The process technicians are affected by hazardous materials which surround the petrochemical industries. However, lack of knowledge about the engineering control for the process technicians and poor knowledge of engineering control training cost the industries lot of time, money and raise the possibility of an accident.

The impact of engineering control is coming from the level of hierarchy control of hazardous materials which coming before the administrative control and the personal

protective equipment. Base of the collected data of surveys from industries in Jubail Industrial City, (JTI) faculty members and the graduates of process technicians [1].

Beside the data of the engineering control of the chemical skills Pilot Plant. The project contains a brief description of the engineering control in the Pilot Plant and the results of surveys from industries, faculty members and graduates, which will reflect the impact of the engineering control of hazards [2].

Physical hazard is any hazard comes from the environmental factors like the temperature and pressure. Industries need different types of controls of physical hazard to ensure safety. Engineering control is one of the most important administrative controls and the personal protective equipment. In other hand using the technology by allowing the devices to control the chemical process ensure the safety. Different types of engineering controls are there such as the available materials, technology and the required equipment [3]. Many forms of the engineering controls in the petrochemical industries, for instance interlocks, alarms and automatic showdown devices…etc.

Training of engineering control is so difficult due to the expensive equipment, materials and infrastructure needed. Process technicians use their knowledge and training as a weapon to perform their daily duties in petrochemical industries [4]. They also provide information about the needs of engineering controls, review and report any problem of the engineering controls. Practical training is the best way to transfer the knowledge concerning the engineering control of hazards.

A chemical process goes through various stages of evolution. These stages are called life cycle stages. The life cycle of a process begins with its initial concept, for example its discovery at the research stage. Then the process grows through stages of process development, design and construction, and matures with operations, maintenance, and modification. The process ends with decommissioning.

Much of the traditional approach to process safety is based on controlling the hazards associated with chemical processes and plants. This is done through improving procedures, installing additional safety interlocks and systems, and improving emergency response. Such control measures aim to reduce the risks [5].

The first step in risk assessment procedure is to identify the hazards. Until you know these hazards it is not possible for you to assess the risks. Process hazards come from two sources [6]:

(a) Hazards those are characteristic of the materials and chemistry used; and

(b) Hazards those are characteristic of the process variables and process plant.

Preventive or protective measures can be used to reduce the risks.

Traditionally these measures are classified into three types:

Passive; these minimize the hazard by process and equipment design features.

They reduce either the frequency or consequence of the hazard without the active functioning of any device. Examples include firewalls, orifice plates or narrow bore piping to control flow, etc.

Active; these use engineering controls, safety interlocks and emergency shutdown systems to detect process deviations and take appropriate corrective or remedial action.

Procedural; these use operating procedures, emergency response and other management approaches to prevent incidents or to minimize the effects of an incident.

MMTS 2014 Mechanical Maintenance Training Skid (Pilot Plants) [7]:

- Lubricating oil circuit (LUB OIL)
- Cooling water circuit (COOL WTR)
- Hydraulic oil circuit (HYD OIL)
- Compressed air supply (COMP AIR)
- Cooling tower circuit (COOL TOWER)

Background

The Impact of Training in Engineering Control of Hazardous Materials Using Pilot Plant is developed for industrial colleges and Institutes environment in which trainees are developing the skills necessary to function within the process industry whether as an operator, researcher or design engineer. Proper management, exercises, training and hazard

awareness are key parts of developing a safe and progressive learning environment [8].

A clear and logical progression of necessary skills are essential to the development of responsible and safe process operations personnel. The trainees should be challenged on a daily basis and a dynamic approach to learning should be exercised by the instructor. This study will stimulate ideas while highlighting time tested techniques and methods currently being used [9].

Scope

The operation of a pilot plant in Chemical Skills Department, Jubail Technical Institute provides a necessary scale up from the benchtop at an intermediate step before beginning full scale production at real plants. This Study has two interrelated goals. The long-term goal is for trainees to become and remain active participants in determining and improving the health and safety conditions under which they work [10].

The immediate training goal is to provide trainees with relevant tools, problem-solving skills, and the confidence needed to use those tools. The study fulfills its long-term goal only when the immediate goal is met. To this end, the program focuses on analyzing and solving problems. The program instructor's focus on where to look for answers as well as on how to use and interpret the information they discover [11].

Description of the Device

The training system MMTS is used for the maintenance of mechanical components as well as for the measurement, control and regulation of various parameters in a piping system with several media. In real applications, such systems can be found in power stations and in facilities for oil refining and natural gas processing. In contrast to industrial applications, the training system does not contain any actual engines or turbines. To simulate the heat input of these machines, a heater is used to heat lubricating oil. In the core process of the training system, the heat generated is dissipated via a heat exchanger and a cooling water circuit.

The main circuits and components are:

•The lubricating oil circuit with the lubricating oil

•The cooling water circuit with the cooling water

•The hydraulic oil circuit with the hydraulic oil

•The compressed air supply with 2 compressors

•The cooling tower circuit with the cooling tower

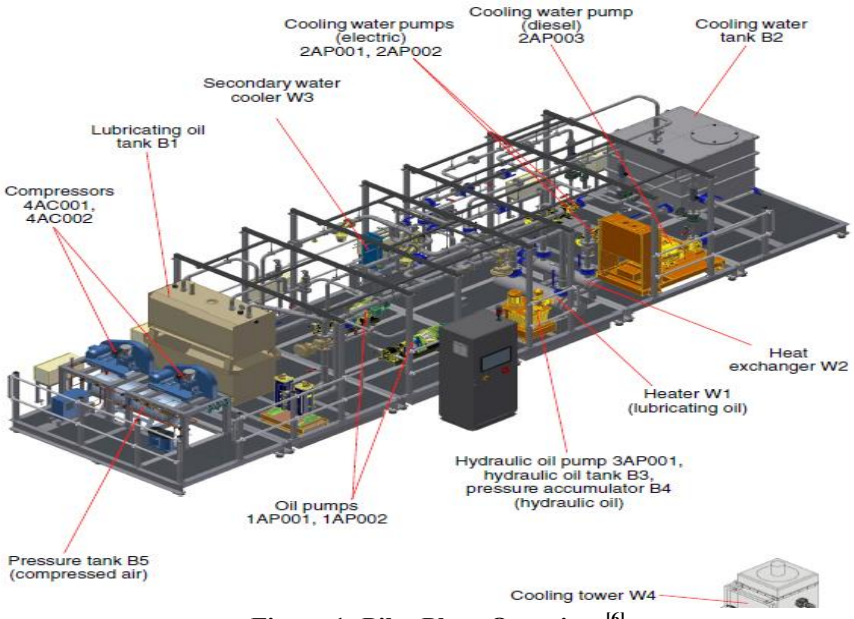

Figure 1: Pilot Plant Overview [6]

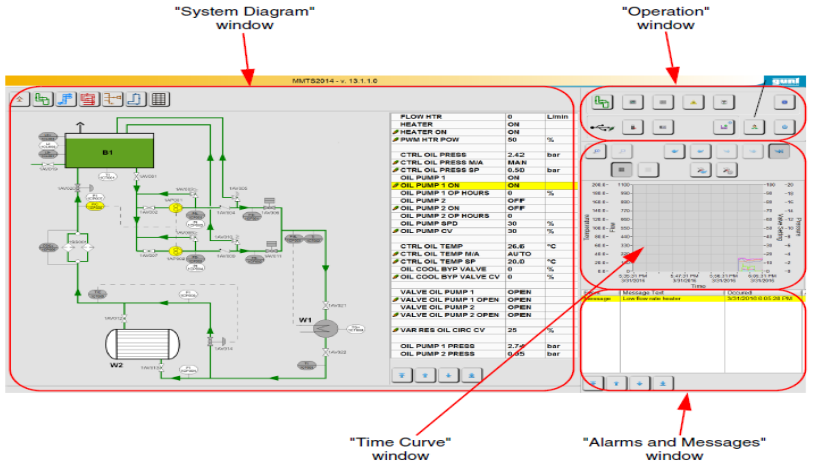

Figure 2: Interface of the Pilot Plant Software

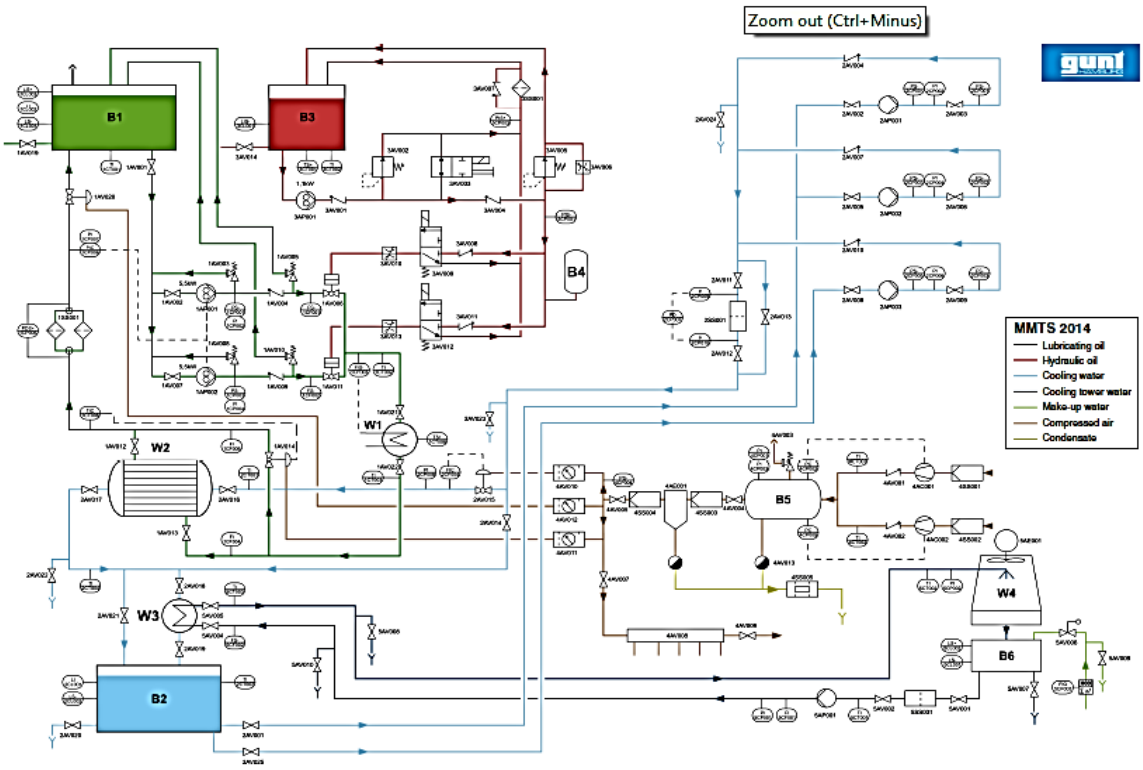

Figure 3: Schematic Diagram of the Pilot Plant

The Safety Devices Include

Safety devices in the piping (check valves, pressure limiting valves, temperature controllers, flow switches, etc.). A programmable logic controller (PLC) for closed loop control, open loop control and monitoring. Signal light and signal tone. 2 fire extinguishers. Various collecting trays for oils and fuels. The training system is operated by means of a touch screen in the control cabinet based on SCADA (Supervisory Control and Data Acquisition). Another software program that runs on a PC acquires measured values. Figure 1,2 and 3 provides an overview of the system. The cooling tower is set up in compliance with local regulations and connected to the system by piping [12].

Research Findings

This research is about the impact of training in engineering control of hazardous materials using

pilot plant which is carried out by conducting a survey about the importance of training by using a pilot plant for learning engineering control of risk which are present in chemical processes and operations in several plants. For this research all important segments were involved which have a direct or indirect connection with the chemical processes plants, and these are following:

Teaching Staff Survey working in the Chemical Skills Department of the Technical Institute

Graduates Survey studying in the Chemical Skills Department of the Technical Institute

Trainees' Survey involve in training in the Chemical Skills Department of the Technical Institute

Industrial Sector Survey from companies operating in the field of petrochemicals

The findings of this research are summarized here separately by discussing each survey report.

Teaching Staff Survey

Figure 4, shows that 96.7% of training staff members confirm that engineering control of risk using pilot plants is one of the risk control methods that reduce the risk of petrochemical plants.

93.3% of the training staff believe that the Competence Based Training is one of the best methods to help the technician in how to control the risks using the pilot plant.

83.3% of the training staff members believe that the use of pilot plant in training helps technicians understand the engineering risk control processes in petrochemical plants.

95% of training staff members confirm that the use of specific experiments in the training of engineering control of risk using pilot plant helps to transfer knowledge and skills to technicians.

93.3% of the training staff believe that technical expertise can be increased when graduating from the engineering risk control program using pilot plant as a training tool.

95% of staff members believe that there are a range of other sectors that can benefit from the training of technicians in engineering control of risk using pilot plants.

81.7% of the training staff members believe that most chemical plants rely on engineering control of risk in a way or other to mitigate and reduce risks in plants.

78.3% of the staff members believe that training in engineering control of risk using pilot-plants is highly adapted to technicians working in petrochemical plants.

90% of training staff members believe that the costs of training on engineering control of risk can be compensated by minimizing the occurrence of accidents and their potential consequences.

90% of the training staff believe that dealing with devices and equipment for engineering control of risk using pilot plants is an essential part of the technical tasks of the workers in the plants.

91.7% of the training staff members believe that technical training on engineering control of risk using pilot plant helps increase the chances of employing technicians in petrochemical plants.

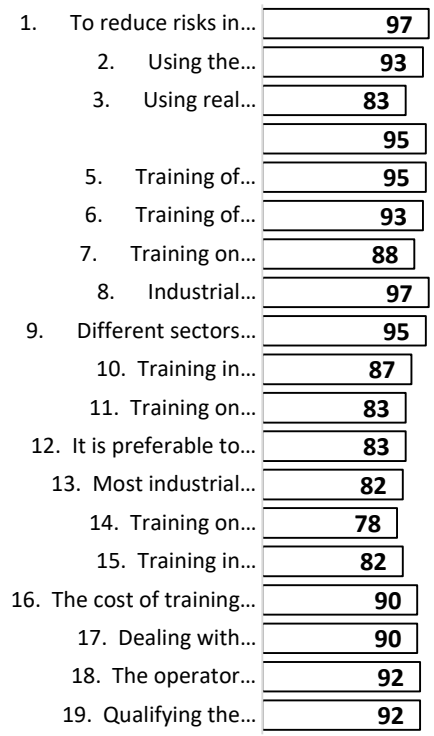

Figure 4: Satisfaction Rate of the staff

Graduates Survey

Figure 5, shows that 100% of the graduates confirmed that the warning devices help in the engineering control of the risks of chemical processes.

94% of the graduates emphasized that the training in engineering control of the risks of chemical processes helps to increase the understanding of the technicians of the industrial processes, increase the technical awareness of the integration of industrial processes in the petrochemical plants. Graduates also confirmed

that the professional performance of technicians improves by training in engineering control of the risks using pilot plant.

88% of the graduates confirmed that the training in engineering control of the risks in a chemical processes at the Institute, before graduation helps to understand the student of risk control operations, and that there is a great need for the technicians to train in risk control methods in the industrial processes because it helps to reduce the rate of accidents of technicians and their causes in operations in petrochemical plants.

75% of the graduates confirmed that training using pilot plant is the best method of training in engineering control of the risks of chemical processes compared to theoretical training or training using models, and that there is a need for training using pilot plant and cannot be satisfied with training in plants after graduation only.

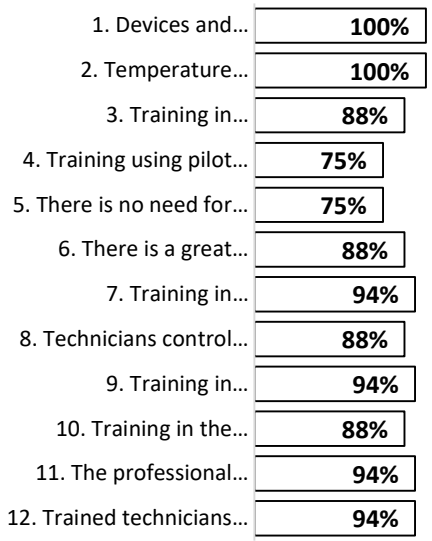

Figure 5: Satisfaction Rate of the alumni

Trainees Survey

Figure 6, shows that 97% of the trainees confirmed that the warning devices as one of the components of engineering control help control the risks of chemical processes.

96% of the trainees confirmed that the temperature measuring instruments on the control help to perform the chemical processes and engineering control of the risk of chemical processes.

93% of the trainees emphasized that the training in engineering control of the risks in chemical processes at the institute and before graduation helps to understand the risk control processes.

99% of the trainees emphasized that training using pilot plant is the best method of training in engineering control of the risks in chemical processes compared to theoretical training or training using models.

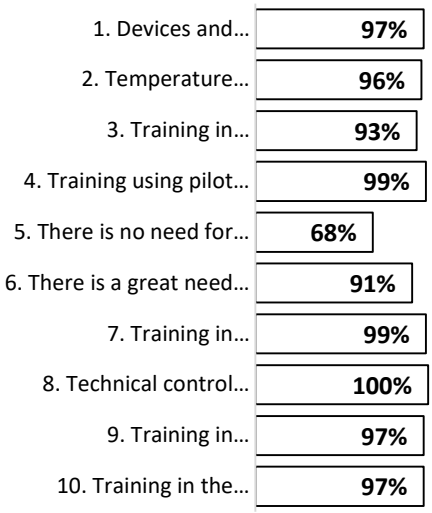

Figure 6: Satisfaction Rate of the students

91% of the trainees confirmed that there is a great need for technicians to train in the risk control methods in the industrial processes because of the great risks in the petrochemical plant work.

99% of the trainees emphasized that training in engineering control of the risks in chemical processes helps to increase the understanding of technicians of industrial processes during training.

97% of the trainees confirmed that training in engineering control of the risks in chemical processes helps to increase the technical awareness of the integration of industrial processes in petrochemical plants.

97% of the trainees confirmed that training in engineering control of the risks in chemical processes helps to reduce the percentage of accidents of technicians and their causes in chemical industrial processes in petrochemical plants.

Industrial Sector Survey

Figure 7, shows that 100% of the industrial sector confirms that the training of operators in the field of engineering control of risk is an important aspect of safety training in industrial processes, and training in the engineering control of risks in chemical processes helps to reduce accidents and their causes in industrial processes. The trained operators on engineering control of risk in chemical processes are better than untrained operators.

80% of the industrial sector confirms that petrochemical plants train operators on engineering control of risk through training courses in the same plants, but petrochemical plants also rely on specialized institutes in training operators on engineering control of risk by using pilot plants which helps improve the performance of plants operators.

60% of the industrial sector confirms that training in engineering control of risk using pilot plant is one of the best methods of safety training in industrial processes and that petrochemical plants prefer to employ qualified operators with better skills than others.

40% of the industrial sector confirms that training in the field of engineering control of risks in industrial processes is very important compared to other methods of risk control (management control, use of personal protective equipment, etc.), and that petrochemical plants focus on training operators on engineering control, and that petrochemical plants train operators to control risk in the same plants without the need for technical institutes.

20% of the industrial sector confirms that the costs of training in engineering control of risk in petrochemical plants are higher than other risk control methods.

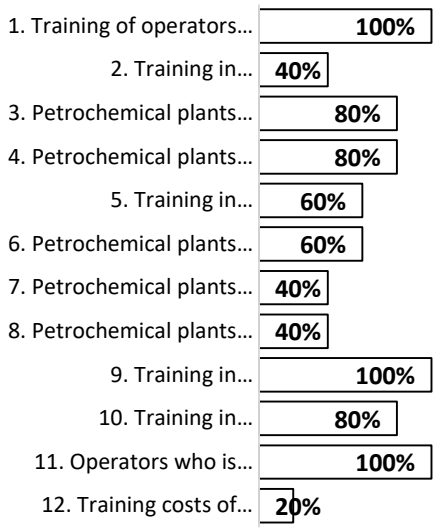

Figure 7: Satisfaction Rate of the industrial sector

CONCLUSION

The study concluded that the method of competence-based training is one of the best ways to help the technician in how to control the risks using pilot plant, compared to other well-known training methods. The use of pilot plant in training helps technicians understand risk engineering control processes in petrochemical plants.

The use of specific experiments in the training of engineering risk control using pilot plant in chemical plants greatly helps to transfer knowledge and skills to technicians. Training on pilot plant should be implemented during graduation and after graduation at technical institutes but not on the plant itself.

It will reduce the risk of accident, will increase skills for operators and technicians, it will produce technical personals with enhanced knowledge and skills, will improve safety during operation and will save a lot of cost. In the survey, similar results were obtained from all industrial personal, staff members, graduates and trainees that competency based training must be used and should be implemented in all areas of petrochemical industries.

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REFERENCES

[1] Barton JA and Nolan PF, (1989), 'Incidents in the chemical industry due to thermal runaway chemical reactions Hazards X: Process Safety in Fine and Speciality Chemical Plants', pp. 63 – 202 – 203, IChem Symposium Series, 115 3–18

[2] Health and Safety Executive, (2012) "Chemical reaction hazards and the risk of thermal runaway Leaflet INDG254 HSE Books, pp. 208.

[3] David J. Frurip Eli Freedman George R. Hertel, (1989) "A new release of the ASTM CHETAH program for hazard evaluation: Versions for mainframe and personal computer" Plant/operations progress, Apr, 8(2):100-104.

[4] Sanderson R. G., (2012) "Chemical bond and bond energy" Academic, pp. 224 - 225

[5] Benson S. W., (1976) "Thermochemical kinetics. Methods for the estimation of Thermochemical data and rate parameters," Second edition, Wiley-Interscience

[6] (1993)"Association of the British Pharmaceutical Industry "Guidelines for chemical reaction hazard evaluation", pp. 77 - 79 Publication ref: 428/89/6600W

[7] Barton JA and Rogers RL (1997), Chemical Reaction Hazards (Second edition) Gulf Professional Publishing, pp. 131 – 145 -194.

[8] Rebrin, O. I., Gugis, N. N., Kamenskij, S. A., Sholina, I. I., Zhilin, A. S. (2019), "Model of "Engineering Forces" for Training of Engineers", KnE Engineering. p304-309. 6p.

[9] Deutscher, Viola, Winther, (2018), "Instructional sensitivity in vocational education", Esther. In Learning and Instruction, 53:21-33.

[10] Paulus J, Joos S, Steinhäuser J, (2006), "A competence-based curriculum for vocational training in general practice in Germany: nearby or far away?" Medical Teacher [Med Teach], ISSN: 1466-187X, 2011; Vol. 33 (4), pp. 340-1; Publisher: Informa Healthcare; PMID: 21591294

[11] Eichhorst, Werner, Rodríguez-Planas, Núria, Schmidl, Ricarda; Zimmermann, Klaus F., "A Road Map to Vocational Education and Training in Industrialized Countries." ILR Review. Vol. 68 Issue 2, p314-337.

[12] Kellie, Deborah. (1999), "The Australian Way: competency-based training in the corporate sector.", International Journal of Training & Development, Vol. 3 Issue 2, p118. 14p.

[13] Zhao, Zhiqun; Rauner, Felix., (2014), "Areas of Vocational Education Research", Series: New Frontiers of Educational Research. Berlin: Springer.

[14] Fauquet-Alekhine, Philippe; Pehuet, Nane. (2016), "Simulation Training: Fundamentals and Applications: Improving Professional Practice Through Simulation Training", Cham: Springer.

[15] Silva de Oliveira, C.; Sanin, C.; Szczerbicki, (2019) "Visual Content Learning in a Cognitive Vision Platform for Hazard Control (CVP-HC)" E.. Cybernetics and Systems, 50(2):197-207

[16] Cook, W. A.., (2009), "Engineering control of occupational-disease hazard", Mechanical Engineering, Vol. 58, p105-108, 4p

[17] Burton DJ, "Engineering control. Using the NIOSH pocket guide to chemical hazards", Occupational Health & Safety, Apr2001; 70(4): 20-22. 2p. (Journal Article - case study, equations & formulas, glossary) ISSN: 0362-4064 PMID: 11326577.

[18] Dugué, Jacques, (2017), "Fired equipment safety in the oil & gas industry A review of changes in practices over the last 50 years", In INFUB - 11th European Conference on Industrial Furnaces and Boilers, INFUB-11, Energy Procedia. August, 120:2-19.

[19] Amaya-Gómez, Rafael; Dumar, Vivian; Sánchez-Silva, Mauricio; Romero, Rosa; Arbeláez, Clara; Muñoz, Felipe, (2019), "Process safety part of the engineering education DNA", In Education for Chemical Engineers. April 27:43-53

[20] Thomson, J. R., (2015), "High Integrity Systems and Safety Management in Hazardous Industries", Oxford: Butterworth-Heinemann.