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Human Error Contributions to Potential Incident in Laboratories at Institut Teknologi Nasional

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***Abstract*—Itenas has 43 laboratories with sufficient means and infrastructures for practice session. However, observation results showed unsafe conditions and near-miss or accidents often occurred. Practice session is a man-machine interface system, with practicioners often incapable or not qualified to operate the machinery or tools required. This research identifies contributing factors that triggers incidents in laboratory around Itenas. According investigation using Human Factor Analysis Classification System (HFACS), it is then identified that level 1 (organizational factors) plays big role on work incident. However, environmental factors contributes the most in the occurrence of unsafe act preceding to an incident. Therefore, a system is required to comprehensively manage safety and health around the precinct of the campus to minimize potential dangers presented by environmental factors.**

Keywords—safety, accident, unsafe acts, human error, human factor

I. INTRODUCTION

Institut Teknologi Nasional (Itenas) was established on 14th of December, 1972, currently operating 13 majors managed by 3 faculties (FTI, FTSP, dan FSRD). Itenas is located on a 52,954 m^2 area with 41,205m^2 building area. One of the mission of Itenas is 'To develop infrastructure and scientific- and technology-based management system to create conducive academic situation'. Therefore Itenas is equipped with various facilities to support learning process, including lecture rooms spread across 21 3-to-4-story buildings, 43 laboratories, and 14 studios spread across 13 majors.

Since 2003 Itenas received plenty of competition grant, both for the development of each majors as well as development of educations in various forms of academic activities. As a result, Itenas has managed to improve the quality of means and infrastructures supporting the educational process. The quality of means and infrastructures of laboratories and studios is referred to the development of necessities in learning process and technologies one wish to acquire. This condition caused a high mobility in the campus vicinity, day-in and day-out, be it indoor or outdoor activity. For example, mobilities in laboratory, interaction between practitioners/assistant/lecturer/technician with tools/machinery, even material, regardless of the goal for every activities in laboratory.

On Man-Machine Interface/ MMI, response and stimuli occurred between man and machine. Technology allowed MMI to become a very complex system where failure becomes a constant consequence from man-machine system. This condition can happen because of the condition of the system itself, be it institutional ignorance, conditions of machine, man, and environment. Failure can occur because of human error, errors in design of the machine, or even the system itself. An error is defined as a failure to achieve desired goal. Unsafe act often occurred during direct contacts with system, where this act is a mistake caused by lapses in action, triggered by conditions encouraging one to act in an unsafe manner. This condition is caused by unsafe supervision caused by terrible resource management influenced by the organization [1]. Unsafe act triggered by conditions are classified into 3 main categories, which are environmental factor, individual condition, and individual/resource management.

According to observations, there are unsafe conditions on several facilities available in Itenas. This caused near-miss or even incidents in the vicinity of Itenas, be it indoor or outdoor. For the time being, health and safety system in Itenas is still not managed comprehensively, and is still being revamped from time to time. There are still unmanaged areas and work systems necessary to support conducive environment in campus. This is indicated by near-misses and small incidents. However, in accordance to the attempt from Itenas to overhaul the health and safety management system, human factors as a contributing factor of incidents should be studied in a more detailed way.

This research is done to observe how much human contributes to a potential incidents, especially in laboratories around Itenas. Swiss Cheese model of human error is a special approach visualizing the relation of human error in between 4 levels in Swiss Cheese model [2]. This approach is used because in laboratories, all personnel involved did mental activity at a higher level than physical activity. This happened because most practicioners worked in laboratory for no more than 8 hours (with the exception for electric vehicle design studio). On several laboratories, activities are not directly practiced by practicioners.

II. METHOD

Human Factor Analysis Classification System (HFACS) is the universal frame from human errors used as a tool to investigate and analyze the cause of incidents caused by humans. In Model Reason (1990) failure or incidents from an unidentified factor and active incidents, HFACS is aimed towards human errors at every level in a system, including

aircrews during flights and other organizational factors [3]. This model was developed during a period of aircraft incidents

Reason concept in HFACS illustrated 4 levels of failure, which are: 1) Unsafe Acts, 2) Preconditions for Unsafe Acts, 3) Unsafe Supervision, and 4) Organizational Influences. Main components and causal categories starts from the level closest to the incident, which is an unsafe act. This is classified within two categories, errors and violation. By-and-large, error illustrates an individual mental or physical activity failed to achieve the main purpose. On the other side, violation usually refers to a deliberate disregard of rules regulating health and safety.

A. *Unsafe Acts*

Three types of basic error includes skill-based, decision, and perceptual error, while violation can occur as routine and exceptional error (Fig. 1). Lases caused by skill-based error happens on skill-based action, which includes attention or memory lapse. Decision error illustrates behaviour designated to fit the purpose, but in reality said behaviour is not suitable for the situation. Decision errors are grouped into 3 main categories: Procedural errors, poor choice, and problem-solving errors. Perceptual error is an unexpected error that happened because of discrepancies between what is perceived and what actually happened, caused by deteriorated or unfamiliar sensory inputs, visual illusion, and spatial disorientation. On violation, routine breach of rules tends to be habitual and often tolerated by governing agencies or regulatory authorities. Exceptional violations appeared as small breach, usually exempted from sanctions by authorities, and does not have to show patterns of individual behaviour or toleration from managements. [3].

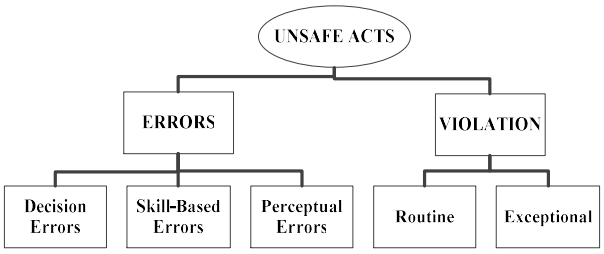

Fig. 1. Kategori unsafe acts

B. *Precondition for Unsafe Acts*

Precondition for unsafe acts needs to be analysed further to understand how unsafe acts occurred. There are several preconditions that needs to be studied, which are environmental factors, substandard operator conditions, and substandard practices (Fig. 2). Operator conditions can be analysed from 3 conditions: Adverse mental status, where it really affects how operators taking decisions. Mental condition is related to how human processes information and responds to stimuli received by the brain, mental fatigue, and loss of motivation. Adverse physiological condition is a decline of physical condition, caused by fatigue or illness. Physical or mental limitation can be observed through reaction time of visual, physical, and intelligence abilities. Substandard practices can be observed from crew resource management and personnel readiness [3].

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Fig. 2. Kategori precondition of unsafe acts

C. *Unsafe Supervision*

A chain of events related as to how supervision is executed. 4 categories of unsafe supervision is identied as inadequate supervision, planned inappropriate operations, failure to correct and solve problems, and violations during supervision (Fig. 3)[3].

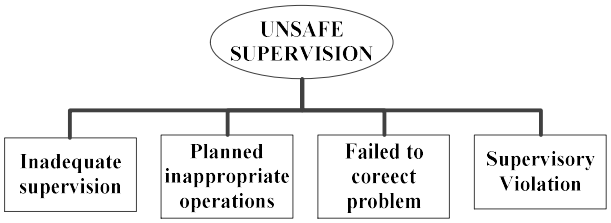

Fig. 3. Kategori unsafe supervision

D. *Organizational Influence*

Wrong decisions from upper-echelon managements can directly affect the supervisory practice as well as operator conditions and actions. Organizational influence are often neglected. In general, latent failure that is hard to comprehend is related to resource management, organizational climate, and organizational process (fig. 4) [3].

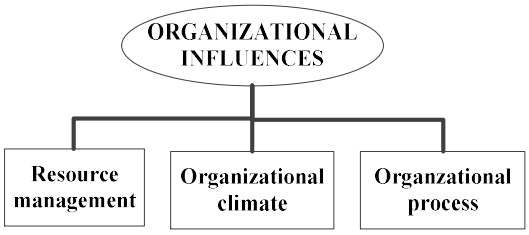

Fig. 4. Organizational factor influencing accidents

III. RESULT AND DISCUSSION

Results from observation and identifications of potential hazards around the vicinity of Itenas, on several laboratories, classes and facilities, showed that electrical and ergonomical hazard posed the highest risk. This potential hazard is usually found around most of the laboratories. The result of identification showed that most potential failure mode has its cause of failure rooted from human errors (practitioners/assistant/technician/researcher). In general, every laboratories already have general rules and regulations during the practice, along with the application of health and safety management with socialization about the importance of health and safety, personal protective equipment, as well as signs of warning in laboratories.

A. *Unsafe acts*

- Error
  a. Skill-based error: errors caused by the skill of practitioners.
     - Mistakes during operating machineries
     - Failure to put on PPE (gloves, goggles, earplugs), Improper application of PPE (masks, goggles, working suit, untied hairs, etc)

- Mis-steps on procedures
- Failure to lock machine guards
- Improper locking of item clamps
- Wrong machine set-ups

b. Decision error
- Failure to rectify and solve problems

c. Perceptual error
- Improper handling of lathe and knife
- Improper processing/handling/housekeeping
- Handling rotating devices during operation

- Violation
Routine
- Disorganized tools and items
- Insufficient housekeeping activities

B. Precondition Unsafe Act

- Environmental factors
- Unsuitable lighting
- Increasingly high temperature around furnaces, stoves and welding
- Welding fume
- Dusts
- Inergonomical design of workstation
- Disorganized wiring
- Inergonomical work posture, both on sitting pose and standing pose

- Conditions of operators

a. Adverse mental states
- Mental fatigue perpetuated by academic activities as well as EV projects
- Workload during practice

b. Adverse physiological states
- Physical fatigue caused by academic activities and EV projects
- Poor time management

c. Physical/mental limitations
- Physical limitation for overtime work on EV projects

C. Supervisory Factors

- Inadequate supervision
- Lack of supervision from assistant as well as the head of the laboratory for health and safety practices around the vicinity of the laboratory

- Failed Correct Problem
- Running practice sessions despite persistent potential hazards still occurring

D. Organizational Factors

- Resource management
- No job description made about health and safety in laboratories
- No comprehensive maintenance managements for machineries and tools as well as facilities
- No continuing development of lab coordinators, technicians, and assistants in regards to the health and safety management

- Organizational climate
- No apparent policies regarding health and safety around campus
- No safety culture habituation around the campus

- Organizational Process
- No comprehensive management of health and safety around campus
- Too few standard operating procedures and work instructions for practice sessions
- No unit specifically tasked with the management of health and safety
- No programs related with the integrated improvement of health and safety

Based from the aforementioned studies, it can be concluded that the categories of potential cause of HFACS around Itenas are:

- Unsafe act: Error and Violation
- Precondition unsafe act: environmental factors
- Supervisory factor: inadequate supervision
- Organizational Factors: resource management, organizational climate, and organizational process.

Itenas does not have a system that comprehensively manage health and safety. Therefore, data and records about the occurrence of near-miss and incidents are non-existent. However, based the result of the identification of potential hazard in laboratories and facilities, it is found that latent danger exists in the form of potential hazards.

In reference to the aforementioned investigation on potential hazards, the high risk potentials can be categorised as error influences on HFACS level for some causes of incidents with higher quality (9). Highest number shows high levels of influence causing the incident

In general, the most influential levels for incident in laboratories around Itenas are on level I (Organizational factors). However, environmental factors played the biggest role in causing incidents.

The lack of safety culture and policies regarding health and safety around campus indicated the lack of commitment to construct a conducive environment. Incomprehensive management of health and safety results in the abandonment of supportive programs for conducive environment around the campus, one of them including the management of physical environment in laboratories around the campus.

Physical environments are one example of physical stressor [4]. In stress assessment process, cognitive and perceptual capabilities are required to determine the stress level as well as developing the capability of managing stressors (inoculation stress), triggering chains of response from the body with negative consequences. These consequences can take shape as psychological, physiological, and behavioural consequences.

Stress is an internal reaction, identified by basic mechanism of how stress happened inside the body of a person [5]. Physiological response towards stress is divided into 3 phase: Alarm phase, resistant phase, and fatigue phase [4][5]. During fatigue phase, overall defense declined both physically and mentally, including (but not exclusive) emotional fatigue and change of perception [4] which can reduce work performance.

One factor causing human errors are fatigue, likely due to an unsafe act and performance [6]. Fatigue is a contributing factors for accidents, injuries, and death in many situation. This implied that person with fatigue are likely to perform an unsafe act

The complexity of man-machine interaction further showed how complex human role is as an operator. In this role, human is expected to have cognitive capabilities to solve problems, analyse and detect errors and lapses, as well as coming up with a solution. Man-machine interaction is based from our thought as human as an information processing system. This condition is related with mental process such as perception, memory, instinct, and motoric response caused by the influence of human interaction as well as other elements in the system. Therefore, during mental fatigue, the process of memory retrieval perception, reasoning and motoric response slows down, and can even cause errors in decision making (human error). This can play huge role in causing accidents.

IV. CONCLUSION

Itenas really have to construct a more comprehensive management system for health and safety. Starting from making policies regarding health and safety to develop a conducive academic situation in accordance to the mission of Itenas. Based from these policies, a program suitable to tackle the problems – minimizing potential hazards – can thus be established. In this way, physical environments in laboratories and studios all around Itenas will support a comfortable and safe working situation, minimizing potential human errors that can have adverse effect on safety, even causing accidents.

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