

The Challenges in Managing Biorisk in National Health Research Laboratory from Facility Engineering Perspective

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ABSTRACT

Biorisk or known as Biosafety and Biosecurity is an activity to promote safety and security when handling dangerous biological agents (pathogen). The application of biorisk management and fulfillment of qualifications for laboratory building facilities according to the standards becomes a necessity. National Institute of Health Research and Development, Ministry of Health of Indonesia constructed Biosafety laboratory level 2 and biosafety laboratory level 3 buildings in 2007. Meanwhile at the time of the construction of the laboratory, the reference and guideline for building a laboratory was limited also regulation were not yet available. Objective: We presented various challenges in conducting biorisk management through facilities engineering in health research laboratories National Institute of Health Research and Development, Ministry of Health of Indonesia. Method: We used descriptive method to present engineering maintenance practice and experience by looking at the gaps between biosafety and biosecurity standard with the availability of resources in laboratory facilities engineering perspective. Result: The challenge in engineering practice presented in BSL-2 and BSL-3 was the pathogen containment, which include building ventilation system, mechanical-electrical system and other engineering based on experience in managing National Health Research Laboratory. Another engineering issue that found quite difficult was managing the presence of condensation and airflow system in order to prevent cross contamination. In conclusion that planning and risk assessment is essential part when constructed a laboratory and the national guidelines for the construction of biosafety laboratories need to be made in Indonesia.

Keywords: *biorisk management, pathogen containment, laboratory facility engineering, biosafety laboratory*

1. INTRODUCTION

Biorisk or known as Biosafety and Biosecurity is an activity to promote safety and security when handling dangerous biological agents (pathogen). With the rapid increase of knowledge in biomedical expertise and technology [1][2], the application of biorisk management in the health research laboratory must be applied in accordance with examinations and research carried out in the lab to prevent the release of dangerous agents into the environment either intentionally or unintentionally. In facing those possible threats, the application of biorisk management and fulfillment of qualifications for laboratory building facilities according to the standards becomes a necessity. The principle of laboratory design according to Association of Public Health Laboratories (APHL) contains the following design: risk base design decision, international best practice, laboratory design fundamental, Biosafety and Biosecurity [3].

Biosafety and biosecurity began to be known and applied to The Laboratories of National Institute of Health Research and Development (NIHRD), Ministry of Health of Indonesia since the emergence of bird flu outbreaks in 2005 followed by the construction of biosafety laboratory level 2 (BSL-2) and biosafety laboratory level 3 (BSL-3) named Infectious Disease Research Laboratory Prof Dr. dr. Sri Oemiyati in 2007 and it soft opening was held on 2010 by Ministry of Health. The NIHRD laboratory was authorized by Ministry of Health Decree no. 658/2009 as the National referral laboratory to perform laboratory diagnosis for emerging infectious disease (EID), such as Avian Influenza (H5N1), H7N9, MERS-CoV, Ebola Virus Diseases (EVD) [4]. The building was also planned as a research laboratory under biosafety level 2 (BSL-2) and biosafety level 3 (BSL-3) to work with such pathogen in biotechnology field. The biological risk and laboratory acquired infections that can occur in this laboratory can be reduced and controlled by the correct application of proper microbiological techniques, proper containment apparatus, adequate facilities, protective barriers, special training and education of laboratory workers. The NIHRD laboratory was built using the WHO Biosafety and Biosecurity guideline as

reference [5]. However, over the time, still has a number of technical issues that need to be fixed so that it can function properly as a laboratory that can protect staff, the population, and the environment, which may be exposed to hazardous pathogen or it release from laboratory to environment intentionally [6].

2. METHOD

We used descriptive analysis to present engineering practice and experience by looking at the gaps between Biorisk standard with the facility engineering of the laboratory building. The Data were collected using WHO checklist from Biosafety Manual 3rd edition, and from in-depth interviews of four laboratory technical engineers including one head of laboratory Engineer, two electrical and Mechanical Engineers and one Laboratory Equipment Engineer in 2019.

3. RESULTS AND DISCUSSION

The health research laboratories have specification because of the use of biology agents that may be harmful to human health. The need for safety must be prioritized, not only when the laboratory workers conduct specimen handling, but also the facilities that are able to safeguard these harmful biological agents from released into the environment. A laboratory was built based on risk assessment of the work carried out in the laboratory [5]. Therefore, according to examination activities carried out in the NIHRD laboratory, the laboratory must follow the BSL-2 and BSL-3 standards which at the time of construction was using WHO Guidelines [5]. The gaps in the facility and the engineering controls refers to WHO Biosafety Manual Checklist for BSL-2 and BSL-3 prior to facility only (Table 1).

The results from the checklist standard showed that the NIHRD Laboratory building was mostly in conformity with the WHO guidelines for BSL-2. Meanwhile, the BSL-3 meets all of the standard. Furthermore, the BSL-3 was periodically certified by international certifiers.

Room ultraviolet light on interlock switch was not available in the NIHRD Laboratory because the method of decontamination of the rooms using chemicals for the effectiveness of inactivation and safety. Meanwhile, the portable space heater was not needed and simply not common in tropical country. The negative airflow in and from laboratory room to general room in BSL-2 was become another challenges that need to be address, in order to comply with the WHO biosafety manual standard which desirable inward airflow and controlled ventilating system for BSL-2. Since the work of research in NIHRD laboratory is using pathogen and the BSL-2 ventilation system was consider not comply with the standard, the way out to comply with the standard was to use biosafety cabinet (BSC) class 2 when handling the pathogen with strict procedures. Furthermore, the infectious and non-infectious rooms were separated to minimize contamination.

3.1 Laboratory Ventilation

Air ventilation system is very crucial in the construction of a health research laboratory building. The higher the level

We presented various challenges in conducting biorisk management through facilities engineering, the gaps with biorisk standard, technical issue and how to overcome them in accordance with the availability of resources in health research laboratories National Institute of Health Research and Development, Ministry of Health of Indonesia.

of safety, the more complex the air ventilation system and must be airtightness with negative pressure. The standards for ventilation system in each biosafety laboratory level are different and clearly stated for high level containment. On the contrary to BSL-2, there is still controversy on air ventilation system. According to BMBL 5th edition, the laboratory ventilation for BSL-2 did not have any specific requirement. However, it should consider to have mechanical ventilation system that provide inward flow of air without recirculation to space outside of the laboratory [7]. Meanwhile, the WHO manual mentions for desirable inward airflow and controlled ventilating system for BSL-2. Furthermore, in the implementing laboratory such as University of South Carolina, it has its own guidelines in order to translate existing standard into implementation of engineering control. The guidelines clearly said that Laboratory High Ventilation Air Conditioned (HVAC) systems should utilize 100 percent outdoor air, conditioned by central station air handling systems to offset exhaust air requirements.[8] The laboratory supply air should not be re-circulated or reused for other ventilation needs and should have directional airflow from the less contamination area to high contamination area whether it using natural ventilation or mechanical ventilation.[9]

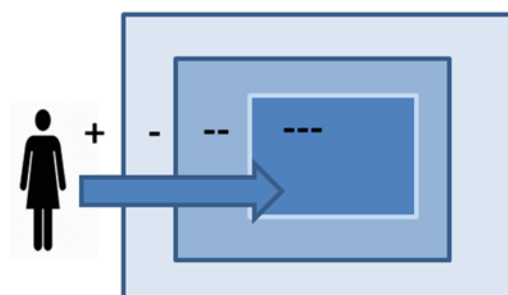


Figure 1. Directional airflow from less to high risk in laboratory

In order to fulfill the standard, the NIHRD laboratory construction follows the requested air flow according to the standard, but the initial design of the laboratory room was not in accordance with the activities to be carried out in the laboratory, such as the separation of infectious and non-infectious spaces. This separation results in disruption of the directional air flow that has been made at the beginning. The second challenge was the presence of condensation in a few areas on the ceiling of laboratory room. Since, Indonesia is a tropical and humid country, the condensation causes mold growth on the ceiling of the laboratory room, which leads to contamination of the laboratory work. The problem occurred due to the existence of space between one floors with another, where the temperature difference in the room resulted in the condensation on the air conditioning pipe. To overcome the condensation occurred in several laboratory rooms and general room, the

engineers used several steps to handle it. For the condensation that occurred in the general room, they made an air grill to equalize the temperature between the spaces on ceiling with the room below it. Different methods was applied to laboratory room, the engineers must open the ceiling and insulate the air conditioning pipe with the materials namely glass wool. Glass wool has benefit that it can absorb heat and easy to install, however the shortage is when it contacted directly with skin it causes irritation, and sometimes respiratory allergies [10]. The insulation foam was also implemented in the laboratory room with heavy condensation. The condensation problem also occurred in BSL-3. It occurred because the room space at the ceiling functioned to place Air Handling Units and blower was hot, due to insufficient ventilation. The temperature difference between upper and below the ceiling caused condensation above BSL-3. To resolve this matter four units of 1 PK Air conditioner were provided. The amount was determined by calculation of the need of the energy in British Thermal unit (BTU) per spacious room.

3.2 Laboratory Flooring

According to the guidelines, there were no requirements for floor, except for the risk assessment based requirement for laboratory design that the floor must be non-pervious, resistant to the acid, solvents and detergent and with covings to the wall [11]. Moreover, the floor surfaces should be easy to clean and impervious to water. The joints in the flooring material should be kept to a minimum or else no joints. The floor of NIHRD laboratory was epoxy coated and coved to the wall. However, due to the thin coating and the base of the floor was poorly concreted, the floor was easily broken. This could make spills penetrate underneath floors and the room was not sterilized. In order to maintain the floor, engineers started to re-coated and dismantle the floor to repair the coating.

Table 1. Simplified checklist to find gaps using WHO guidelines checklist for BSL-2 and BSL-3 Laboratories – only for facility and engineering controls.

No	Check Item	Yes	No	NA	Re-mark
BSL-1 and BSL-2					
I	Laboratory design				
1	Designed for Easy cleaning	✓			C
2	Room Ultraviolet light on interlock switch			✓	NA
3	All shelves secured	✓			C
4	Bench-top waterproof and resistant to acids, alkali, organics solvent, and heat	✓			C
5	Adequate illumination provided	✓			C
6	Adequate storage space available and appropriately used	✓			C
II	Electrical Equipment				
1	Extension cords present	✓			C
2	Outlet earthed/grounded and with proper polarity	✓			C
3	Connections by sinks, under showers, etc	✓			C
4	Equipment with frayed or damaged wiring		✓		C
5	Overloaded outlets or electrical strips		✓		C
6	Power strips mounted off the floor	✓			C
7	Proper fuses in conduit	✓			C
8	Electrical Outlets near water source meet local codes	✓			C
9	Earth or ground present on electrical cords	✓			C
10	Portable space heater			✓	NA
III	General Engineering Controls				
1	Laboratory airflow is negative to general occupancy, corridor and office areas		✓		NC
2	Sink available for hand-washing	✓			C
3	Exposed machine parts (pulleys, gear)		✓		C
4	Vacuum line has filters and traps on laboratory benches	✓			C
5	Backflow hazards to water supply	✓			C
6	Distilled water system in good conditions	✓			C
7	Active and effective arthropod and rodent programmed	✓			C
BSL-3c					
IV	Facility				
1	Laboratory separated from unrestricted traffic flow in building	✓			C
2	Access to laboratory through an anteroom with self-closing doors	✓			C
3	All penetrations in laboratory sealed or sealable for decontamination	✓			C
4	Room Exhausts air single-pass and exhausted away from occupied areas	✓			C
5	Controlled Ventilation system to Monitor directional airflow available	✓			C

NA: Not Available, C: Comply, NC: Not Comply

The laboratory flooring was an important aspect to consider when conducting activities with infectious agents in laboratory, specifically for activities in BSL-2 and higher level lab. It should be ensure that no gaps in the floors, in joints and in the coved because spills can penetrate enter to underneath the floors. The floors should be water resistant and also chemical resistant so it can be easy to clean when there is an infectious material spill accident.

4. CONCLUSION

We conclude that the NIHRD Laboratory was met almost all the biorisk standard on facility area with some adjustment in engineering and administration controls. However, condensation in ventilation systems pose quite difficult challenges in engineering practice in order to prevent cross contaminations, likewise with the flooring. Laboratory buildings with high risk activities need to be well planned as well as its maintenance and need to refer to the biorisk standard to avoid the occurrence of fatal losses or economic losses. When carrying out laboratory design and constructions, the institutions should collaborate with all experts such as microbiologists, architects, engineering's and biosafety expert to have a safe and secure laboratory. Furthermore, Country must consider to have National guidelines and related regulations for public health and microbiology laboratory construction according to Biorisk standard.

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