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Research Article

LEAD TO OCCUPATIONAL EXPOSURE IN THE QUALITY CONTROL LABORATORY

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ABSTRACT

Occupational exposure to lead among fire assay workers in quality control laboratory normally impact greater to workers who actively contact with lead in metal analysis processes including activities like chemical preparation and fire assay process. Based on the measurement result of Pb concentration, the mean exposure to Pb in fire assay laboratory workers is 0.04 mg/m^3, with the average personal intake of lead is obtained at 0.018 mg/m^3. Threshold limit values (TLV) for chemical factor in workplace based on Ministry of Manpower and Transmigration of Republic of Indonesia Regulation Number PER.13/MEN/X/2011 about of 0.05 mg/m^3, and thus the results of this research is still below the stated threshold limit value. Cumulatively, fire assay workers are still in the range of the reference interval 0 μg/dl to 14 μg/dl, although there is a gradual increase in PbB concentrations counted from 2012 until 2015. Regular maintenance of the ventilation system, monitoring the health of workers, job rotation and compliance to work safety procedures are among others very important in the effort and action to prevent and reduce their exposure.

INTRODUCTION

PTFI quality control (QC) Laboratory operates metallurgical analysis on gold (Au), silver (Ag) and copper (Cu). Fire assay analytical method is one of gravimetric methods which involves smelting, and known as a way to recover valuable metal content such as gold (Au) and silver (Ag). Gold (Au) usually contains small amounts of sulfide or oxide, not to have a reductive or oxidizing properties in smelting. Additional chemical used in the analysis are $Na_2B_4O_7$ (borax), Na_2CO_3 (soda ashes), and Pb_3O_4 (meni lead). $Na_2B_4O_7$ is flux (additional ingredient which contains high acid) functions as dissolver for some metal oxide to be changed into slag. Na_2CO_3 (alkali flux) as desulfurizer which smelts quickly together with minerals which contain silica and forms sodium silicate (Na_2SiO_3) which turns into slag. Pb_3O_4 (alkali flux) becomes oxidizer. Pb_3O_4 will oxidize to form (PbO) then it will bond valuable metals (Au and Ag) and other metals in the forms of buttons (Supriadidjaya, *et al.*, 2007; Susanto, *et al.*, 2016).

During gold (Au) and silver (Ag) metal content analysis, heavy metal (Pb) exists as PbO which can potentially create emission to the environment. The greatest exposure to workers occurs usually during analysis when workers are close contact with the lead during preparation and fire testing process.

Pb emitted to the environment comes from materials lost in the process and described as follows:

$$6FeS_2 + 10KNO_3 + 8PbO + 4Na_2CO_3 + 4Na_2B_4O_7 + 8SiO_2 + ZnO + (heat) \rightarrow 3FeO + 5K_2SO_4 + 5N_2 + 3SO_2\uparrow + 7Pb + 4CO_2\uparrow + 2Na2O + 2SO_3 + Na4SiO_4 + 6Na_2B2O_4 + FeB_2O_4 + 2FeSiO_3 + 4Na_2SiO_3 + PbSiO_3 + ZnB_2O_4$$

In chronic Pb intoxication of occupational exposure, gradual developing exposure on the symptoms occurs, such as fatigue, less concentration, irritability and confusion disorder (Riyadina, 1997). Various attempts and preventive actions are required to prevent and reduce exposure to Pb especially to workers with higher acute and chronic risk of exposure to Pb.

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To know how much lead exposure to the workers', the company do the periodic medical test. The test includes:

1. **Work history-**Emphasis on individual exposure and work site hygiene

2. **Physical test-**Emphasis on the condition of the lungs, where evaluation of respiratory protection suit will be based on

a. **Blood test-**Pb concentration in blood, a zinc protoporphyrin or erythrocyte protoporphyrin

b. **Miscellaneous test-**If other clinical indications appear.

Prevention in the QC laboratory is by environmental monitoring for Pb element in ambient air (Anderson, *et al.*, 2013). To enable monitoring and awareness of Pb pollutant, the lab uses accurate method to refer to highest level exposure called constant of Pb level monitoring in the air (Occupational Safety and Health Division, 2016). Lead usage with various background reasons becomes serious problems in industries. Although the lead effect disturbs health condition, some industries including construction, mining, and manufacturing are still using lead (NIOSH, 2016) including for laboratory analysis. Lead had two different types; they are inorganic and organic. In the mining industries, lead emits to environment from QC laboratory as lead inorganic (Compensation Board of British Columbia, 2016). In addition, the worker who works in QC laboratory has the most risk to high lead exposure from the lead spread out in the air in forms of dust or fume (Fig. 1 and 2).

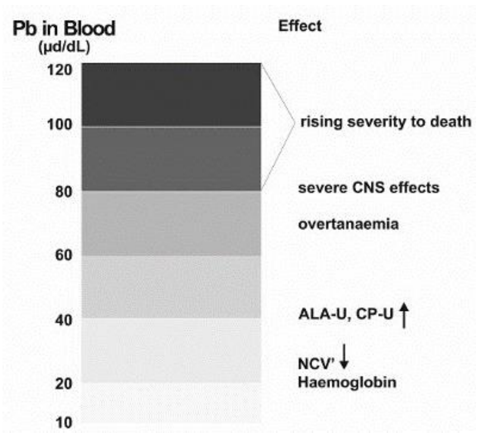

Fig. 1 Lead exposure dose-effect relationships.

METHODS

The method of research is a case-referent or retrospective study which is an analytical observational study and carried out in a QC laboratory specific especially in fire assay laboratory workers at PTFI.

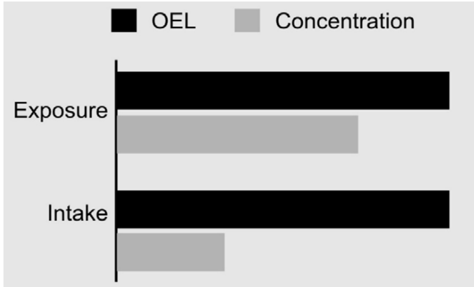

Fig. 2 Exposure of Pb-intake concentration in QC laboratory.

The measurement of inhaled Pb concentration by workers is carried out according to NIOSH 7082 issue 2 (1994) method, using a Personal Sampling Pump using cellulose ester filter pores of 0.8 µm and 37 mm in diameter, for 6 (six) hours based on the average time spent by workers analyzing gold and silver content. The PbB, blood Lead level test is carried out based on NIOSH 8003 issue 2 (1994).

DISCUSSION

The average measurement of Pb exposure to the workers' on fire assay is 0.04 mg/m^3 and the average of lead intake is 0.018 mg/m^3. The result of lead exposure and intake to the workers is below level 0.05 mg/m^3 OEL (Occupational Exposure Limit) (Ministery of Manpower and Transmigration of Republic of Indonesia, 2011). From the result, estimation of inhaled Pb particles can be figured out using the following equation (Ruchirawat, *et al.*, 2013).

intake (mg/[kg-day]) = CAP × IR × ET × EF × ED/[(BW × AT)]

CAP: chemical concentration in air (mg/m^3)

IR: inhalation rate (m^3/day)

ET: exposure time (hours/24 hours)

EF: frequency of exposure (days/year)

ED: exposure duration (years)

BW: average body weight(kg)

AT: averaging time (exposure period averaged in days)

With variable value:

IR: 20 m^3/day

EF: 365 days/year

ED: average working year time

BW: 70 kilogram for adult

AT: 70 year × 365 days/years for carcinogenic effects.

Based on inhale lead particles above, the average lead intake by each worker is 0.007 mg/kg-day. So according the analysis, the 49 fire assay workers are still exposed to risk of lead exposure during fire assay process performance in daily work activity. The lead exposure permitted to the workers is 0 µg/dL to 4 µg/dL (normal range reference). According to that permissible limit, there are 9 workers in period of four years have blood lead above the permitted exposure, they are 2 workers in 2015, 4 workers in 2014 and 3 workers in 2013. Whereas in 2012, the workers have blood lead below of normal range reference. Cumulatively the workers of fire assay laboratory have blood lead below the normal range reference and only 9 workers from 2012-2015 that have blood lead above range reference and need special attention to decrease lead intake to those workers. The interpretation of blood lead of the workers in 2012-2015 shown in Fig. 3 and 4 shows an average increase of Pb concentration level for the last 5 years.

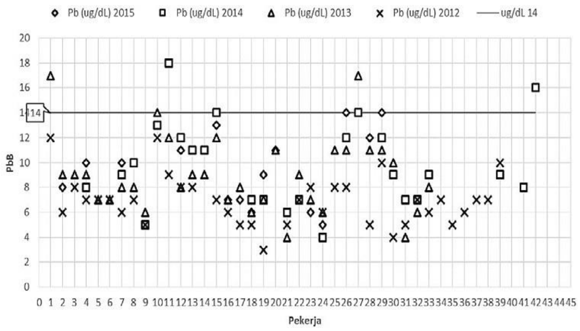

Fig. 3 Pb exposure and intake concentration among laboratory workers.

Fig. 4 below shows a significant increase of blood lead concentration of the workers during 2012-2015. The trend average for the period of 4 years is still within the reference range of 0 µg/dL to 14 µg/dL. However, the 2012-2015 graphic shows an average of slow increase of blood lead level. Statistic test reveals a score of 0.237 on significance level of p 0.05, therefore, work hours (duration of Pb exposure) does not extremely influence the PbB concentration on workers. This is made possible by the average intake of below the Occupational Exposure Limit (OEL) which means that the exposure does not influence the blood lead concentration on workers, or in other words it will take a significantly longer period of time to produce a negative effect.

Such condition is made possible by implementation of safety efforts and preventions by the fire assay laboratory to prevent and reduce Pb exposure by applying superior engineering which results in low Pb concentration from fire assay activity in the environment and low impact to workers.

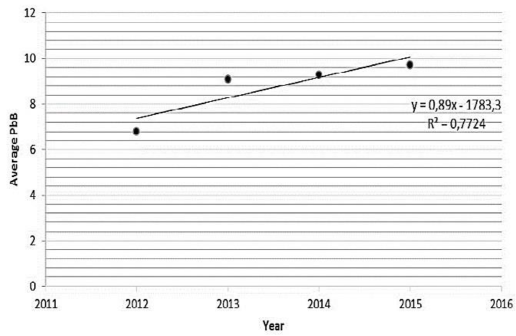

Fig. 4 Average increase of PbB concentration level.

In addition to the above, adequate workplace ventilation and hygiene can minimize release of Pb to the environment resulting in very low intake through inhalation. The explained conditions above show why the average PbB concentration of workers is below the reference range of 0 µg/dl to 14 µg/dl, although some workers have blood lead concentration above normal range reference. The condition may be contributed by:

1. Discipline in complying with the Standard Operating Procedure in QC laboratory.

2. Compliance with the use of Personal Protective Equipment while inside the QC laboratory.

3. Unhealthy life style of the workers such as smoking which affects Pb level in their blood, and the frequency of physical exercise.

To prevent or minimize the amount of lead absorbed by the body workers, the exposure control must be implemented. To the workers, environmental (in this case in fire assay laboratory) and the materials that used in the metal burning process. Based on occupational health and safety regulation (OHSR), air monitoring and exposure control must be required and developed to reduce or minimize lead exposure where the workers exposed to the lead in excess of 50% of the exposure limit, or when the lead exposure through any route into the body system of workers that could cause elevated blood levels.

Types of exposure control to minimize or prevent high-level lead exposure are developed after reviewing the actual analytical process by engineering control to minimize and prevent the lead released into the air by local exhaust ventilation, separation particle or process modification. Personal protective equipment (PPE) control are used to protect the workers and those do not eliminate the lead exposure but only minimize the lead exposure to the workers based on the regulation and PPE capability, such as; respirators, safety shoes, coverall work clothes, hand glows and others. Personal hygiene must be strictly adhered to, such as; removing respirator, removing coverall work clothes, hand and the body washing before drinking and eating during break or after finishing work activities.

CONCLUSION

The following conclusion withdrawn from this study are the daily intake of blood lead by workers through inhalation in quality control laboratory is 0.007 mg/kg-day, with cumulatively; the reference range of PTFI workers is within 0 µg/dl to 14 µg/dl. There has been a slow increase of blood lead concentration during 2012 to 2015. For managing work environment at quality control laboratory to reach healthy and safety, condition of routine maintenance on air ventilation system is done by ensuring fresh air supply free from lead. Monitor the health of QC laboratory workers' by specific medical monitoring of the lead concentration in the blood at least every semester; and if possible have a laboratory that can carry out a zinc protoporphyrin or erythrocyte protoporphyrin test. Work rotation for fire assay workers whose blood lead concentration have exceeded the reference range; and workers are obligated to comply with the standard operating procedure (SOP) for working safely at a quality control laboratory.

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