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Comparative study on Korean and international chemical control regulations of the physical hazards of sodium cyanide and hydrogen cyanide

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ABSTRACT

This study highlights existing problems and system improvements within the Accident Precaution Chemical Codes (APCC) in Chemicals Control Act (CCA, 2015) of Korea for the physical hazards control of sodium cyanide and hydrogen cyanide. We carried out comparative analyses with international industrial safety regulations, focusing on regulations within the U.S.A. and E.U. Previous technical studies and reviews of the regulations, which were referenced in this paper, have evaluated their clarity and interpretation. This paper focused on categorizing similar components from the different regulations of each country in terms of regulatory characteristics. The collected information was then assessed, defining each components merits and demerits in accordance with criterion which had been adopted in advance. The analyzed components were then used to improve current regulatory limits of the physical hazards control of sodium cyanide and hydrogen cyanide in Korea. The proposals of this exploratory study should provide guidance for future regulatory codes allowing a greater ease of interpretation and compliance by stakeholders.

1. Introduction

An inspection of six hundred Korean businesses handling sodium cyanide and hydrogen cyanide was carried out by the Korean Ministry of Environment during September 2015 (The Korea Herald, 2015). The inspections focusing on these two chemical substances, sodium cyanide and hydrogen cyanide, reflected the heightened concern which has arisen since the chemical disaster in Tianjin, China, in September 2015. The inspected businesses were mostly small-sized companies, though Ed. - Highlight - Please verify. Wasn't it in August 2015? many deal with large volumes of sodium cyanide and hydrogen cyanide. It is assumed that many of these smaller businesses do not take any routine precautions and that their owners are unaware of the existence of any specific and separate sanctions for storing these materials, but would rather say that the “paperwork is too far from the iron”, a Korean expression meaning that there is a gap between the formal safety system and the shop floor (Paolo et al., 2015). Ed. - Highlight - Please verify/ clarify the technical meaning.

Independent of the situation in Korea, there is an existing international treaty, “the International Cyanide Management Code (ICMC) For the Manufacture, Transport, and Use of Cyanide in the Production of Gold (hereinafter “ICMC”)”, which specifically deals with the control of the hazards associated with cyanide. The ICMC was developed by a multi-stakeholder Steering Committee following the United Nations Environmental Program (UNEP) and the then International Council on Metals and the Environment (ICME) (ICMC, 2015) and is commonly referred to as the Cyanide Code. According to this treaty, active operations are required to be audited to verify their compliance with the Cyanide Code within three years of being designated for certification. A certified operation must have the site inspection portion of its next audit conducted within three years of the effective date of its previous audit, which is the date the Institute posts its Summary Audit Report and announces its certification on the Cyanide Code website (ICMC, 2015).

Subsequently, it is necessary to understand the framework of gold mining where Cyanide is used and for which the ICMC plays the role of the regulatory system. Gold mining operations use very dilute solutions of sodium cyanide (NaCN), whose concentrations

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are generally in the range of 0.01%–0.05%. The process of metal dissolution is called leaching. The sodium cyanide dissolves in water where, under mildly oxidizing conditions, it dissolves the gold that is contained in the ore. The resultant gold-bearing solution is called the “pregnant solution”. Either zinc metal or activated carbon is then added to the pregnant solution to recover the gold by removing it from the solution. The residual or “barren” solution may be re-circulated to extract more gold or routed to a waste treatment facility. (Logsdon et al., 1999).

Cyanides most commonly refer to salts of the anion CN. Cyanide can naturally be found in about 2000 sources (Arbabi et al., 2015). The principal human-made cyanide forms are gaseous hydrogen cyanide and solid sodium or potassium cyanide (Kuyucak and Akcil, 2013). Cyanide is produced industrially in one of two ways: as a by-product of the manufacture of acrylic fibers and certain plastics or as a result of combining natural gas and ammonia at high temperatures and pressures to produce hydrogen cyanide (HCN) gas. Subsequently, hydrogen cyanide gas can be combined with sodium hydroxide (NaOH) to produce sodium cyanide (NaCN) and water (H2O) (Logsdon et al., 1999). Maxwell et al. (2007) discusses the fact that oxygen from the air, ammonia and natural gas react in a gas phase converter to produce hydrogen cyanide, water and combustion products in the DuPont and Aker Kvaerner HCN process. The HCN reaction is as follows:

$$NH_3 + CH_4 + 1.5O_2 \xrightarrow[Pt/Rh]{1200^\circ C} HCN + 3H_2O, \Delta H = 482.3 \text{ kcal/mol HCN}$$

Maxwell et al. (2007) argue that the hazardous properties of hydrogen cyanide (HCN) require process safety management (PSM) in order to ensure that safety is the highest priority during the design, engineering, construction, start-up and operation of a HCN plant. Maxwell et al. (2007) also stressed the importance of ensuring that safety information relating to hazardous chemical substances is properly communicated at all stages of production and handling.

Considering that the starting point of this study focuses on the direct physical effects of hydrogen cyanide, the United States and EU were chosen as appropriate target countries to compare the different regulatory systems in the initial stage of the paper. According to the chemical economics report of the IHS company (2013), Korea is the fourth largest consumer of hydrogen cyanide (2012) (Fig. 1). Korea is also a major exporter of solid sodium cyanide (Fig. 2). The above pie charts represent the global consumption of hydrogen cyanide and sodium cyanide. Incidents and spills involving sodium cyanide have prompted a voluntary industrial program known as the International Cyanide Management Code for the Manufacture, Transport and Use of Cyanide in the Production of Gold (ICMC), commonly referred to as the Cyanide Code. A representative incident was the cyanide spill at Baia Mare in Romania. According to the report from the United Nations Environment Programme (UNEP) and Office for the Co-ordination of Humanitarian Affairs (OCHA), the uncontrolled spill of some 100,000 m^3 of liquid and suspended waste occurred on 30 January 2000 at the Aurul S.A. gold and silver producing plant in Baia Mare (Romania). This spill released an estimated 50–100 tonnes of cyanide, as well as heavy metals, particularly copper, into the Lapus, Somes, Tisza and Danube river catchment system. According to official Romanian sources, this cyanide spill caused an interruption of the water supply in 24 localities, inconvenience to citizens, and supplementary costs in the sanitary field and in industry due to the interruption of the production process. The amount of dead fish reported was very small and 60% of the phytoplankton and zooplankton in the Somes river was regenerated within 16 days (UNEP and OCHA, 2000). The ICMC is an international association which was founded under the auspices of the UNEP and the International Council on Metals & the Environment (ICME). Even without considering the success or failure of the ICME in terms of its organizational performance or achievements, its establishment alone represents as important milestone, being the first meaningful international policy for the control of cyanide. Considering the industrial prevalence of cyanide, the main focus of this study was the regulatory guidelines derived from the Globally Harmonized System of Classification and Labeling of Chemicals (GHS) of UNEP.

Sodium cyanide and hydrogen cyanide are listed in the Accident Precaution Chemical Codes (APCC), which constitute Annex 10 in the Chemicals Control Act (CCA, 2013) of the Korea Ministry of Environment (KME). Nevertheless, the regulations relating to the control of the physical hazards of these two chemical substances in the existing regulation are not sufficient to ensure safety in the industrial field, as specific guidelines are not provided for all levels of operation (Sungwoon et al., 2013). This paper includes a study procedure, the results from mutual comparisons between different regulatory systems, discussion of the issues arising from the study procedure and conclusions.

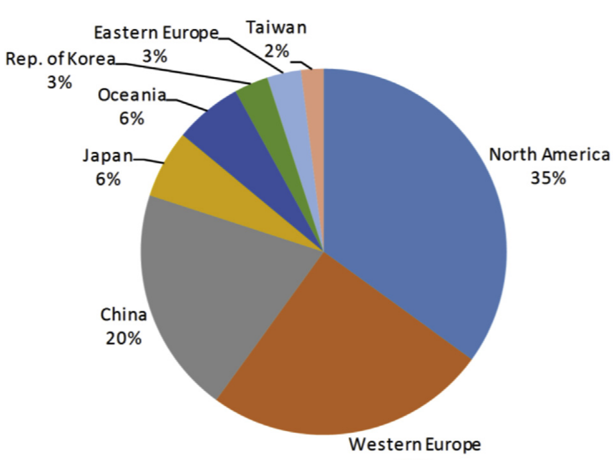

Fig. 1. World consumption of hydrogen cyanide (IHS Inc, 2013).

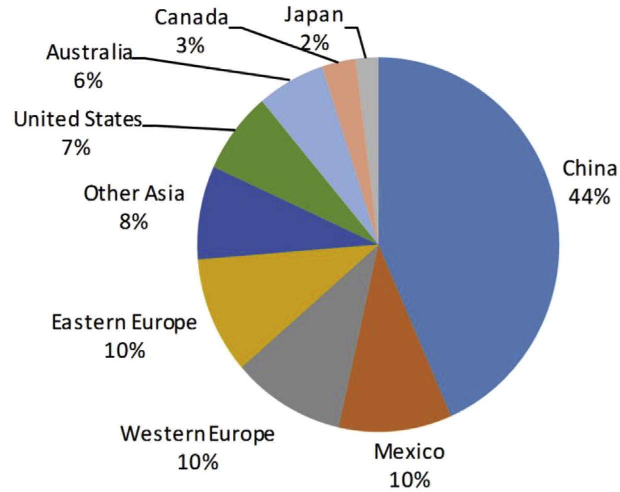

Fig. 2. World consumption of sodium cyanide (IHS Inc, 2013).