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The development and implementation of occupational exposure limits in Hong Kong

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Abstract

The blooming of economy in Hong Kong started in 1950s. People witnessed the change from a rural town to a modern city. It required the participation of a large number of labours. The development of a list of "practical" hygiene standards for control of airborne contaminants in workplaces is important to protect the well beings of those workers. It follows the pace of economic changes, and it takes quite a long while for the current Code of Practice on Control of Air Impurities in workplace environment to be published. There had been a consultation with stakeholders, professional bodies, representatives of trades, and industries as well as other related parties before it was finalized in 2002. Although the Code of Practice comprises just more than 200 chemicals, its application will be monitored and reviewed. In light of new knowledge, it will be updated to ensure the workers could be well protected.

Keywords: Occupational exposure limits; Occupational hygiene standard; Evaluation of chemical hazard

1. Introduction

Hong Kong is located at the Southern part of China. It is composed of many islands and occupies about 1100 km^2 land area. (See Table 1 for the details.) For the last 60 years, after the World War II, she has gone through tremendous social, economic, and political changes and the population has been growing from less than a million to over 6.8 millions. The development of occupational health service follows the change of the economy. Roughly, we can divide the development into three phases. From early 1950s to 1970, people witnessed the change from a rural town to a city and the blooming of industries. From 1970 to late 1980s, manufacturing industries was the dominant sector and there were almost a million workers (over the total working population of 2.4 million at that same period). From 1990 until now, the economy is expanding from manufacturing industry to commercial and financial services. The manufacturing sector shrunk to less than 200,000 workers while the commerce and finance expanded fast to more than 2 millions people. Now, the total working population is around 3.5 millions. The Labour Department all along is the authority regulating the safety and health of workers employed by all trades and industries. The Factories and Industrial Undertakings Ordinance, which is a piece of prescriptive law protecting and targeted at the industrial workers was first enacted in 1955. It is still being enforced though it has been amended many times. However, the ideas of exposure limits even in "voluntary" codes of practices were not available until mid-1980s. In 1997, a new set of Occupational Safety and Health Ordinance was introduced. It embraces almost all employees. On the other hand, to reinforce the confidence and determination of the management in the evaluation of health hazard, an approved Code of Practice on the control of air impurities was published in 2002. The concept of workers' protection from exposure to hazardous substances is moving from a less distinct manner to a clearer and more defined approach. This latest publication has a legal status that the public should follow to ensure the adequacy of protection for workers' health while at work.

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Table 1
Change of economy in Hong Kong in the last 60 years

	Trades and activities	1956/57 (Labour Department, 1947)	1982/83 (Labour Department, 1973)	2000/01(Information Services Department, 2000)
Major events		F&IUO enacted in 1955	First guide with OEL in 1984	COP on Control of Air Impurities issued in 2002
Population		2.5 million	5.2 million	6.8 million
Labour force		750,000	2,405,000	3,529,000
Land area		1012 km^2	1064 km^2	1098 km^2
Major trades or occupations	Farmers	200,000+	20,000	altogether
	Fishermen	50,000	28,000	17,500[a]
	Workers in illegal workplaces	100,000+	NA	NA
	Manufacturing	150,000	856,137	226,205
	Construction	200,000 (all workers)	71,159 (only manual workers)	83924 (only manual workers)
	Transport and public utilities	25,000	66,000	184,949
	Wholesale and retails	2,852	527,000	1,009,094
	Community, social, and personal service	[a]	193,500	354,537
	Business finance and banking	[a]	158,600	434,105
	Civil servant	35,000	168,000	165,000
Major industries	Food	6,448	17,150	22,464
	Textile	39,237	114,000	27,489
	Footwear, leather, etc.	1,144	9,764	609
	Wearing/clothing garment	8,354	254,280	36,330
	Plastic and toys	[a]	83,187	7,601
	Rubber	8,756	3,497	[a]
	Various chemical	3,120	8,019	5,124
	Metal product	24,675	82,000	11,185
	Electrical and electronics	2,035	131,224	20,943
	Shipbuilding	9,290	10,262	<1,000[a]
	Printing	6,754	28,672	43,849
	Quarrying and mining	2,000	852	154

Remark: The figures represent roughly the numbers of persons engaged in the trades/industries in the year around the quoted periods and the definitions of the trades or industries might not be the same throughout the whole period.
[a] No complete data set was available.

2. The past and present of local trades and industries

Over the decades, there was quite a drastic change in the profile of industries. Farming and fishery were once the primary economy in the old Hong Kong. Shipbuilding and ship repair industry appeared after the World War II. Iron, wolfram, and lead mining were once very active. Light industries came about in the late 1950s (Labour Department, 1947). Textile, garments, metals, and plastics were getting important by the 1960s. Together with electrical and electronics, toys, and metal fabricated products, the textile, and garment continued to flourish throughout the 1970s and 1980s (Labour Department, 1973). They were labour intensive industries. Altogether, they once had almost a million workforces, dominating the local economy for decades. However, construction activities for infrastructure of a modern city have not been stopped for the last 60 years. Site formation and reclamation were and are still very active (the land area increases from about 1000 to 1100 km^2). Housing would be in need when population is growing. Moreover, electrical and electronics, once the symbol of Hong Kong industries bloomed in 1970–1990, have been downsized. Today, the working population mounts to 3.5 millions but its profile has been changed significantly. Majority of the people are now working in the sectors of community, financial, and personal services. The "surviving" manufacturing industries, including electronics, plastics, metal works, garment, printing, etc., employ now only 200,000 people. Many of the workers are nevertheless still likely exposed to hazardous substances, though at a smaller scale. It is difficult to trace the origins or locate the sources of the health and hygiene problems from the side of the government alone, because new technologies are being introduced from time to time and the use of chemicals are diversified in all trades at a less labour intensive manner. It requires more than just a few safety rules but comprehensive surveys and regular (or self-regulatory) check up of the workplace conditions. The establishment of occupational exposure limits for chemicals could definitely help the private sectors in making workplace risk assessment and the initiation of follow-up actions.

3. Occupational health service

In 1956, an Industrial Health Section was first established with an industrial health officer, who headed the team, and was then responsible for the enforcement of health and hygiene conditions at workplaces. At that time, the major industrial health concerns were associated with the use of radioactive substances, silicosis among the mining, and construction industry, and lead poisoning in manufacturing industries. Gas poisoning and dermatitis were not uncommon too. The Industrial Health Division was re-named as "Occupational Health" Division in 1981 to pave the way for the extension to cover all industries including the non-industrial and service sectors. Nowadays, the Occupational Health Service contains more than 100 staff and is the authority for the development, promotion, and enforcement of workplace hygiene regulations. The occupational health statistics (Labour Department, 2005) for 2004 demonstrated that silicosis is still a prominent issue (although it has been in a declining trend) (Pneumoconiosis Compensation Fund Board, 2001), and is followed by occupational deafness, tenosynovitis, tuberculosis, gassing incidents (e.g., hydrogen sulphide), dermatitis, etc. Chemical poisonings could be episodic—such as the cadmium poisoning incident in a battery manufacturing company in 2004.

4. Procedure of OEL development

The legislative framework of Hong Kong on health and safety was modeled from the Factories Act of the United Kingdom. The Factories and Industrial Undertaking Ordinance, which replaced the former Factories and Workshops Ordinance in 1955, contains now 30 pieces of subsidiary regulations (Government of HKSAR, 2005). Basically, the regulations in 1955 required the proprietors to secure and maintain the general hygienic conditions of the workplaces—including workplace cleanliness, good ventilation, lighting, drainage, overcrowding, provisions of sanitary conveniences, washing facilities, drinking water, first aid, etc. Statutory power was granted to public officers to conduct surveys and to take samples from workplace environment for purpose of analysis and assessment of work conditions in those early days. The industries however took no active role in workplace air monitoring. They remained reactive and adopted advice from the government. Nevertheless, several voluntary Codes of Practice and Guides were publicised by the government in mid-1980s. The general knowledge on anticipation of the hazard, good occupational hygiene practice, and precautionary measures were highlighted. Dust hazards were the major concerns. Recommended occupational exposure standards were therefore provided for some of the specified substances, like lead, silica, cotton dust, and asbestos, as a reference for reduction of exposure. Employers and employees could seek additional guidance on application of hygiene standards for control of airborne substances in workplace atmosphere on voluntary basis. However, exposure to other chemicals could also be a problem. Once, there was an accident in 1983. Over 200 workers were affected by toxic gas and vapour produced as by-products of a printing process in a motor manufacturing factory (Ng et al., 1985a). In 1993, a comprehensive booklet known as "Reference Note (Labour Department, 1998) on occupational exposure limits for control of over 200 chemical substances at workplaces" was introduced. With a few exceptions, the standards of chemical exposure on the list were mainly adopted from the Threshold Limit Values of the American Conference of Governmental Industrial Hygienists (ACGIH) and its documentation in 1984. However, some hazardous substances like asbestos, raw cotton, silica dust, and *n*-hexane, have a different background of development. The setting of the occupational exposure standards are based largely on findings or information related to the local examples—such as case studies in cotton dust hazards, silica dust exposures, and application of benzene as a solvent and the exposure of printing workers to *n*-hexane. There were separate booklets on the substances as guidance for the industries. In most of them, specific hazards and measurement methods were mentioned and recommended for assessment. These documents were later combined and transformed into a statutory Code of Practice on "Control of Air Impurities (Chemical Substances) in the Workplace" in April 2002.

The approved Code of Practice proposed in 2002 now includes a list of occupational exposure limits (OEL) for more than 230 chemical substances commonly found in the workplace environment, except exposure to asbestos that has been promulgated in a separate statutory Code of Practice known as "Code of Practice: Safety and Health at Work with Asbestos". The main objective of the Code of Practice for OEL is to give practical guidance for the public to maintain a hygienic workplace atmosphere and as far as reasonably practicable free from air impurities for the protection of workers. Employers are expected to make assessment on potential health hazards for their own workplace environment and to conduct air monitoring when necessary, before undertaking the basic occupational hygiene control measures.

In the drafting of the Code of Practice on Control of Air Impurities, consultation was made with 169 representatives from the trades and industries, government agencies, and private consultants, universities and professional bodies were undertaken. Open talks to explain the application of the occupational exposure limits to the general public were also given. Thirty seven useful and constructive replies had been received; in general, they supported the move and agreed that it could form a useful guideline to facilitate employers to perform hazard/risk assessment and to protect health of the workers. Some however showed concerns on the competency and training in occupational hygiene, in particular, the measurement methods for airborne substances as well as the interpretation of the exposure data. The returns helped a lot in the forward planning and the promotion of good occupational hygiene practice in the industries. On the other hand, being a Code of Practice, it has the advantage that amendment of the content for the best protection of workers can be made simpler and more efficient.

In the preparation of the new Code of Practice, the majorities of the standard values are being made reference to the Threshold Limit Values published by the American Conference of Governmental Industrial Hygienists (ACGIH). Other reference sources include the occupational exposure limits issued by the Health and Safety Executive (HSE), the United Kingdom. Reference to local studies is also important in some selected chemical substances before their standard values are being adopted. They include asbestos, benzene, cotton dust, *n*-hexane, lead, and crystalline silica. Considerations have been made on factors like its toxic effect, application, and impact on local trades and industries, recommended methods/techniques for the monitoring and so on.

5. Enforcement and communication of OEL

The voluntary Codes and Guides published in the early days were mainly for the guidance of local industries for good practice in the control of hazardous substances to safeguard the health of persons employed. The booklet "A Reference Note on occupational exposure limits for Chemical Substances in the Work Environment" was a comprehensive list of standards for reference. It was first published in 1993. The application of limit for exposure levels, although they were not mandatory in local legislation, formed part of the criteria for workplace air monitoring. They could be used in assessing compliance with the statutory duty of the employer to ensure that his employees were not exposed to occupational disease hazard. Where the atmosphere of a workplace was likely to be contaminated, sampling of the atmosphere and subsequent analysis should be carried out on a periodic basis with a frequency determined by conditions. By then, advice on monitoring methods or other aspects of the prevention of occupational health hazard could be available from the former Occupational Health Division of the Labour Department. The Reference Note was widely accepted by the industries, and had been used by the safety and health professionals as a reference guide for assessing the risks to health of workers for almost 10 years.

The publication of the Code of Practice on the Control of Air Impurities has however replaced the Reference Note since April 2002. The listing of occupational exposure limits has been revised and formed based on the previous Reference Note. The data are incorporated into the new publication to provide practical guidance to the proprietors/employers to take adequate measures for the safeguard of the workers against air impurities or airborne chemicals that are released from use, handling, storage, and transport of the substances. The maintenance of air impurities in the workplace well below the exposure limits of the chemicals listed in the Code of Practice shall demonstrate the discharge of the general duties under Section 6A of the Factories and Industrial Undertakings Ordinance (Chapter 59) and compliance with the relevant requirements of the subsidiary regulations under the same Ordinance. For some management of establishments not included under the definition of industrial undertakings, they may make reference to the Code of Practice for the control of chemical exposure in their workplace environment. The Code of Practice is issued by the Commissioner for Labour under Section 7A(1) of the Factories and Industrial Undertakings Ordinance and has a special legal status. Although failure to observe the provisions of the Code of Practice is not itself an offence, that failure may be taken by a court in criminal proceedings as a factor in determining whether or not a person has breached the relevant safety and health provisions under the legislation.

In Hong Kong, the breach of the safety and health law is a criminal offence. An employer who contravenes the provisions commits an offence and is liable to a maximum fine of HK$500,000, and in case, it is a willful act and without reasonable excuse, the person is liable to a fine of HK$500,000 as well as to imprisonment for 6 months (Government of HKSAR, 1998). There are penalties to employees too but the fines are relatively lower being HK$50,000 if it is willfully and to imprisonment of 6 months. In short, under the general duties, proprietors are required to ensure, so far as is reasonably practicable, the health at work of all persons employed by him, or the maintenance of the safe system of work, or arrangements for ensuring the absence of health risk in connection with the use and handling of substances, or the maintenance of a safe working environment and without risks to health. Monitoring of workplace environment may be required in the above-mentioned situations to assist in risk assessment for ensuring the protection of employees' health.

6. Training in occupational hygiene

In 1986, the Chinese University of Hong Kong offered the first local training course in occupational hygiene. That was a post-graduate diploma course, offered on the basis of part-time day release. The course content now includes recognition of occupational health hazards, toxicology, hazard evaluation, air monitoring, and workplace assessment, prevention, and control. Field practical and instrumentation are emphasized so that students can learn how to conduct a field survey and make use of instruments to measure the amount of air contaminants in the atmosphere. Decision making and recommendations are made based on results of sampling, other collected information and associated factors. Today, there are many training programmes in occupational hygiene offered by several universities—from elementary level to post-graduate degree courses.

7. Examples of OEL development

7.1. Benzene

To review workers' exposure to benzene, a field study was conducted in 1987 to find out the application of benzene in the local manufacturing industries as well as its importation. Surveys and enquires were made to the suppliers or distributors. Samples of solvent liquid were collected from the stock and products of local chemical plants as well as small workshops for confirmation of the liquid composition. As a result, it was found that benzene was not marketed or imported as a pure chemical by the major distributors. No mixing or repackage of the chemical was carried out in the local chemical plants. The major use of the chemical by most trades was being a known additive to petrol and sometimes as a minor ingredient, or "impurity" in solvents and adhesives for shoe making and plastic ware manufacture, as well as a cleansing agent for electronic, printing, and fur industries. Potential exposures were therefore limited to mainly attendants of petrol stations or petrochemical plants and workers in some specific trades during manufacturing. The initial proposed exposure standard value for benzene was 5 ppm, 8-h time weighted average (TWA), based on the fact that it was recognized as a suspected human carcinogen (A2) after the recommendation of ACGIH. The figure was first published in the Reference Note in 1993, but it had been modified when the chemical was re-classified as A1—a confirmed human carcinogen. The change has also taken into consideration of the exposure to benzene for workers in the petrol stations and petrol chemical plants. The revised 8-h TWA was 0.5 ppm with a Short-Term Exposure Limit (STEL) of 2.5 ppm in the 1998 edition of the same publication before the statutory Code of Practice is produced in 2002.

7.2. Crystalline silica including quartz

Dust problem has a long history in Hong Kong because granite and volcanic rock form mainly the bedrock structure of the whole area. Therefore, silica dust exposure were not uncommon among mining, quarrying (Lawrie, 1964), construction, and tunnelling as well as in foundry work, stone work, gemstone polishing (Ng et al., 1985b), sand blasting, glass, and enamel making. Silicosis had been well known since early 1950s. The introduction of caisson work (Ng et al., 1987) in late 1960s and 1970s for foundation of structures and buildings brought even more disease cases in the next decade. The onset of the disease is usually slow and begins only after the workers have been exposed to silica containing dust for commonly 15 years (but may vary from 3 to 40 years). Acute and severe cases were found among caisson workers (Lo, 1998). Since the establishment of the Pneumoconiosis Compensation Scheme in 1980, the figures of confirmed cases remained high. Until recently, 10 years after the amendment of the Building Ordinance to restrict the use of caisson as a construction technique, the figures of newly confirmed cases seem to take a declining trend (Labour Department, 2004).

In the development of exposure limit for silica dust, in 1960, a review (Lawrie, 1964) on "dust control and workers' exposure in the dusty trades" was first conducted by Mr. Lawrie. In his final report on the suppression of dust in Hong Kong (1964), the occupational exposure limit to dust was recommended as 5 mppcf (TLV-TWA) for dust with more than 5% free silica. The assessment of dust exposure could be based on the field instrument like Watson Konimeter (a dust microscope available by the Industrial Health Section at that moment). It became an internal guide to the field officers for some time until new instrumentation was available for measuring the dust by gravimetric method and direct measurement on its quartz content. It is also understood that the effect of the respirable portion of dust are most important. The dust monitoring procedure then aims to find out the respirable dust content—the use of formula for the calculation of potential hazard was introduced. In the early days, the exposure limit was worked out based on the percentage of respirable crystalline silica found in each air sample, such that the recommended exposure limit $= \frac{10}{\%\text{of silica}+2}\,\text{mg/m}^3$. The formula for calculating the limit value was recommended and published in the voluntary Code of Practice for the Protection of Quarry and Construction Workers from Silicosis and that for the Protection of Tunnel Workers from Silicosis by 1983/1984, respectively. The basic method for dust assessment was by sampling with a particle-size selective cyclone sampler for its respirable content. To sample accurately the selected particle-size range, the prescribed flow rate should be at 1.9 L/min, according to the design of the sampler head in use. The amount of dust collected on filter would be weighed and followed by either measurement with infrared spectrometry or X-ray diffractometry—a bench top analysis by a supporting laboratory to determine the quartz content. However, it would take a relatively long time to complete the analysis. To resolve the problem, an interim action level of 1.25 mg/m^3 was also proposed for workers involved with tunnelling work because the work conditions down in the tunnels might change fast. The simplification of measurement procedure allowed the management to have direct readings and could make a quick decision on whether the situation was acceptable or a modification of the engineering control or protective measure in tunnelling work was required. The proposal was based on a series of field study and assumed that the general respirable quartz content was 6% during most of the time in tunnelling work. A quick check with a grab sampling aerosol monitor, like Kanomax, was a feasible method for preliminary risk assessment and prompt corrective action. Temporary suspension of the dusty operations inside tunnels or effective personal protection for workers might be required in critical situation. The practice is still acceptable for engineering control. For confirmation of health conditions of workers, personal samples are still required.

By early 1987, a review of the exposure limit was made that direct application of exposure to respirable quartz content was recommended for assessment of silica dust hazard. The value of 0.1 mg/m^3 is adopted as the 8-h TWA of respirable crystalline silica or quartz. The standard is generally applicable to all workplaces, in particular, the dusty trades or the construction sites.

8. Conclusion

The occupational exposure limits are useful guide for health hazard assessment in workplaces. The development of the standards has taken a long history in Hong Kong. The initial guide was not widely promulgated because the industries had limited knowledge and lack of the available expertise in air monitoring as well as interpretation of hazard information, and there was also lack of instrument and laboratory support service for the measurement. Until the establishment of local training courses in the universities, the concept of OEL has been widely accepted. The current Code of Practice on the Control of Air Impurities in Workplace forms the basis for evaluation of chemical hazard and recommendation for prevention and control strategies in workplace environment. The Code of Practice will be monitored, reviewed, and amended in the light of new information in safeguarding the health of workers. Methods for air monitoring are going to be recommended, so that, the industries would be encouraged to take up more active role in measuring field exposure before decision making for better improvement of workplace environment conditions. On the other hand, the building up of an exposure data bank would help the further development of the OEL for better protection of workers.

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