

Review Article

Perspectives on New Chemical Regulatory Framework and Research Direction in Korea

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Abstract: In response to new information about the health risk of chemical and concern expressed by academia, labor, and industry, chemical regulatory framework under Industrial Safety and Health Act was completely restructured in Year 2003 to be more systematic and to meet the particular needs in Korea. The history and the current status of chemical regulatory framework in the Republic of Korea are reviewed.

Key words: Korea, Industrial Safety and Health Act, Chemicals, Hazard-risk assessment, Regulation

Introduction

Currently, 37,000 chemicals are known to be present and used in the workplace in Korea (MOE 2002), and 300 new chemicals are being imported each year. There are several millions of these chemical mixtures and products being manufactured and used throughout the workplaces in Korea (Roh 2000, MOL 2000). All these chemicals are essential in manufacturing various products in workplaces, but there are increase of occupational disease, fire, explosion, environmental contamination due to increase of chemical products production and lack of understanding concerning hazards and risks. Therefore, to prevent workers and people from suffering from accidents and diseases, 7 different Ministries have 12 different Acts to manage and regulate chemicals in Korea (Table 1). Out of these 12 Acts, Toxic Chemical Control Act in Ministry of Environment focusing on people's health protection and environment preservation and Industrial Safety and Health Act in Ministry of Labour

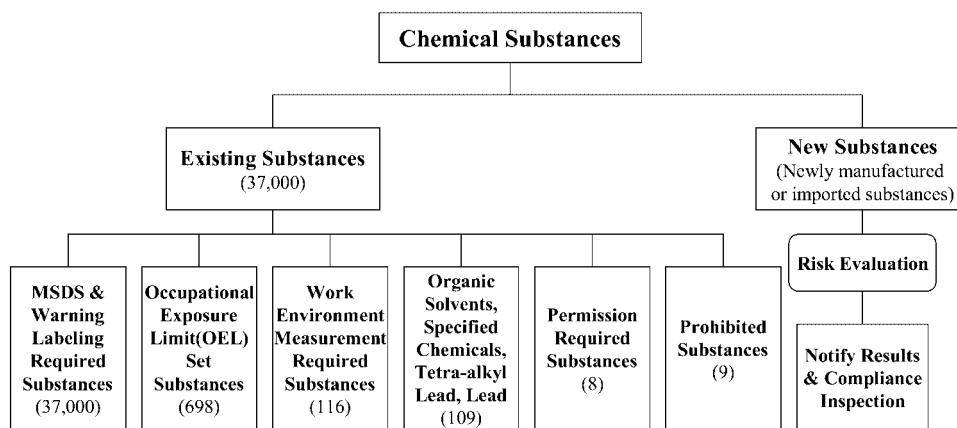
focusing on safe use of chemicals in workplace to protect worker's health are the key regulatory system in Korea. However, this article intends to focus on worker's health protection and chemical regulatory system in Industrial Safety and Health Act from industrial health perspective.

Based on the result of Work Environment Status National Survey in 1999, 20,557 (39.5%) companies, out of 52,070 manufacturing companies employing more than 5 workers, either manufacture or use chemicals. Considering the fact that this figure does not include manufacturing companies employing less than 5 workers and non-manufacturing companies such as construction worksite, actual number of companies exposed to chemicals will be tremendous (KOSHA, 2000). The Ministry of Labour in Korea manages all chemical manufacturing and handling companies where workers may be exposed to chemicals by applying Industrial Safety and Health Act. However, 322 workers were diagnosed as occupational diseases caused by chemical exposure in Year 2002 (MOL, 2003), and occupational disease caused by chemicals has been on the increasing trend for past three years (202 in Year 1999, 322 in Year 2000,

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Table 1. Chemical regulating Acts and its purpose in Korea

| Target Substances | Chemicals Regulated | Jurisdiction | Related Acts | Regulating Purpose |
|--------------------------------|---------------------|--|---|---|
| Health Hazard Substances | 698 | Ministry of Labour | Industrial Safety and Health Act | Worker's Safety and Health |
| Toxic Chemicals | 512 | Ministry of Environment | Toxic Chemical Control Act | Public Health and Environment Protection |
| Agrochemical, fertilizer, feed | 314 | Ministry of Agriculture and Forestry | Agrochemicals Control Act, Fertilizers Control Act, Control of Livestock and Fish Feeds Act | Quality improvement and appropriate management of Agrochemicals, fertilizer, feed |
| Medical supplies, narcotics | 2,600 | Ministry of Health and Welfare | Pharmaceutical Affairs Act, Narcotics Control Act | Appropriate management of pharmaceutical and cosmetics |
| Food additives | 461 | Ministry of Health and Welfare | Food Sanitation Act | Management of food additives |
| Dangerous article, Explosives | 64 | Ministry of Government Administration and Home Affairs | Fire Service Act, Control of, Firearms, swords, Explosives, etc. Act | Fire prevention · watch · suppression, Management of chemicals for explosives |
| High pressure gas | 51 | Ministry of Commerce, Industry and Energy | High Pressure Gas Safety Control Act | Safety control of high pressure gas |
| Radioactive agents | Isotope | Ministry of Science and Technology | Atomic Energy Act | Management of radioactive agent |

**Fig. 1. Former Chemical Regulatory System used in Korea until June 2003**

394 in Year 2001). Although the amount of circulating chemicals is increasing along with the increase in the level of technology and sophistication, and in size of domestic industries, the continuous increasing number of occupational disease cases caused by chemicals shows that our response to such increase is lagging behind.

Korea's first chemical regulatory system under Industrial Safety and Health Act was built using the model in Japan's Industrial Safety and Health Law since its enactment in 1981 with its adoption of exactly same chemicals regulated in Japan as banned substances, permission required substances, and work environment measurement required chemicals

without any filtering. Since then, there were many concerns expressed by academia for previous chemical regulatory system not being systematic and not taking into account of unique industrial situation in Korea (Kim *et al.*, 1999; Roh *et al.*, 2000). Figure 1 shows the chemical regulatory system being used in Korea until June 2003.

In response to new information about the health risk of chemical and concern expressed by academia, labor, and industry, chemical regulatory system under Industrial Safety and Health Act was completely restructured in 2003 to be more systematic and to meet the particular needs in Korea by adopting worker's chemical exposure status national

survey and hazard · risk assessment system for all hazardous chemicals along with periodic risk review system for updating chemical regulatory system. The new chemical regulatory system classifies hazardous chemicals into five different categories: banned substances, permission required substances, regulated substances, work environment monitoring required substances, occupational exposure limit set substances. Along with it, the restructured regulatory system increased banned substances from 9 to 66, permission required substances from 8 to 14, regulated substances from 109 to 168, and work environment monitoring required substances from 116 to 191 based on the current chemicals usage status in Korea. Also, the Hazardous Agent Review Committee was created for the purpose of systematic chemical selection and assessment for its hazard and risk along with coherent chemical regulatory classification update based on its hazard-risk assessment results.

Revised Chemical Regulatory System

Hazard-risk assessment of chemicals

Recently, the hazard risk assessment system was introduced to assess the hazard and risk of domestically circulating chemicals, whose hazard and risk have not discovered, and to classify them into banned or permission required substances, regulated substances, or work environment monitoring required substances based on

assessment results (Yu *et al.*, 2000; Yu & Lee, 2002). This system is to find out the hazard and risks of chemicals through government-led toxicology tests and to publicize the test results. It does not impose any separate obligations on employers. In addition, the Good Laboratory Practice (GLP) system was introduced to secure the reliability of test data to realize the regulation of chemicals based on hazard and risk assessment. It is different from the ones implemented by the other Ministries in that it is focused on protecting workers from the physical and chemical hazards by establishing GLP standards on testing physical and chemical characteristics of substances.

Since the Ministry of Labour revamped its Industrial Safety and Health Act, the regulation of chemicals can be made in an organized manner based on the hazard · risk assessment. The Ministry now has the systematic mechanism needed to select key substances out of the many hazardous substances present in the workplace and conduct researches and assessment each year with the KOSHA, academies, research institutes, etc. to establish and revise related standards regularly.

First, the Hazardous Agent Review Committee identifies substances needed to be specially controlled from the existing 37,000 chemicals based on the result of hazard-risk assessment, in which case they are classified into five different categories: banned substances, permission required substances, regulated substances, work environment

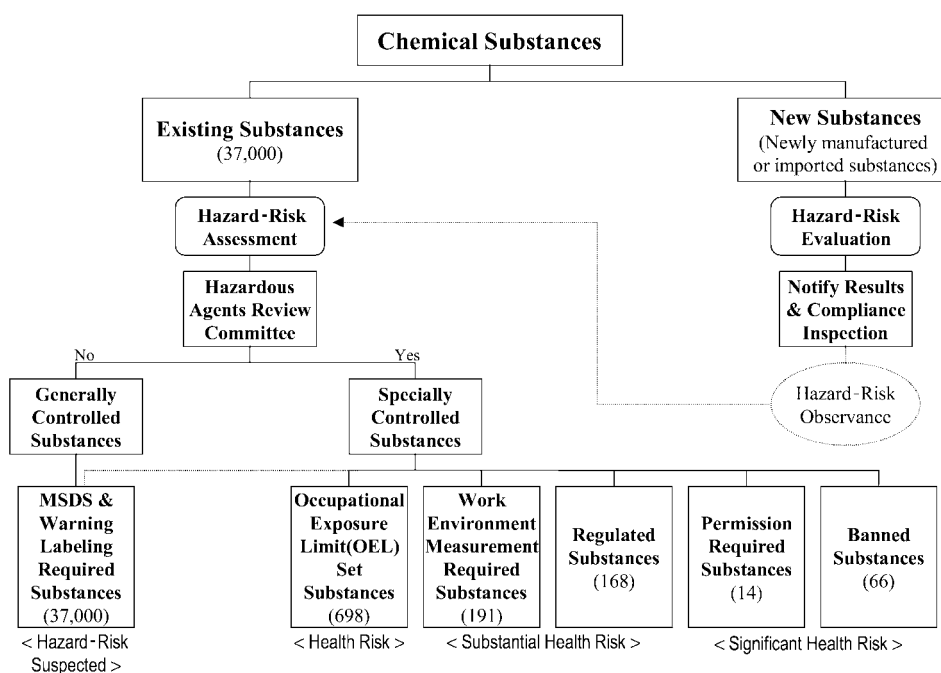


Fig. 2. Revised Chemical Regulatory System in Korea since July 2003

Table 2. List of banned and permission required substances in Industrial Safety and Health Act

| Classification | Banned Substances (n=66) | Permission required Substances (n=14) |
|------------------------------|---|--|
| Existing chemicals | Yellow phosphorous match, Benzidine and its salts, 4-Aminodiphenyl and its salts, 4-Nitrodiphenyl and its salts, Bis(chloromethyl) ether, β -Naphthylamine and its salts, Crocidolite asbestos and Amosite asbestos, Rubber glue containing benzene (excluding those whose volume ratio of benzene is less than 5 percent) | Dichlorobenzidine and its salts, α -Naphthylamine and its salts, <i>o</i> -Tolidine and its salts, Dianisidine and its salts, Beryllium, Benzotrchloride, Asbestos (excluding Crocidolite asbestos and Amosite asbestos) |
| Removed chemicals | Benzidine and its salts, 4-Aminodiphenyl and its salts, Bis(chloromethyl) ether (removed since these are prohibited under the Toxic Chemicals Control Act) | Polychlorinated biphenyls (PCBs) (removed since PCBs is now classified as Banned substance under the Toxic Chemicals Control Act) |
| Additionally added chemicals | Paint containing white lead (excluding those whose volume ratio of white lead is less than 5 percent), Polychlorinated terphenyl(PCT), Actinolite asbestos, Anthophyllite asbestos, Tremolite asbestos, Substances prohibited from being manufactured, imported or used under Article 11(1) of the Toxic Chemicals Control Act [†] | Zinc chromates, Arsenic and its inorganic compound, Chromite ore (limited to the case of plastic treatment by adding heat thereto), Chromium(VI), Coal tar pitch volatiles, Nickel sulfide, Vinyl chloride, Asbestos (excluding Actinolite asbestos, Anthophyllite asbestos, Tremolite asbestos) |

[†]: Chemicals prohibited from being manufactured, imported or used under Article 11(1) of the Toxic Chemicals Control Act[†] (n=55) : 2-Naphthylamine, Nitrofen, Dialifos, DDT, Dimethoate, 1,2-Dibromoethane, 1,2-Dibromo-3-chloropropane, Disulfoteon, Dieldrin, Leptophos, Methamidophos, Monocrotophos, Benzidine, Lead arsenate, Bis (2-chloroethyl) ether, Bis (chloromethyl) ether, Strychnine, 4-Aminobiphenyl, Thallium acetate, Phenylmercuric acetate, Acrinathrin, Antu, Aldrin, Aldicarb, Endosulfan, Endrin, Isobenzan, Aluminium phosphide, Tallium nitrate, Camphochlor, Captafol, Captan, Chlorobenzilate, Chloropicrin, Chlorodane, Chlorodimeform, Tris (2,3-dibromoprophyl) phosphate, Trifluralin, 2,4,5-T, Paraquat salts, Methyl parathion, Parathion, Phenylmercuric triethanol ammonium borate, Pentachlorophenol, Fenpyroximate, Phosphamidon, Fluazinam, Fluoroacetamide, Pyraclofos, Pymiminil, PBBs, PolyChlorinated Biphenyls, Hexacyclohexane, Heptachlor, Thallium Sulfate.

monitoring required substances, occupational exposure limit set substances for regulatory purposes. For the chemicals identified by the Committee as generally controlled substances, only MSDS and warning label obligations are imposed. With regard to new chemicals, hazard-risk evaluation is conducted first, and then if needed, detail assessment to determine the hazard and risk level is performed for classification into general or specially controlled substances. Figure 2 shows the revised chemical regulatory system.

Banned substances from manufacturing, etc.

Eight chemicals, known to be carcinogenic and to inflict serious health impairment upon workers such as β -Naphthylamine, have been prohibited from being manufactured, imported, and used in the workplace since Industrial Safety and Health Act enactment. However, there were many controversies over the clear evidence and reasoning behind its classification standard. In a response to that, the clear selection criteria for the strictly banned substances were set up. For the chemical to be classified as banned substances, it has to fall under any of the three following criteria. First, it has to be a substance proven to

cause occupational cancer and identified as especially hazardous to worker's health. Second, it has to be a substance likely to cause significant health risk to workers based on the results of hazard · risk assessment under Article 39 or hazard-risk evaluation under Article 40 of Industrial Safety and Health Act. Third, it can be any substance likely to cause significant health risk to workers as determined by the Presidential Decree. If the chemical falls under any one of above criteria, it can be classified as banned chemical after the review of Industrial Safety and Health Policy Deliberation Committee set up by Article 7 of Industrial Safety and Health Act. Also, previous 9 prohibited substances were changed with 66 banned substances by adding Polychlorinated terphenyl (PCT) from International Labour Organization (ILO) Convention 13 (White Lead Painting Convention, 1921) and Prior Informed Consent (PIC) and 55 prohibited substances from Toxic Chemical Control Act (Table 2). However, legal import and restricted usage was granted for the further development of chemical industries if such banned substances are to be imported, manufactured or used for test or research purpose only under the appropriate laboratory condition after acquiring Labour Minister's permission in advance.

Permission required substances for manufacturing, etc.

If anyone desires to manufacture, use, dismantle or remove any permission required substances such as asbestos, he/she needs to obtain the permission from the Labour Minister in advance after equipped with appropriate facilities.

Permission required substances has the similar significant health hazard and risk to banned substances, but either its substituting material has not been developed or banning them entirely will cause significant effect to national economy and industry. Therefore, its selection criteria and procedure is same as banned chemical. Six new chemicals, determined to be carcinogenic by American Conference of Governmental Industrial Hygienists (ACGIH), were added to the list of permission required substances increasing the total number of permission required substances from 8 to 14. Also, based on the ILO Convention 162 (Asbestos Convention, 1986), it is now also required to obtain the permission from the Labour Minister in advance before demolition of plants or structures containing friable asbestos insulation materials and removal of asbestos from buildings or structures in which asbestos is liable to become airborne (Table 2).

Regulated substances

Formerly, the country's regulated substances included 54 organic solvents, 53 Specified chemicals, lead, tetraalkyl lead, and dust similar to those under Japan's Industrial Safety and Health Law. However, some of those chemicals have never been manufactured or used in Korea, and others, which caused significant health risk to workers, were not properly regulated under the previous system. Therefore, the scope of regulated substances was revised to exclude those chemicals that have never been manufactured or used in the country and expanded from 109 to 168 chemicals by including chemicals that have caused occupational diseases and those which are likely to pose significant health risks to workers in case of exposure. In particular, in the full-scale revision of the Ministry of Labour Ordinance on Industrial Health, new chapter called "Prevention of Health Hazards caused by Regulated Substances" was added to specify detail requirement for employers such as appropriate facilities standard, management method, personal protective equipments along with separate chapters for banned substances and permission required substances (Appendix 1). Finally, one major change in the new regulatory system is its systematic classification of regulated substances into organic compounds (113), metals (23), acid and alkali (17), and gaseous agents (15) based on its characteristics unlike previous unclear classification method of organic solvents, specified chemicals, etc.

Work environment monitoring required substances and their management

Korean Industrial Safety and Health Act requires employers to monitor and evaluate the work environment of those workplaces where workers are exposed to hazardous substances and then to report its results to the Labour Minister every 6 month. Flexible monitoring period system was introduced recently to give incentive to employers to improve its workplaces on his/her own initiative. If any one of the monitoring results turned out to be exceeding occupational exposure limit (OEL) by 2 times (1 time for carcinogens), the monitoring period has to be shortened to every 3 month for entire workplace. On the other hand, if the monitoring results for entire workplace show that they are below OEL altogether two times in a row, the period can be stretched out to 12 months.

The scope of work environment monitoring required substances was revised and expanded to include a total of 191 substances, which is composed of 168 regulated chemicals, 14 permission required chemicals, 6 dust-causing materials, metal working fluid, noise, and heat (Appendix 2). In addition to its expansion of chemicals, workplaces subject to monitoring were also expanded from indoor spaces to include outdoor places to protect workers working outside of buildings from exposure to chemicals.

Workplaces exceeding occupational exposure limit are specially managed by compliance officers in the regional and area Labour offices throughout the country until the work environment is determined to be improved significantly. Along with the strong compliance, the public corporation, Korea Occupational Safety and Health Agency (KOSHA), provides needed technical assistance to small and medium-sized enterprises with limited capacities in manpower, facilities and expertise.

Establishment and revision of occupational exposure limit for chemicals

With regards to 698 chemicals that can cause harm to workers, the Ministry of Labour establishes and notifies occupational exposure limit (OEL) in workplaces. The OEL is different from the Permissible Exposure Limit (PEL) by the Occupational Safety and Health Administration (OSHA) in the United States, which is used as a legal regulatory measure in that country. Rather, it is a recommendation in terms of its legal status in Korea, serving as a standard for work environment improvement, drawn up on the basis of work environment monitoring results. However, if the workplace is determined to be above OEL, the employers have to take the considerable measures such as the installation

Table 3. Annual Performance of Hazard · Risk Evaluation

| Year | '92 | '93 | '94 | '95 | '96 | '97 | '98 | '99 | '00 | '01 | '02 | '03.11 | Total |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|--------|-------|
| New Chemicals | 14 | 22 | 66 | 57 | 132 | 240 | 199 | 153 | 308 | 341 | 311 | 277 | 2,120 |

and improvement of facilities and equipment for the protection of the worker's health. One important advancement in Korea's industrial health in 2003 is that the OELs on asbestos and benzene were dramatically strengthened to 0.1 fiber/cc (from 2 fiber/cc) and 1 ppm (from 10 ppm), respectively, starting from July 2003 after the consensus among labor, management and government due to the increased health risk of exposure, including cancer occurrence amongst workers handling these chemicals.

Material safety data sheets

The Material Safety Data Sheets (MSDS), which was implemented in July 1996, was designed to secure the right of workers handling chemicals to know the hazard and risk of those substances. It was expanded to include workplaces with fewer than 5 employees in August 2000. The purpose of the MSDS is to inform workers of the hazard and risk of chemicals through announcement, education, and warning labels and to provide information to enable workers to promptly respond to unexpected accidents and protect themselves. For the MSDS system to take its root in the country, large-scale training efforts, targeting employers who manufacture, import, or use those substances, are being made, and pamphlets to provide information about the system are published and distributed to relevant workplaces every year. In addition, in order to help employers draw up the MSDS, a Korean MSDS for about 50,400 chemicals out of all substances circulating in the nation was built into a database and is being provided via the internet homepage for free of charge.

Hazard-risk evaluation for new chemical

The purpose of hazard · risk evaluation of new chemicals is to prevent domestic workers, who handle hazardous chemicals imported indiscreetly from developed countries, from being exposed to health risks. Hazard and risk of new chemical are evaluated before manufacturing or import, and its evaluation results are notified to the concerned employers to take appropriate protection measures for workers in advance. This evaluation system is not a post factum regulation system, which seeks remedies after occupational diseases and other social problems occurred by new chemicals. It is a system focused on the prevention of

occupational diseases by regulating new chemicals in advance. From the start in July 1991 to November 2003, a total of 2,120 new chemicals have gone through the evaluation (Table 3).

Work environment status national survey

The national survey is conducted every 5 yr to gather basic data for establishment and enforcement of industrial health measures in accordance with the comprehensive occupational disease prevention plan enacted by the Ministry of Labour in 1991. The 1st survey was conducted in 1993 on 52,522 manufacturing companies with more than 5 employees, which are insured to an industrial accident compensation insurance. The 2nd survey was conducted on 52,070 companies in 1999, 6 yr after the 1st effort, due to the financial crisis in 1998. The areas of survey included are the general state of workplaces, work process flow, its safety management status, hazardous · dangerous machinery and equipment possession status, and the status of handling chemicals, and the actual workplace visit survey was in principle performed. Survey results were structured to allow continued modifications and supplements by using the newly developed database program. With the scope of the Industrial Safety and Health Act expanded to include workplaces with one or more employees from August 2000, a work environment status national survey is planned for manufacturing companies with one or more full-time employees in 2004.

Future Tasks & Research Direction

As the scope of chemicals regulated under the Industrial Safety and Health Act was revised and expanded recently, the Chemical Information Card (CIC), which provides an one-page summarized information about the hazards and risks of chemicals and the handling precaution of these substances to help worker's understanding about the chemicals they are dealing with, was developed for each specially controlled chemical and distributed to relevant workplaces. In addition, as compensation for damage issues between the labor and the management are likely to occur a lot because of the insufficient descriptions and explanations in Material Safety Data Sheets (MSDS) and warning labels

after the enforcement of the Producer Liability Act, a research effort to validate the reliability of the contents of MSDS is being pursued with the Occupational Safety and Health Research Institute (OSHRI) playing a central role in the effort. Also, considering the importance of providing information about chemicals, efforts have started to establish the Chemical Safety Data Sheets (CSDS) Center within the OSHRI by year 2004 to provide accurate safety information and education to employers and workers. The center will perform overall management of the MSDS system, which includes performing physical and chemical characteristics tests, updating the MSDS database, validating the reliability of MSDS, and operating MSDS education programs.

The 1992 UN Conference on Environment and Development (UNCED) adopted and recommended 6 action items, which emphasized national and international efforts for sound management of chemical substances (Agenda 21, Chapter 19). In line with this recommendation, the UNCED pursued to establish a Globally Harmonized System for classification and labeling of chemicals (GHS), which unifies globally the classification of chemicals, warning labels, and safety data sheets, in cooperation with the Organization for Economic Cooperation and Development (OECD) and the International Labour Organization or ILO through the Interorganization Programme for the Sound Management of Chemicals (IOMC) from 1992 to 2001. Recently, the IOMC released a final GHS draft in its manual publication and is now conducting post-production efforts for its international implementation. The World Summit on Sustainable Development (WSSD) adopted Plan of Action to have the new GHS system globally operational by 2008. Last year, 15 member countries of the European Union or EU, Australia, and New Zealand resolved to implement the GHS from 2005, while in the Asian region, there is still no

visible movement for its implementation, and only separate research efforts are being made by each nation.

In the mean time, Korea plans to draft a standard for hazardous chemicals classification and warning labels, which is compatible with those of developed countries, including EU member countries, based on the final GHS draft released by the UN early this year, and to finish the legal revision by the end of 2005.

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Appendix 1. Regulated Substances

1. Chemical agent

A. Organic compounds (n=113)

- (1) Glutaraldehyde
- (2) Nitroglycerin
- (3) Nitromethane
- (4) Nitrobenzene
- (5) p-Nitroaniline
- (6) p-Nitrochlorobenzene
- (7) Dinitrotoluene
- (8) Dimethylaniline
- (9) Dimethylamine
- (10) N,N-Dimethylacetamide
- (11) Dimethylformamide
- (12) Diethanolamine
- (13) Diethylene triamine
- (14) 2-Diethylaminoethanol
- (15) Diethyl ether
- (16) Diethylamine
- (17) 1,4-Dioxane, Diethyl dioxide
- (18) Diisobutylketone
- (19) Dichloromethane
- (20) o-Dichlorobenzene
- (21) 1,2-Dichloroethylene
- (22) Dichlorofluoromethane
- (23) 1,1-Dichloro-1-fluoroethane
- (24) Dihydroxybenzene
- (25) 2-Methoxyethanol
- (26) 4,4'-Methylenedi(bis) phenyl diisocyanate
- (27) Methyl amine
- (28) Methyl alcohol
- (29) Methyl ethyl ketone
- (30) Methyl isobutyl ketone
- (31) Methyl chloride
- (32) Methyl n-butyl ketone
- (33) Methyl n-amylketone
- (34) o-Methyl cyclohexanone
- (35) Methyl cyclohexanol
- (36) Methyl chloroform
- (37) Maleic anhydride
- (38) Phthalic anhydride
- (39) Benzene
- (40) 1,3-Butadiene
- (41) sec-Butyl alcohol
- (42) n-Butyl alcohol
- (43) 1-Bromopropane
- (44) 2-Bromopropane
- (45) Methyl bromide
- (46) Vinyl acetate
- (47) Carbon tetrachloride
- (48) Styrene
- (49) Cyclohexanone
- (50) Cyclohexanol
- (51) Cyclohexane
- (52) Cyclohexene
- (53) Aniline & homologues
- (54) Acetonitrile
- (55) Acetone
- (56) Acetaldehyde
- (57) Acrylonitrile
- (58) Acrylamide
- (59) Allylglycidylether
- (60) Ethanolamine
- (61) Ethyl benzene
- (62) Ethylamine
- (63) Ethyl acrylate
- (64) Ethylene glycol dinitrate
- (65) 2-Methoxyethyl acetate, EGMEA
- (66) 2-Ethoxy ethanol, EGEE
- (67) 2-Ethoxyethylacetate, EGEEA
- (68) 2-Butoxyethanol, EGBE
- (69) Ethylene glycol mono butyl acetate
- (70) Ethylene glycol
- (71) Ethylene chlorohydrin
- (72) Ethyleneimine
- (73) 2,3-Epoxy-1-propanol
- (74) 1,2-Epoxypropane
- (75) Epichlorohydrin
- (76) Methyl iodide
- (77) Isobutyl alcohol
- (78) Isoamyl alcohol
- (79) Isopropyl alcohol
- (80) Ethylene dichloride
- (81) Carbon disulfide
- (82) Methyl acetate
- (83) n-Butyl acetate
- (84) Ethyl acetate
- (85) n-Propyl acetate
- (86) Isobutyl acetate
- (87) Isopropyl acetate
- (88) Isoamyl acetate
- (89) Cresol, all isomers
- (90) Xylene, o,m,p-isomers
- (91) Chlorobenzene
- (92) 1,1,2,2-Tetrachloroethane
- (93) 1,1,2-Trichloroethane
- (94) 1,2,3-Trichloropropane

- (95) Tetrahydrofuran
- (96) Toluene
- (97) Toluene-2,4-diisocyanate
- (98) Toluene-2,6-diisocyanate
- (99) Triethylamine
- (100) Trichloromethane
- (101) Trichloroethylene
- (102) Perchloroethylene
- (103) Phenol
- (104) Pentachlorophenol
- (105) Formaldehyde
- (106) Stoddard solvent
- (107) Propylene imine
- (108) Pyridine
- (109) Hydrazine
- (110) Hexamethylene diisocyanate
- (111) Hexane, n-hexane
- (112) Heptane, n-Heptane
- (113) Dimethylsulfate
- (114) Preparations containing more than one percent of any substance (1) through (113)

B. Metals (n=23)

- (1) Copper and compounds
- (2) Lead and inorganic compounds
- (3) Nickel and compounds
- (4) Manganese and inorganic compounds
- (5) Barium and soluble compounds
- (6) Platinum and compounds
- (7) Magnesium oxide
- (8) Selenium and compounds
- (9) Mercury and compounds
- (10) Zinc and compounds
- (11) Antimony and compounds
- (12) Aluminum and compounds
- (13) Iodine
- (14) Silver and compounds
- (15) Titanium dioxide
- (16) Tin and compounds
- (17) Zirconium and compounds
- (18) Iron and compounds
- (19) Cadmium and compounds
- (20) Cobalt and inorganic compounds
- (21) Chromium and inorganic compounds
- (22) Tungsten and compounds
- (23) Preparations containing more than one percent of any substance (1) through (23)

C. Acid and alkali (n=17)

- (1) Formic acid
- (2) Hydrogen peroxide
- (3) Acetic anhydride
- (4) Hydrogen fluoride
- (5) Hydrogen bromide
- (6) Sodium hydroxide
- (7) Potassium hydroxide
- (8) Sodium cyanide
- (9) Potassium cyanide
- (10) Calcium cyanide
- (11) Acrylic acid
- (12) Hydrogen chloride
- (13) Phosphoric acid
- (14) Nitric acid
- (15) Acetic acid
- (16) Trichloro acetic acid
- (17) Sulfuric acid
- (18) Preparations containing more than one percent of any substance (1) through (17)

D. Gaseous agents (n=15)

- (1) Fluorine
- (2) Bromine
- (3) Ethylene oxide
- (4) Arsine
- (5) Hydrogen cyanide
- (6) Ammonia
- (7) Chlorine
- (8) Ozone
- (9) Sulfur dioxide
- (10) Nitrogen dioxide
- (11) Nitric oxide
- (12) Carbon monoxide
- (13) Phosgene
- (14) Phosphine
- (15) Hydrogen sulfide
- (16) Preparations containing more than one percent of any substance (1) through (15)

Appendix 2. Work Environment Monitoring required Substances

1. Chemical agent

A. Organic compounds (n=113)

- (1) Glutaraldehyde
- (2) Nitroglycerin
- (3) Nitromethane
- (4) Nitrobenzene

- (5) p-Nitroaniline
- (6) p-Nitrochlorobenzene
- (7) Dinitrotoluene
- (8) Dimethylaniline
- (9) Dimethylamine
- (10) N,N-Dimethylacetamide
- (11) Dimethylformamide
- (12) Diethanolamine
- (13) Diethylene triamine
- (14) 2-Diethylaminoethanol
- (15) Diethyl ether
- (16) Diethylamine
- (17) 1,4-Dioxane, Diethyl dioxide
- (18) Diisobutylketone
- (19) Dichloromethane
- (20) o-Dichlorobenzene
- (21) 1,2-Dichloroethylene
- (22) Dichlorofluoromethane
- (23) 1,1-Dichloro-1-fluoroethane
- (24) Dihydroxybenzene
- (25) 2-Methoxyethanol
- (26) 4,4'-Methylenedi(bis) phenyl diisocyanate
- (27) Methyl amine
- (28) Methyl alcohol
- (29) Methyl ethyl ketone
- (30) Methyl isobutyl ketone
- (31) Methyl chloride
- (32) Methyl n-butyl ketone
- (33) Methyl n-amylketone
- (34) o-Methyl cyclohexanone
- (35) Methyl cyclohexanol
- (36) Methyl chloroform
- (37) Maleic anhydride
- (38) Phthalic anhydride
- (39) Benzene
- (40) 1,3-Butadiene
- (41) sec-Butyl alcohol
- (42) n-Butyl alcohol
- (43) 1-Bromopropane
- (44) 2-Bromopropane
- (45) Methyl bromide
- (46) Vinyl acetate
- (47) Carbon tetrachloride
- (48) Styrene
- (49) Cyclohexanone
- (50) Cyclohexanol
- (51) Cyclohexane
- (52) Cyclohexene
- (53) Aniline & homologues
- (54) Acetonitrile
- (55) Acetone
- (56) Acetaldehyde
- (57) Acrylonitrile
- (58) Acrylamide
- (59) Allylglycidylether
- (60) Ethanolamine
- (61) Ethyl benzene
- (62) Ethylamine
- (63) Ethyl acrylate
- (64) Ethylene glycol dinitrate
- (65) 2-Methoxyethyl acetate, EGMEA
- (66) 2-Ethoxy ethanol, EGEE
- (67) 2-Ethoxyethylacetate, EGEEA
- (68) 2-Butoxyethanol, EGBE
- (69) Ethylene glycol mono butyl acetate
- (70) Ethylene glycol
- (71) Ethylene chlorohydrin
- (72) Ethyleneimine
- (73) 2,3-Epoxy-1-propanol
- (74) 1,2-Epoxypropane
- (75) Epichlorohydrin
- (76) Methyl iodide
- (77) Isobutyl alcohol
- (78) Isoamyl alcohol
- (79) Isopropyl alcohol
- (80) Ethylene dichloride
- (81) Carbon disulfide
- (82) Methyl acetate
- (83) n-Butyl acetate
- (84) Ethyl acetate
- (85) n-Propyl acetate
- (86) Isobutyl acetate
- (87) Isopropyl acetate
- (88) Isoamyl acetate
- (89) Cresol, all isomers
- (90) Xylene, o,m,p-isomers
- (91) Chlorobenzene
- (92) 1,1,2,2-Tetrachloroethane
- (93) 1,1,2-Trichloroethane
- (94) 1,2,3-Trichloropropane
- (95) Tetrahydrofuran
- (96) Toluene
- (97) Toluene-2,4-diisocyanate
- (98) Toluene-2,6-diisocyanate
- (99) Triethylamine
- (100) Trichloromethane
- (101) Trichloroethylene
- (102) Perchloroethylene

- (103) Phenol
 - (104) Pentachlorophenol
 - (105) Formaldehyde
 - (106) Stoddard solvent
 - (107) Propylene imine
 - (108) Pyridine
 - (109) Hydrazine
 - (110) Hexamethylene diisocyanate
 - (111) Hexane, n-hexane
 - (112) Heptane, n-Heptane
 - (113) Dimethylsulfate
 - (114) Preparations containing more than one percent of any substance (1) through (113)
- B. Metals (n=23)**
- (1) Copper
 - a) Fume
 - b) Dusts and Mists, as Cu
 - (2) Lead and inorganic compounds, as Pb
 - (3) Nickel, as Ni
 - a) Elemental
 - b) Soluble inorganic compounds
 - c) Insoluble inorganic compounds
 - d) Nickel carbonyl
 - (4) Manganese and inorganic compounds, as Mn
 - (5) Barium and soluble compounds, as Ba
 - (6) Platinum
 - a) Metal
 - b) Soluble salts
 - (7) Magnesium oxide
 - (8) Selenium and compounds, as Se
 - (9) Mercury, as Hg
 - a) Alkyl compounds
 - b) Aryl compounds
 - c) Elemental and inorganic forms
 - (10) Zinc oxide
 - a) Fume
 - b) Dust
 - (11) Antimony and compounds, as Sb
 - (12) Aluminum and compounds, as Al
 - (a) Metal dust
 - (b) Pyro powders
 - (c) Fume
 - (d) Soluble salts
 - (e) Alkyls, NOS
 - (13) Iodine
 - (14) Silver
 - (a) Metal
 - (b) Soluble compounds, as Ag
- (15) Titanium dioxide
 - (16) Tin, as Sn
 - (a) Metal
 - (b) Oxide & inorganic compounds, except tin hydride
 - (c) Organic compounds
 - (17) Zirconium and compounds, as Zr
 - (18) Iron oxide dust and fume, as Fe
 - (19) Cadmium and compounds, Cd
 - (20) Cobalt and inorganic compounds, as Co
 - (21) Chromium and inorganic compounds, as Cr
 - (a) Metal and Cr III compounds
 - (22) Tungsten, as W
 - (a) Metal and insoluble compounds
 - (b) Soluble compounds
 - (23) Vanadium pentoxide
 - (a) Dust and fume
 - (24) Preparations containing more than one percent of any substance (1) through (23)
- C. Acid and alkali (n=17)**
- (1) Formic acid
 - (2) Hydrogen peroxide
 - (3) Acetic anhydride
 - (4) Hydrogen fluoride
 - (5) Hydrogen bromide
 - (6) Sodium hydroxide
 - (7) Potassium hydroxide
 - (8) Sodium cyanide
 - (9) Potassium cyanide
 - (10) Calcium cyanide
 - (11) Acrylic acid
 - (12) Hydrogen chloride
 - (13) Phosphoric acid
 - (14) Nitric acid
 - (15) Acetic acid
 - (16) Trichloro acetic acid
 - (17) Sulfuric acid
 - (18) Preparations containing more than one percent of any substance (1) through (17)
- D. Gaseous agents (n=15)**
- (1) Fluorine
 - (2) Bromine
 - (3) Ethylene oxide
 - (4) Arsine
 - (5) Hydrogen cyanide
 - (6) Ammonia
 - (7) Chlorine
 - (8) Ozone

- (9) Sulfur dioxide
- (10) Nitrogen dioxide
- (11) Nitric oxide
- (12) Carbon monoxide
- (13) Phosgene
- (14) Phosphine
- (15) Hydrogen sulfide
- (16) Preparations containing more than one percent of any substance (1) through (15)

E. Permission required substances by Presidential Decree

Article 30 of Industrial Safety and Health Act (n=14)

- (1) Dichlorobenzidine and its salts
- (2) α -naphthylamine and its salts
- (3) Zinc chromate, as Cr
- (4) o-Tolidine and its salts
- (5) Dianisidine and its salts
- (6) Beryllium & compounds
- (7) Arsenic and inorganic compounds, as As
- (8) Chromite ore processing (chromate), as Cr
- (9) Chromium VI, as Cr
 - (a) Water soluble Cr VI compounds
 - (b) Insoluble Cr VI compounds
- (10) Coal tar pitch volatiles, as benzene soluble aerosol
- (11) Nickel subsulfide, as Ni
- (12) Vinyl chloride
- (13) Benzotrithloride
- (14) Asbestos, crysotile
- (15) Preparations containing more than one percent of any substance (1) through (14). Except, preparations containing more than 0.5 percent of substance (13)

F. Dusts (n=6)

- (1) Mineral dusts
 - (a) Silica
 - 1) Quartz
 - 2) Cristobalite
 - 3) Trydimite
 - (b) Silicates, less than 1% crystalline silica
 - 1) Mica
 - 2) Potland cement
 - 3) Soap stone
 - 4) Talc, non-asbestiform
 - 5) Graphite
 - (c) Inert or nuisance particulates
- (2) Grain dust
- (3) Cotton dust
- (4) Wood dust
 - (a) Soft wood
 - (b) Hard wood
- (5) Welding fume
- (6) Glass fiber

G. Metal working fluids (n=1)

2. Physical agents (n=2)

- A. Noise above 80dBA level in 8 h time weighted average
- B. Heat defined in Chapter 7 of the Ministry of Labour Ordinance on Industrial Health

3. Other hazardous agents to worker's health made public by the Labour Minister