

Risk Management and Regulatory Control of Toxic Chemicals in Taiwan

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In this paper, we describe the evolution of Toxic Chemical Substances Control Act (TCSCA) regulated by Taiwan Environmental Protection Administration during the past two decades. The TCSCA was originally drafted for the management of utilization and operation of toxic chemical substances from cradle to grave. Following the 921 earthquake in central Taiwan in 1999, the newly issued Disaster Prevention and Mitigation Act further required that the risk management and disaster mitigation from all listed toxic chemicals must also be regulated in TCSCA. Since then, significant modification in the Act and new regulations are added and implemented. In addition, Taiwan EPA is also established information and monitoring centres and seven emergency response teams. These facilities provide 24-hour service and have at least 25 people on duty at all times. The main tools used by these facilities are environmental monitoring equipment, personal protection equipment, and response equipment for leak patching and chemical transfer. The increased regulatory control and response capabilities have greatly reduce the occurrence and potential impact from toxic chemicals incidents as evident from the incident statistics.

1. Introduction to Toxic Chemicals Control Act in Taiwan

Taiwan is a well-populated island stocked with industries ranging from refineries, petrochemicals, specialty chemicals, pharmaceuticals, semiconductor fabrication, and electronics manufacturing, etc. All these industries rely heavily on the use or production of chemicals. Although the rapid industrial development brings prosperity to the people, it also brings adverse effects such as pollution and, more recently, the disasters from the use or production of chemicals.

The Environmental Protection Administration (EPA) of Executive Yuan, ROC Taiwan, is in charge of the implementation of Toxic Chemical Substances Control Act (TCSCA) (EPA, 2012a) since its promulgation in 1986. The Act aims to reduce the potential hazards and prevent potential pollution from the use of these chemicals. Under the Act, the Taiwan EPA has currently declared 298 toxic chemicals under state control. The number is increased at a rate of about 10 chemicals per year as shown in Figure 1. Licenses are required for the manufacturing, import, sale, and use of these toxic chemicals. The TCSCA was originally drafted for the management of utilization and operation of toxic chemical substances from cradle to grave. Article 24 of the Act also requires that persons handling the toxic chemical substances shall immediately take emergency measures and report to the Responsible Agencies at the local government level where the accident occurred, within one hour of the occurrence of one of the following incidents:

1. Pollution of the environment surrounding the handling site as the result of chemical leaking, reactions, or other incidents; or
2. Potential pollution of the environment or endangerment of human health as the result of accidents occurring during toxic chemical substance transportation.

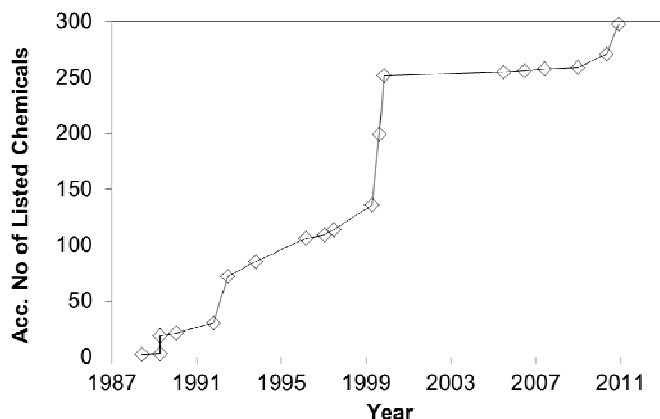


Figure 1: Number of listed toxic chemicals.

The Responsible Agency shall order persons handling toxic chemical substances to take necessary measures addressing the aforementioned incidents, and may order such persons to partially or totally terminate handling of the substances upon the occurrence of the incidents. The persons handling toxic chemical substances shall, after the incidents, be responsible for cleaning up according to relevant regulations and shall submit a written report describing the incidents and the remedial measures taken to the Responsible Agency at the local government level where the accident occurred for reference. Clearly, the Act has required the operating facilities to be responsible for the response and clean up in case of incident occurrence. The requirement, however, has posed a significant burden for small facilities that have very limited resources, experience, and capabilities. Unfortunately, small facilities represent more than 90 % of the total facilities using the listed toxic chemicals.

After the implementation of the Disaster Prevention and Response Act (NDPPC, 2002) in 1999, the Taiwan EPA is also in charge of disaster prevention and response of toxic chemicals. Thus, Taiwan EPA contracted the Centre for Environmental, Safety, and Health Technology (CESH) of Industrial Technology Research Institute (ITRI) for the level-one response service to the whole island, namely providing necessary response information service over the phone, fax, or internet to the incident facilities. The information provided includes the materials safety datasheets (MSDS), the emergency response guidelines, selection of personal protective equipment etc. The level-one response service has helped the local EPA office and fire brigades to handle the response properly till early 2001.

2. Toxic Chemical Substance Control Act Between 2001 and 2007

2.1 The initiation of on-scene response aids

In May 2001, a runaway reaction incident (Kao and Hu, 2002) in an acrylic plant in Hsinchu, northern Taiwan, resulted in 1 fatality and 109 injuries and raised great awareness of the proper response of toxic chemical incidents. The explosion energy was estimated to be about 1000 kg TNT, implying a possible vapour cloud explosion from the runaway reactor. Glass windows of buildings within 500 m radius were shattered. The explosion and fire also resulted in significant fire, smoke, and chemical and gas spillage. The incident required significant response aids and monitoring equipment and were provided by ITRI which happened to be located in close proximity to the plant. ITRI provided, during the response and cleanup of this incident, the following support:

- On-scene technical advice for chemical spillage and clean up.
- On-scene coordination for locating resources such as personal protection equipment (PPE) from other operating facilities.
- On-scene air monitoring of smoke and chemical vapour by Fourier Transform Infrared (FTIR) spectroscopy.

The incident could have been worse if it occurred elsewhere, without the direct and prompt help from ITRI. EPA appreciated the importance of the on-scene response and decided in late 2001 to setup level-two response centres in northern, central, and southern Taiwan for a more prompt and direct response of toxic chemicals incidents. ITRI, National Yunlin University of Science and Technology (NYUST), and National Kaohsiung First University of Science and Technology (NKFUST) were chosen for the setup of joint

response centres in northern, central, and southern Taiwan, respectively. ITRI was chosen for its proven experience in emergency response while NYUST and NKFUST were chosen for their combined expertise in environmental and safety engineering.

In five years' time from 2002 to 2006, more than five hundred on-scene response services were provided. The incidents ranged from a leak of a toxic gas cylinder to a large-scale fire in a high-tech facility. The effective response service has greatly reduced the potential impact from these incidents. More details on the level-two response systems have been provided in Chen et al. (2003) and Chen (2010).

2.2 The Setup of Emergency Response Team

Although the three response centres did provide effective responses to the incidents, the growing number of incident has increased the burden and timing on the response work. In 2007, EPA proposed a Plan to Strengthen Toxic Chemical Safety Management and Incident Response which was ratified by the Executive Yuan. This involves commissioning the establishment of information and monitoring centres and seven Emergency Response Teams (ERTs) with increased staffs and equipment to reduce the response load and timing.

The responsible counties for the seven ERTs were divided according to geographic and traffic considerations. Taiwan is an island, with 70% of its land consisting of hills and mountains that spread from the north to the south, dividing the island into west and east areas. Traffic from west to east relies on three roads that cross the Central mountains. Among the seven teams, six teams are located in the west, while one team is located in the east, reflecting the fact that most industrial parks and small industries are also located in the west. The three ERTs in the northern and eastern part of Taiwan are operated by a response centre held by the Chung Yuan Christian University. The two ERTs in the central part of Taiwan are operated by a response centre in National Yunlin University of Science and Technology. The two ERTs in the southern part of Taiwan are operated by a response centre in National Kaohsiung First University of Science and Technology. In addition, there is one Information Centre and a Control Centre both operated by Industrial Technology Research Institute. Figure 2 shows the geographic location of the seven teams.

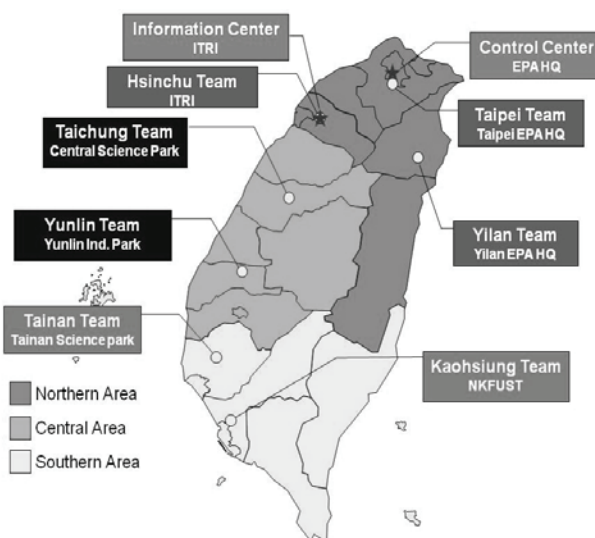


Figure 2: Geographic location of the seven ERTs. The separation line is the county borderline.

The primary objectives of the seven ERTs are as follows:

- Provide round-the-clock on-scene emergency response aid to a toxic chemical incident within one hour after the incident's occurrence. The aid includes technical advice, coordination of the response, PPE for the responders, kits for stopping leaks or spills, advice on clean up, etc.
- Provide on-scene air pollution monitoring. The monitoring equipment includes a portable GC-MS, a dual function open-path and closed-cell FT-IR spectrometer, photo-ionisation detector (PID), flame-ionisation detector (FID), multiple gas detector, and detection tubes.
- Provide surface water, soil, solid waste analysis at the incident site. The analytical equipment includes a headspace module of portable GC-MS for water and solid waste or soil, a Smith

Detection Identify IR for unknown solid, and a portable X-Ray Fluorescence (XRF) for heavy metal detection.

- Provide assistance for incident investigation.

The other objectives of the ERTs include but are not limited to:

- Provide non-emergency information service to local EPA bureaus.
- Hold response training courses for persons in charge of toxic chemical management in operating facilities.
- Assist large-scale drills for the response of toxic chemicals in each county.
- Assist local EPA officers in inspecting and auditing the operating facilities.

In addition to the seven ERTs, an Information Centre is also set up to provide safety related information during emergency response and non-emergency inquiries. The Information Centre also holds all relevant information from every toxic chemical operating facility. This information helps to assess the operating facilities should an incident occur. Another Control Centre is also set up directly in the EPA headquarters to help EPA officers in acquiring photos or video clips from the incident, monitoring the progress of the incident, and assessing the impact from the incident. Both centres are operated by Industrial Technology Research Institute.

For the service to be effective and prompt, it is necessary that the ERTs are promptly notified of the incident. Article 24 of the Toxic Chemical Substances Control Act (EPA, 2012a) has regulated that the operating facilities must report the incident to the local EPA office within one hour after occurrence. This is usually the case when the incident is caused directly by the listed toxic chemicals. In the cases when the incident was not caused directly by the listed toxic chemicals, the reporting may be delayed.

The best practice found is to have a direct link between the Information Centre and the local fire brigades where most incidents, regardless of the causes, were reported. Upon receiving incident messages from the fire brigade, the Information Centre immediately check and confirm for the chemicals involved and provide relevant information to the ERTs and the fire brigade. On-scene emergency response of the ERTs is activated, depending on the cause of the incident and possible chemicals involved.

Another rapid source of acquiring incident information is through the TV news. CNN-like TV news media in Taiwan are popular and compete vigorously for breaking news like a chemical incident. They usually arrived at the incident site almost the same time as the fire brigade and broadcasted the incident immediately with Satellite News Gathering (SNG) systems. Therefore, regular monitoring of the TV news is also done in the Information Centre.

The Taiwan EPA founded the seven ERTs through contracted projects. Each ERT has full-time staffs of sixteen people. EPA also provided directly the following equipment to each team:

- 20+ sets of Level A suits with self-contained breathing apparatus (SCBA).
- 1000+ sets of personal protection kits, each including a disposable Level C suit, a half-mask air-purifying respirator, a pair of chemical resistant gloves, and a chemical absorbent pad.
- 1 medium-size vans, 1 medium-size truck, and 1 large-size truck.
- 2 sets of portable four-gas detectors.
- 2 sets of direct-reading gas-detecting tubes covering all possible toxic gases or vapours
- A Photo-ionisation detector (PID) for continuous monitoring of air pollutant down to ppb level.
- A Flame-ionisation detector (FID) for the continuous monitoring of all flammable air pollutant down to sub-ppm level
- A portable FT-IR with dual open path and closed cell sampling loops for identification and monitoring of air pollutant down to ppm level at the incident site.
- A portable GC-MS system for the identification and monitoring of volatile organic chemicals at the incident site.
- A solid FTIR system for the identification of unknown waste or powder at the incident site.
- A portable X-Ray Fluorescence (XRF) for the detection of heavy metals in soil or solid waste at the incident site.
- Dispersion modelling tools with Gaussian models and models with terrain effects (Pontiggia et al., 2012; Gariazzo et al., 2012).

2.3 Regulatory control on toxic incidents

In addition to the ERT system that helps the operating facilities in responding to the toxic incidents, EPA also strengthen the regulatory control towards the response of toxic incidents. The new regulations issued in 2007 included:

- *Toxic Chemical Substances Accident Investigation and Disposal Report Operating Standards (EPA, 2012b)*

The handler of toxic chemical substances shall submit a preliminary accident investigation and disposal bulletin within three days after an accident occurs, and shall submit a summary accident investigation and disposal report within 14 days after the accident to the special municipality, county, or city competent authority in the area where the accident occurred for subsequent reference, and shall send copies to the central competent authority.

- *Toxic Chemical Substance Handling Liability Insurance Regulations (EPA, 2012c)*

When the total quantities of manufactured, used, stored, or transported toxic chemical substances exceed a specific quantity, the handler shall purchase liability insurance prior to handling.

Both regulations aimed at the enforcement of the handlers to have more liability and learning in an incident.

3. Further Stringent Management and Control of Toxic Incidents in Transportation

Although the establishment of the ERTs helped greatly the control of the toxic incidents, the number of responded incidents reached a record high in 2007, among which more than 20 % were transportation incidents as shown in Figure 3. The transportation incidents which consisted mainly tank truck incidents on the road not only require significant resources and efforts to respond but also put nearby communities into risk. Regulatory efforts were initiated in 2008 and revised regulations were issued for transportation of toxic chemicals.

- *Regulations Governing the Transportation Management of Toxic Chemical Substances (EPA, 2012d)*

A real-time tracking system shall be installed in transportation vehicles when the total quantities of transported toxic chemical substances exceed a specific quantity.

- *Regulations Governing the Establishment and Management of Dedicated Environmental Protection Units or Personnel (EPA, 2012e)*

When the total quantities of transported toxic chemical substances exceed a specific quantity, the carrier shall assign one Class C dedicated personnel, and shall provide the name of that dedicated personnel and the carrier he is employed by on the toxic chemical substance transport manifest.

- *Toxic Chemical Substances Hazard Prevention and Response Plan Regulations (EPA, 2012f)*

Owners of toxic chemical substances who carry out on their own or commission others to transport toxic chemical substances shall submit a transportation hazard prevention and response plan to the special municipality, county or city competent authority for future reference.

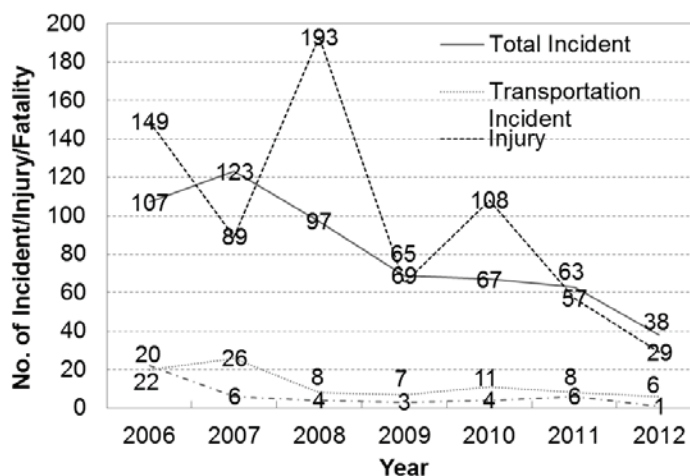


Figure 3: Analysis of number of incident from year 2006 and onward. Data for year 2012 is updated to August.

The stringent requirement on the management of toxic chemicals transportation drastically reduced the number of all transportation incidents, whether it was listed toxic chemicals or non-listed chemicals, from 26 incidents in 2007 to below 10 incidents after 2008. Overall numbers of injury and fatality from these incidents are also reduced. Training and education of truck drivers and toxic facility operators are increased as a result of the new regulations.

4. Conclusions

Growing industrial development has brought the growing need for the use of a wide range of toxic chemicals. Taiwan EPA implemented both regulatory measures as well on-scene response supports to minimize the potential impacts from toxic chemical incidents. The efforts have shown that the number of incidents has declined from 2009 but yet eliminated completely. Challenges remain with the proper response and prevention of incidents.

With the technical supports from Chung Yuan Christian University, National Yunlin University of Science and Technology, National Kaohsiung First University of Science and Technology, and the Industrial Technology Research Institute, Taiwan EPA is planning to further expand the regulatory control and support in the following two issues:

- A total solution to the incident response and recovery: Although the Toxic Chemical Substances Control Act requires the operating facilities to be responsible for the response and clean up in case of an incident, there remain small facilities with very limited staff that are unable to fulfil any response task. The well-equipped ERTs will play an increasing role in the incident response in these small facilities. The ERTs may also contract specialists to perform post-incident recovery and the cost will be compensated later through the facility or its insurer. The total solution from incident response and recovery will help to prevent any incident from endangering the environment.
- Establishment of training fields and training regulations for emergency response of toxic incidents: A comprehensive training field for toxic incident response is under construction in northern Taiwan to aid the training and education of tank truck drivers and toxic facility operators. Another two training fields are also under planning and will be built in central and southern Taiwan. All these three training fields are planned to be completed by 2015 and will be operated by the ERTs. Regulations are also planned to be issued that requiring toxic facility operators be trained in these training fields.

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