Lessons Learned for SME’s Process Safety Management

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The CPI in China

- The chemical process industry (CPI) in China has been the pillar industry.
- By the end of 2012, China boasted 26,000 petrochemical businesses.
  - Gross industrial output value US $2 trillion
  - 23.5% of China’s GDP
  - More than 90% are SMEs
- The CPI has presented a significant safety risk to human lives and the environment as well as sustainability.
## Ten years ago

### Comparison of death tolls and rates of industrial accidents between China and some other countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Death</th>
<th>Death rate (1/10^5)</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>5900</td>
<td>4.0</td>
<td>2001</td>
</tr>
<tr>
<td>Japan</td>
<td>1790</td>
<td>2.79</td>
<td>2001</td>
</tr>
<tr>
<td>Germany</td>
<td>1155</td>
<td>7.0</td>
<td>2001</td>
</tr>
<tr>
<td>Canada</td>
<td>882</td>
<td>7.1</td>
<td>2000</td>
</tr>
<tr>
<td>France</td>
<td>730</td>
<td>4.4</td>
<td>2000</td>
</tr>
<tr>
<td>Australia</td>
<td>198</td>
<td>2.0</td>
<td>2002</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>210</td>
<td>0.8</td>
<td>2001</td>
</tr>
<tr>
<td>Austria</td>
<td>122</td>
<td>4.5</td>
<td>2001</td>
</tr>
<tr>
<td>Denmark</td>
<td>50</td>
<td>2.0</td>
<td>2001</td>
</tr>
<tr>
<td>China</td>
<td>14,924</td>
<td>14.14</td>
<td>2002</td>
</tr>
<tr>
<td>Russia</td>
<td>4370</td>
<td>15.0</td>
<td>2001</td>
</tr>
<tr>
<td>Brazil</td>
<td>2503</td>
<td>11.5</td>
<td>2000</td>
</tr>
<tr>
<td>South Korea</td>
<td>1298</td>
<td>6.16</td>
<td>2001</td>
</tr>
<tr>
<td>Italy</td>
<td>1155</td>
<td>7.0</td>
<td>2000</td>
</tr>
<tr>
<td>Ukraine</td>
<td>1321</td>
<td>9.2</td>
<td>1999</td>
</tr>
<tr>
<td>Mexico</td>
<td>1502</td>
<td>12.0</td>
<td>2001</td>
</tr>
<tr>
<td>Argentina</td>
<td>915</td>
<td>18.6</td>
<td>2000</td>
</tr>
<tr>
<td>Malaysia</td>
<td>858</td>
<td>10.8</td>
<td>2002</td>
</tr>
<tr>
<td>Thailand</td>
<td>616</td>
<td>11.3</td>
<td>2000</td>
</tr>
<tr>
<td>Poland</td>
<td>510</td>
<td>5.0</td>
<td>2001</td>
</tr>
</tbody>
</table>

Lessons Learning

→ We learned our lessons the hard way

→ We need to learn lessons the smart way

→ Make changes

→ Lesson learning - a core value in the Chinese philosophy

→ Confucius ever said “In a group of three people, there is always something I can learn from”

→ In the area of chemical safety management, China has also learned many lessons from developed countries and international organizations
## More than 300 Chemical Safety Related Laws/Standards in the last decade (Partial List)

<table>
<thead>
<tr>
<th>Year</th>
<th>Law/Standard</th>
<th>Identification Standard of Major Hazard installations</th>
<th>Measures for the Administration of Registration of Hazardous Chemicals</th>
<th>Safety Regulations for Dangerous Chemical Goods</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>Law on the Prevention and Control of Atmospheric Pollution</td>
<td></td>
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<td></td>
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<tr>
<td>2001</td>
<td>Law on Prevention and Control of Occupational Diseases</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>2002</td>
<td>Work Safety Law</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2003</td>
<td>Law on Road Traffic Safety</td>
<td></td>
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<td></td>
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<tr>
<td>2004</td>
<td>Technical guidelines for environmental risk assessment on projects</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>Code for design of fire-dike in storage tank farm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2006</td>
<td>Guidelines for enterprises to develop emergency response plan for work place accidents</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>2007</td>
<td>Law on Emergency Responses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>Guideline of safety management system implementation for petrochemical corporation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>Identification Standard of Major Hazard installations (Revised)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>Guidelines for process safety management of petrochemical corporations</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Zeng SX et. Al., 2010, Journal of Cleaner Production

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Example Regulations based on Lessons Learned

Our first Work Safety Law released in 2002

- Many key articles in the Law
  - the duties of employers
  - The duties of employees
  - Inspections
  - Investigations
  - Recordkeeping

- Enacted by referring to the Occupational Health and Safety Act promulgated in the U.S.A. in 1970
In order to prevent major accidents, the International Labor Organization released its Prevention of Major Industrial Accidents Convention (C174) in 1993.

Seven years later, to fight against major accidents, the Chinese national standard on Identification of Major Hazard Installations (GB 18218) was released in 2000 and then amended in 2009.

The definition of major hazard installation in GB 18218 is the same as that in C174.
Example Regulations based on Lesson Learning

→ 800 died from SARS in the spring 2003
  ➤ The “SARS” exposed the weaknesses of original emergency response system in China

→ A petrochemical plant exploded in Jilin Province, China in 2005
  ➤ 100 tons of toxic substances including benzene spilled into the Songhua River with waste fire-fighting water
  ➤ Drinking water supply terminated for four consecutive days

  ➤ Emergency response plan has to be made by each chemical plant and each level of government
Example Regulations based on Lessons Learned

- The natural gas well blowout accident in Chongqing, China in December 2003
  - 243 deaths
  - 1242 hospitalizations
  - 65,000 evacuations

- A new standard released in 2008
  - Specification for ignition time of out of control on wellhead of natural gas well involving hydrogen sulfide
    - An out of control natural gas from a well has to be ignited within 15 minutes after a blowout if there is any resident not evacuated 500 meters away from the well

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Example Regulations based on Lesson Learning

- Process safety has been widely recognized as one of the keys to major accident prevention in the chemical industry.
- SAWS released its first Process Safety Management (PSM) regulation AQ/T 3034-2010.
- It resembles OSHA’s PSM standard.

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Statistics of Chemical Accidents

![Graph showing the number of accidents and fatalities from 2004 to 2012. The x-axis represents the years from 2004 to 2012, and the y-axis represents the number of accidents. The graph indicates a trend with the number of accidents and fatalities peaking in 2006 and declining thereafter.]
Safety Situations Still Severe

- Two major SME accidents this year
  - A fire disaster involved ammonia in a SME poultry plant in Jilin Province, China
    - June 3rd, 2013
    - 121 deaths
    - 76 injuries
  - An ammonia leak accident in a SME cold storage facility in Shanghai
    - August 30, 2013
    - 15 people died
    - 25 injured
SMEs and Chemical Safety

80% of the chemical accidents occurred in SMEs
SMEs

- Chemical technologies in SMEs are out-dated
- Some primitive equipments are used
- Safety management is poor
- Safety investment is far from sufficience
- Employees have not received enough education and training

Are these really the root causes of SME accidents?

- Key to control SME accident effectively
26 Chemical Accidents Reports from April 2006 up to July 29, 2013

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Findings for SME Accidents Reported on SAWS’ Website

- 80% of the accidents occurred in SMEs
- For the 17 SME accidents with causal analysis, PSM elements PHA(14), ERP (12), and training (11) are the top three causes
Lessons Learned before

- Blair (2004) conducted a simple statistical study on 21 chemical accident investigation reports.

- The top five ranked causes
  - maintenance procedures
  - PHA
  - Engineering design and review
  - Management of change
  - Operation procedures

Lessons Learned before

10 common lessons by Yang and Dinh et. al.(2011)

- Carefully review the materials of construction
- Periodically inspect and maintain equipment to ensure adequate equipment reliability
- Develop effective worker training program
- Manage the design of hazardous installations to minimize the impact of an explosion
- Install plants far away from residential areas
- Design and effectively implement a good emergency response plan
- Periodically conduct process hazard analysis
- Take proactive actions to use lessons learned to prevent potential hazards
- Periodically inspect safeguards and protection system to ensure their functionality when needed
- Prevent accidents by designing and effectively using operating procedures that include standard industrial best practices

Yang and Dinh et. al.(2011) Progress Safety Progress, 30(2):143-147

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Organizational Learning Disability

- 5 hydrogen sulfide poisoning accidents are quite similar in the SAWS website.
  - ERP for working in a constrained space was not established so that more people got poisoned when they tried to rescue one suffering from hydrogen sulfide
- The accident reports have been on the website of SAWS for a few years
- The chemical companies just did not learn the lessons that are easily accessible.
- The organizational “learning disability” of Chinese SMEs is very severe

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Organizational Learning Disability

→ In the Baker Panel, it was found that personal safety had overshadowed process safety at BP.

→ The lessons about the importance of process safety had been widely available in numerous accident analysis reports before.

→ BP just had not really learned those lessons because of a kind of organizational “learning disability.”
How to Overcome Learning Disability

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Responsible Production

Combining best practice approaches from APELL, CSR and Safer Production...

Awareness and preparedness for emergencies at local level
Corporative social responsibility
Safer production

Responsible Production

... into a single framework – easy to understand and apply. Systematic and continuous improvement approach aimed at SMEs
Responsible Production

A systematic, five-step model, for practical guidance and tools for assisting SMEs in identifying and understanding the hazards and risks related to chemicals and company products as well as operations on-site and along the value-chain.
Responsible Production Pilot Project

- Financial Support
- Technical Support

Technical consultant

Pilot application of RP Handbook

Pilot company 1

Project Team CNCPC

Pilot company 2
Responsible Production Pilot Projects

- In the electroplating company, five risk scenarios were identified
  - Strong acid solution was replaced by weak caustic solutions to protect workers
- In the bio-chemical company, twelve risk scenarios were identified
  - Power failure alarms were added

Zhao, Joas, Abel, Marques, Suikkanen (2013)
SME’s Sustainable Development

- The more developed that a country was, the greater its population’s concern was for their environment and the greater their demand was for risk.
  - In June 2007, a chemical project involved in producing p-xylene in Xiamen City was suspended and finally relocated as a result of public demonstrations in opposition to the project.

- This event indicates that public attitudes toward the chemical industry have already become an important factor in investment decisions controls.

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SME’s Sustainable Development

- Awareness and Preparedness for Emergency at Local Level (APELL) is a programme developed by UNEP in 1986

- The strategy of the APELL approach is to

  - identify and create awareness of risks in an industrialized community,
  - initiate measures for risk reduction and mitigation
  - develop coordinated preparedness between the industry, the local authorities and the local population
During the last twenty 27 years, the APELL programme has been introduced in more than 30 countries such as Argentina, Thailand, India and China and implemented in over 80 communities.

The APELL programme was quite successful in the chemical park in Bahia Blanca, Argentina in a sense that the industry’s credibility was improved and the community got ready for emergency events through risk communications.
SME’s Sustainable Development

- An APELL pilot project sponsored by Dow Chemical was implemented in ZhangJiaGang chemical park in Jiangsu province in China from 2008 to 2010
- The comprehensive emergency response plan of the chemical park was evaluated by the UNEP experts and 14 recommendations were given to improve the plan.
  - One recommendation was to establish an emergency warning system in the nearby community
Conclusions

- About 80% of the chemical accidents occurred at SMEs.
- Priorities for Chinese SMEs should be put on improving their capabilities in PHA, ERP and trainings to their employees.
- Organizational Learning disability is especially severe in SMEs.
- Big firms need to implement Responsible Production to help their SME suppliers, contractors and customers.
- For sustainable development, SMEs should practice APELL and responsible production.

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