เทคโนโลยีควบคุมสารเคมีอันตราย Technologies for Hazardous Waste Management

คม 200 การจัดการสารเคมีอันตรายและวัตถุมีพิษ 15/07/2556

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ตารางสอน คม 200 ภาคเรียนที่ 1/2556

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วันที่	หัวข้อ	ชั่วโมง	ผู้สอน
15 กรกฎาคม *24-26 กรกฎาคม	4. เทคโนโลยีควบคุมสารเคมีอันตรายและวัตถุมีพิษ	4	อ.ดร.นเร
5 สิงหาคม	5. กรณีศึกษา 1 (ควบคุมสารเคมีในอุตสาหกรรม)	2	อ.ดร.นเร
*13-16 สิงหาคม 19 สิงหาคม	8. การบรรยายรับเชิญจากภาคหน่วยงานภายนอกและภาคอุตสาหกรรม	4	อ.ดร.นเร
26 สิงหาคม 2 กันยายน	6. เทคโนโลยีเพื่อทำความสะอาดสารเคมีอันตรายและวัตถุมีพิษ	4	อ.ดร.ณัฐพล
9 กันยายน	7. กรณีศึกษา 2 (ทำความสะอาดสารเคมีอันตราย)	2	อ.ดร.ณัฐพล
16 กันยายน 23 กันยายน	9. การเสนอผลงานเป็นกลุ่ม	4	อ.ดร.ณัฐพล

* คือสัปดาห์ที่วันจันทร์ตรงกับวันหยุด มีการนัดสอน make up ภายในสัปดาห์เดียวกันโดยการตกลงกับนักศึกษาก่อน

แหล่งอ้างอิง References

http://msds.pcd.go.th/
http://www.hse.gov.uk/chemicals/index.htm
http://www.fda.moph.go.th/eng/hazardous/index.stm
http://www.cdc.gov/niosh/topics/

Technologies and management strategies for Hazardous Waste Control (1983)

Old hazard symbols

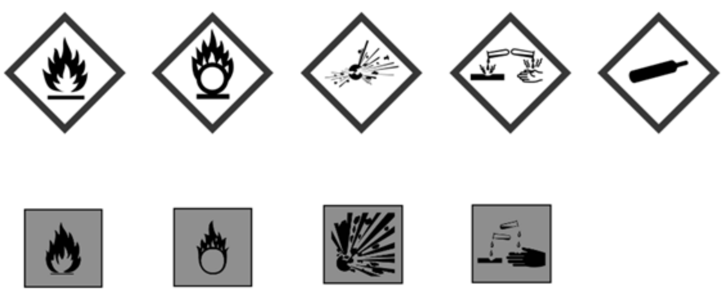
อันตรายของสารเคมีแบ่งได้เป็น 3 ประเภท

1. อันตรายทางกายภาพ Physical Hazard
2. อันตรายต่อสุขภาพ Health Hazard
3. อันตรายต่อสิ่งแวดล้อม Environmental Hazard

อันตรายทางกายภาพ Physical Hazards

Combustible liquids	ของเหลวติดไฟได้
Compressed gases	ก๊าซความดันสูง
Explosives	วัตถุระเบิด
Flammables	วัตถุไวไฟ
Oxidizers	สารที่เกิดปฏิกิริยาออกซิไดส์ง่าย
Pyrophorics	สารที่ลุกติดไฟได้เองเมื่อสัมผัสกับอากาศ
Unstable/reactive chemicals	สารเคมีที่ไม่เสถียร (เกิดปฏิกิริยาง่าย)
Water-reactive chemicals	สารเคมีที่ทำปฏิกิริยากับน้ำ

Physical Hazard



Health Hazard

อันตรายต่อสุขภาพ Health Hazards

Carcinogens	สารก่อมะเร็ง
Corrosives	สารกัดกร่อน
Highly toxic chemicals	สารเคมีที่มีความเป็นพิษสูง
Irritants	สารระคายเคือง
Sensitizers	สารที่มีผลต่อระบบประสาท
Toxic	สารที่เป็นพิษ

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อันตรายต่อสุขภาพ - อวัยวะที่ได้รับผลกระทบ

Hepatotoxins (liver)	ตับ
Nephrotoxins (kidney)	ไต
Neurotoxins (nervous system)	ระบบประสาท
Hemato-poietic system (blood)	ระบบเลือด
Pulmonary (lungs)	ระบบทางเดินหายใจ
Reproductive organs	ระบบสืบพันธุ์
(chromosomal damage or fetal effects)	(โครโมโซม/DNA/ทารกในครรภ์)
Cutaneous (dermal layer of the skin)	**ผิวหนังชั้นบน**
Optical (eye or vision)	ตา

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อันตรายต่อสิ่งแวดล้อม Environmental

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เทคโนโลยีควบคุมสารเคมีอันตรายและวัตถุมีพิษ

1. Waste reduction alternatives
2. Hazard reduction alternatives: treatment and disposal
3. Ocean use: disposal and dispersal
4. Uncontrolled sites

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Waste reduction alternatives

1.1 Source segregation

1.2 Process modification

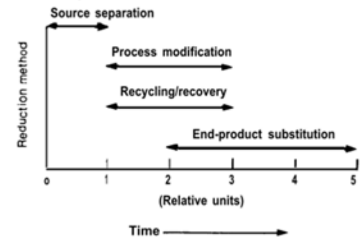
1.3 End product substitution

1.4 Recovery and Recycling

- Linked to proprietary manufacturing technology

เปรียบเทียบระยะเวลาในการนำกระบวนการไปใช้

Figure 7.—Relative Time Required for Implementation of Reduction Methods



SOURCE: Off ice of Technology Assessment

1.1 Source segregation

- Best method is to reduce the volume of waste
- Permanently eliminate hazardous character
- contain and immobilize hazardous constituents

- Smaller firms might find this a disincentive based on economics, e.g. electroplating plant sending waste to municipal waste treatment plant instead of extracting cyanide itself.

1.2 Process modification

- Changes in operation temperature, pressure, raw material composition
- New process or equipment
- Usually process specific, not industry-wide

e.g. metal-finishing industry replacing cyanide-based electrolytes for “safer” acids, MSA, etc.

1.3 End product substitution

- substitute end product for another new one
- manufacture of new product would reduce the generation of hazardous waste

E.g. asbestos pipes (แร่ใยหิน-ก่อให้เกิดโรคปอด) can be replaced with iron, clay, or pvc

การเปลี่ยนแปลงผลิตภัณฑ์/ของเสียเคมี

Table 25.—End-Product Substitutes for Reduction of Hazardous Waste

Product	Use	Ratio of waste:[a] original product	Available substitute	Ratio of waste:[a] substitute product
Asbestos	Pipe	1.09	Iron Clay PVC	0.1 phenols, cyanides, 0.05 fluorides 0.04 VCM manufacture + 1.0 PVC pipe
	Friction products (brake linings)	1.0+ manufacturing waste	Glass fiber Steel wool Mineral wools Carbon fiber Sintered metals Cement	o
	Insulation	1.0+ manufacturing	Glass fiber Cellulose fiber	0.2
PCBs	Electrical transformers	1.0	Oil-filled transformers Open-air-cooled transformers	0 0
Cadmium	Electroplating	0.29	Zinc electroplating	0.06
Creosote treated wood	Piling		Concrete, steel	0.0 (reduced hazard)
Chlorofluorocarbons	Industrial solvents	70/81 =0.9	Methyl chloroform; methylene chloride	0.9 (reduced hazard)
DDT	Pesticide	1.0+ manufacturing waste	Other chemical pesticides	(reduced hazard) 1.0+ manufacturing waste

[a]Quantity of hazardous waste generated/unit of product
SOURCE Office of Technology Assessment

Encouraging end product substitution

- regulations
- limitation of raw materials
- tax incentives
- Federal procurement practices
- consumer education

1.4 Recovery and Recycling

- Recovery = separation of substance from mixture
- Recycling = reuse of such substance
- Materials that can be easily separated through physical/chemical differences.
  - organic acids by distillation
  - solids by filtration
- In-plant and commercial (off-site)

ตัวอย่างการกู้คืนของเสียด้วยกระบวนการต่างๆ

Table 26.—Commercially Applied Recovery Technologies

Generic waste	Typical source of effluent	Recovery technologies
Solids in aqueous suspension	Salt/soda ash liming operations	Filtration
Heavy metals	Metal hydroxides from metal-plating waste; sludge from steel-pickling operations	Electrolysis
Organic liquids	Petrochemicals/mixed alcohol	Distillation
Inorganic aqueous solution	Concentration of inorganic salts/acids	Evaporation
Separate phase solids, grease/oil	Tannery waste/petroleum waste	Sedimentation/skimming
Chrome salt solutions	Chromium-plating solutions/tanning solutions	Reduction
Metals; phosphate sulfates	Steel-pickling operations	Precipitation

SOURCE Off Ice of Technology Assessment

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Table 27.—Description of Technologies Currently Used for Recovery of Materials

Technology/description	stage of development	Economics	Types of waste streams	Separation efficiency	Industrial applications
Physical separation:					
Gravity settling:					
Tanks, ponds provide hold-up time allowing solids to settle; grease skimmed to overflow to another vessel	Commonly used in wastewater treatment	Relatively inexpensive; dependent on particle size and settling rate	Slurries with separate phase solids, such as metal hydroxide	Limited to solids (large particles) that settle quickly (less than 2 hours)	industrial wastewater treatment first step
Filtration:					
Collection devices such as screens, cloth, or other; liquid passes and solids are retained on porous media	Commonly used	Labor intensive: relatively inexpensive; energy required for pumping	Aqueous solutions with finely divided solids; gelatinous sludge	Good for relatively large particles	Tannery water
Flotation:					
Air bubbled through liquid to collect finely divided solids that rise to the surface with the bubbles	Commercial application	Relatively inexpensive	Aqueous solutions with finely divided solids	Good for finely divided solids	Refinery (oil/water mixtures) paper waste; mineral industry
Flocculation:					
Agent added to aggregate solids together which are easily settled	Commercial practice	Relatively inexpensive	Aqueous solutions with finely divided solids	Good for finely divided solids	Refinery; paper waste; mine industry
Centrifugation:					
Spinning of liquids and centrifugal force causes separation by different densities	Practiced commercially for small-scale systems	Competitive with filtration	Liquid/liquid or liquid/solid separation, i.e., oil/water; resins; pigments from lacquers	Fairly high	Paints
Component ***separation***					
Distillation:					
Successfully boiling off of materials at different temperatures (based on different boiling points)	Commercial practice	Energy intensive	Organic liquids	Very high separations achievable (99 + % concentrations) of several components	Solvent separations; chemical and petroleum industry
Evaporation:					
Solvent recovery by boiling off the solvent	Commercial practice in many industries	Energy intensive	Organic/inorganic aqueous streams; slurries, sludges, i.e., caustic soda	Very high separations of single, evaporated component achievable	Rinse waters from metal-plating waste

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Technology/description	Stage of development	Economics	Types of waste streams	Separation efficiency	Industrial applications
Electrolysis:					
Separation of positively/negatively charged materials by application of electric current	Commercial technology; not applied to recovery of hazardous materials	Dependent on concentrations	Heavy metals; ions from aqueous solutions; copper recovery	Good	Metal plating
Carbon/resin absorption:					
Dissolved materials selectively absorbed in carbon or resins. Absorbents must be regenerated	Proven for thermal regeneration of carbon; less practical for recovery of adsorbate	Relatively costly thermal regeneration; energy intensive	Organics/inorganics from aqueous solutions with low concentrations, i.e., phenols	Good, overall effectiveness dependent on regeneration method	Phenolics
Solvent extraction:					
Solvent used to selectively dissolve solid or extract liquid from waste	Commonly used in industrial processing	Relatively high costs for solvent	Organic liquids, phenols, acids	Fairly high loss of solvent may contribute to hazardous waste problem	Recovery of dyes
Chemical transformation:					
Precipitation:					
Chemical reaction causes formation of solids which settle	Common	Relatively high costs	Lime slurries	Good	Metal-plating wastewater treatment
Electrodialysis:					
Separation based on differential rates of diffusion through membranes. Electrical current applied to enhance ionic movement	Commercial technology, not commercial for hazardous material recovery	Moderately expensive	Separation/concentration of ions from aqueous streams; application to chromium recovery	Fairly high	Separation of acids and metallic solutions
Chlorinolysis:					
Pyrolysis in atmosphere of excess chlorine	Commercially used in West Germany	Insufficient U.S. market for carbon tetrachloride	Chlorocarbon waste	Good	Carbon tetrachloride manufacturing
Reduction:					
Oxidative state of chemical changed through chemical reaction	Commercially applied to chromium; may need additional treatment	Inexpensive	Metals, mercury in dilute streams	Good	Chrome-plating solutions and tanning operations
Chemical dechlorination:					
Reagents selectively attack carbon-chlorine bonds	Common	Moderately expensive	PCB-contaminated oils	High	Transformer oils
Thermal oxidation:					
Thermal conversion of components	Extensively practiced	Relatively high	Chlorinated organic liquids; silver	Fairly high	Recovery of sulfur, HCl

'Good implies 50 to 8O percent efficiency, fairly high implies 80 percent, and very high Implies 90 percent

SOURCE: Office of Technology Assessment.

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สรุปข้อดี/ข้อเสียของวิธีการลดปริมาณของเสีย

Table 22.—A Comparison of the Four Reduction Methods

Advantages	Disadvantages
Source segregation or separation	
i) **Easy** to implement; usually low investment 2) Short-term solution	1) Still have some waste to manage
Process modification	
1) Potentially reduce both hazard and volume 2) Moderate-term solution 3) Potential savings in production costs	1) Requires R&D effort; capital investment 2) Usually does not have industrywide impact
End product substitufion	
1) Potentially industrywide impact—large volume, hazard reduction	1) Relatively long-term solutions 2) Many sectors affected 3) Usually a side benefit of product improvement 4) May require change in consumer habits 5) Major investments required—need growing market
Recovery/recycling	
• */n-p/ant*	
1) Moderate-term solution 2) Potential savings in manufacturing costs 3) Reduced liability compared to commercial recovery or waste exchange	1) May require capital investment 2) May not have wide impact
• *Commercial recovery (offsite)*	
1) No capital investment required for generator 2) Economy of scale for small waste generators	1) Liability not transferred to operator 2) If privately owned, must make profit and return investment 3) Requires permitting 4) Some history of poor management 5) Must establish long-term sources of waste and markets 6) Requires uniformity in composition
• *Waste exchange*	
1) Transportation costs only	1) Liability not transferred 2) Requires uniformity in composition of waste 3) Requires long-term relationships—two-party involvement

SOURCE: Office of Technology Assessment.

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2. Hazard reduction alternatives

- Thermal and/or thermal treatment
- Land disposal
- Advanced landfills, injection wells
- Indirect monitoring, e.g. aquifer contamination
- Waste water treatment: chemical, physical, and biological

Table 31 .—Comparison of Some Hazard Reduction Technologies

	Disposal		Treatment		
	Landfills and Impoundments	Injection wells	Incineration and other thermal destruction	Emerging high.temperature decomposition *	Chemical stabilization
Effectiveness How well It contains or destroys hazardous characteristics	Low for volatiles, questionable for liquids based on lab and field tests	High, based on theory, but limited field data available	High, based on field tests, except little data on specific constituents	Very high, commercial scale tests	High for many metals, based on lab tests
Reliability issues:	Siting, construction, and operation Uncertainities long-term integrity of cells and cover, liner life less than life of toxic waste	Site history and geology, well depth, construction and operation	Long experience with design Monitoring uncertainties with respect to high degree of DRE, surrogate measures, PICs, incinerability	Limited experience Mobile units, onsite treatment avoids hauling risks Operational simplicity	Some inorganics still soluble Uncertain leachate test, surrogate for weathering
Environmental media most affected	Surface and ground water	Surface and ground water	Air	Air	None likely
Least compatible waste:	Liner reactive, highly toxic, mobile, persistent, and bioaccumulative	Reactive, corrosive, highly toxic, mobile, and persistent	Highly toxic and refractory organics, high heavy metals concentration	Possibly none	Organics
Costs Low, Mod, High	L-M	L	M-H (Coincin = L)	M-H	M
Resource recovery potential	None	None	Energy and some acids	Energy and some metals	Possible building material

Figure 8.— Injection Liquid Incineration

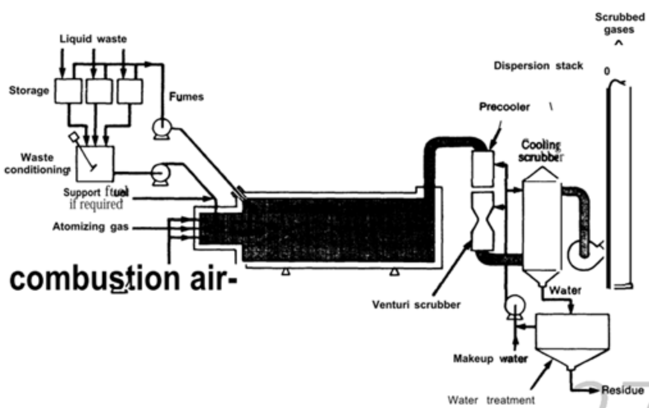
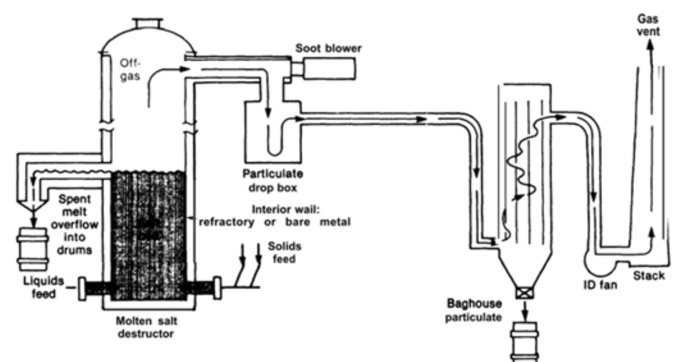


Figure 9.—Molten Salt Destruction: Process Diagram



Bath of sodium bicarbonate/calcium carbonate, 1800 ^oC

Figure 10.—Generalized Depiction of a Hazardous Waste Landfill Meeting Minimum Federal Design Criteria

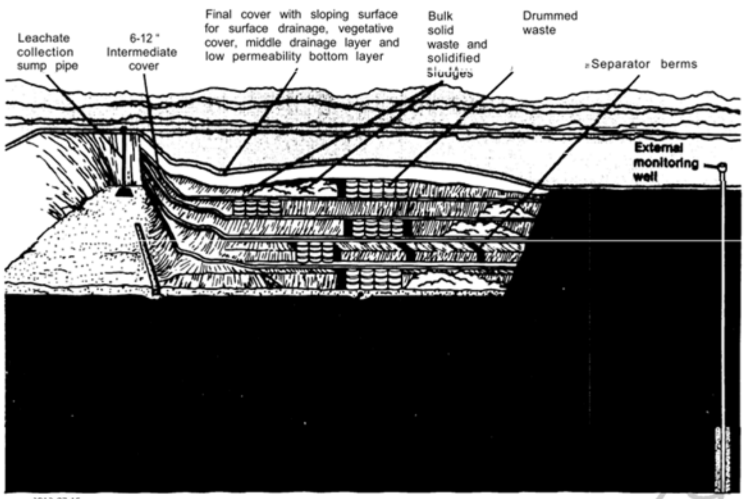


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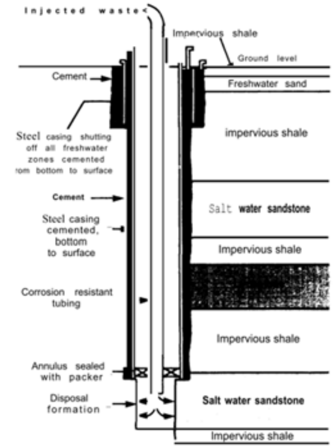
Figure 13.—Schematic of Typical Completion Method for a Deep Waste Injection Well



SOURCE: R. B. Pojasek, Toxic and Hazardous Waste Disposal, vol. 4, Ann Arbor Science, 1980.

Industry type	*Percent*
Chemical and allied products	49
Petroleum refining	20
Sanitary service	9
Oil and gas extraction	6
Primary metals	6
All others	10

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Table 34.—Comparison of Quoted Prices for Nine Major Hazardous Waste Firms in 1981[a]

Type of waste management	Type or form of waste	Price 1981	$/tonne[b] 1981
Landfill	Drummed	$0.64-$0.91/gal ($35-$50/55 gal drum)	$168-$240
	Bulk	$0.19-$0.28/gal	$55-$83
Land treatment	All	$0.02-$0.09/gal	$5-24
Incineration clean	Relatively clean liquids, high-Btu value	$(0,05)'-$0.20/gal	$(13) '-$53
	Liquids	$0.20-$0.90/gal	$53-$237
	Solids, highly toxic liquids	$1.50-$3.00/gal	$395-$791
Chemical treatment	Acids/alkalines	$0.08-$0.35/gal	$21-$92
	Cyanides, heavy metals, highly toxic waste	$0.25-$3.00/gal	$66-$791
Resource recovery	All	$0.25-$1 .00/gal	$66-$264
Deep well injection	Oily wastewater	$0.06-$0.1 5/gal	$16-$40
	Toxic rinse water	$0.50-$1 .00/gal	$132-$264
Transportation		$0.15/ton mile	

[a]Interviews were conducted in May of 1980 and February of 1982
[b]Factors used t. convert gallons and tons into tonnes are described in the appendix
[c]Some cement kilns and light aggregate manufacturers are now paying for waste

SOURCE Booz, Allen & Hamilton, Inc

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Done for today, see you next week!

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