2020TSAST
HAZMAT FRO Training

行政院環境保護署
毒物及化學物質局
Toxic and Chemical Substances Bureau,
Environmental Protection Administration Executive Yuan, R.O.C. (Taiwan)

Introduction to toxic chemicals disaster response

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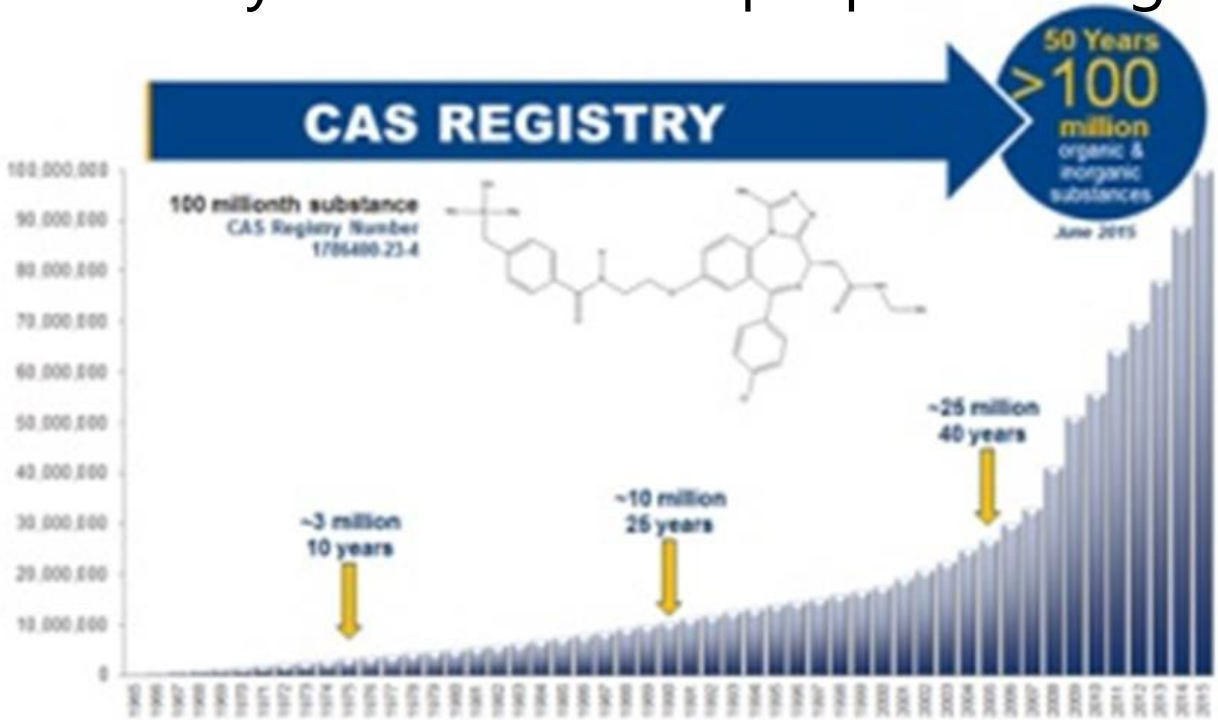
Introduction 1

- Chemicals are widely used to advance our living standards and the technology.
- These chemicals can be dangerous or harmful, to use them safely and should be proper managed.

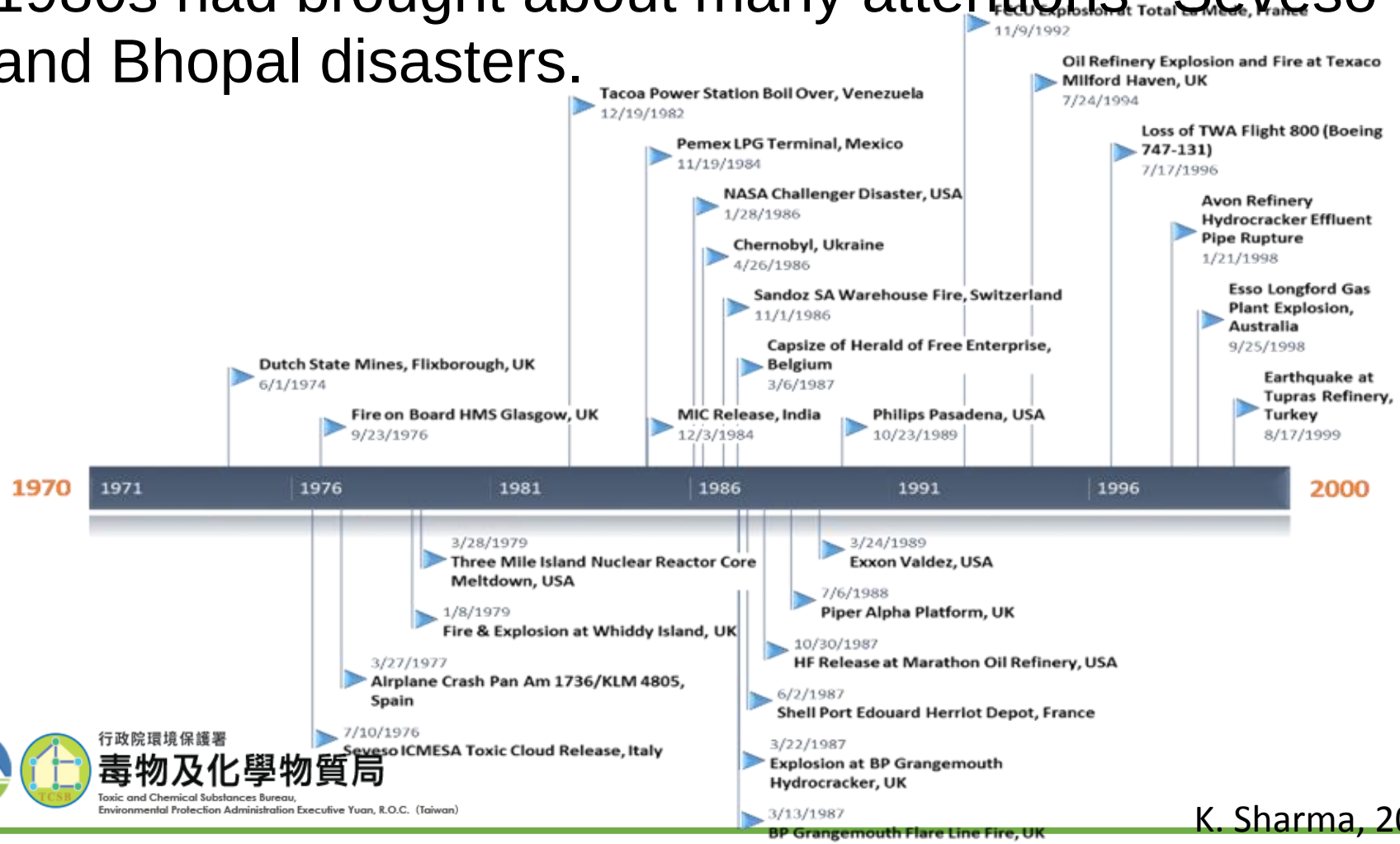


2020

?????

Introduction 2

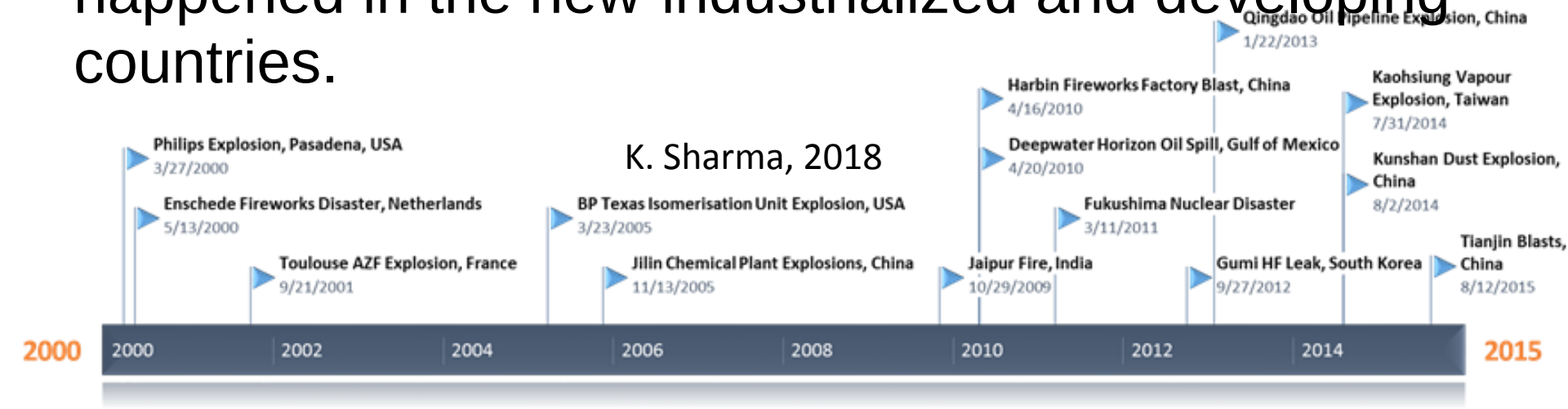
Many incidents happened in the 1970s and 1980s had brought about many attentions--Seveso and Bhopal disasters.



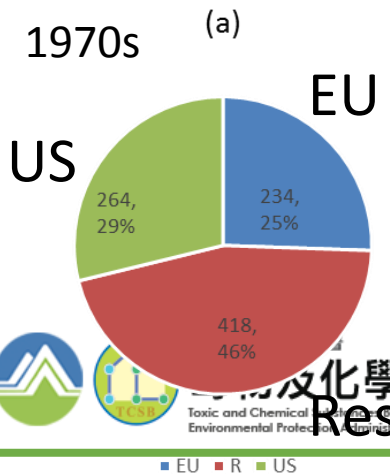
K. Sharma, 2018

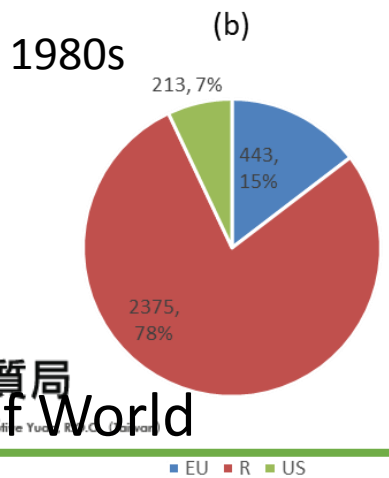
Introduction 3

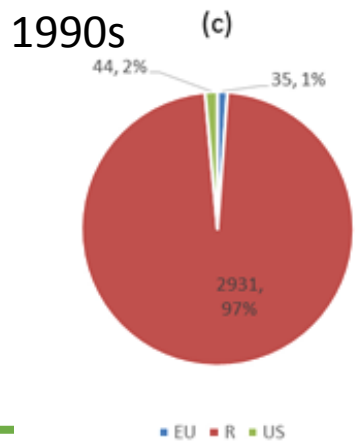
Many severe incidents in 1990s and after 2000s happened in the new-industrialized and developing countries.

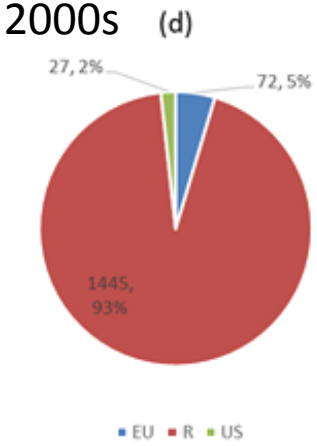


K. Sharma, 2018





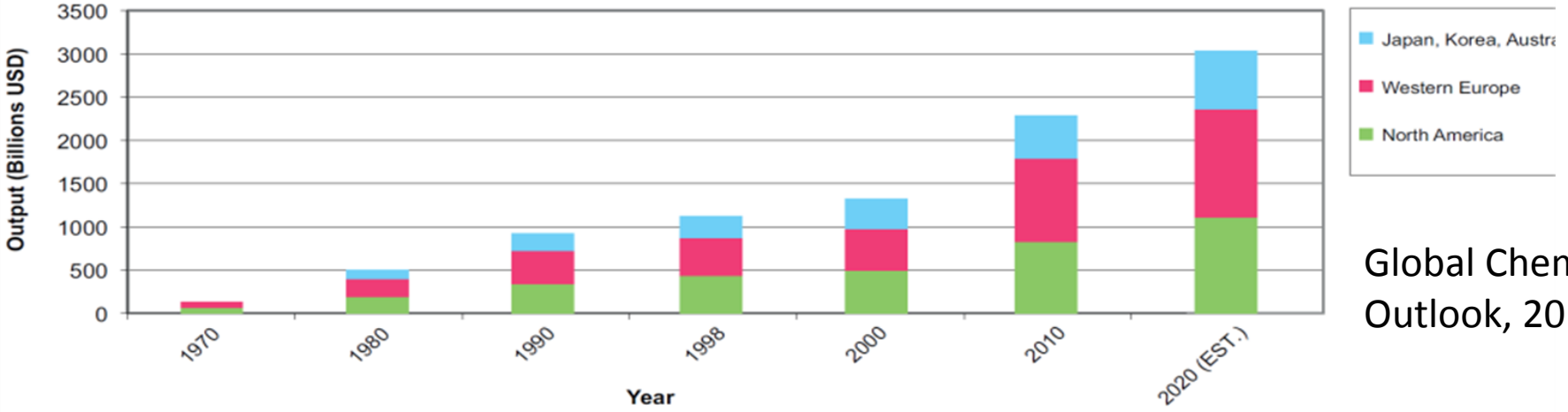




Rest of World

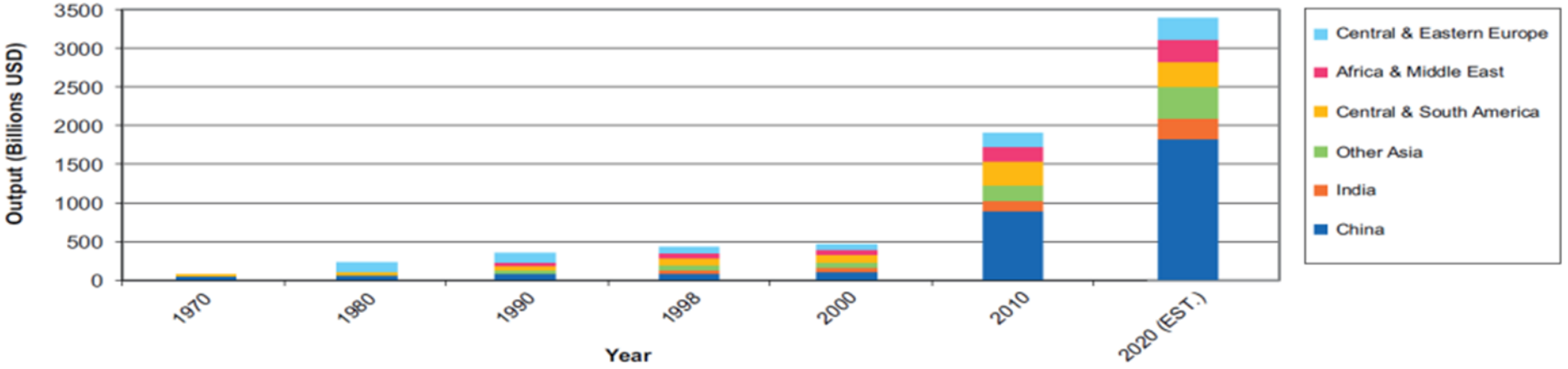
Chemical production in the world

Figure 1. Chemical Industry Output: Developed Regions*



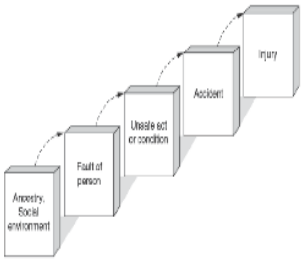
Global Chemical Outlook, 2013

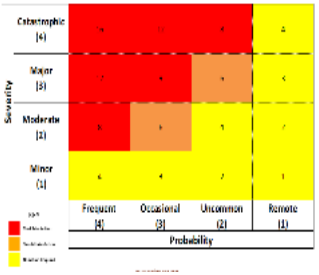
Figure 2. Chemical Industry Output: Developing Regions* & Countries with Economies in Transition



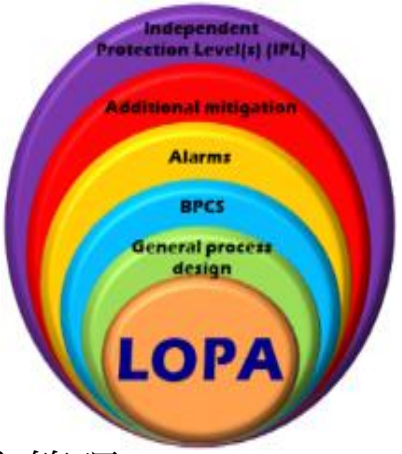
*As categorized by UN Statistics Division, http://unstats.un.org/unsd/methods/m49/m49regin.htm, accessed 24 November, 2011, with the exception of the Republic of Korea. ***1970-1990 Source:*** U.S. Chemical Manufacturers Association (1998). *U.S. Chemical industry Statistical Handbook*. Chemical Manufacturers Association, Inc. ***2000-2010 Source:*** American Chemistry Council (2011). "Global Business of Chemistry: Global Chemical Shipments by Country/Region (billions of dollars)." Retrieved from: http://www.americanchemistry.com/Jobs/EconomicStatistics/Industry-Profile/Global-Business-of-Chemistry. Accessed: 11 August, 2011. ***2020 Estimation Source:*** American Chemistry Council, *Mid-Year 2011 Situation & Outlook*, June 2011.

Hazard analysis method





HAZOP危害與
可操作性分析



PSM
製程安全管理

1930 1940 1950 1960 1970 1980 1990 2000 2010

Domino

FMEA

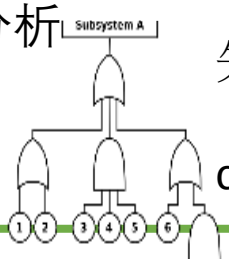
FTA HAZOP ETA

FMECA

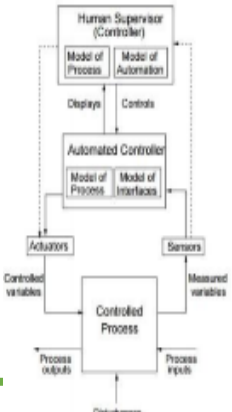
PSM/
LOPA

STAMP

失效模式与影响分析



失效模式效應與關鍵性分析法
（failure mode, effects and criticality analysis; FMECA）



Top chemical export in the world

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- 2019 Top 15 Chemical Export (**77% of the world**)

http://www.worldstopexports.com/chemical-exports-by-country

1. China: US$73.7 billion (13.5% of total exported chemicals)
2. United States: $50.8 billion (9.3%)
3. Ireland: $36.5 billion (6.7%)
4. Germany: $35.7 billion (6.6%)
5. Belgium: $34.6 billion (6.4%)
6. Netherlands: $26.3 billion (4.8%)
7. South Korea: $26.1 billion (4.8%)
8. Japan: $24.1 billion (4.4%)
9. Switzerland: $22.5 billion (4.1%)
10. India: $20.1 billion (3.7%)
11. Saudi Arabia: $15 billion (2.8%)
12. United Kingdom: $14.9 billion (2.7%)
13. France: $14.8 billion (2.7%)
14. Singapore: $13.5 billion (2.5%)
15. Taiwan: $10.6 billion (2%)

East Asia totaled 27.2%

Top 3rd

EU totaled 34%

Top 6th

East Asia's technology disasters after 2010s

- *Japan's Fukushima Daiichi nuclear power plant accident 2011.*
- Korean's Gumi-si chemical plant toxic leakage accident 2012.
- Taiwan's Kaohsiung gas explosions accident 2014.
- China's Tianjin explosions accident 2015.

http://fukushima-nuclear-plant.blogspot.com/2012/02/march-14-31-2011fukushima-daiichi.html

경찰 "구미 화학공장 사고는 폭발 아닌 가스유출"Sept 29,2012

https://www.dailymail.co.uk/news/article-2713259

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Incident management

Response principles

- **Response principles from CSTI**,(California Specialized Training Institute)

Scene	Command	Rescue	Restore
Safety	**Command /Management**	**Protective equipment**	**Decontamination & Cleaning**
Isolation (Deny Entry)	**Identification & Hazard Assessment**	**Containment & Control**	**Disposal**
Notification	**Action planning**	**Protection actions**	**Documentation**

Scene

Safety

Isolation
(Deny Entry)

Notification

On-Scene—1.Safety

- Evacuate injured ,unrelated personnel –might need emergency decontamination

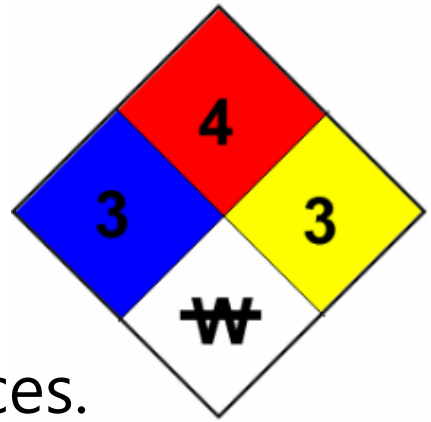
  Ensure personnel’ s safety.

- **Evaluate Scene**

  - I.D. is Safety/Protection

- **Id. Hazard Materials**

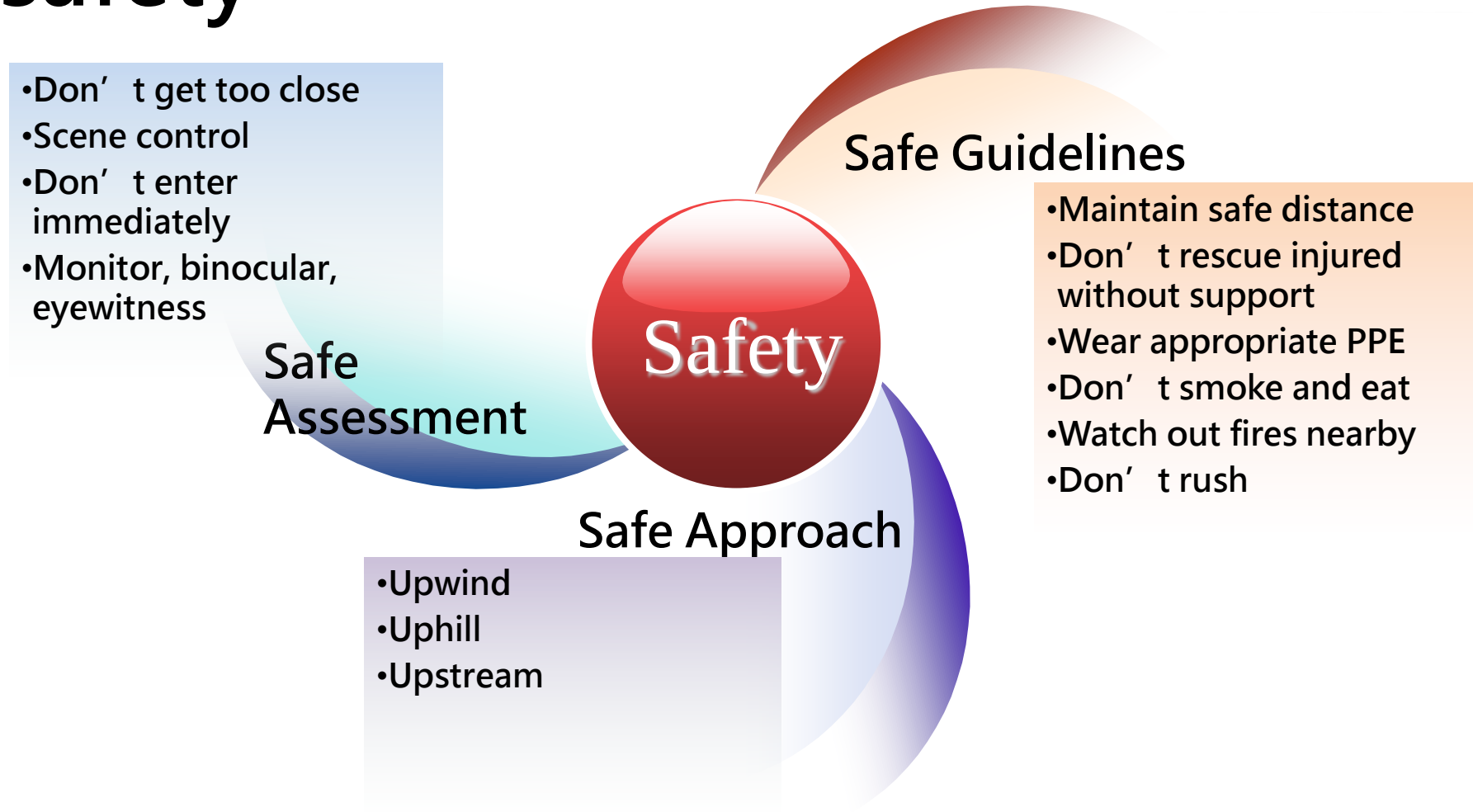
  - GHS
  - SDS
  - Transport document



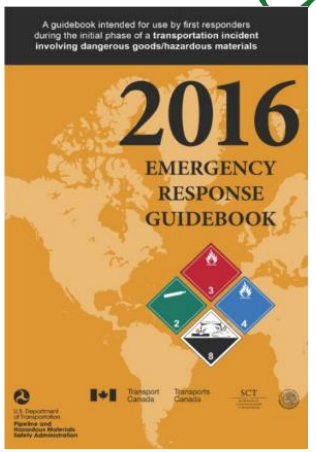
- Donot enter the scene without efficient resources.

Donot become problem yourself !

Three key points to ensure safety



ON-Scene- 2.Isolation and Deny Entry

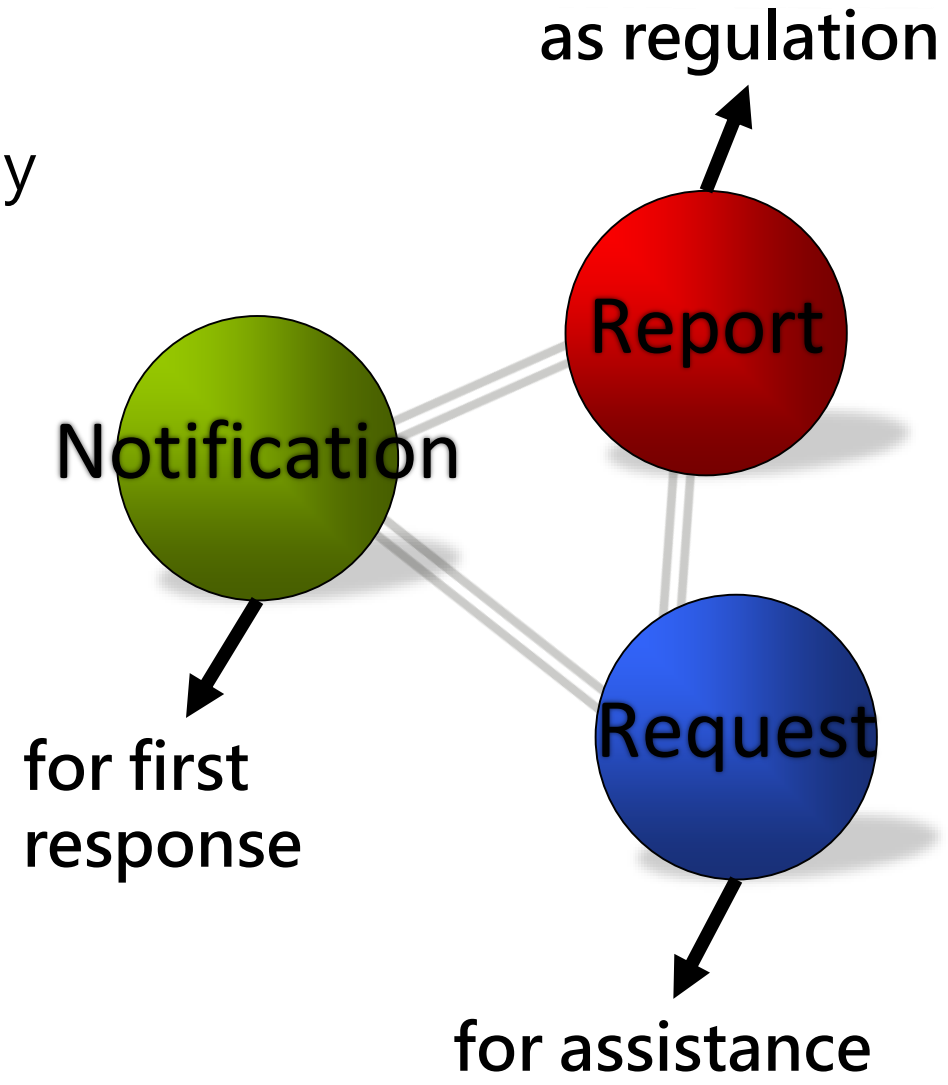


- **Isolation**
  Separate Scence according to
  - Chemical’ s characteristics
  - Environmental conditions
    (wind direction、terrain)
  - Leaking speed/Fire nearby
  - Using SDS/ERG as reference

- **Divide the RED, ORANGE, GREEN zones**
  - Prevent the responders cross-contaminated.
  - Prevent the pollutants from spreading.
  - Restrict personnel’ s action in the RED area.

On-scene--3. Notification

- Reporting to relevant or command agencies initially and regularly.
- **Report:**
  - Who
  - When
  - Where
  - What
  - What
  - How
  - Request support

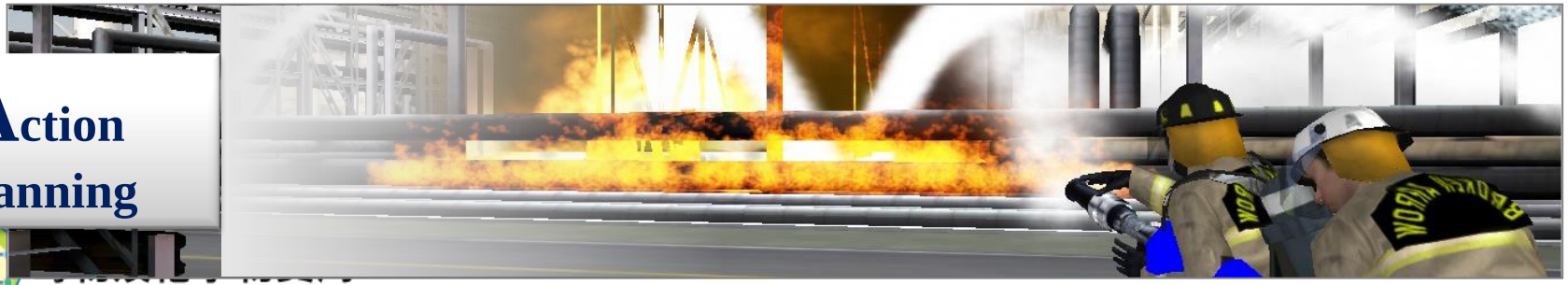


Command

Command /Management

Identification & Hazard Assessment

Action planning

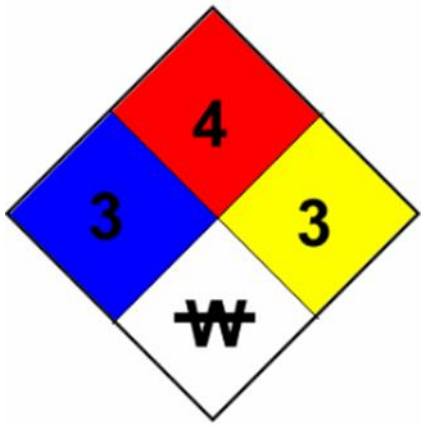


4 Command and Management

- The first responder arrived the scene as the site commander first.
- As more responders arrived, the responsible or capable party would serve as the commander. The commandership could be transferred after the situation worsened and more aids arrived.
- The previous commander could serve as the advisor.
- The commander need to use information to assess the incident.
- Jobs- Staff assignments
  - Situation Assessment
  - Pans and Measures

5 Identification & Hazard Assessment (1/4)

- Main step to respond to HAZMAT
- First, identify the chemical(s) and to assess hazards.



Identification & Hazard Assessment (2/4)

Three directions to assess the hazard

Is there any factors would cause damage? (flammability ,TIH)

What is the source of the hazard ? (leak, fire)

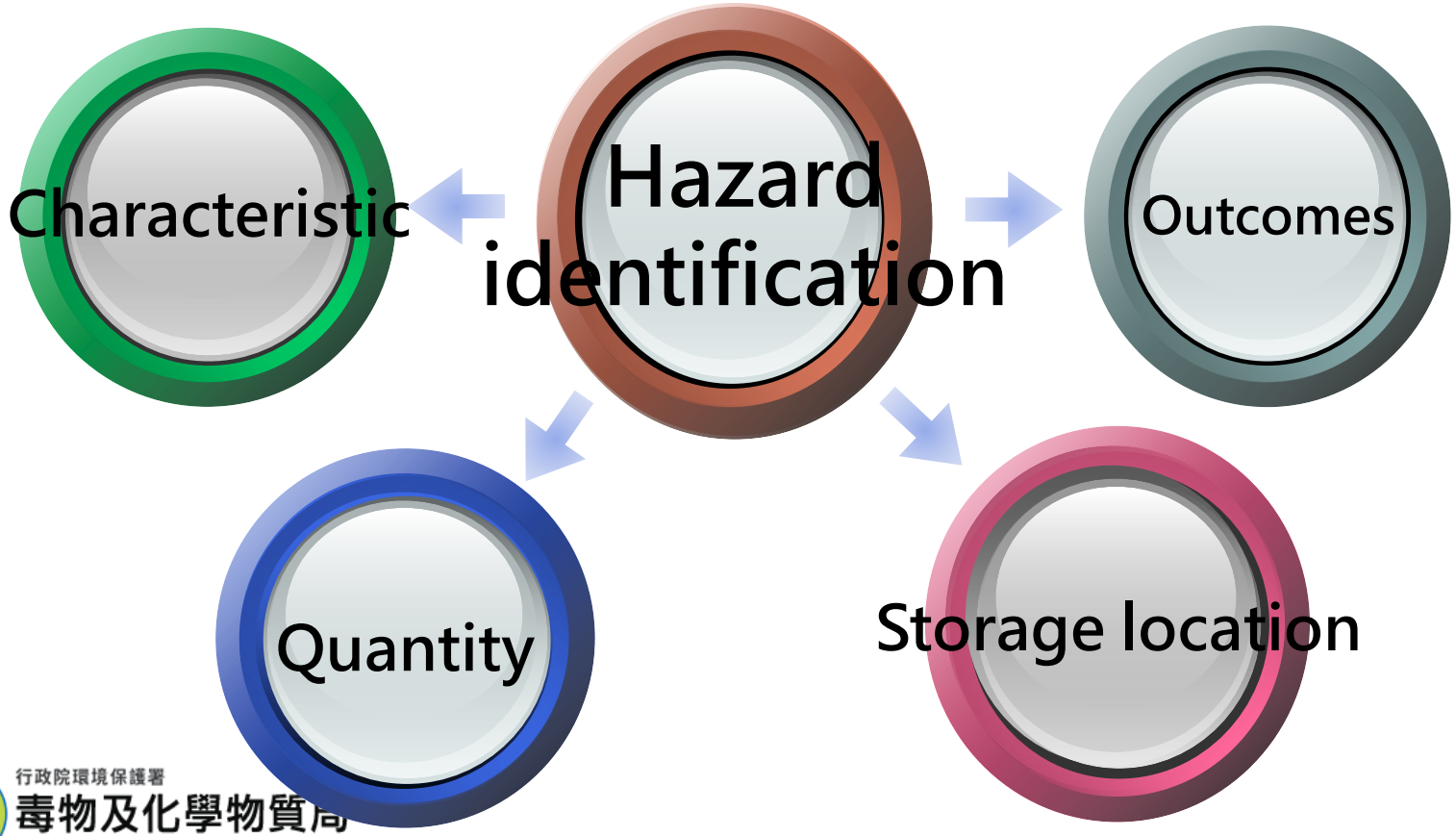
How does the hazard happens ? (leak, transport)

Who could be hurt ? (workers, responders…)

How bad the damage could be ? (fire、explosion)

Identification & Hazard Assessment (3/4)

- Assess the **hazards to personnel , environment, and equipment.**
- Predict possible trends and outcomes



Identification & Hazard Assessment (4/4)

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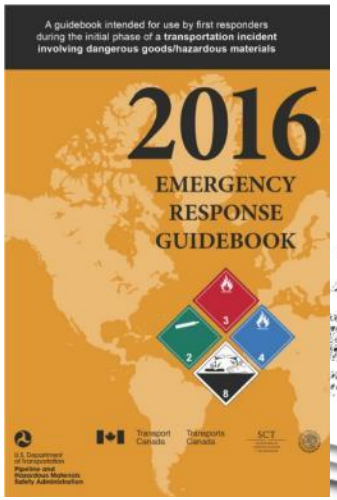
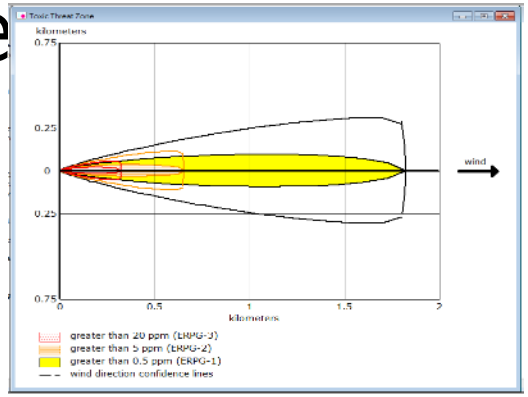
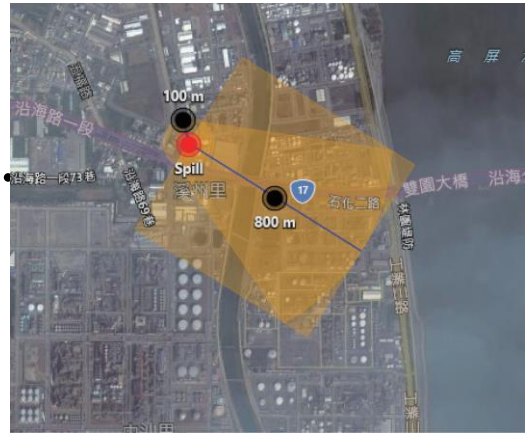
- **Hazard identification:**
  - Location
  - Shapes of the containers
  - Signs and their colors(GHS)
  - Notices and Labels
  - Transport document and SDS
  - Others（Warning, Diagram..... ）



6 Action planning (1/3)

- **First Q: "What if I did not do anything?"**
- **Preparing for the worst scenarios** before response—Evac route
  - Who could be injured ?
  - How big is the effected area ?
  - What kind of hazard would the chemical cause ?
  - Predict with model simulation.

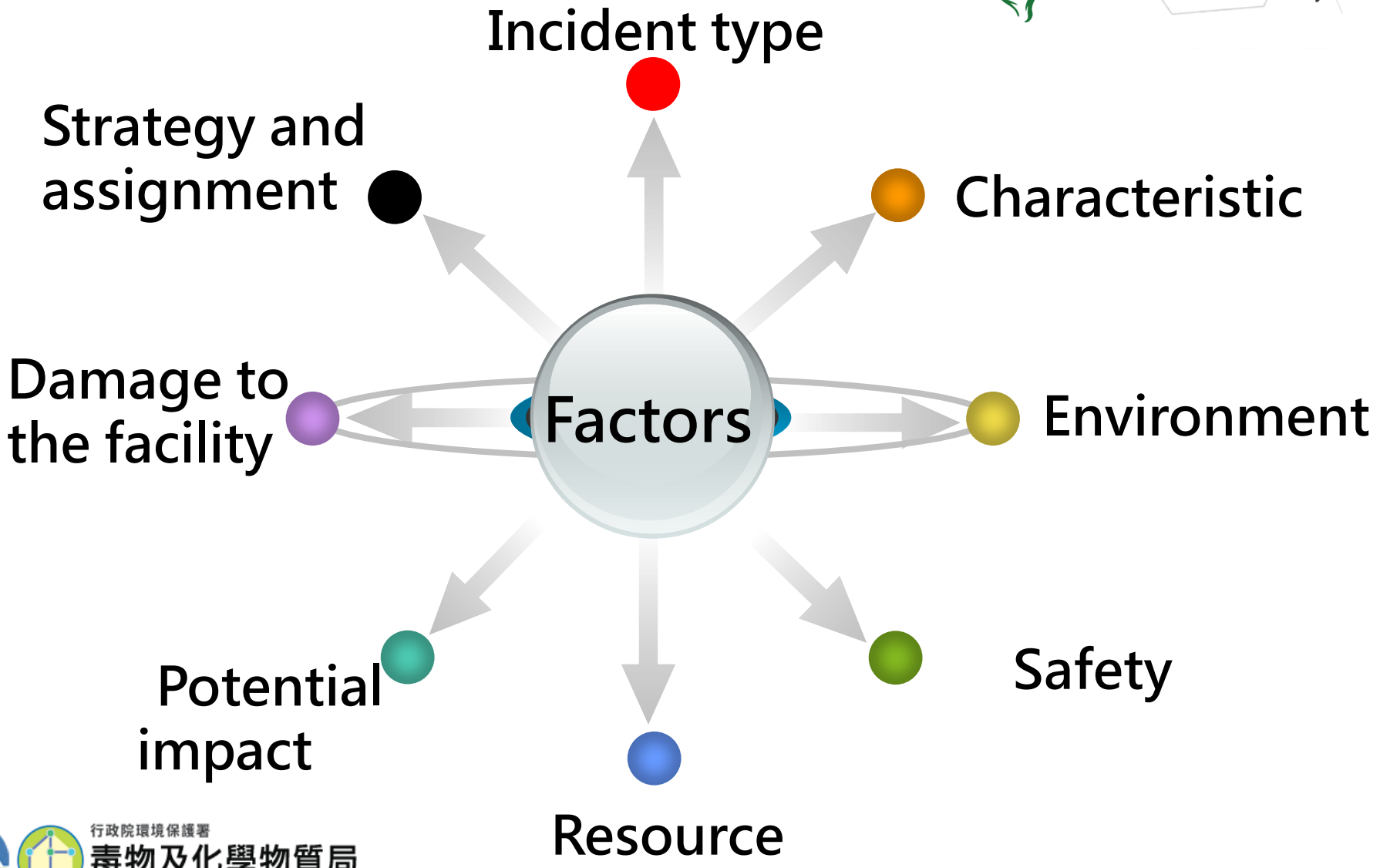




6 Action planning (2/3)

- **Draw up action plans:**
  - STRATEGY v.s. TACTICS
  - OFFENSIVE v.s. DEFENSIVE
  - Set response goals.
  - Choose response types and personal protection.
  - Determine priority.
  - **Regularly** evaluate the situation.
    - ➢Do not become a problem

Action planning (3/3)



Rescue

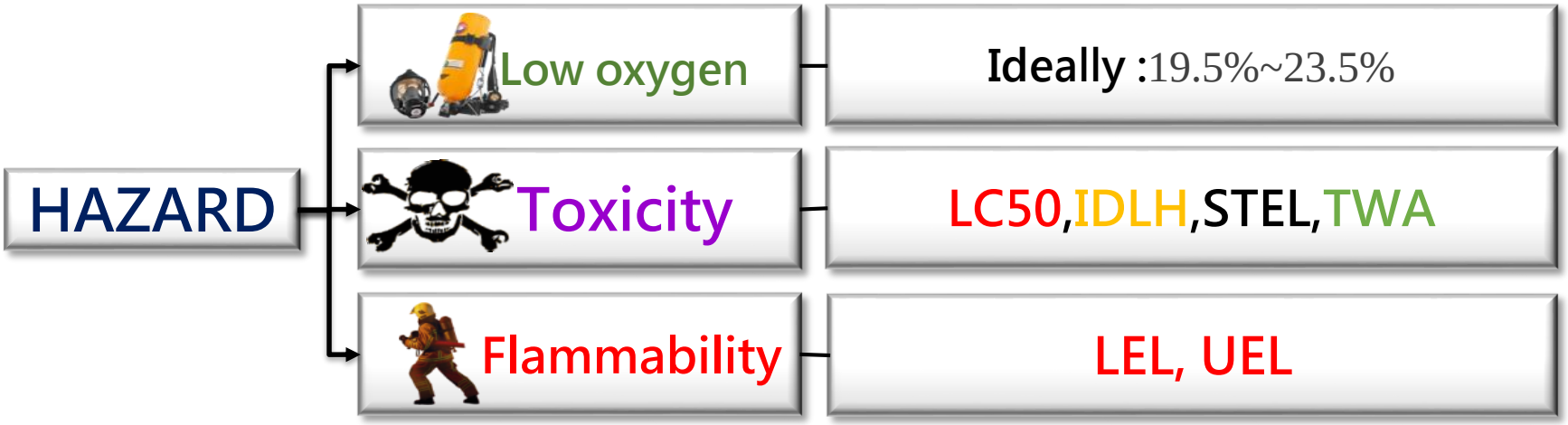
Protective equipment

Containment & Control

Protection actions

7 Protective equipment

- Assess the hazards in order to determine what to wear? what action to take?



8 Containment & Control

- **Contain contaminated area with means- Sawdust, chemical sorbent, mini-boom..**
- **Control means:**

  - Stop leak, move container..

- **Factors:**

  - Chemical Characteristics
  - Leaking speed and leakage
  - Weather and terrain
  - Time, support, equipment…
  - Nearby environment

9 Protection actions

- **Responders have to protect nearby civilians, environment, properties as well.**
- **Monitor and document the data continuously.**
- **Take actions to protect civilians if necessary:**

  - Evacuation : Guide civilians to safe area.

  - Sheltering-in-place : Keep civilians in place from contamination.

- **Evacuate or shelter-in-place?**

  - Chemical’ s characteristic
  - Nearby population distribution
  - How much resource do we have?
  - Situation

Reference for evacuation

Detection device’ s value	Actions
< PAC-1 or the concentration is very low.	No evacuation action needed
PAC-1 ~ PAC-2	Issue control area and the alert for shelter-in-place.
> PAC-2	Issue control area and the alert for shelter-in-place, or evacuate.
> PAC-3.	Issue the alert for evacuation , force the evacuation if necessary.

＊The PACs dataset is a hierarchy-based system of the three common public exposure guideline systems: AEGLs, ERPGs, and TEELs.

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Restore

Decontamination & Cleaning

Disposal

Documentation

10 Decontamination & Cleaning

Why:

- If Personnel and equipment are not properly decontaminated, the pollutants will be pollute the medical staff, and other personnel, causing secondary pollution.

Where:

- Time for decontamination needs to be considered.
- warm zone and upwind
- Benefit to the traffic flow
- **Decontamination traffic flow:**
  - Single：Minor leakage, few injured
  - Double：separate responder and injured, more efficient
  - Multiple：Mass leakage, many injured

11 Disposal

- **Consideration:**
  - Safety first
  - Characteristic
  - Choose appropriate container and PPE
  - Choose appropriate method
  - Shipped by registered hazardous waste carriers
- **What to dispose of:**
  - Damaged building or equipment
  - Waste produced during the response
  - Leakage
  - Water that sprayed during the response

12 Documentation

Good documentation is beneficial for reviewing and improving

- Record from the start.
- Camera, DV, paper,…
- Content:
  - Time, location, hazard, injured
  - Situation, witness’ s statement, device’ s data
  - Action, personnel, equipment
  - Resource, cost

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Incident Command System
ICS

ICS developments

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5. Shared communication frequency and system

1. Single command system

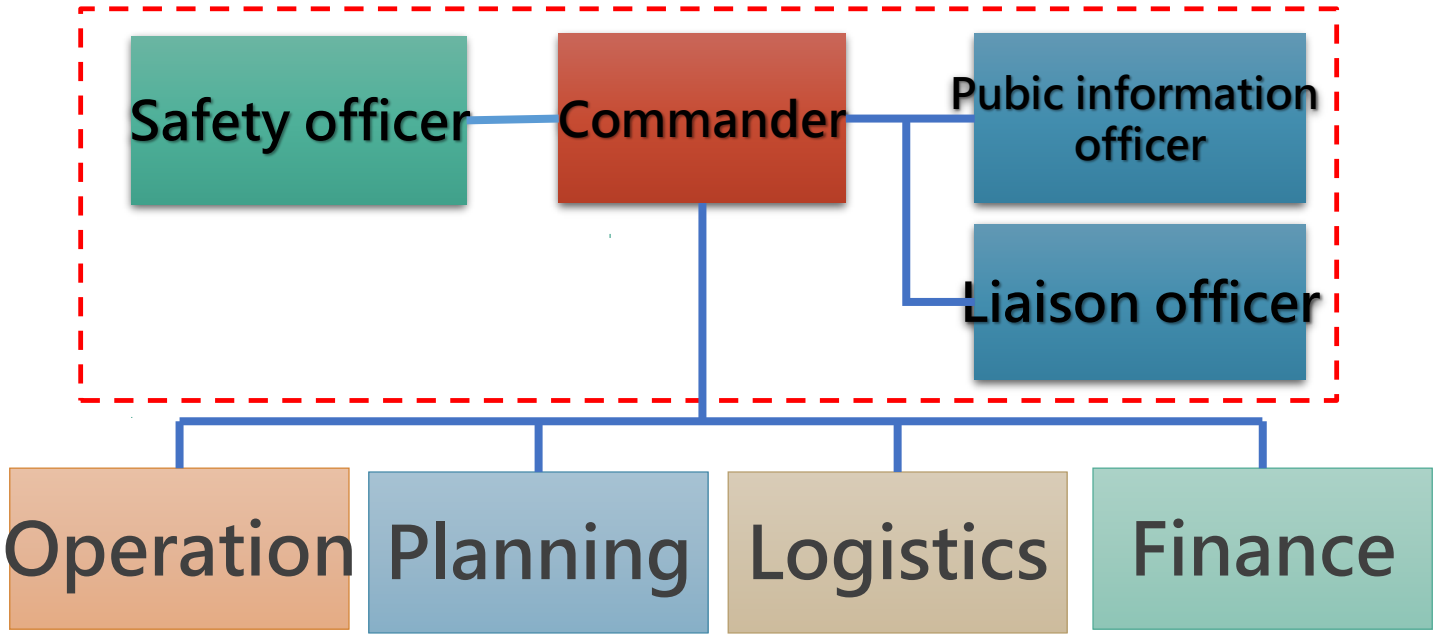
4. Common terminology/communication

2. Resource distribution

3. System work among different units/agencies

ICS structure

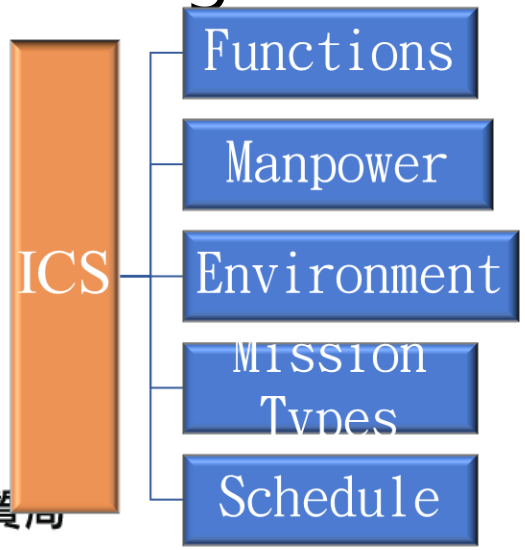
On-scene ICP Or EOC

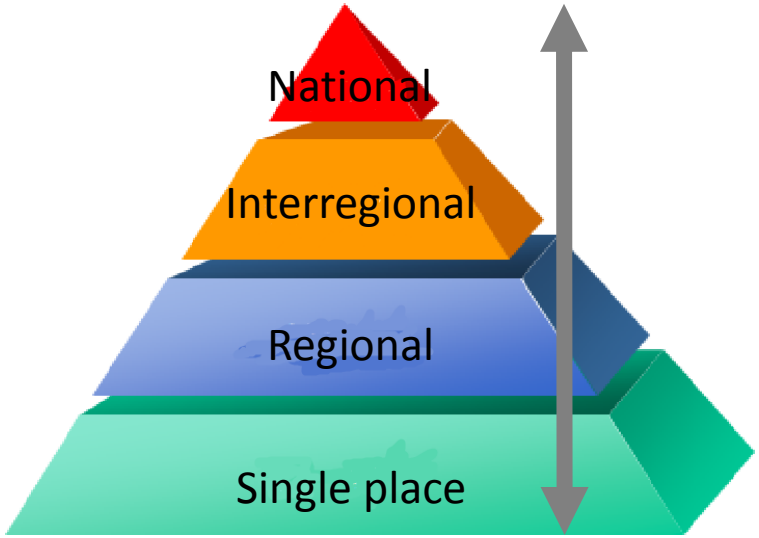


Small incident ： Commander for all
Big incident ： Commander authorizes others

Modular Organization

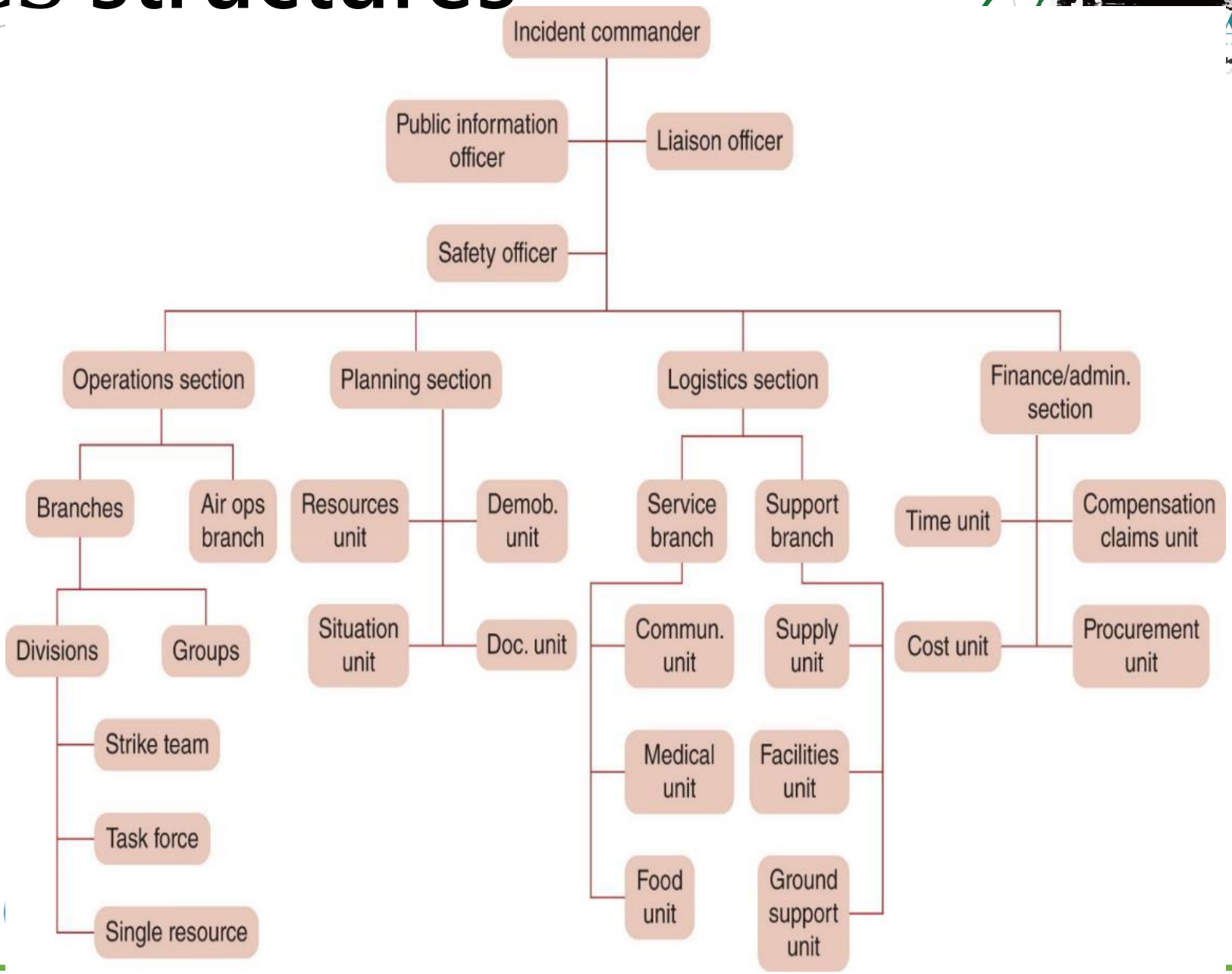
- ICS for small and/or big events.
- ICS could expand or downsiz to be suitable.
- Top-down modular/organization.
- Positions set up as needs.
- for multiple use.
- Efficient management.





Roles and responders

ICS structures



Incident Commander

Who should be the commander?

- Initially, the first supervisor on scene.
- Later, resource manager or legal duty agency

Commander’ s duties:

- Determining strategy
- Selecting incident tactics
- Creating the action plan
- Developing the ICS organization
- Managing resources
- Coordinating resource activities
- Providing for scene safety
- Releasing information about the incident
- Coordinating with outside agencies

The seven Hazwoper requirements for the IC

1. Identify all hazardous substances or conditions present.
2. Based on identification, implement appropriate operations, and assure use of proper personal protective equipment.
3. Assure personnel exposed to inhalation hazard wear SCBA.
4. Limit number of personnel on-site, but use Buddy System.
5. Assure back-ups and standby EMS are available.
6. Designate “Safety Official” with knowledge of safe operations.
7. Implement appropriate decontamination; etc.

Safety officer (SA)

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Safety recommendations

Commander

Coordinate with supervisors

Operation/Logistics/Plaanning

Supervisors

Safety officer (SA)

Ensure all personnel’ s safety

The authority to terminate any unsafe operations.

Operators

Pubic information officer(PIO)

Recommendations on related news

Release news by commander’ s authorization

Commander

PIO

Information exchanges

Supervisors

Information exchanges

Establish good relations with media

Media and publics

Liaison officer (LO)

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Helps commander communicate with or request supports from other units

Commander

LO

Answer questions from other units

Medical staff

Engineering staff / Technical staff

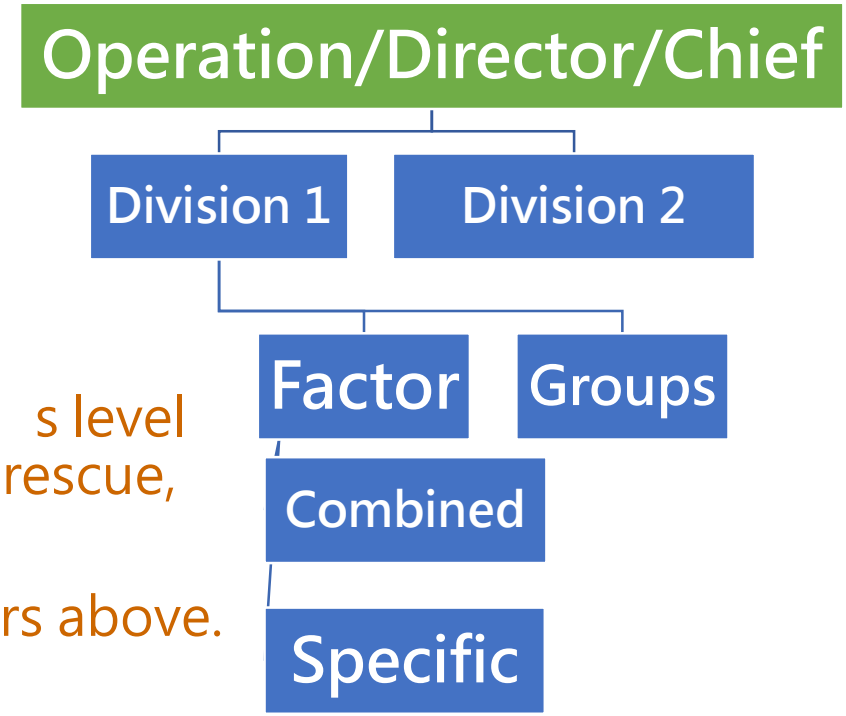
Operation

Responsible for main operations

- Implement commander’ s plan /Provides professional opinions and services
- **Rescue, Mitigation, leaking/Hazard control**
- Utilizes resources appropriately.

if encountering difficulties

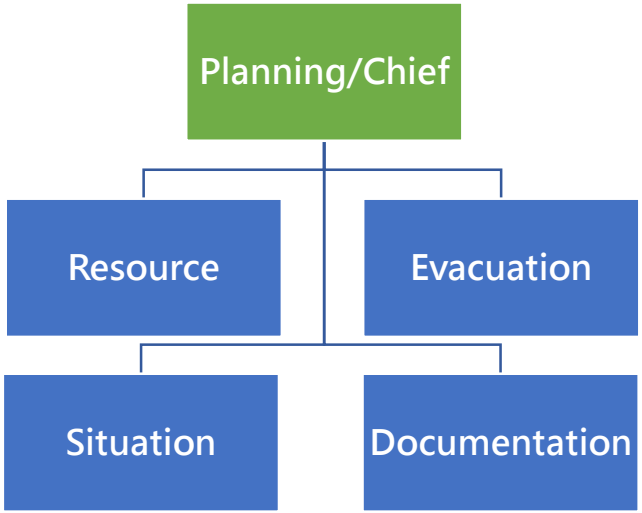
Safety Officer’ s main concerns



- **Division**：
  - Divided by Locations ： building’ s level
  - Divided by Functions ： medical, rescue, Firefight, recon…
  - Combined ： Integrate two factors above.

Planning

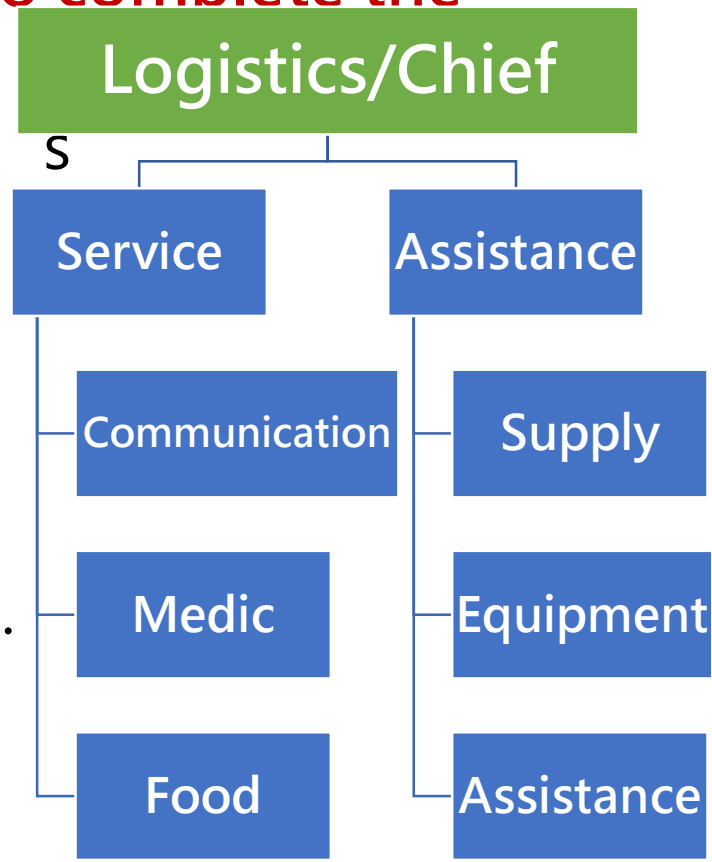
Evaluation and application of the event and resources



- Help to set up plan
- Predict and prepare alternative plans
- Data record and document management
- **Resource team：** In charge of resource usage
- **Situation team：** Gather and analyze the information about current situation
- **Document team：** Document management
- **Evacuation team：** Responsible for evacuation plan when emergency happens

Logistics

Provides manpower and equipment to complete the mission

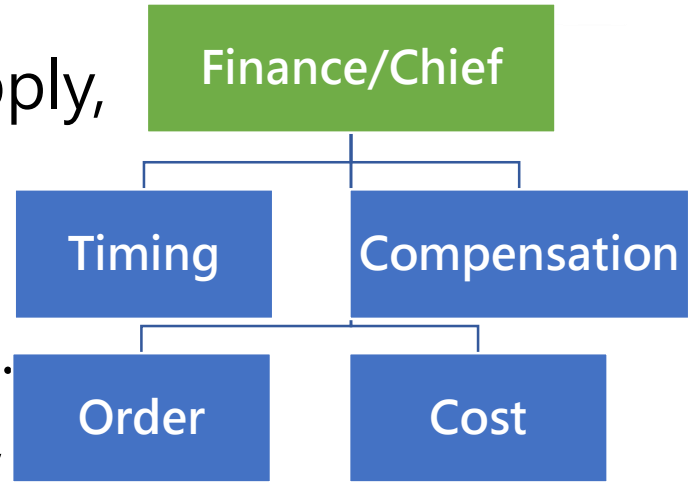


- **Supply team**：Responsible for supply’ s storage and management.
- **Equipment team**：Maintain and Provide the equipment that is needed.
- **Assistance team**：Provide transportation and vehicle maintenance.
- **Communication team**：Provide communication and it’ s maintenance.
- **Medic team**：Provide medical assistance.
- **Food team**：Provide foods and water for all personnel.

Finance(omit for small/simple task)

Financial management

- Records/monitors the usage of supply, equipment and all the expenses
- Fund dispatch is important when encountering a big or long incident.
- Personnel’ s salary, compensation,



- **Timing team：** Confirm and record all personnel’s work time
- **Order team：** Responsible for the supply and equipment’s orders and contracts
- **Compensation team：** Record personnel’ s injury, diseases, responsible for lodging a claim and compensation,
- **Cost team：** Collect record, provides evaluation for costs.

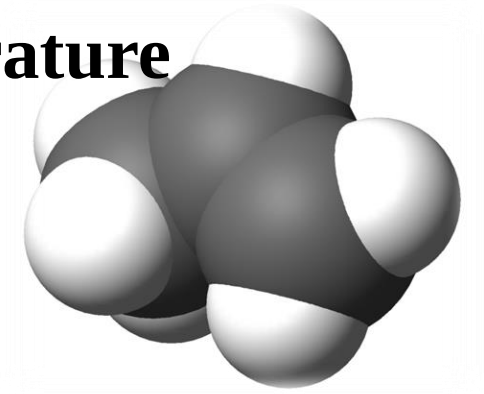
Case Review Kaohsiung Gas Explosion Accident

07.31 Kaohsiung Gas Explosion Summary

1. **Time: July 31, 2014, 20:46**
2. **Place: Kaixuan 3rd Rd. and Ersheng Rd. intersection, Qianzhen Dist., Kaohsiung City**
3. **Casualties: 30 dead, 305 injured**
4. **Type of Accident: Gas Explosion**
5. **Disaster Area: about 4.3kilometer X 0.5kilometer**
6. **Chemical: Propylene**

Propylene(C_3H_6) Properties

- Physical Description: Colorless gas, faint odor
- Flash Point: Ignite in room temperature
- Ignition Temperature: 455℃
- Vapor Density: 1.5 (Air=1)
- Explosion Limit：2%~11%
- Health Effects：6.4~75% concentration leads to central nervous system depression, other symptoms like headaches, nausea, vomiting, dizziness and unconsciousness.



Kaohsiung Gas Explosion Location Map

Toxic and Chemical Substances Bureau,
Environmental Protection Administration Executive Yuan, R.O.C. (Taiwan)

Culvert pipeline accident

According to the specialist team, the 4-iche pipeline hole of 榮化 was the leaking point, the leaking propylene followed the fire fighting water and widespread in the sewer.

Taiwan Kaohsiung gas explosion accident editing film

HF leak at Container Field

HF leaking at a Container Field, Keelung Habor

time ➡ 20150213am0720

loca ➡ Keelung Harbor

Inj/Fat ➡ None

Damage ➡ Area 400 m^2

Chem ➡ HF(cas no：7664-39-3)
(Adm. Under Labor Dept)

HF leaking at a Container Field, Keelung Habor

Summary：

- **HF leaking out from a 20 ton ISO-tank at a container field, Keelung.**
- **Calcium Chloride was used to adsorb leaking HF. Another ISO-tank was used to transfer the remaining HF.**

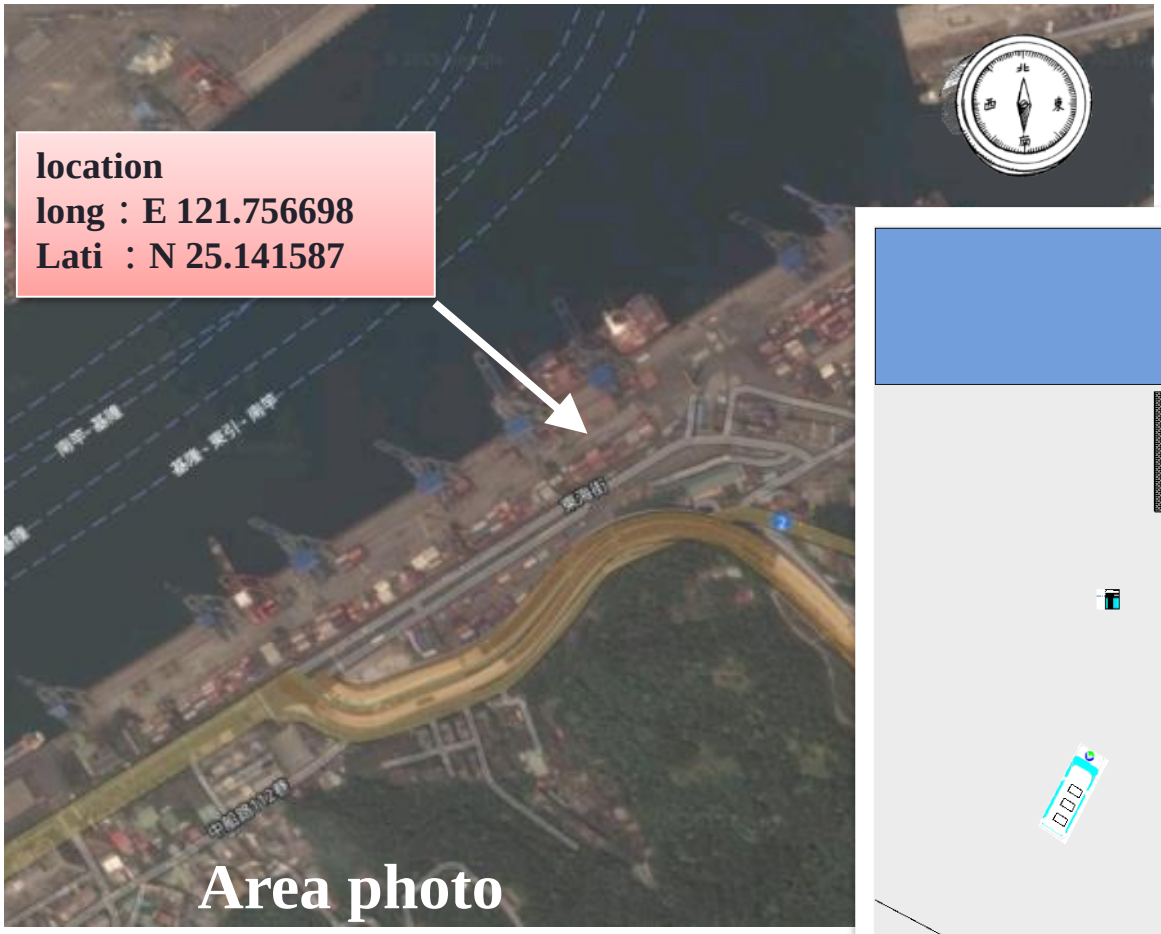
Cause：bleach on tank wall

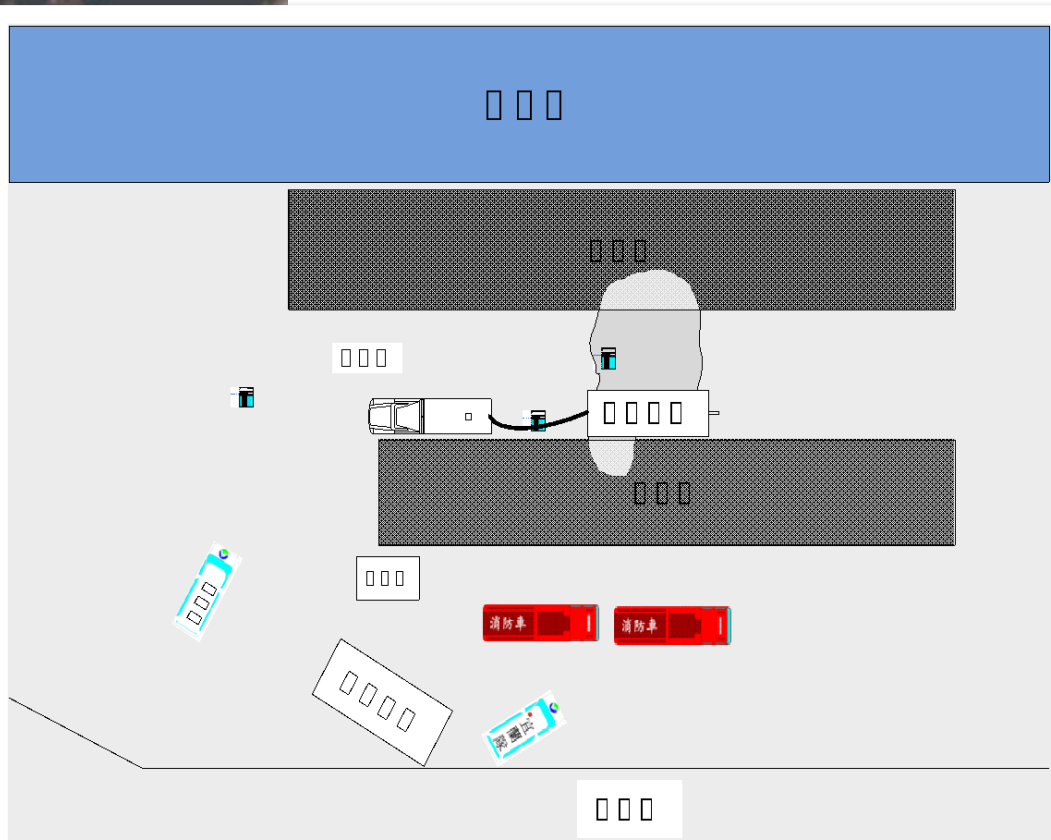
- **leaking at welded and corroded seam on ISO-tank.**

HF leaking at a Container Field, Keelung Habor

Location

Wind：
Northwest





HF leaking at a Container Field, Keelung Habor

07:48 ERIC notified ERTs

09:00 First ERT arrived
09:07 2nd ERT arrived

07:20
Iso-tank leaking

09:53 HF 1ppm at down wind locations

10:42 discussed with owner at site

10:59 decon unit setup and 1st attempt to stop leakage
14:04
2nd attempt to stop leakage

15:01 an ISO-TANK on-site for transfering

15:27 3rd attempt to stop leakage
16:00
Leak stop and ready to transfer

HF leaking at a Container Field, Keelung Habor

16:13 HF 10-20 ppm in air at nearby

18:50
Tank transfering

20:30 Complete patching work for ISO Tank

23:00 Complete ISO TANK transfer

23:39 Thermal image detecting no leakage

23:50
Task Complete

ISO TANK leaking

Color tube detecting

On-site meeting

Patching operation


Neutralization


Containment


Decontamination
02 13 2015


Transfering

HF leaking at a Container Field, Keelung Habor

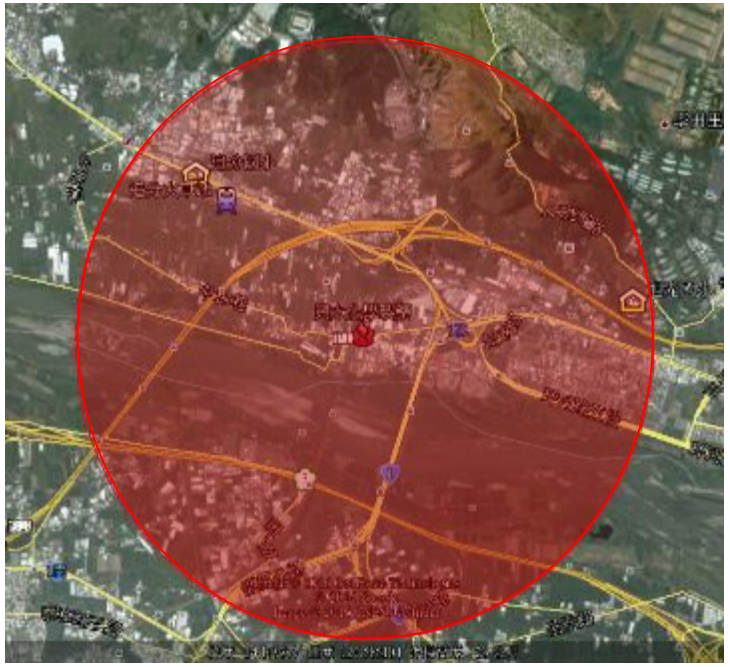
Consequence management

- No HF was detected at near-by areas after ISO TANK transfering.
- Both ISO-tanks moved to safe place and verified with thermal imaging with NO leakage.
- After a de-briefing meeting, EPB monitor the site clearing.

Fire at a pharmaceutical manufacturer

A FIRE AT A PHARMACEUTICAL MANUFACTURER, TAI-CHUNG

Ti	20160201 am0555
Lo	Pharmaceutical Plant
Ty	Fire at processing area



Area Map

- **Summary：**

A pharmaceutical plant at Tai-Chung was caught on fire at 5am and involved toxic chemicals of Methyl isobutyl ketone(MIK) **660 kg and methyl chloride (MC) 9,000 kg. There were one injury and one fatality with damage area 1500 m^2**. The wastewater 490 tons was treated by its WWTP and the remaining 1800 kg MC was delivered back to suppliers.

Material hazard characteristics

METHYL ISOBUTYL KETONE - Highly flammable liquid and vapour

Melting point	-80 ˚C	LEL / LC50	1.2%（V）/ 480 mg/l - 48 h
boiling point	118 ˚C	Vapour pressure	20 hPa at 20,0 ˚C
Flash point	14 ˚C - closed cup	Water solubility	ca.20 g/l

GHS

NFPA 704

Transport hazard class(es):3

UN No.:1245

- Causes serious eye irritation and respiratory irritation. Repeated exposure may cause skin dryness or cracking.
- Conditions to avoid
  Heat, flames and sparks. Extremes of temperature and direct sunlight.
- Incompatible materials
  Oxidizing agents, Strong bases

Material hazard characteristics

Chloromethane - Extremely flammable gas

Melting point	-97 ˚C - lit	LEL / LC50	7%（V）/ 550 mg/l - 96 h
boiling point	-24,2 ˚C	Vapour pressure	5.060,9 hPa at 20,0 ˚C
Auto-ignition temperature	632,0 ˚C	Water solubility	5,32 g/l at 25 ˚C - soluble

GHS

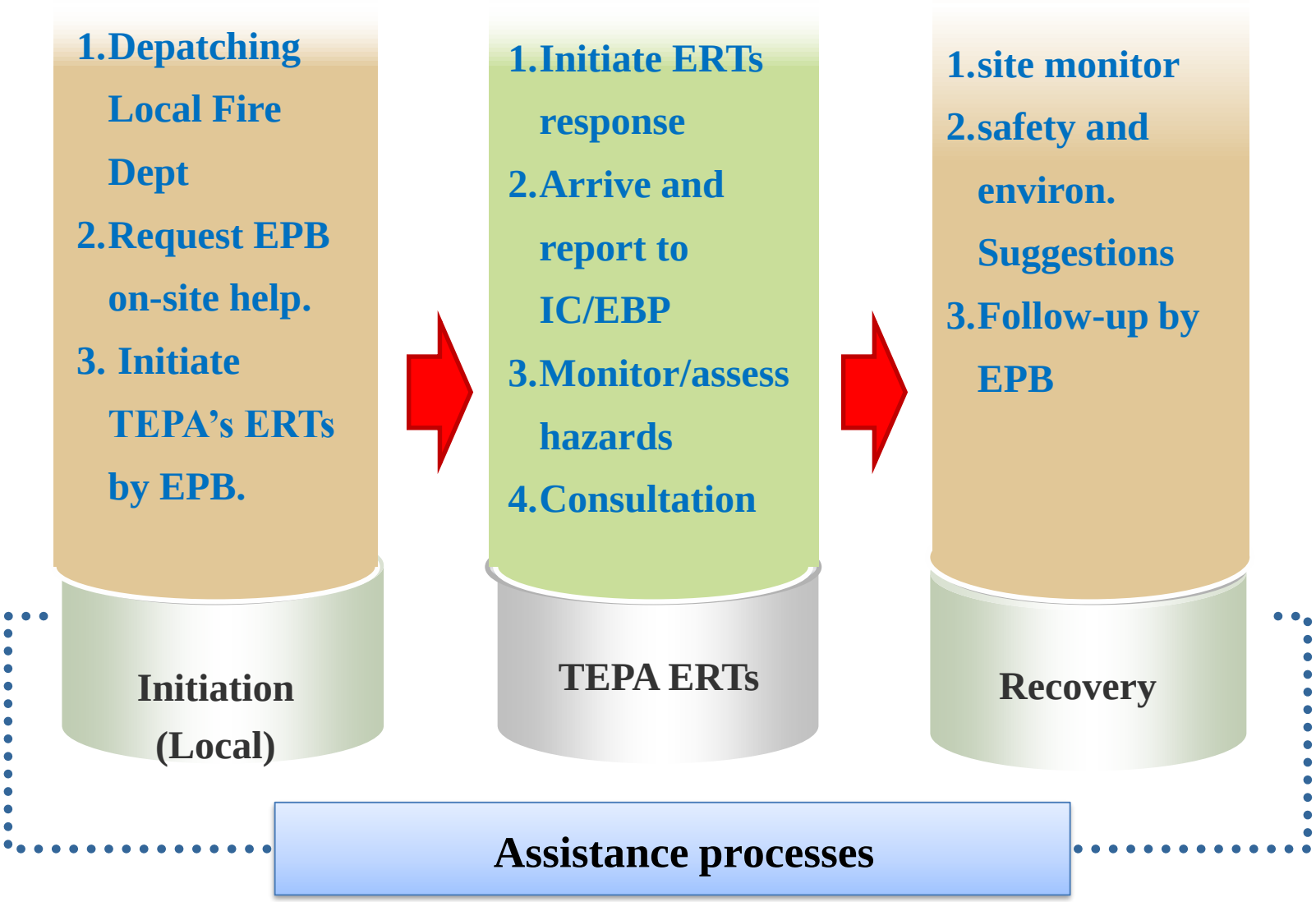
NFPA 704

Transport hazard class(es):2.1

UN No.:1063

- Suspected of causing cancer. Suspected of damaging fertility. Suspected of damaging the unborn child.
- May cause damage to organs through prolonged or repeated exposure. Precautionary statement(s).
- Hazardous decomposition products formed under fire conditions Carbon oxides, Hydrogen chloride gas.

Incident Supports



Assign

Initate

Assess

Plan

Act

Recovery

05：50 Fire/Explosion

06：15 ERTs Initiated

06：50 ERTs arrived

07：00 EPB arrived

08：12 Check on all toxic chemicals

08：43 Injury to Hosp.

Assign

Initiate

Assess

Plan

Act

Recovery

08：53 Cylinder leakage

09：12 Confirmed that MC, MIK involved

09：43 Plant wastewater containment

11：19 660 kg of Methyl isobutyl ketone has been burned

09：05 Water mist protection

09：43 Residual fire treatment

10：45 Empty vehicles arrived

11：19 1 burned and 6 suspected leaks of 14 cylinders of *MC*.

Assign

Initiate

Assess

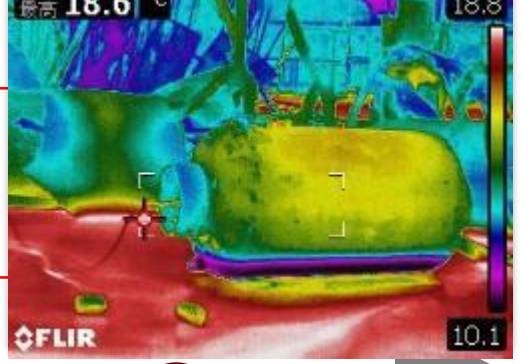
Plan

Act

Recovery

13：32 Request assistance of cylinder supplier

14：23 Thermal imaging cylinders



Spray water mist on cylinders

15：15 Stop water mist

15：54 pacting cylinders by supplier

Assign

Initiate

Assess

Plan

Act

Recovery

17：00 Complete cylinder patch

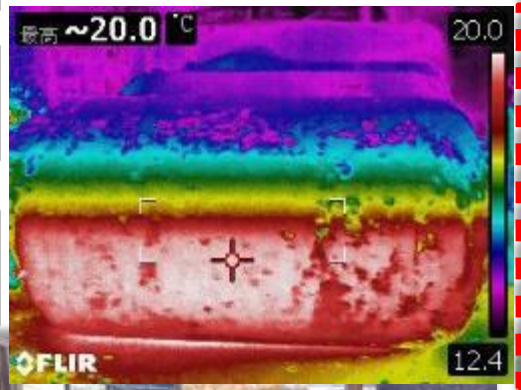
17：49 fire affected on 9tons of MC and 660kg of MIK

2/3 08：00 cylinders to Supplier

17：20 De-briefing /recovery meeting

18：10 Complete Task

2/2 14 ： 43 EPB monitored cylinders reinforcement



ammonia leakage and response for XX optoelectronic

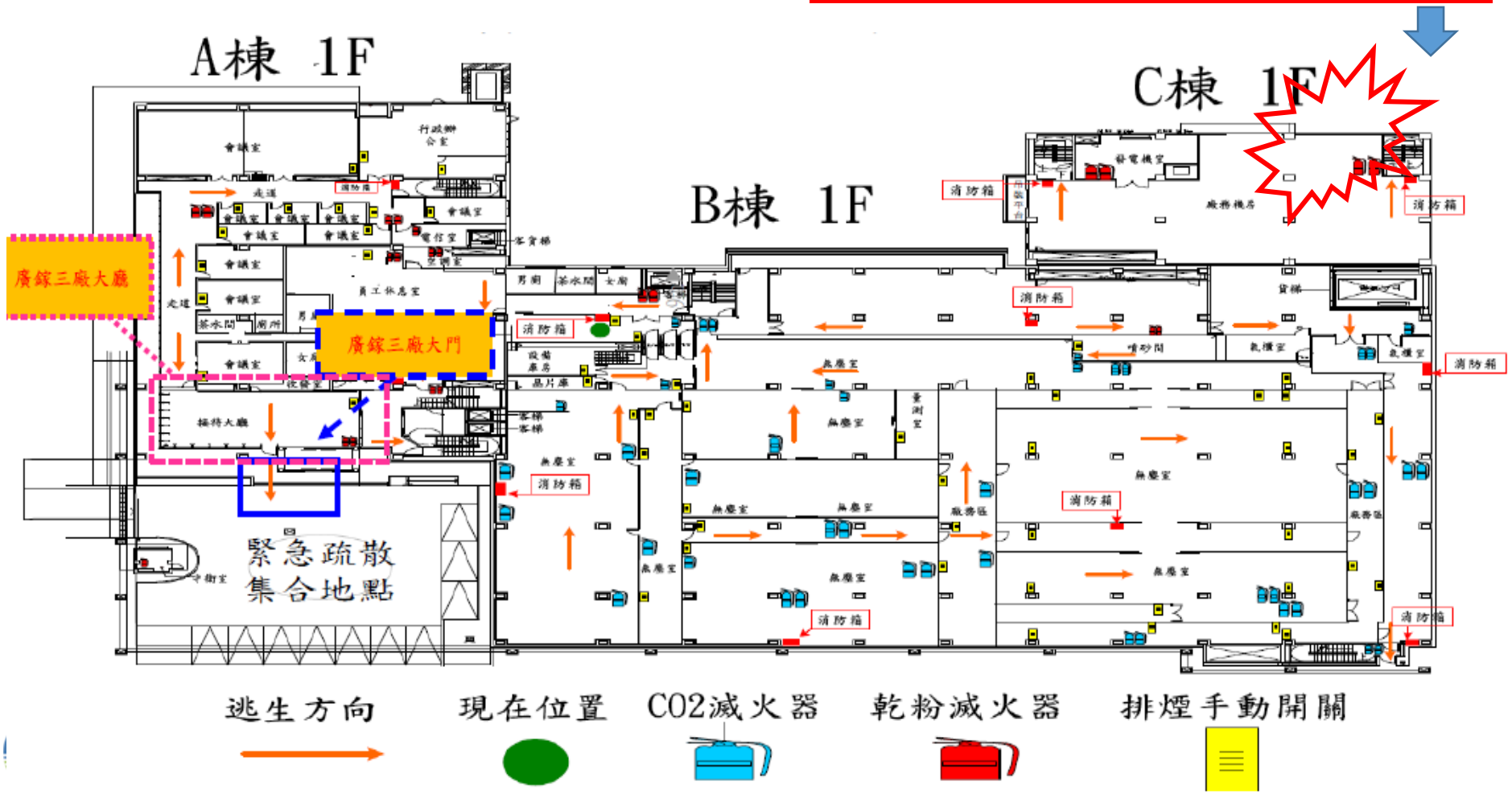
- Time：July,2013
- Place：x, Keya Rd., Daya Dist., Taichung City, Taiwan (R.O.C.)
- Casualties and scale： 0 injured . damage area35 square meters
- Chemicals： liquid ammonia(CAS No：7664-41-7、UN No:1005)。
- **Summary ：**

Safety valve of horizontal ammonia cylinder bleached in XX optoelectronic company and the factory initiated emergency response team using water mist to protect and to reduce dispersion to adjacent areas. Failed to stop leakage, the factory reported to authorities and ask for helps. The authority of the Central Taiwan Science Park activated the mutual aids and dispatched the assistants.

Factory layout

2020TSAST
HAZMAT FRO Training

Gas Room



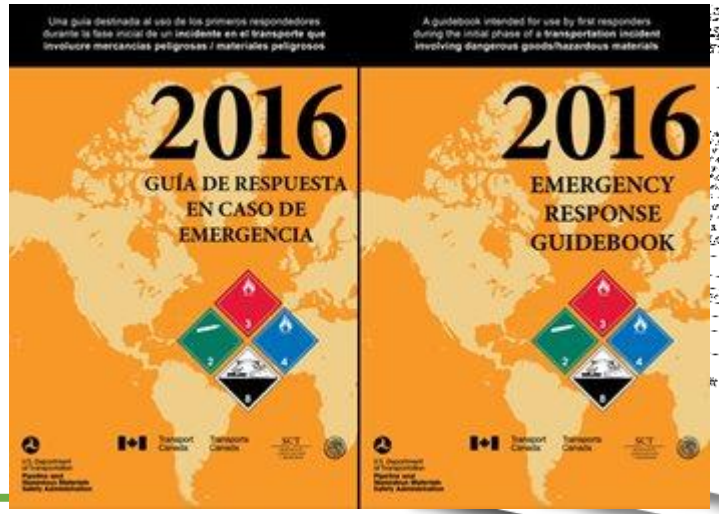
Response Stage 1

- On emergency scene —safety , isolation and report
  - **In a incident, the safety of workers on-the-spot should be cared first.**
  - **A blockade line and traffic control should be set up to divide cold, warm, hot zones. The action of prohibiting non-related personnel into the scene should be enforced.**
  - **A reporting should be activated to authorities– the Central Taiwan Science Park Bureau, the Fire Department, the Environmental Protection Agency (for activating Environmental Incidents Specialist Team) to request for assistances.**

Response Stage 2-1

- Incident management-command/management、Identification and hazard assessment

- **The site contingency response command center was set up by CTSP Bureau to respond to the incident. There were several units responded to the incident including the factory, CTSP, the Environmental Protection Agency , and the Environmental Protection Agency Environmental Incidents Specialist Team. A meeting was held to discussion the situation and to handle the action.**
- **The hazards of ammonia were identified and situation was assessed.**



Ammonia hazards/ characteristics

- Ammonia hazard
  - Corrosive gas
  - Inhalation would damage lung and could be fatal
  - Liquefied gas could cause frostbite and damages eyes and skin
- Particular hazard
  - **Avoid to mix with an oxidant (perchlorate , chlorate , etc.) will react violently or explode.**
  - **Avoid to mix with heavy metals and salts (gold, silver, etc.) will be explosive mixture**
  - **Avoid to mix with calcium will have exothermic reaction, high temperature will ignite.**

Ammonia hazards/ characteristics

- Physical and chemical properties

Material condition：Gas	Shape：compress or liquefied gas
Color：colorless	Smell：pungent smell
pH value：11.6（soluble in water， based on 25℃ ）	Boiling point/ Boiling point range：-33.4 ℃
Autoignition temperature：850℃	Explosion limits：15.5 % ~ 25 %
Vapor pressure：7.76 atm @21.1 ℃	Steam density：0.6
Density：0.682 @ -33℃ （water＝1 ）	Solubility：soluble in water

- Expose allowable concentration

- **The average allowable concentration for eight hours (TWA):50ppm**
- **The average allowable concentration for a short period of time (STEL):75ppm**

Response Stage 2-2

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HAZMAT FRO Training

- Action plan
  - First, the action plan was discussed and palnned. The action was to confirm horizontal cylinder safety valve and the bleaching location.
  - **The protection of water mist was continuously to protect the evacuating workers and adjacent areas.**
  - **The gas supplier was notified and ready to move in to support**
  - **Before the XX gas response team arriving, the technical team recommended to fill the leak point to stop leak and to gradually slow the rate of leakage.**

mmonia protection1

- **Escape：**
  - Use gas masks with organic vapor protection
- **Hand protection：**
  - Use impervious gloves made by butyl rubber 、Teflon、Viton、Responder 、Trellchem HPS 、Tychem 10000 are better
- **Eyes protection：**
  - Use chemical safety goggles , mask , eyewash equipment
- **Skin and body protection：**
  - Use coveralls protective clothing , protective boots

mmonia protection2

- Personal protective equipment(breathing protection)：

Under250ppm：

- Us respirators with Anti-ammonia cartridge of chemical cartridge; air supply or self-contained breathing respirators

Unknown concentration：

- Use positive pressure self-contained breathing apparatus (SCBA) , positive pressure comprehensive air supply respiratory protection with auxiliary pressure self-contained breathing apparatus

esponse Stage 3-1

- Protection Equipment, Contain/Control Action-

- As XX gas response team arrived , they wear class A protective clothing to stop leaking but failed due to limited space.
- **Then, they changed to class B protective clothing with self-contained breathing apparatus (SCBA) to enter small space to stop leaking.**

esponse Stage 3-2

Protective Action

- The wastewater from the water mist was pumped to the waste water treatment on site .
- CTSP Wastewater Service Center help to close the nearby manholes to protect the downstream areas and to avoid the wastewater into the stormwater drains.

esponse Stage 3-3

2020TSAST
HAZMAT FRO Training

- protective action

- From the beginning, the manufacturers set up two streams of water mist for perimeter protection
- Specialist team assisted in the perimeter monitoring and about leakage . the ammonia gas detector showed at the upper wind measurement 30 ppm downhill 4 ppm
- The wastewater from the water mist was measured at pH 10.

Response Stage 4-1

- Decontamination/Clean up, disposal and record

  - XX gas response team finished the operation of stopping leakage , staff , equipment start to cleaning .
  - **The cylinders in the accident will handle by gas supplier ， 40 metric ton of fire waste water recycle to waste storage equipment and handle after .**

Response Stage 4-2

- Clean up the mess-decontamination , disposal and record
  - **Central Taiwan Science Park Bureau , Environmental Protection Bureau , specialist team , manufacturers , gas suppliers , etc. 氣體供應商等 Hold a conference of clean up and recover .**

Response procedure analysis (1/4)

Disaster situation in the site	2014	2016
Safety 安全	1.Start response team in the field 2. Set up blockade line on site 3.Start to evacuate in the field	1. Start response team in the field 2. Set up blockade line on site
Isolation (Deny Entry) 隔離及禁入	1.Set up staffs control station 2.Adjust staffs on/off duty route	1.Set up staffs control station
Notification 通報	1. Central Taiwan Science Park Bureau , Environmental Incidents Specialist Team , Environmental Protection Bureau , Special Police , fire bureau 。 2.Inform Lien Hwa	1. Central Taiwan Science Park Bureau , Environmental Incidents Specialist Team , Environmental Protection Bureau , Special Police, Central environmental police unit 2. Inform Lien Hwa

Response procedure analysis(2/4)

Command and Assessment	2014	2016
Command /Management 指揮及管理	1.XX set up emergency response team 2. Central Taiwan Science Park Bureau serve as response commander on site	1.XX set up emergency response team 2. Central Taiwan Science Park Bureau serve as response commander on site
Identification & Hazard Assessment 辨識及評估	1. Ammonia flammable, corrosive toxic gases, soluble in water, heat may explode, liquefied ammonia may cause frostbite	1. Ammonia flammable, corrosive toxic gases, soluble in water, heat may explode, liquefied ammonia may cause frostbite
Action planning 行動規劃	1. Water mist perimeter protection 2.Contact with XX gas supplier 3. fill the leak point to stop leak, gradually slow the rate of leakage.	1. Water mist perimeter protection 2. Contact with XX gas supplier，use a sleeve to force a rupture disc to stop the plug.

Response procedure analysis(3/4)

Rescue and protect	2014	2016
Protective equipment 防護裝備	1. Responders wear class B protective clothing and with self-contained breathing apparatus (SCBA) , then enter to stop leaking	1. Responders wear class B protective clothing and with self-contained breathing apparatus (SCBA) , then enter to stop leaking
Containment & Control 圍阻及控制	1.XX gas staffs enter to stop leaking 2.Stop leakage Finished : 2hours and 37 minutes。	1.XX gas staffs enter to stop leaking 2.Stop leakage Finished : 1hours and 24 minutes
Protection actions 保護行動	1. Water mist perimeter protection 2. Ammonia gas detector at the upper wind measurement 30 ppm downhill 4 ppm 3. Fire waste water pH value is 10 pump to waste water equipment	1. Water mist perimeter protection 2. Ammonia gas detector at the upper and downhill wind measurement 0 ppm 3. Waste water pH value at 7 to 8 pump to waste water equipment

Response procedure analysis(4/4)

Clean up and recover	2014	2016
Decontamination & Cleaning 除污及清理	1. 40 metric ton of fire waste water recycle to waste storage equipment and central science park waste water system	1. 24 metric ton of fire waste water recycle to waste storage equipment and central science park waste water system
Disposal 棄置	1. The cylinders will handle by XX gas supplier to do after treatment	1. The cylinders will handle by XX gas supplier to do after treatment
Documentation 紀錄	1.Finished a conference about clean up and recover 2.Check toxic chemicals Ammonia affect or not	1.Finished a conference about clean up and recover 2.Check toxic chemicals Ammonia affect or not

Thanks for You Attentions!