2019 TSAST
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 of initial response action and detection instrument

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General Container Type

Bulk Storage Tanks

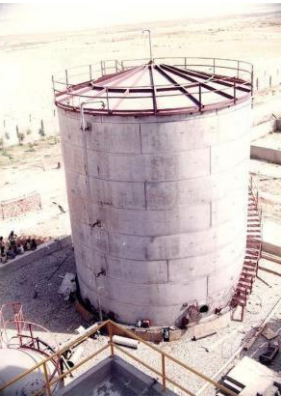
Bulk Storage Tanks

- Types:
  - Above ground
    - Atmospheric
    - Low pressure
    - Pressure
  - Below ground

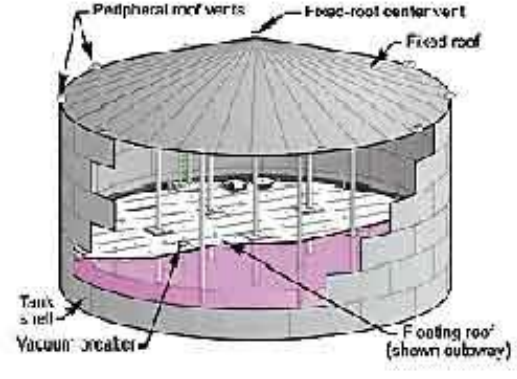
- The types and sizes of bulk storage tanks vary by location and type of operation at that location.
- Typical storage tank emergencies include fires and leaks.
- Causes of these emergencies include lightning strikes, mechanical failures, and operator error (typically overfilling).

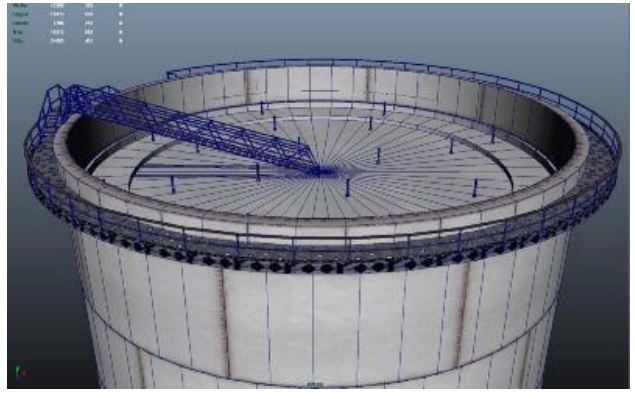
Atmospheric (non pressure) Tanks

- Common types:



  - Cone roof / dome roof tank - higher flash point materials
  - Open top floating roof - low flash point liquids and crude oil
  - Covered internal floating roof - low flash point/high vapor pressure liquids.
  - Vapor dome roof tank (less)- smaller quantities of flammable and combustible liquids, corrosives, poisons
  - Horizontal tank - flammable and combustible liquids, corrosives, poisons
  - Lifter roof tank (less)- flammable and combustible liquids



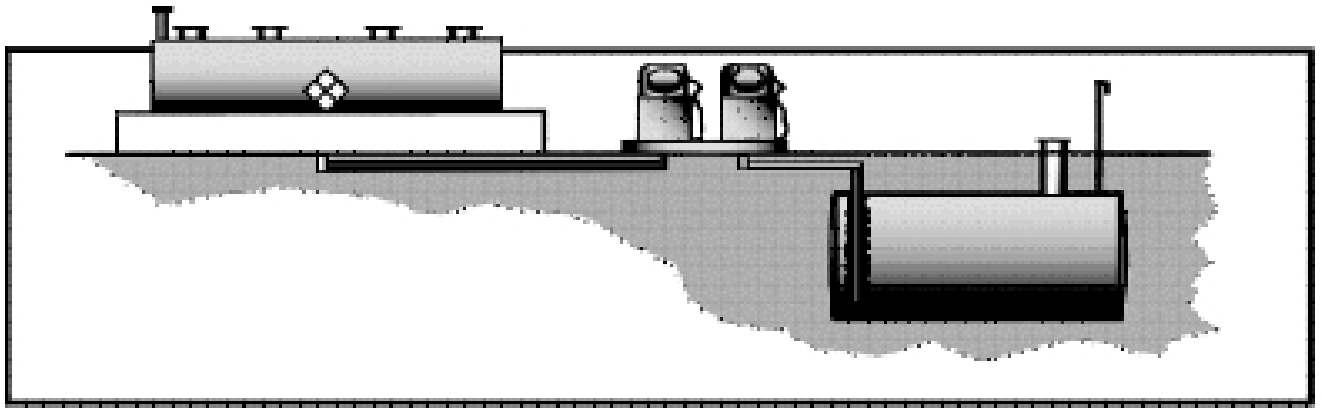


Pressure Facility Tanks

- Pressure Tanks are divided into
  - Low pressure (0.5 - 15 psig.)
    - Spheroid, and Node Spheroid
  - Pressure (>15 psig.)
    - Sphere, Horizontal, Cryogenic
- Most pressure tanks seen in industry are of the high pressure nature. Low pressure storage tanks are rather uncommon

Underground Storage Tanks

These types of tanks contain liquids or gases and petroleum products. They are commonly stored this way in many facilities. Tanks are underground to help protect from fire. They are more susceptible to corrosion than above ground tanks. Indications of an underground tank are vents, fill points and types of occupancy such as a gas station.



Road Trailers and Cargo Tanks

Flat Bed

- Decking
  - Wood, steel or Aluminum
- Freight
  - IBC’s, drums, equipment, etc

Van Trailers

- Floors
  - Wood 1 1/4" thick
  - Braces 8 to 10" apart
  - Nails
- Not liquid or air tight
- Construction
  - Aluminum or Fiberglass
- DOT does not regulate box construction
- DOT regulates
  - safety features such as running gear, brake systems, lights, length and weight

swinging doors

Roll Up Doors

wing roof

Refrigerated Trailers

- Aluminum floors
  - Ribs / groves
- Insulated
  - Liner
- Refrigeration systems
- Fuel systems
- Refrigerated trailer fuel tank underneath and the refrigeration unit on the front. Diesel, gas or propane are common types of fuels.

BulK Transportation Containers:Cargo tank Trucks

- Cargo tank truck
- Dry bulk containers
- Compresses gas tube trailers
- Mixed load container

- MC
  - MC 306
  - MC 307
  - MC 312
  - MC 331
  - MC 338

- DOT
  - DOT 406
  - DOT 407
  - DOT 412
- Post Aug 31 1995

- The 400 series trucks have
  - Thicker shells
  - Reinforced rollover protection
  - Man hole pressure capacity
  - Self reclosing fittings

Cargo Tank General

MC306

MC307

- Design and Construction Features
  - Manhole has to be 15” or larger(>400 gallons)
  - Outlets, valves, closures, piping, or any devices that if damaged in an accident could result in a loss of lading from the cargo tank must be protected by accident damage protection devices.
- Design and Construction Features
  - Shell less than 3/8”
    - Requires bulkheads, baffles, ring stiffeners
  - Pressure relief
  - Primary
    - Minimum 120% MAWP (Maximum allowable working pressure)
    - Maximum 132% MAWP
    - reclose at not less than 108% MAWP

MC312

DOT406

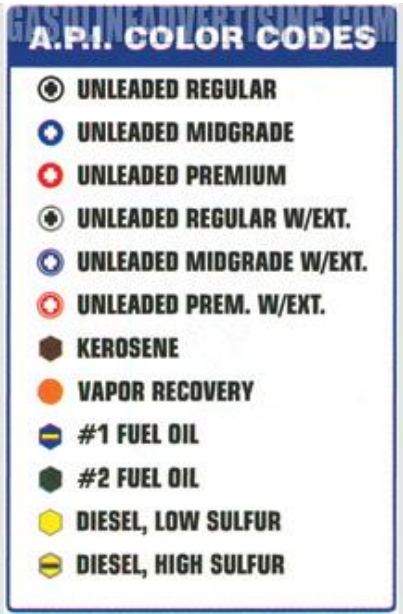
Non Pressure Tank Trucks

- MC-306
- DOT 406

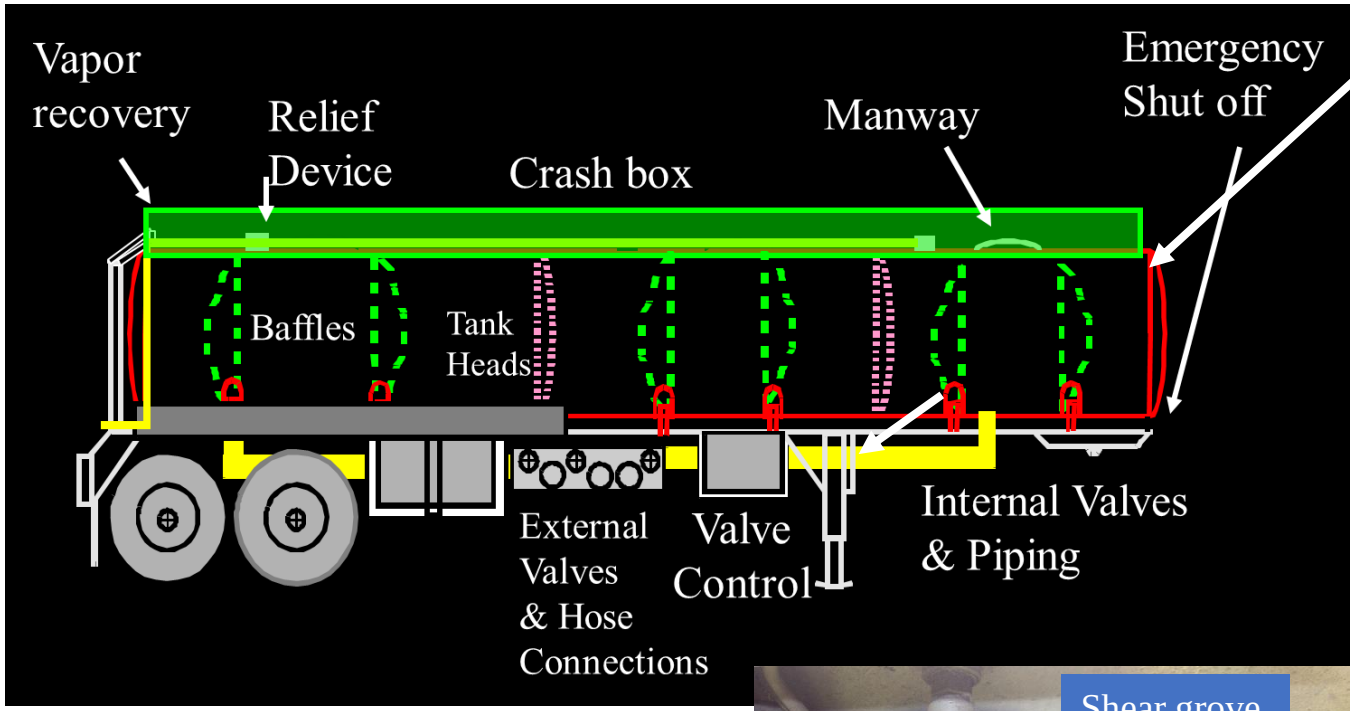
- Maximum Allowable Working Pressure (MAWP)
  - No Lower than 2.65 psig
  - No Higher than 4 psig
- Vacuum relief device
  - Open at 6 ounces vacuum
- Design and Construction
  - 1 - 8 compartments, 4-5 most common
  - Total typical capacities between 1500 – 10,000 gallons
    - But may be up to 14,000 gallons
- Specifications
  - Products like gasoline, petroleum fuels, alcohol
  - Color coding for product identification


Fusible links (212F)

Capacity Markings

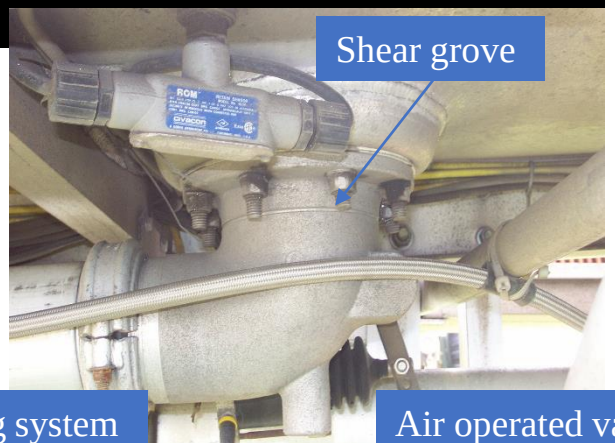


Typical MC-306 Non Pressure Cargo Tank



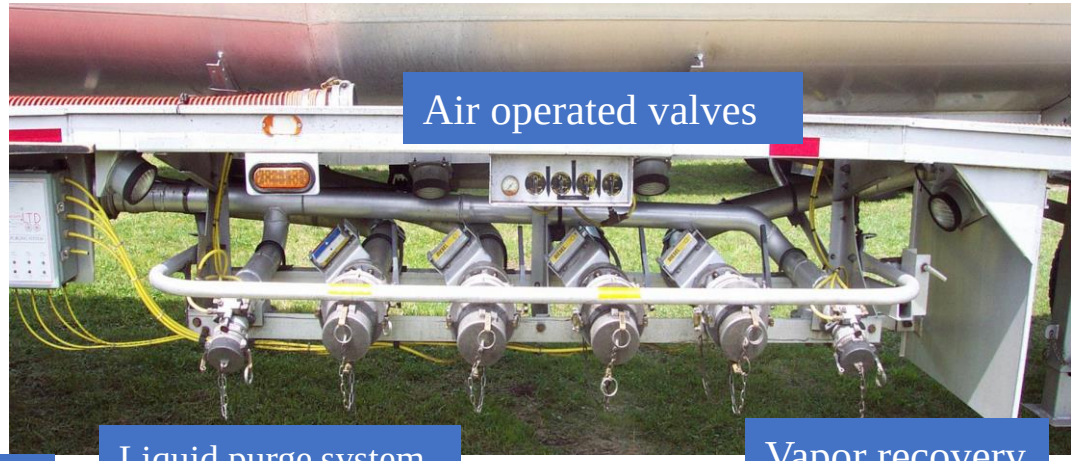
Manway

Pipe coupling system



Shear grove

Air operated valve



Air operated valves

Liquid purge system

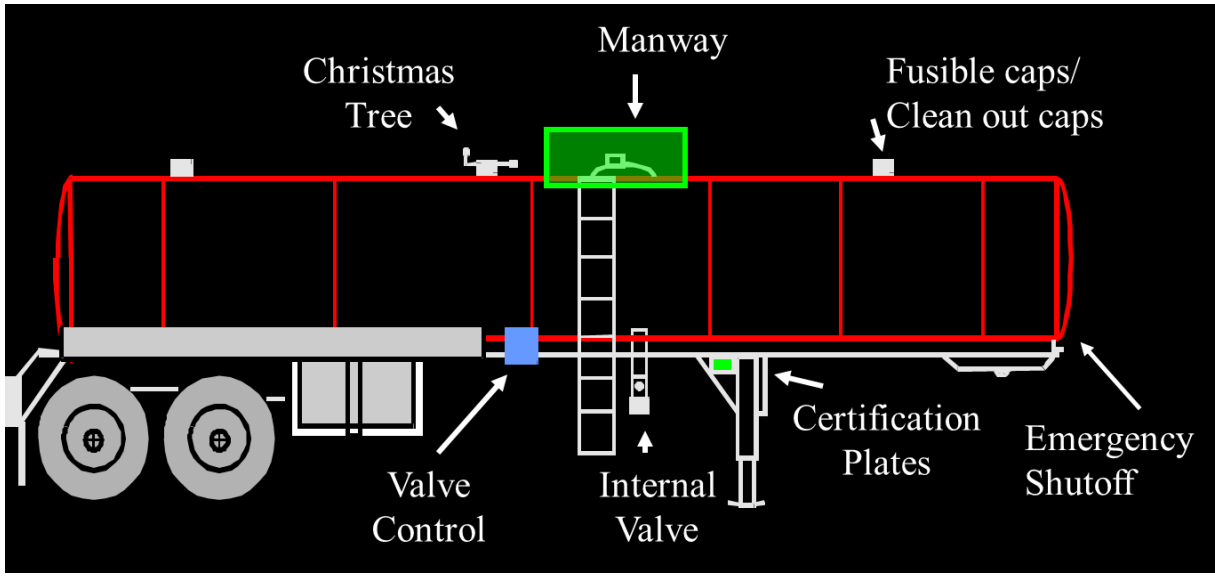
Vapor recovery

Low Pressure Tank Trucks

- MC-304
- MC-307
- DOT 407

- Chemical workhorse - transport of light corrosives, flammable/combustible liquids, some toxics/poisons
- Design and Construction
  - Must be circular cross section
  - MAWP of at least 25 psig，Typical pressure 25-35 psig
  - Typical capacities of 5500 ~ 7000 gallons (20820 ~ 26500 L)
  - Material of construction
    - Stainless steel、Mild steel、Aluminum
  - May be lined with rubber or other materials
  - 1-4 compartments, normally 1 or 2
  - Overturn protection for fittings, man-way covers, and vents
  - These containers may be insulated and equipped with heaters

Typical MC-307 Low Pressure Cargo Tank



- Rounded or horseshoe-shaped end
- Stiffening ring that may be visible or covered
- Rollover/turnover protection
- Single or multiple compartments
- Discharge piping at midship or rear
- Rear or middle unloading
- Ppressure and vacuum protection
- Manway assembly protected by the rollover / turnover protect (crash box)
- Drain hose from the rollover/turnover protection down the side of tank
- Emergency shutoffs (hydraulic or pneumatic) located on the leftfront of the tank

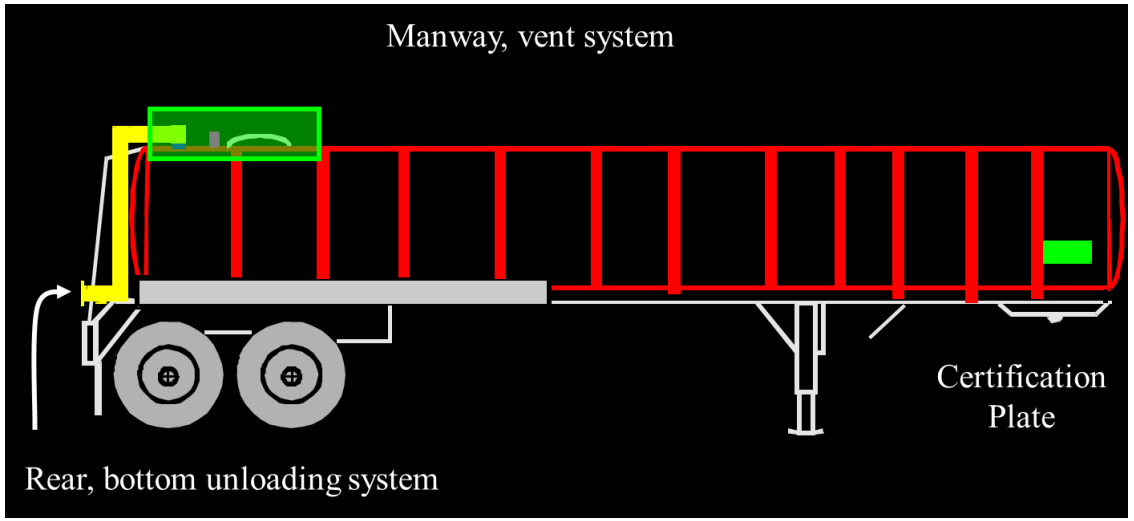
Medium Pressure or Corrosive Tank Trucks

- MC-310
- MC-311
- MC-312
- DOT 412 (newest)

- Design and Construction
  - Materials of construction
    - Typically stainless 、mild steel、aluminum or FRP
  - Typical pressures from 35-55 psi (241 kPa-379 kPa)
  - May be lined with rubber or polymer
  - Carries high density liquids, TIH materials, and heavy corrosives
    - TIH materials, like dimethyl sulfate and phosphorous trichloride and heavy corrosives like sulfuric acid and sodium hydroxide.
    - Typical capacities for 3300-6300 gallons (12492 – 23848 L)
  - 1 - 4 compartments, normally 1 compartment
    - Separate manholes per compartment

Typical MC-312-Medium Pressure Cargo Tank

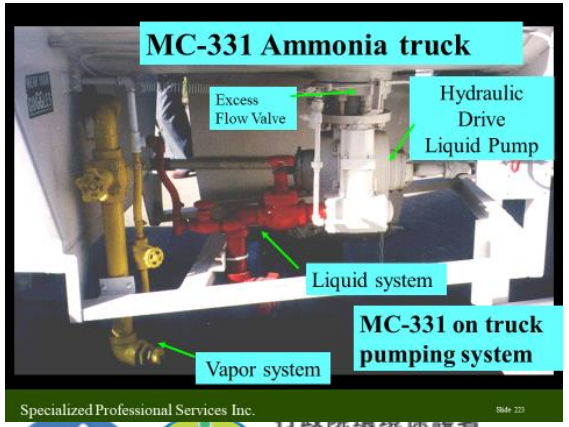
- Small-diameter round shape
- Exterior stiffening ring (may be visible on uninsulated tanks)
- Top unloading on the rear of the tank with exterior piping extending to the bottom of the tank
- Rollover protection around the valve assembly
- A pressure relief device (PRD) typically located in turnover protection
- Discolored loading/ unloading area
- An area painted or coated with corrosive-resistant material



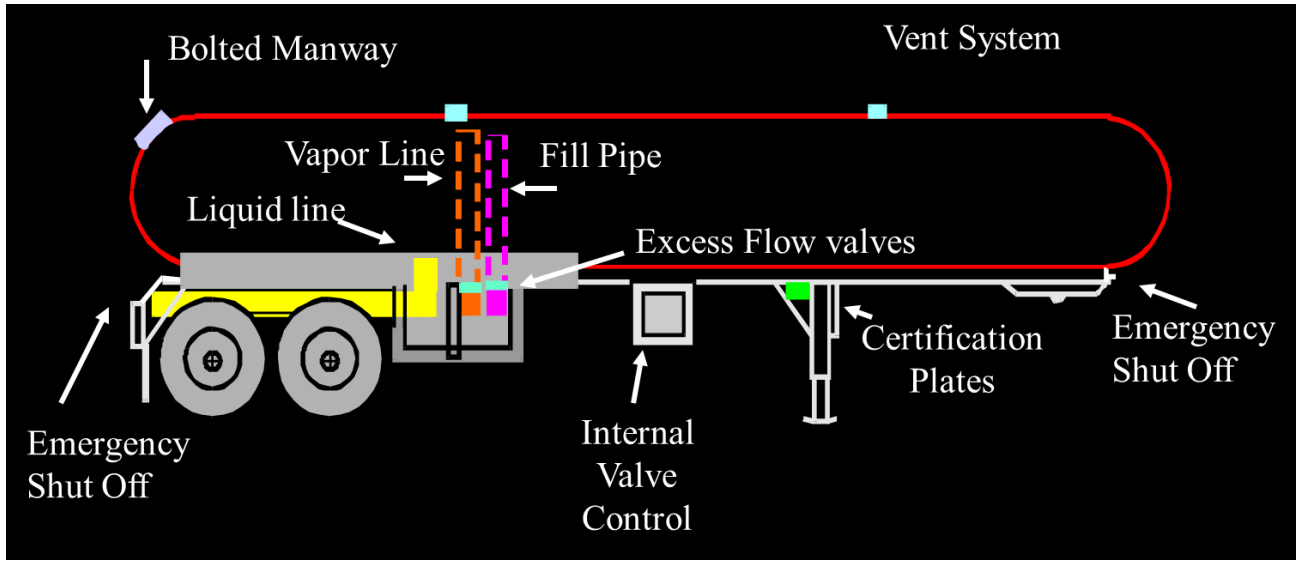
High Pressure Tank Trucks

- MC-330
- MC-331

- Design and Construction
  - Liquefied compressed gases
    - Materials may have very high expansion ratios
  - Highly toxic materials、Very high vapor pressure materials
    - Ammonia, LPG, methyl parathion, vinyl chloride or methyl amines
  - Rounded Ends、Normally One Compartment
  - Steel or Insulated Aluminum
  - Typical pressures from 100 – 500 psi (LPG 250-265 psig)
  - Capacities from 3000 – 11,000 gallons (11356-41640 L)
  - Typically fitted with internal thermometer wells, pressure gauges, and some type of fill gauging device
  - Equipped with excess flow valves、Protection for fittings and PRD's



Typical MC-331-High Pressure Cargo Tank



- Bolted manway
- Inlet and outlet valves
- White or other reflective paint scheme (typically)
- Large hemispherical heads on both ends
- Guard cage around the bottom loading /unloading piping
- Uninsulated tanks, single-shell vessels
- Emergency shut-offs (typically located in the left front and right rear)
- Permanent marking such as flammable gas, compressed gas, shipping name, or identifiable manufacturer or distributor name

Cryogenic Tank Trucks (MC 338)

- Cryogenic materials like liquefied nitrogen, liquefied oxygen, liquefied argon, liquefied carbon dioxide
- Carry refrigerated liquid gases at temperatures between -130 to -450 F.
- Materials have a very high expansion ratio when released.
- 8,000 - 10,000 Gallons
- MAWP 25 psi，but someone can be up to 500 psi
- Thermos bottle design with a tank in a tank and vacuum on the annular space
  - Usually 8” insulation
- Aluminum (except oxygen)
- Design Service Temperature
- Emergency shutoffs same as MC 331
- Relief valve set for 110% of MAWP
- Access through jacket to manhole
- Fusible links for flammables set for 250F

Cryogenic Tank Trucks (MC 338)

- Relief valves that may be discharging nonhazardous vapor such as nitrogen or oxygen
- Round tank with flat ends
- Large and bulky double shelling and heavy insulation
- Loading/unloading station attached either at the rear or in front of the rear dual wheels
- Permanent markings such as refrigerated liquid or an identifiable manufacturer name, proper shipping name
- Emergency shutoffs on the left-front and right-rear

Tube Trailers

- Multi - tube configuration, these transport bulk non liquefied compressed gases
- Pressures up to 5000 psi
- Multiple individual tanks
- One product
- Products
  - Compressed gases – helium, hydrogen, oxygen, anhydrous hydrochloric acid

Tube Trailers

- A pressure relief device (PRD) for each cylinder
- Bolted manway at front or rear
- Valves in a protected housing
- Permanent markings for the material or ownership that is locally identifiable, including proper shipping name

Dry Bulk Cargo Tanks

- Construction materials
  - Aluminum, carbon or stainless steel
- Cement, fertilizer, sand, salt, plastics
- Material typical weight
  - 18-125 lbs per cubic foot
- Unloading pressure 15 psi

- Typically not under pressure
- Varying shapes that often include bottom valves with V- or W-shaped bottom-unloading compartment.
- Rear-mounted, auxiliary-engine-powered compressor or tractor-mounted power-take-off air compressor
- Air-assisted, exterior loading and bottom unloading pipes
- Top manway assemblies

Intermodal Containers

Intermodal Containers

- Freight containers
  - Dry van Intermodal Containers (box container)
  - Refrigerated Intermodal Containers (reefers)
  - Open Top Intermodal Containers
  - Flat Intermodal Containers
- Tank containers
  - Pressure Intermodal tanks
  - Specialized intermodal tanks
    - cryogenic intermodal tanks 、tube module
  - Low pressure intermodal tanks

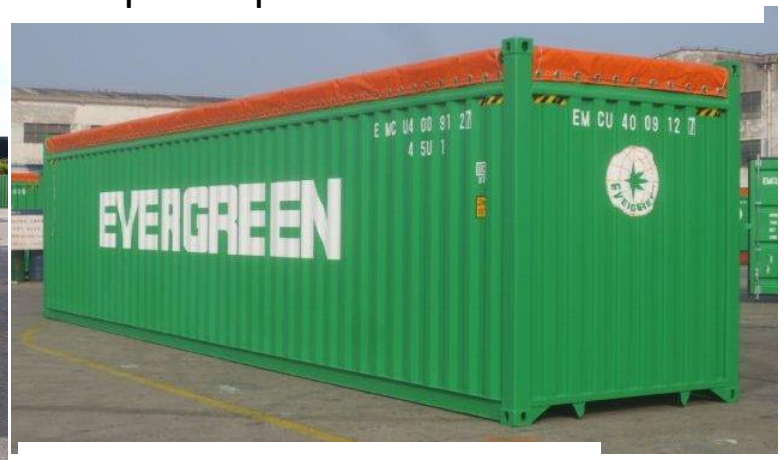
The Standard International Box

- TEU
  - Twenty-foot Equivalent Unit, i.e. 20’ long, 8 ‘ wide, 8.5 ft high
- FEU
  - Forty-foot Equivalent Unit, i.e. 40’ long, 8 ‘ wide, 8.5 ft high

box container

Refrigerated Intermodal Containers

Open Top Intermodal Containers



cryogenic intermodal tanks

Flat Intermodal Containers

Tank containers

tube module

Markings

- Identification system
  - Owner code - 3 Letters
  - Equipment category identifier (U、J、Z)
  - Serial number (Six numerals 0-9)
  - Check digit
- Size and type codes
- Operational marks
- Approvals

A	B	Z	U

Owners code

1	2	3	4	5	6

Serial Number

6

Check Digit

A	B

Country code

2	2

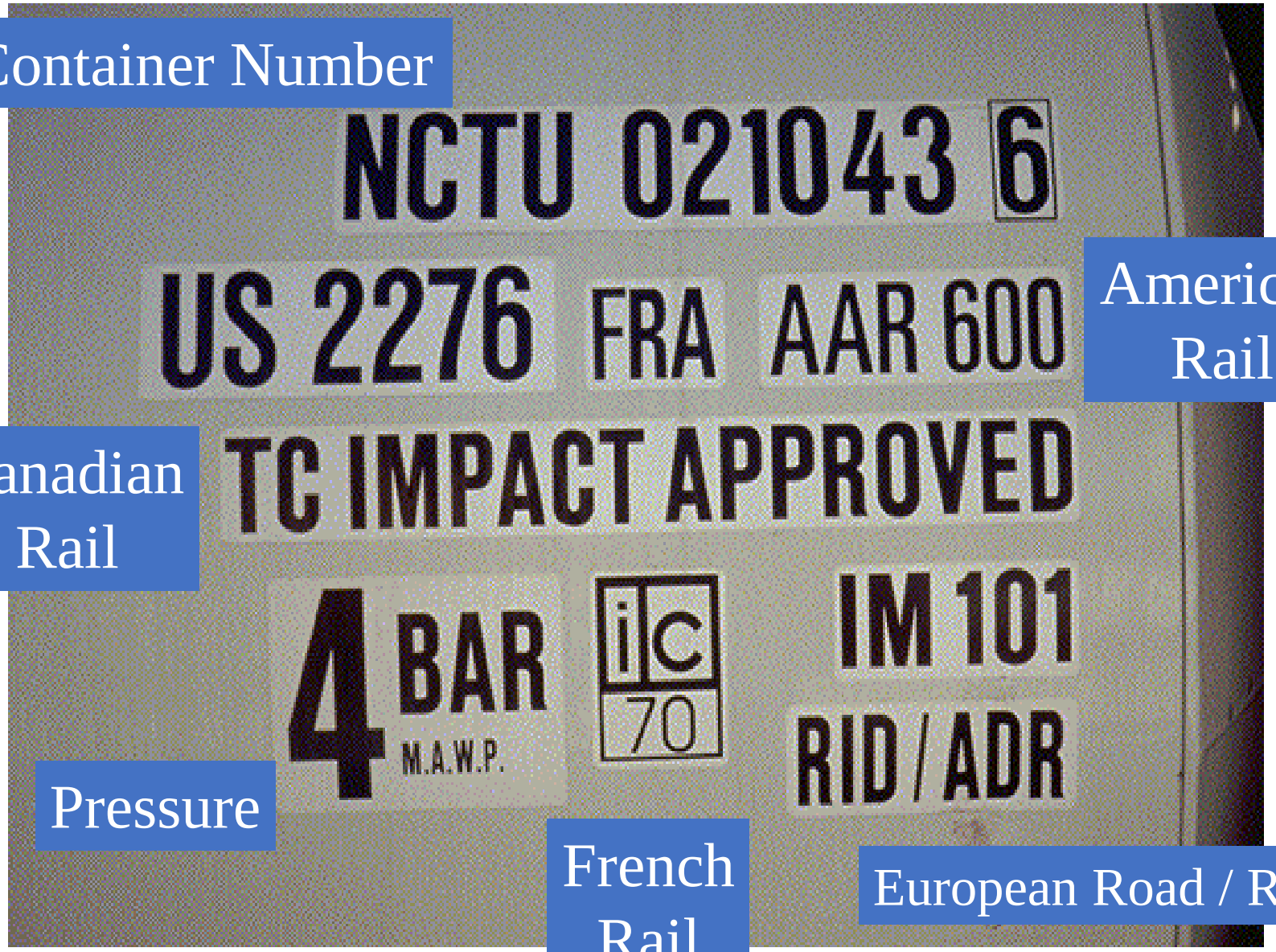
Size Code

T	4

Type Code

ADR/RID

Container Markings



Container Number

American Rail

Canadian Rail

Federal Railroad Administration

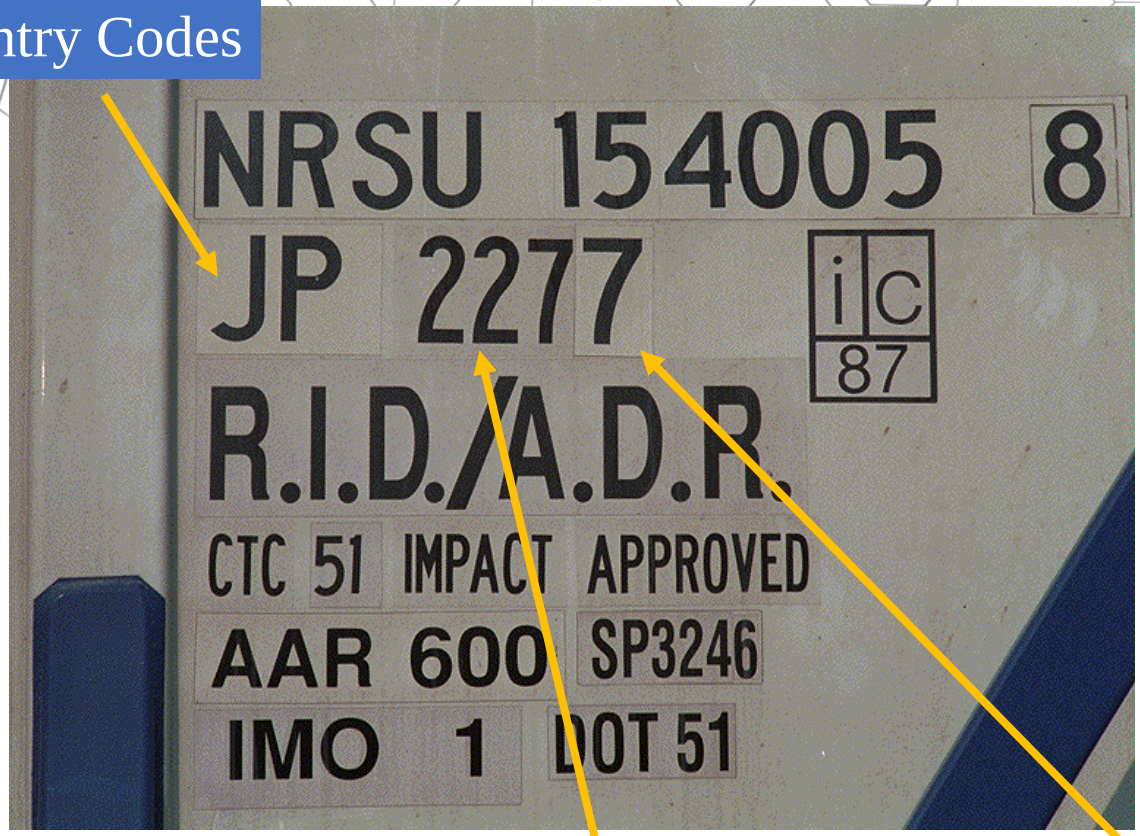
Pressure

French Rail

European Road / Rail


Container Markings
Marine Pollutant
Name
Special Markings
European Guide UN Number
EXFU 183879
FR 2276
IM 101 - CTC IMPACT APPROVED
SP 3246
TRANSPORTATION OF
THIA - 4 - PENTANAL
TOXIC
6
SUPER HEAVY
60
2785
2785
6
POLLUANT MARIN
MARINE POLLUTANT

Country Codes



Common Size Codes

Code	Length	Height
20	20 ft	8 ft
22	20 ft	8 ft 6 in
24	20 ft	>8 ft 6 in

MAWP Codes - Bar (psi)

Non-dangerous liquids

70	0.45	(6.5)
71	1.5	(21.8)
72	2.65	(38.4)

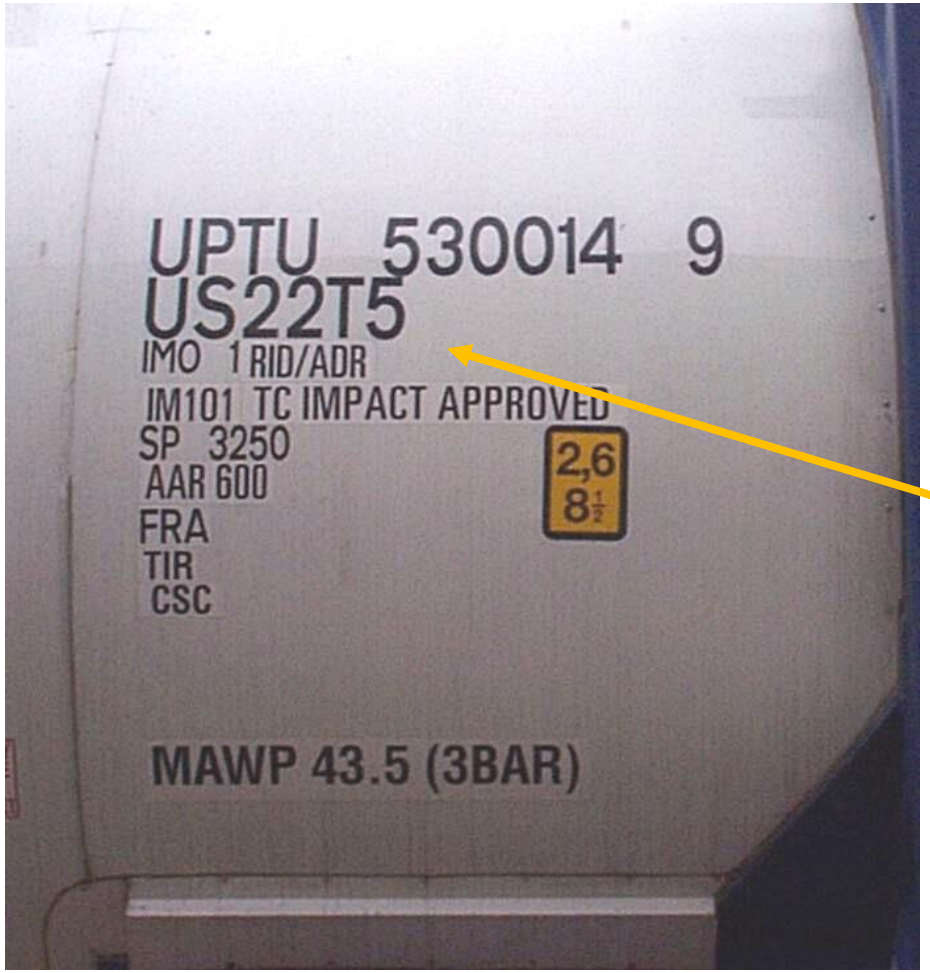
Dangerous liquids

73	1.5	(21.8)
74	2.65	(38.4)
75	4.0	(58.0)
76	6.0	(87.0)

Dangerous gases

77	10.5	(152.3)
78	22.0	(319.1)
79	spare	

New Markings



MAWP Codes - Bar (psi)

Non-dangerous liquids

T0	0.45	(6.5)
T1	1.5	(21.8)
T2	2.65	(38.4)

Dangerous liquids

T3	1.5	(21.8)
T4	2.65	(38.4)
T5	4.0	(58.0)
T6	6.0	(87.0)

Dangerous gases

T7	10.5	(152.3)
T8	22.0	(319.1)
T9	spare	

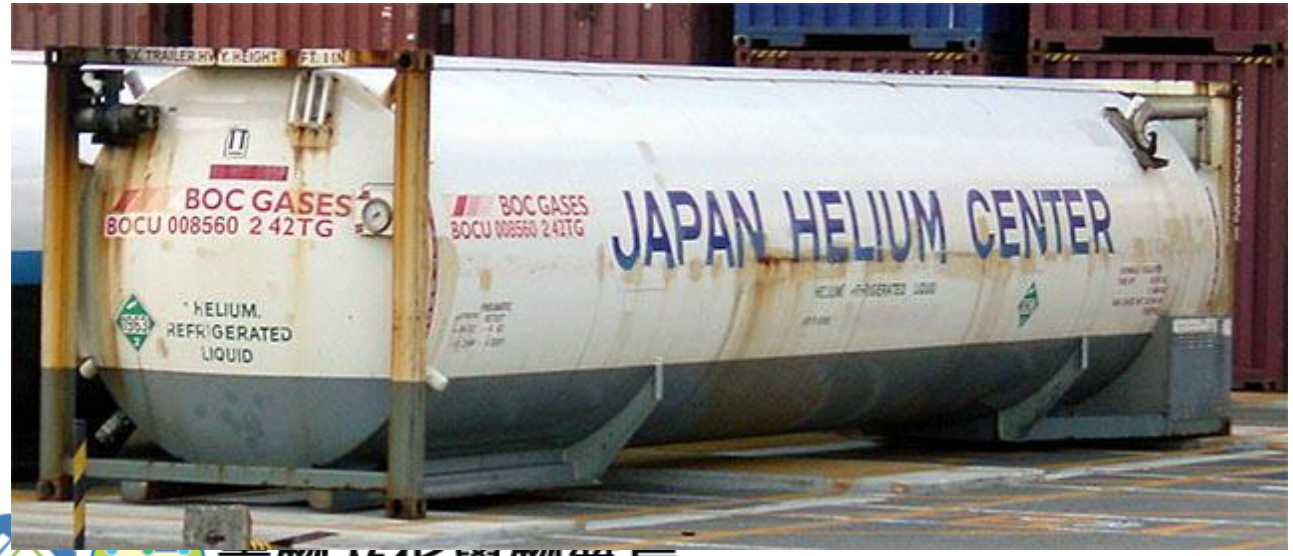
Low pressure /Pressure intermodal Tank/no

Specification	Materials Transported	Capacity	Design Pressure
IM 101 Portable Tank	Hazardous and nonhazardous materials. Including toxic, corrosive, and flammables with flash points below 32℉ (0℃)	Normally range from 5000 ~6300 gallons (18927 L~ 23848 L)	25.4 – 100 psi (175 kPa – 689 kPa)(1.75 bar – 6.89 bar)
IM 102 Portable Tank	Whiskey, alcohols, some corrosives, pesticides, insecticides, resins, industrial solvents, and flammables with flash points ranging from 32℉ to 140℉ (0 ℃ to 60℃)	Normally range from 5000 ~6300 gallons (18927 L~ 23848 L)	14.5 – 25.4psi (100 kPa – 175 kPa)(1 bar – 1.75 bar)
Spec. 51 Portable Tank IMO type 5	Liquefied gases such as LPG, anhydrous ammonia, high vapor pressure flammable liquids, pyrophoric liquids (such as aluminum alkyls), and other highly regulates materials	Normally range from 4500 ~5500 gallons (17034 L~ 20820 L)	100 – 500 psi (689 kPa – 3447 kPa)(6.89 bar – 34.5 bar)

T-Code	Minimum Test Pressure (bar)	Minimum Shell Thickness	Pressure-Relief Requirements	Bottom Opening Requirements
T1	1.5	> or = 6mm	normal	2 shut-off devices (Int + Ext)
T2	1.5	> or = 6mm	normal	3 shut-off devices (Int + Ext + cap/blank)
T3	2.65	> or = 6mm	normal	2 shut-off devices (Int + Ext)
T4	2.65	> or = 6mm	normal	3 shut-off devices (Int + Ext + cap/blank)
T5	2.65	> or = 6mm	normal + rupture disc	Not Allowed
T6	4	> or = 6mm	normal	2 shut-off devices (Int + Ext)
T7	4	> or = 6mm	normal	3 shut-off devices (Int + Ext + cap/blank)
T8	4	> or = 6mm	normal	Not Allowed
T9	4	6mm	normal	Not Allowed
T10	4	6mm	normal + rupture disc	Not Allowed
T11	6	> or = 6mm	normal	3 shut-off devices (Int + Ext + cap/blank)
T12	6	> or = 6mm	normal + rupture disc	3 shut-off devices (Int + Ext + cap/blank)
T13	6	6mm	normal	Not Allowed
T14	6	6mm	normal + rupture disc	Not Allowed
T15	10	>or = 6mm	normal	3 shut-off devices (Int + Ext + cap/blank)
T16	10	> or = 6mm	normal + rupture disc	<3 shut-off devices (Int + Ext + cap/blank)/td>
T17	10	6mm	normal	3 shut-off devices (Int + Ext + cap/blank)
T18	10	6mm	normal + rupture disc	Not Allowed
T19	10	6mm	normal + rupture disc	3 shut-off devices (Int + Ext + cap/blank)
T20	10	8mm	normal + rupture disc	Not Allowed
T21	10	10mm	normal	Not Allowed
T22	10	10mm	normal + rupture disc	Not Allowed

Specialized intermodal tanks

- Cryogenic type containers – IMO Type 7 specifications
  - MAWPs: 2400 – 5000 psi (16547 kPa – 34474 kPa)
  - Refrigerated liquid gases, argon, oxygen, helium



Tube Trailers

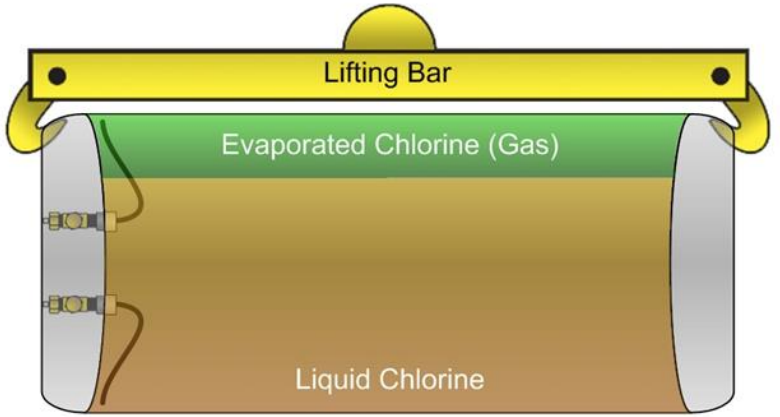
- Multi - tube configuration, these transport bulk non liquefied compressed gases
- Pressures up to 5000 psi
- Multiple individual tanks
- One product
- Products
  - Compressed gases – helium, hydrogen, oxygen, anhydrous hydrochloric acid

Intermodal Box Containers

- 20、40、45、48、53 ft Dry Freight
- Material loaded must be in proper condition for transportation
- Any slack space between packages must be filled with dunnage
- Bulk packaging containing hazardous material may be transported inside a transport vehicle provided it is properly secured with a restraint system
- Packages containing any hazardous material must be secured against shifting including relative motion between packages under conditions normally incident to transportation

Bulk Transportation Containers

- **Ton Containers**
  - Capacity : 1 short ton or 2000 pounds (907 kg；0.91 tonnes)
  - The end (heads) of the containers are convex or concave, one above the others.
  - One valve connects to a tube that extends into the liquid space
  - The other valve connects to a tube that extends into the vapor space above
  - Have pressure- relief devices or fusible plugs in case of fire or exposure to elevated temperatures.
  - Chlorine、Sulfur dioxide、anhydrous ammonia .or Freon® refrigerant



Bulk Transportation Containers

- **Y Cylinders / Y ton Containers**
  - DOT/TC 3AA-2400 ； DOT/TC 344-480
  - 7 feet (2m) long, 2 ft (0.6m) in diameter
  - Wall thickness of about 0.6 inches (15mm)
  - Seamless steel cylinder

DOT/TC 3AA-2400
Water capacity of not over 1000 lbs (454kg)
Service pressure of at least 150 psig (1034 kPa)

DOT/TC 3AAX
Water capacity of not less than 1000 lbs (454kg)
Service pressure of at least 150 psig (1034 kPa)

Intermediate BulK Containers (IBC)

- Capacity
  - Liquid - 119 gallons (450 liters) to 793 gallons (3000 liters)
  - Solid - 15.9 cubic feet to 106 cubic feet
  - Maximum net mass < 400 kg (882 lbs)*
- Construction
  - Steel, aluminum, wood, fiberboard, plastic, textile, paper, multi-wall, metal
- Products
  - Aviation fuel (turbine engine)、Gasoline、Hydrochloric acid、Methanol、Toluene、Corrosive liquids、Solid materials in powder flake, or granular forms
- Type
  - Flexible intermediate bulk containers (FIBCs)
  - Rigid intermediate bulk containers (RIBCs)

FIBCs

RIBC

Other Containers

Nunbulk Packaging

Bags	Carboys and Jerricans	Cylinders
• Made of paper, plastic, film, textiles, woven material, or others • Sizes vary • **Contents:** Explosives, flammable solids, oxidizers, organic peroxides, fertilizers, pesticides, and other regulated materials.	• Made of glass or plastic • Often encased in a basket or box • Sizes vary • **Contents:** flammable and combustible liquids, corrosives	• Pressure higher than 40 psi (276kPa) but vary • Sizes range from lecture bottle size to very large • Contents: Compressed gases.

Nunbulk Packaging

Drums	Dewar Flasks
• Made of metal. Fiberboard, plastic, plywood, or other materials • May have open heads (removable tops) or tight (closed) heads with small openings • Sizes vary from 55 gallons (208L) to 100 gallons (379L) • **Content:** Hazardous and nonhazardous liquids and solids.	• Vacuum insulated • Made of glass, metal, or plastic with hollow walls from which the air has been removed • Size vary • **Contents:** cryogenic liquids; thermoses may contain nonhazardous liquids.

Incident Action Plan (IAP)

Incident Action Plan (IAP)

- Incident action plans are critical to the rapid, effective control of emergency operations.
- An IAP is a well-through-out, organized course of events developed to address all phase of incident control within a specified time.
- Written IAPs may not be necessary for short-term, routine operations; however, large-scale or complex incidents require the creation and maintenance of a written plan for each operational period
- Action planning starts with identifying the response objective (strategy) to achieve a solution to the confronted problems.
- Once the strategy has been defined, the command staff needs to select the action options (tactics, the how, where, and when) to achieve the objective.

Incident Action Plan (IAP)

- Action options are measurable in both time and performance.
- An IAP also provides for necessary support resources such as water supply, utility control, or SCBA cylinder filling.
- The IAP ties the entire problem-solving process together by stating what the analysis has found, what the plan is, and how it shall be safely implemented.
- Once the plan is established and resources are committed, it is necessary to assess its effectiveness.
- Gather and analyze information so that necessary modifications may be made to improve the plan if necessary.
- Continuous size-up process

Incident Action Plan (IAP)

- All incident personnel must function according to the IAP.
- Company officers or sector officers should follow predetermined procedures, and every action should be directed toward achieving the goals and objectives specified in the plan.
- All first responders should be familiar with the concept of IAPs and site safety plans
- The incident commander will need to develop and implement an IAP.

Incident Action Plan (IAP)

- Strategies/incident objectives
- Current situation summary
- Resource assignment and needs
- Accomplishments
- Hazard statement
- Risk assessment
- Safety plan and message
- Protective measures
- Current and projected weather conditions
- Status of injuries
- Communications plan
- Medical plan

Elements of an Incident Action Plan

- What do we want to do?
- Who is responsible for doing it?
- How do we communicate with each other?
- What is the procedure if someone is injured?

IAP Development Steps

- Determine the response objectives.
- Determine the available response options that could favorably change the outcomes.
- Identify the personal protective equipment for the response options.
- Identify an appropriate decontamination process for each response option.
- Select the response options within the response community's capabilities that will most favorably change the outcomes.
- Plan of action must include safety considerations.

Basic Objectives

- Keep the big picture
- Ensure your protection and safety
- Protect the public
- Protect property
- Protect the environment

Modes of Operation

Modes of Operation

- Nonintervention – allows the incident to run its course on its own.
- Defensive – Provides confinement of the hazard to a given area by performing diking, damming, or diverting actions.
  - Defensive Operation - operations in which responders seek to confine the emergency to given area without directly contacting the hazardous materials involved.
- Offensive – Includes actions, such as plugging a leak, to control the incident.
  - Offensive Operation – operations in which responders take aggressive, direct action in the material, container, or process equipment involved in an incident.

Operation

- Defensive Operation
  - Dikes，Dam，Retention
  - Dilution
  - Vapor Dispersion
  - Vapor Suppression
  - Decontamination
  - Isolation and deny entry
  - Evacuation

- Offensive Operations
  - Rescue / recovery
  - Neutralization
  - Plug and patch
  - Overpacking
  - Control of fire / extinguishment
  - Field repairs of valves and fittings
  - Field transfers
  - Vent and burn

Defensive Operations

Dikes

Dikes

Dilution

move to

Vapor Dispersion

cool down

Defensive Operations

Decontamination

Decontamination

Isolation and deny entry

Evacuation

Offensive Operations

Neutralization

Overpacking

Plug and patch

Plug and patch

Plug and patch

Offensive Operations

Control of fire

Field transfers

Field repairs of valves and fittings

Vent and burn

Zoning

Control Zones

- Control zones provide the scene control ewquired at hazardous materials incident to:
  - Prevent interference by unauthorized persons.
  - Help regulate first responder' movement within the zones.
  - Minimize contamination (including secondary contamination from exposed or potentially exposed victims).
  - Help ensure accountability of all personnel operating at large, multiagency response incident.
- Hot, Warm, and Cold zone
  - Concentric circles (typically), but often dictated by the features of the location and incident
  - Are not necessarily static and con be adjusted as the incident changes

Hot Zone

- Close to a disaster, the hazardous materials in its area may be harmful to the responders and have the highest pollution area.
- Potentially hazardous area immediately surrounding the incident site; requires appropriate protective clothing and equipment and other safety precautions for entry. Typically limited to technician-level personnel also known as exclusion zone.
- IDLH、10 TWA、 25%LEL、19.5% O2
- Emergency Response Guidebook

Warm Zone

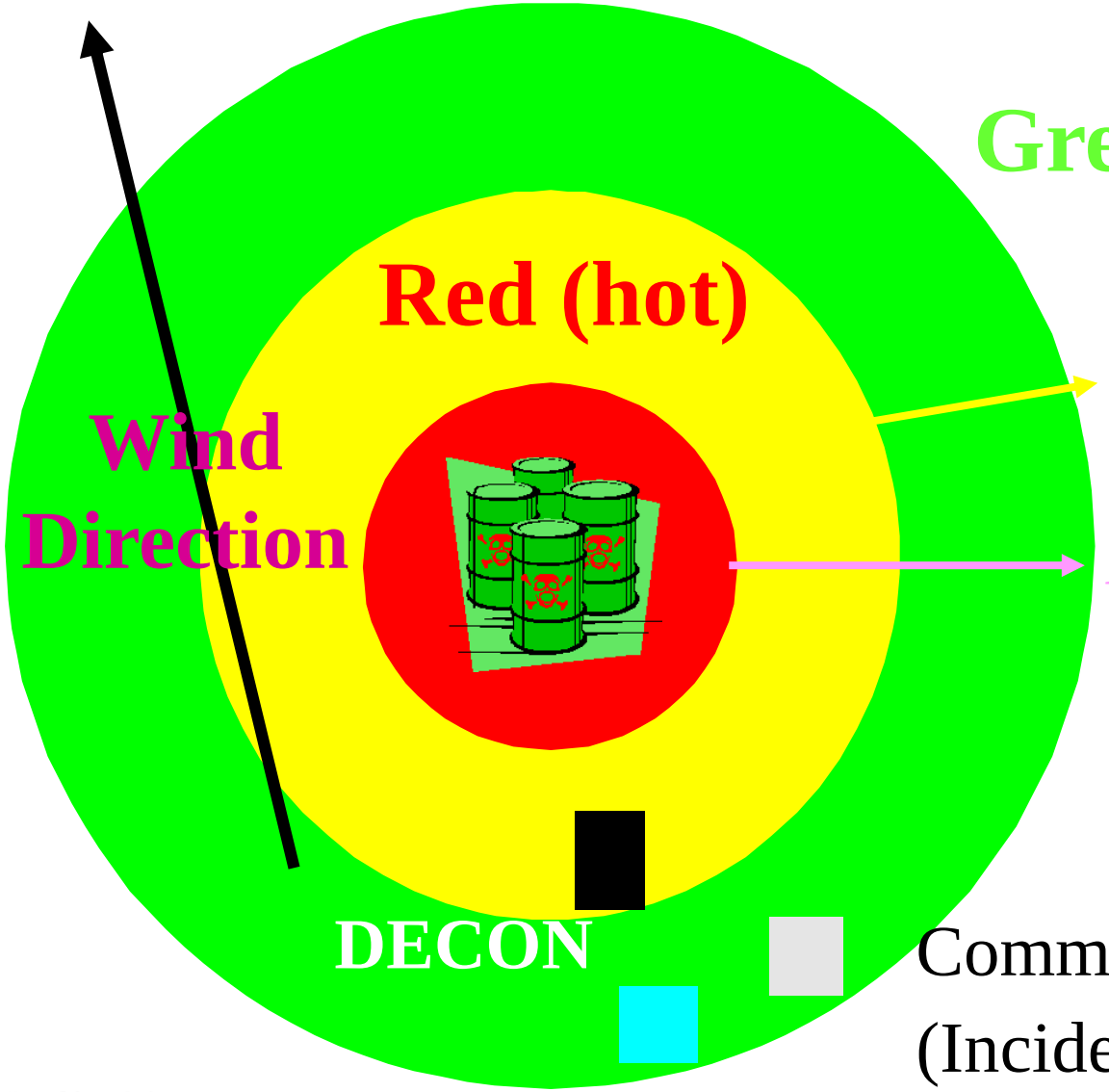
- Area between the hot and cold zones that usually contains the decontamination corridor; typically requires a lesser degree of personal protective equipment than the Hot Zone. Also known as Contamination Reduction Zone or Contamination Zone or Contamination Reduction Corridor.
- The hazardous materials may cause a large amount of leakage due to special circumstances, they can also serve as a buffer zone for the hot zone.
- Uphill and upwind
- 10*TWA~TWA ；25%LEL ~10% LEL

Cold Zone

- Cold Zone – Safe area outside of the warm zone where equipment and personnel are not expected to become contaminated and special protective clothing is not required; the incident command post and typically located in this zone. Also known as Support Zone.
- Although the cold area is located on the periphery of the decontamination area, this area is not a completely safe area. It is only a temporary rest area for the disaster relief personnel.
- It is necessary to adjust the position in a timely manner as the wind direction and the disaster situation evolve.

Staging area

- Prearranged, temporary strategic location, away from the emergency scene, where units assemble and wait until they are assigned a position on the emergency scene; these resources (personnel, apparatus, tools, and equipment) must then be able to respond within three minutes of being assigned.
- staging areas should be located at spots in the cold zone where occupants cannot interfere with ongoing operations.
- ideally, emergency responders and equipment at terror incidents should be staged between multiple locations in case staging areas are attacked.
- spreads out emergency response personnel from one another to limit their exposure as a target and minimizes the effect of a secondary type of attack/device.
- allows personnel to envelop the scene and provide multiple treatment areas or operation function points.


Green (cold)
Red (hot)
Yellow (warm)
Wind Direction
Alternate escape route
DECON
Command Post
(Incident Commander)
Staging Area

Note

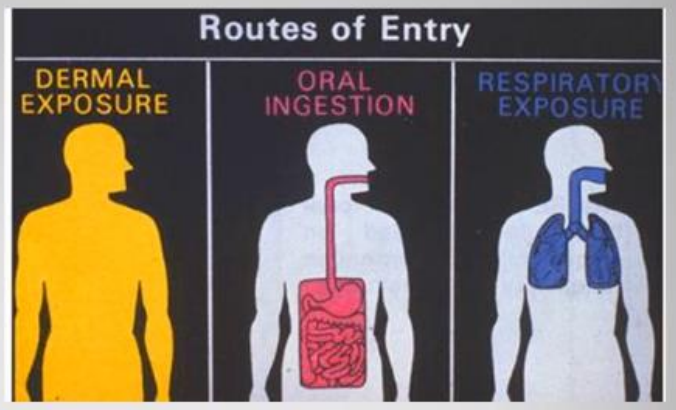
- Rescuers in and out of the control area should record controls: name, cylinder inventory, entry time, mission location, etc., and check the integrity of their protective equipment, prohibiting people without proper protective equipment from entering and exiting the control area.
- In addition to the decontamination of personnel and equipment in the warm zone, the space required by the on-site medical dispatch team and the fire brigade rescue technician must be considered.
- The control area needs to consider whether the disaster relief personnel have time to return to the safe area. The amount of air in the SCBA needs to be considered.
- If the occurrence area is a specific area (such as gasification room, FAB, tank car or other airtight and air-conditioned space), the area is a hot zone.

Detection, and monitoring equipment

Concentration, Dose, Exposure Limits

- Devices that measure **concentrations** – Measure materials that responders might inhale.
- Devices that measure **dosage** – Measures materials that may enter responders' bodies via a means other than inhalation.(ex. Ingestion 、absorption)
- Exposure limits – values expressing the maximum dose or concentration to which individuals should be exposed given a specific time frame.

- Inhalation
- Ingestion
- Absorption
- Injection



Concentration/Dose unit

- mg/m^3(Milligrams per cubic meter):Expresses concentrations of dusts, gas, or mists in air.
- mg/kg(Milligrams per kilogram):Toxicological dose that denotes milligrams of a substance dosed per kilogram of test animal body weight.
- ppm(parts per million):May describe the concentration of a gas or vapor in air or the concentration of a specific material in a liquid or solid. $1/10^6$
- Ppb(Parts per billion):1 ppb = 0.001 ppm；1ppm=1000 ppb，$1/10^9$

Exposure Limits(1)

- TLV(Threshold Limit Value) : An occupational exposure value recommended by ACGIH(American Conference of Governmental Industrial Hygienists) to which it is believed nearly all workers can be exposed day after day for working lifetime without ill effect. (TLV-TWA、TLV-STEL、TLV-C) ；only airborne concentrations.
- PEL(Permissible Exposure Limit) : The Maximum concentration to which the majority of healthy adults can be exposed over a 40-hour workweek without suffering adverse effects. (OSHA/USA ; Ministry of labor / Taiwan；PEL-TWA 、PEL-STEL、PEL-C)
  - TWA(Time-Weighted Average): A regulatory limit on the amount or concentration of a substance in the air. 8-hour day or 40-hour workweek
  - STEL : The maximum concentration allowed for a 15-minute exposure period.
  - C(Ceiling limit) : The maximum concentration to which an employee may exposed at any time, even instantaneously.

Exposure Limits(2)

- IDLH condition (Immediately Dangerous to life or Health condition) : A situation that poses a threat of exposure to airborne contaminants when that exposure is likely to cause death or immediate or delayed permanent adverse health effects or prevent escape from such an environment.
- IDLH value: A maximum (airborne concentration) level above which only a highly reliable breathing apparatus providing maximum worker protection is permitted [NIOSH 2004]. IDLH values are based on a 30-minute exposure duration
- ERPG(Emergency Response Planning Guideline)
  - ERPG1 : The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to one hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor.
  - ERGP2 : The maximum airborne concentration below which it is believed nearly all individuals could be exposed for up to one hour without experiencing or developing irreversible or other serious health effects or symptoms that could impair an individual's ability to take protective action.
  - ERPG3 : The maximum airborne concentration below which it is believed nearly all individuals could be exposed without experiencing or developing life-threatening health effects.

Why Do Air Monitoring?

- Required by regulations(USA:29 CFR 1910.120)
- Can be used to determine if contamination is present or absent
- Used to establish ZONES
- Determine if IDLH conditions, explosive atmospheres, or deficient Oxygen levels exist
- Needed to determine levels of PPE required
- Maintain the Health and Safety of the responders
- Evaluate the effectiveness of response actions and reference for follow-up

Using

- Have a good understanding of the capability of each device.
- Use the devices correctly.
- Understand what is being measured and how the instrument relays the information to the user.
- Interpret accurately the data each device provides.
- Maintain, field test, and calibrate the devices per manufacturers' instructions.
- Use the devices in accordance with predetermined procedures based on the availability, capabilities, and limitations of PPE, other resources available at the incident and in accordance with the IAP.
- Use more than one sampling method and more than one technology to verify monitoring and sampling results, when possible

Initial Assessment

- Establish priorities for on-going monitoring
  - High priority : Low lying areas、Confined spaces、 Containers
  - Low priority : Open area
- Determine if IDLH conditions exist
- Establish PPE requirements for the response
  - In most cases the initial assessment should be done with the HIGHEST LEVEL of protection available—Level A

Monitoring Strategy(1)

- Establish monitoring priorities based on whether the incident is in open air or in an enclosed or confined space environment.
- Always use the appropriate monitoring instrument(s) based on dealing with known or unknown materials.
- The instrument(s) should be able to detect the anticipated hazard(s), measure appropriate concentrations, and operate under the given field conditions.
- Monitoring personnel should have a good idea of what readings to expect.

Monitoring Strategy(2)

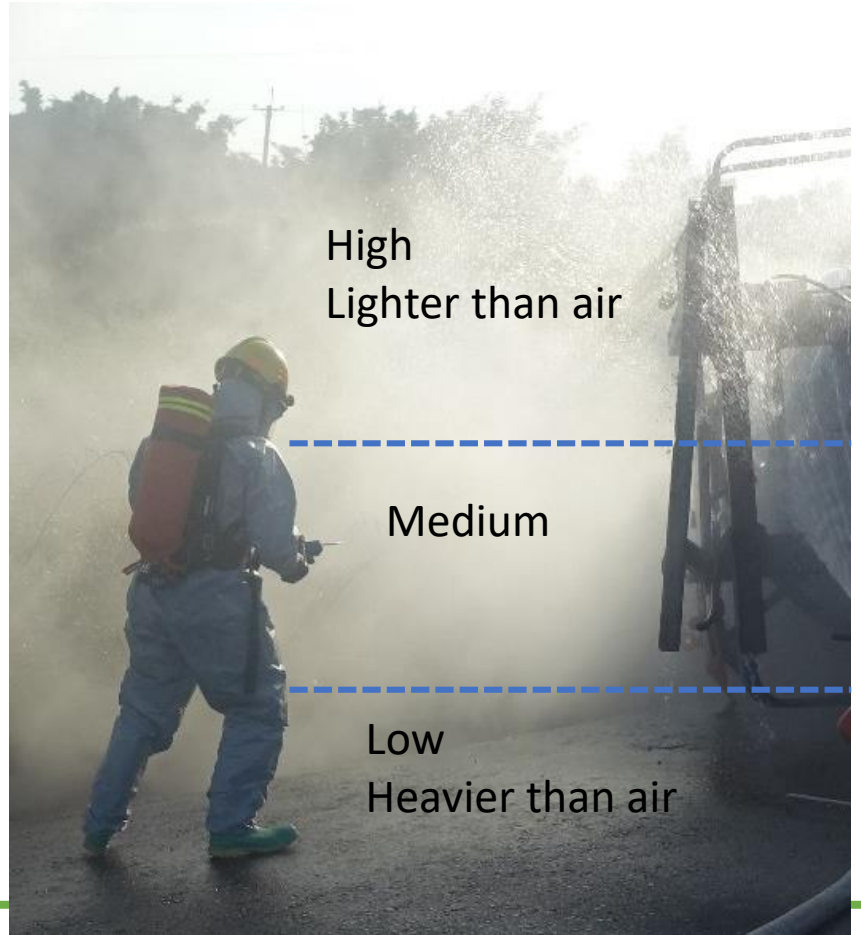
- In the event that abnormal or unusual readings are encountered, the possibility of instrument failure should be considered.
  - another instrument
  - Recalibrate and field test
- The absence of a positive response or reading does not necessarily mean that contaminants are not present.
  - wind, temperature, and moisture…..
- Never assume that only one hazard is present!
  - use several types of detection technologies to classify or identify the hazard.
- Interpret the instrument readings in more than one manner
- Establish action levels based on instrument readings.

Monitoring Levels

- Always take measurements at

  Three levels

  - Reading at floor level
  - Reading at waist level
  - Reading at ceiling level



Detection equipment selection considerations

- Faster reaction rate and Monitoring results are available immediately
- Continuous monitoring
- Measure multiple gases at the same time
- High sensitivity and low detection limit

Equipment

pH paper & pH meter

- pH METER
- pH PAPER

Concentration of Hydrogen ions compared to distilled water		Examples of solutions and their respective pH
1/10,000,000	14	Liquid drain cleaner, Caustic soda
1/1,000,000	13	bleaches, oven cleaner
1/100,000	12	Soapy water
1/10,000	11	Household Ammonia (11.9)
1/1,000	10	Milk of magnesium (10.5)
1/100	9	Toothpaste (9.9)
1/10	8	Baking soda (8.4), Seawater, Eggs
0	7	"Pure" water (7)
10	6	Urine (6) Milk (6.6)
100	5	Acid rain (5.6) Black coffee (5)
1,000	4	Tomato juice (4.1)
10,000	3	Grapefruit & Orange juice, Soft drink
100,000	2	Lemon juice (2.3) Vinegar (2.9)
1,000,000	1	Hydrochloric acid secreted from the stomach lining (1)
10,000,000	0	Battery Acid

pH paper & pH meter

- On pH paper the color changes, indicating the pH level. By comparing the color of the pH paper with the color chart provided, the responder can determine the pH of the material.
- The pH meters provide a more accurate reading than pH paper.
- Both pH paper and strips may be difficult to read if the material sampled has been contaminated with oil, mud, or some other material.

pH paper limitations

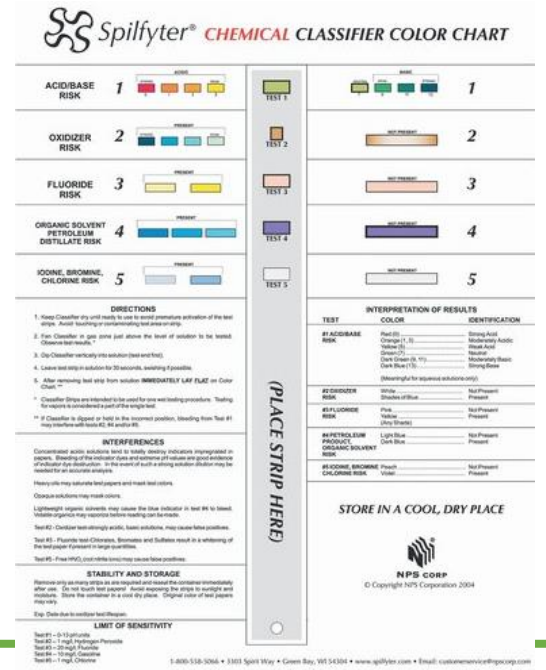
- Need for close proximity and/or contact with the hazardous material in order to conduct testing.
- Inability to detect the concentration of the material.
- Difficulty reading the paper if the material sampled is contaminated with oil, mud, or other opaque materials.
- Difficulty reading the paper if the material sampled chemically strips the paper or alters it in unexpected ways, such as with highly concentrated acids and bases, certain oxidizers, and hydrocarbons.

Other test paper

- Fluoride test Paper-fluorides (HF in particular)

  pinkish-red → yellowish-white

- SpilFyter@-detects a variety of hazardous materials in a liquid spill
  - Test1-acid/base(pH)-0-13
  - Test2-oxidizer (1mg/L-hydrogen peroxide)
  - Test3- fluoride(20mg/L-Fluoride)
  - Test4-petroleum, organic solvent(10mg/L-gasoline)
  - Test5-iodine, bromine or chlorine(1mg/L-chlorin)



Colorimetric indicator tubes (Detector Tubes)

- Colorimetric indicator tubes consist of a glass tube impregnated with an indicating chemical. The tube is connected to a piston or pump. A know volume of contaminated air is pulled at a predetermined rate through the tube by the pump. The contaminant reacts with the indicator chemical in the tube, producing a change in color where the length is proportional to the contaminant concentration.

Advantages / disadvantages

Advantages

1. Easy to use
2. Low price
3. lightweight
4. Easy to carry
5. many chemicals to choose

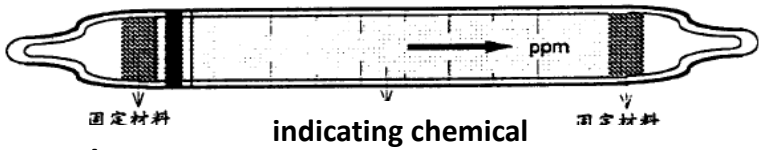
disadvantages

1. Limit of use
2. Low specificity
3. Low accuracy
4. Interference effects
5. Everyone's interpretation may be different

Types

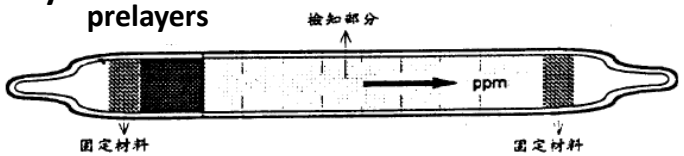
- A single indication layer
- With one or more prelayers
- With a built in ampoule
- Combination of two tubes
- With connecting tubes
- Simultaneous measurement set

single indication layer



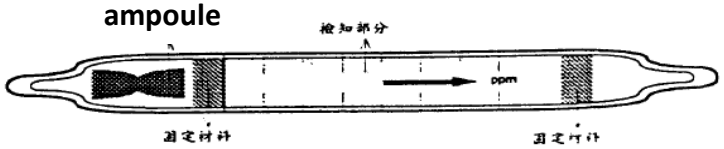
More prelayers

prelayers

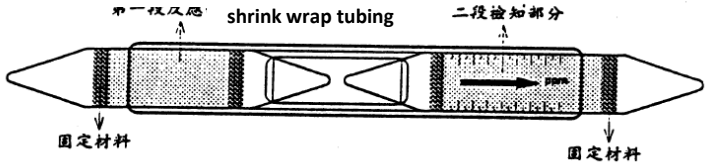


ampoule

ampoule

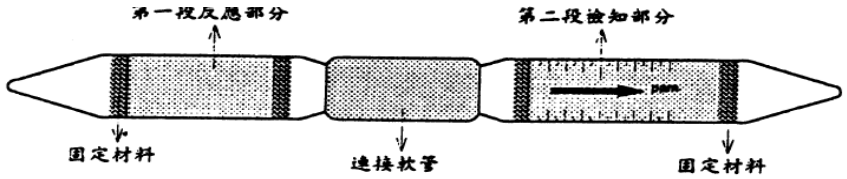


Combination of two tubes



Simultaneous measurement set

connecting tubes



A single indication layer

With one or more prelayers

With a built in ampoule

Combination of two tubes

With connecting tubes

Pump

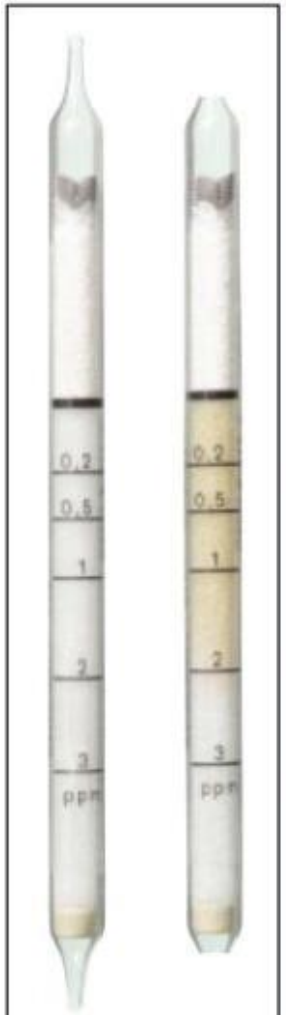
Draeger
- Bellows pump
- Stroke volume:100 ml
- Easy to use
- single-handed operation

Gastec
- piston style pumps
- Stroke volume::50-100 ml
- Cheaper
- operated with both hands

Before use

- Read The Instructions
  - Measuring range
  - Number of strokes (n)
  - Time for measurement
  - Color change
  - Cross sensitivity
- Confirm airflow direction
- Remember to cut the tube

Chlorine 0.2/a — Order No. CH 24301



Standard Measuring Range	:	0.2 to 3 ppm
Number of Strokes (n)	:	10
Time for Measurement	:	app. 3 min
Standard Deviation	:	± 10 to 15 %
Colour Change	:	white —> yellow orange

Ambient Operating Conditions

Temperature	:	0 to 40 °C
Absolute Humidity	:	< 15 mg H_2O / L

Reaction Principle

Cl_2 + o-Tolidine —> yellow orange reaction product

Cross Sensitivity

Bromine is indicated with the same sensitivity, but with a paler discoloration.

Chlorine dioxide is indicated with different sensitivity of chlorine.

Nitrogen dioxide is indicated with a lower sensitivity and paler discoloration.

Extension of the Measuring Range

Using n=1, multiply the reading by 10; the range of measurement is 2 to 30 ppm.

Precautions

- Draw an appropriate amount of gas into the detection tubes.
- The specifications of the pumps of each label are not the same. The pumps and detection tubes of different labels cannot be mixed.
- Accuracy - [+/-] 10 to 50 %； NIOSH:1/2PEL: +/- 35%； 1~5PEL: +/- 25%
- Read the degree of discoloration of the tube in a well-lit area.
- The tube is only good till the expiration date.
- Store at temperatures below 30 °C and avoid direct sunlight.
- Before use. It should be noted the temperature and humidity of the site. Some detection tubes may have an effect.
- When in doubt use the highest value that would be obtained from reading the different aspects of the tube.

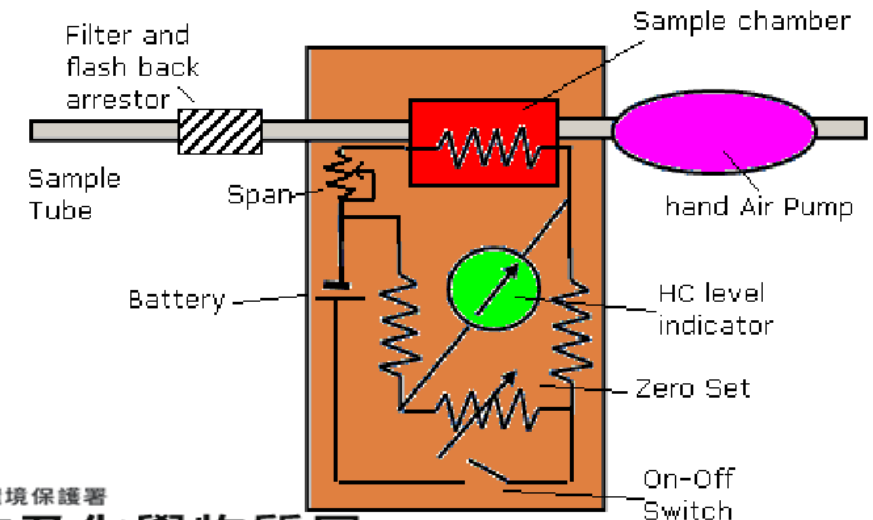
Unknown liquid disposal

Only mark “**Hydrofluoric acid**”

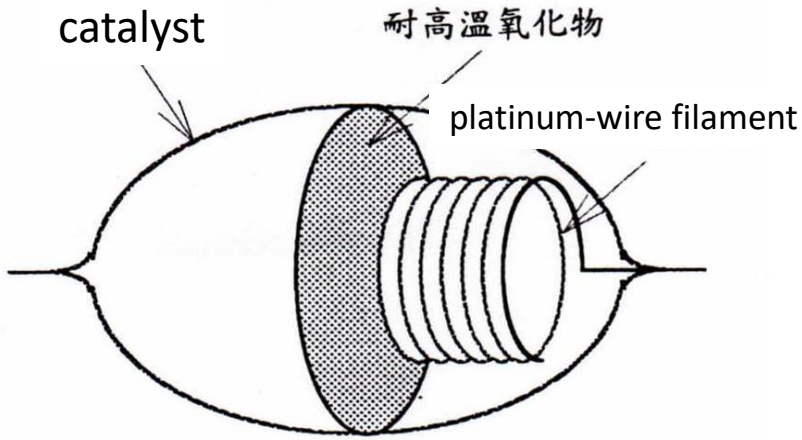
NO “Container Labeling”

Combustible gas indicators (CGI)

- Type
  - Filament type (Catalytic bead sensor) (common)
  - Electronic sensor- Explosimeter
  - IR (Usually used for fixed)



Filament type



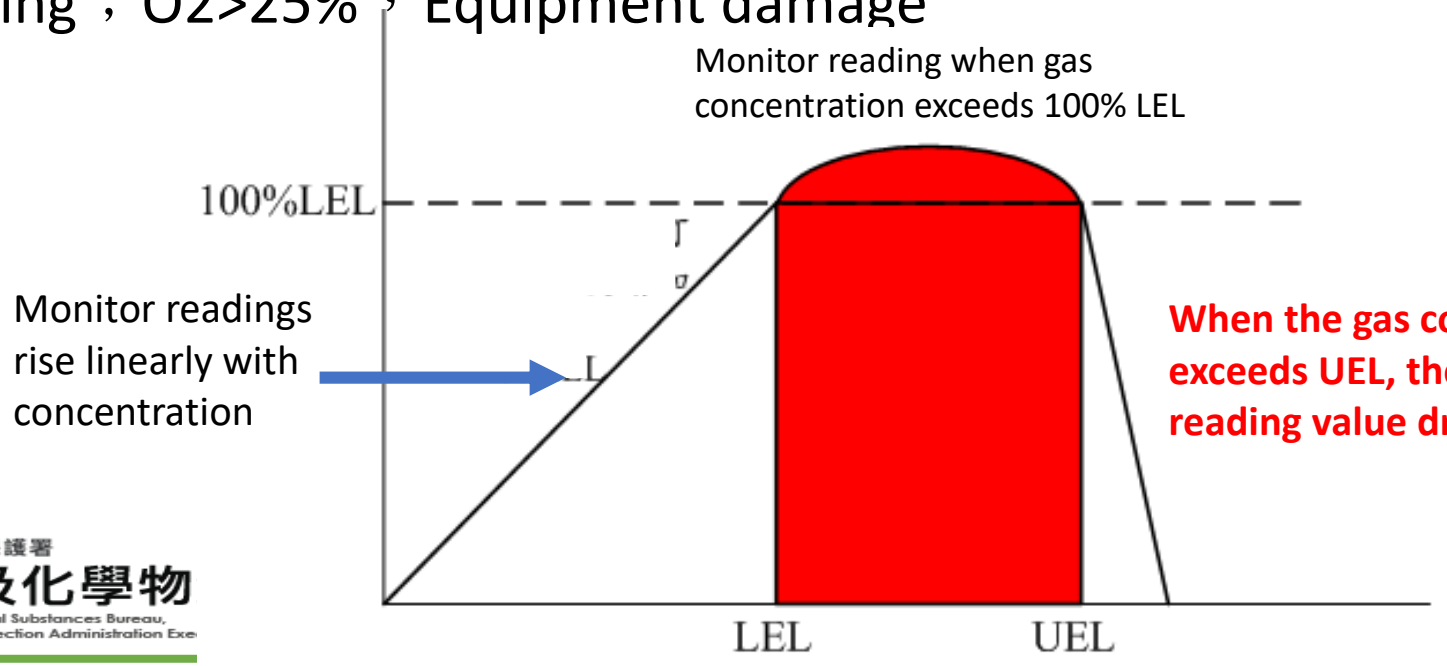
Combustible gas indicators (CGI)

- Concentration display
  - % LEL for calibration gas - common
  - ppm
  - % V/V

- How to calculate actual concentration?
  - Conversion factors
  - Calibration gas for CGI & LEL

Combustible gas indicators

- Limitations and considerations
  - Corrosive gases corrode the filament. (HCl、SO_2、H_2S、HF…)
  - Organic lead, sulfur and silicone poison the filament.
  - Normal oxygen atmospheres(O2:10-15%，lowered readings；O2<10%，No reading；O2>25%，Equipment damage



When the gas concentration exceeds UEL, the monitor reading value drops sharply.

Interpretation

- %LEL CH4- Combustible Gas Indicator Calibrated to Methane

  For example, Methane(CH4) is know, If the Combustible gas Indicator measures %LEL@CH4 is 10% ，Methane’s actual concentration is ？

  Cal.：LEL@CH4 is 5%，CGI %LEL@CH4 =10%，

  actual concentration (CH4) = 5 % x 10 %= 0.5 % = 5,000 ppm

- The concentration is less than 100% LEL as CH4, which means that the site has not reached the explosion range??

  The Combustible gas Indicators of each brand shall have a correction factor for common combustible gases. The user shall be aware of the actual calibration factor and the lower explosion limit of the chemical. ◦

calibration factor

Chemical	100% LEL (Vol%)	LEL CF*
Acetaldehyde	4.0	*1.8*
Acetic acid	4.0	*3.4*
Acetic Anhydride	2.7	*2.0*
Acetone	2.5	2.2
Acetylene	2.5	*2.8*
Allyl Alcohol	2.5	1.7
Amm		
Anil		
Ben		
Buta		
Buta		
Buta		
Buta		
Butanol, i-	1.7	*2.5*
Butanol, t-	2.4	*1.8*
Butene-1	1.6	*2.1*
Butene-2, cis	1.7	*2.1*
Butene-2, trans	1.8	*1.9*
Buty		
Carb		
Carb		
Carb		
Chlo		
Chlo		
Cyan		
Cyclohexane	1.3	*2.5*
Cyclopropane	2.4	*1.5*
Decane, n-	0.8	*3.4*
Dichloroethane, 1,2-	6.2	*1.5*
Dichloromethane	13.0	*1.0*
Dimethylbutane	1.2	*2.7*
Dimethylpentane, 2,3-	1.1	*2.3*
Dimethyl sulfide	2.2	*2.3*
Dioxane, 1,4-	2.0	*2.5*
Ethane	3.0	*1.4*
Ethanol	3.3	*1.7*
Ethene	2.7	1.4
Ethyl acetate	2.0	2.2
Ethylamine	3.5	*1.4*

Chemical	100% LEL (Vol%)	LEL CF*
Ethyl benzene	0.8	*2.8*
Ethyl bromide	6.8	*0.9*
Ethyl chloride	3.8	*1.7*
Ethyl ether	1.9	*2.3*
Ethyl formate	2.8	*2.4*
Ethyl mercaptan	2.8	*1.8*
	2.0	*2.3*
	1.2	*2.4*
	3.0	*2.3*
	1.3	2.1
	1.1	2.4
	2.0	*1.5*
	1.1	2.3
Hydrazine	2.9	*2.1*
Hydrogen	4.0	1.1
Hydrogen cyanide	5.6	*2.0*
Hydrogen sulfide	4.0	**
Isobutene	1.8	1.5
	2.0	2.6
	0.7	*3.4*
	5.0	1.0
	6.0	*1.5*
	3.1	*2.2*
	4.9	*1.3*
Methyl bromide	10.0	*1.1*
Methyl chloride	8.1	*1.3*
Methylcyclohexane	1.2	*2.6*
Methyl ether	3.4	*1.7*
Methyl ethyl ketone	1.4	2.6
Methyl formate	4.5	*1.9*
Methyl hexane	1.2	*2.4*
Methyl mercaptan	3.9	*1.6*
Methylpentane	1.2	*2.7*
Methyl propionate	2.5	*2.1*
Methyl n-propyl ketone (2-pentanone)	1.5	*2.7*
Naphthalene	0.9	*2.9*
Nitromethane	7.3	*2.1*
Nonane, n-	0.8	*3.2*

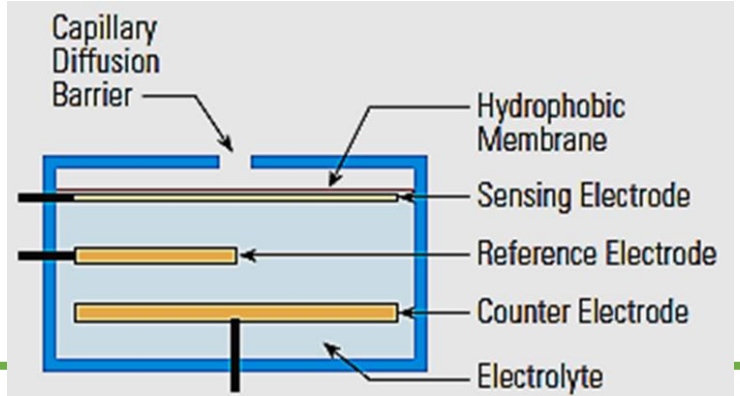
Chemical	100% LEL (Vol%)	LEL CF*
Pentane, n-	1.5	2.2
Pentane, i-	1.4	*2.3*
Pentane, Neo-	1.4	*2.5*
Pentene, 1-	1.5	*2.3*
Phosphine	1.6	*0.3*
Propane	2.1	1.6
Propanol, n-	2.2	*2.0*
Propene	2.0	1.5
Propylamine, n-	2.0	*2.1*
Propylene oxide	2.3	*2.6*
Propyl ether, iso-	1.4	*2.3*
Propyne	1.7	*2.3*
Toluene	1.1	2.6
Triethylamine	1.2	*2.5*
Trimethylamine	2.0	*1.9*
Trimethylbutane	1.2	*2.3*
Turpentine	0.8	*2.9*
Vinyl chloride	3.6	*1.8*
Xylene, m-	1.1	*2.7*
Xylene, o-	0.9	*3.0*
Xylene, p-	1.1	*2.8*

Propene，% LEL as CH_4=30%
Actual concentration?

0.3*1.5*50,000=22500 ppm
= **2.25%**

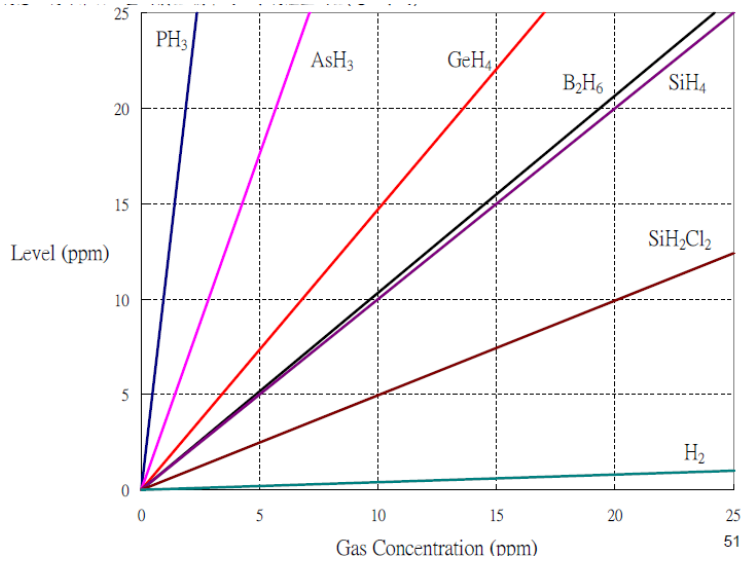
Electrochemical detector

- Electrochemical detectors
  - potentiostatic electrolysis - **the most common,** Many gases
  - membrane type ion-selective electrode - Ammonia
  - membrane type galvanic cell. **-** oxygen.
- Principle - when the gas to be tested is dissolved in the electrolyte through the membrane, a redox reaction occurs on the surface of the sensing electrode, and a relative redox reaction occurs on the surface of the counter electrode, and the current is measured. The gas concentration can be known by changes or potential changes.



Limits and considerations

- Slower reaction time
- Gas interference problem
- Electrode fouling and neutralization of electrolytes
- separator blockage
- A shorter service life
- Easy to be affected by temperature changes



100 ppm gas\detector	Detecyor reading									
	CO	H_2S	Cl_2	H_2	SO_2	NO_2	NO	HCl	HCN	C_2H_2
H_2S	<0.5	100	-20	<0.1	<15	-15	0	0	0	0
Cl_2	0	<-10	100	0	0	105	0	0	0	0
H_2	<1	<20	0	100	3	0	35	3	35	85
SO_2	<1	0	-40	0	100	-100	0	0	15	0
NO_2	0	-20	90	0	0	100	0	0	-3	0
NO	0	35	0	0	5	25	100	15	0	0
HCl	0	75	-10	0	35	-2	0	100	-8	0
HCN	<0.5	-	-50	0	160	-190	-5	30	100	<1
NH_3	0	0	0	0	40	0	0	-	-	-
HF	0	0	9	0	9	-5	-	6	-	-

Oxygen Indicators

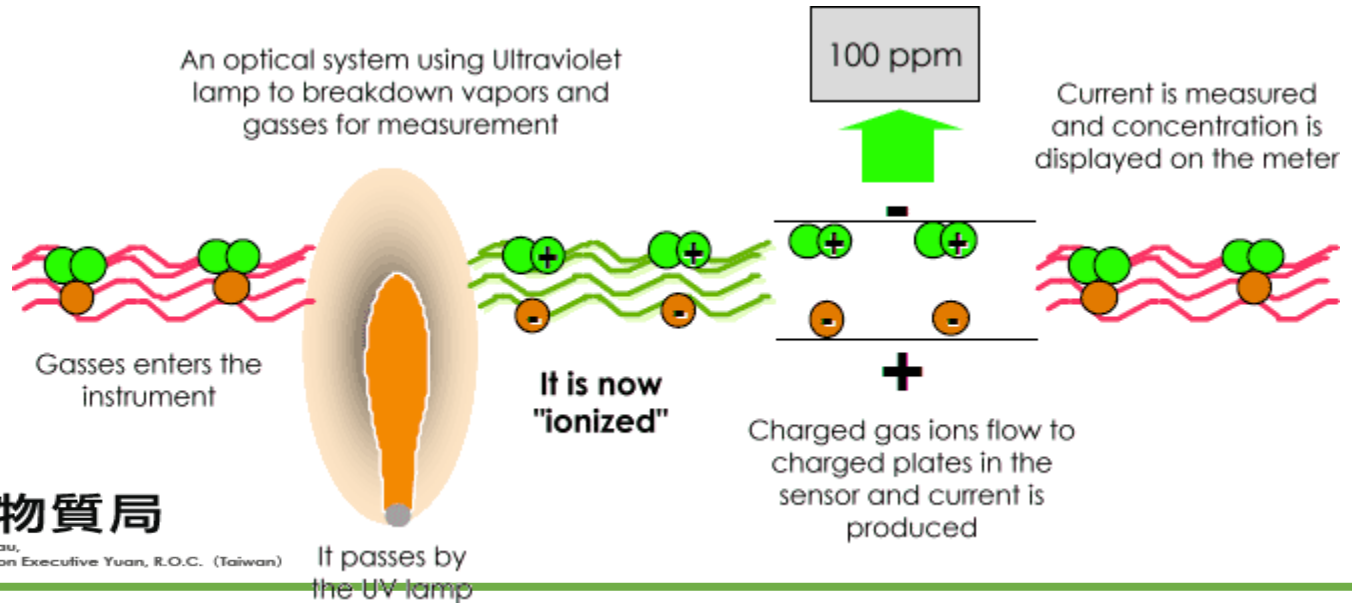
- General range 0-25%
- Principle components
  - Sensor(electrochemical sensor)
  - Meter readout
  - Pumping / diffusing
- Evaluate
  - Oxygen for respiratory purposes > 19.5%.
  - Increased risk of combustion > 25%.
  - Use of other instruments.(ex fid >15%)
  - Presence of contaminates.

Oxygen Indicators

- Limits and considerations:
  - The sensors deteriorate over time and need replacement based on manufacturer's recommendations
  - May be affected by changes in temperature, humidity, and atmospheric pressure as well.
  - High levels of carbon dioxide shorten the life.
  - Corrosive gases can cause rapid sensor failure in some meters.
  - Temperature can effect response. (0℃~50 ℃)
  - Strong oxidizers can increase readings. (Cl_2、Br_2、F_2.....)
  - No change in oxygen concentration does not mean the absence of contaminants. but reduced oxygen levels may represent a potentially significant toxicity

Photo Ionization Detector

- A Photo Ionization Detector (PID) uses an UV light (9-12eV) to break down chemicals to positive and negative ions (Ionization). The high energy UV light excites the molecule and results in the temporary loss of a negatively charged electron and the formation of positively charged ion. Charged gas ion flow to charged plates in the sensor and current is product. The ions quickly recombine after the electrodes in the detector to "reform" their original molecule.
- aromatic compounds have good response ；O_2、N_2、CO、CO_2 no effect



Advantages / Disadvantages

- Advantages
  - PIDs are non-destructive;(can use for sample gathering)
  - There are many different voltages UV lamp (9-12 eV)
  - Can detect inorganic compounds / aromatic compound / Chlorine Compounds / unsaturated hydrocarbon
  - high sensitivity
  - No need for auxiliary gas (H_2/O_2), it can be used in anoxic environment
- Disadvantages
  - moisture interference
  - Saturated organics (such as methane, propane) are not responding
  - Different gases have different ionization energy

Correct factor-PID

Compound Name	Synonym/Abbreviation	CAS No.	Formula	9.8	C	10.6	C	11.7	C	IE (eV)	TWA
Acetaldehyde		75-07-0	C_2H_4O	NR	+	6	+	3.3	+	10.23	C25
Acetic acid	Ethanoic Acid	64-19-7	$C_2H_4O_2$	NR	+	22	+	2.6	+	10.66	10
Acetic anhydride	Ethanoic Acid Anhydride	108-24-7	$C_4H_6O_3$	NR	+	6.1	+	2.0	+	10.14	5
Acetone	2-Propanone	67-64-1	C_3H_6O	1.2	+	0.9	+	1.4	+	9.71	500
Acetone cyanohydrin	2-Hydroxyisobutyronitrile	75-86-5	C_4H_7NO					4	+	11.1	C5
Acetonitrile	Methyl cyanide, Cyanomethane	75-05-8	C_2H_3N					100		12.19	40
Acetylene	Ethyne	74-86-2	C_2H_2					2.1	+	11.40	ne
Acrolein	Propenal	107-02-8	C_3H_4O	42	+	3.9	+	1.4	+	10.10	0.1
Acrylic acid	Propenoic Acid	79-10-7	$C_3H_4O_2$			12	+	2.0	+	10.60	2
Acrylonitrile	Propenenitrile	107-13-1	C_3H_3N			NR	+	1.2	+	10.91	2
Allyl alcohol		107-18-6	C_3H_6O	4.5	+	2.4	+	1.6	+	9.67	2
Allyl chloride	3-Chloropropene	107-05-1	C_3H_5Cl			4.3		0.7		9.9	1
Ammonia		7664-41-7	NH_3	NR	+	10.9	+	5.7	+	10.16	25
Amyl acetate	mix of n-Pentyl acetate & 2-Methylbutyl acetate	628-63-7	$C_7H_{14}O_2$	11	+	2.3	+	0.95	+	<9.9	100

CF = Correction Factor (multiply by reading to get corrected value for the compound when calibrated to isobutylene)

NR = No Response

IE = Ionization Energy (values in parentheses are not well established)

C = Confirmed Value indicated by "+" in this column; all others are preliminary or estimated values and are subject to change

ne = Not Established ACGIH 8-hr. TWA

C## = Ceiling value, given where 8-hr.TWA is not available

A GUIDELINE FOR PID INSTRUMENT RESPONSE

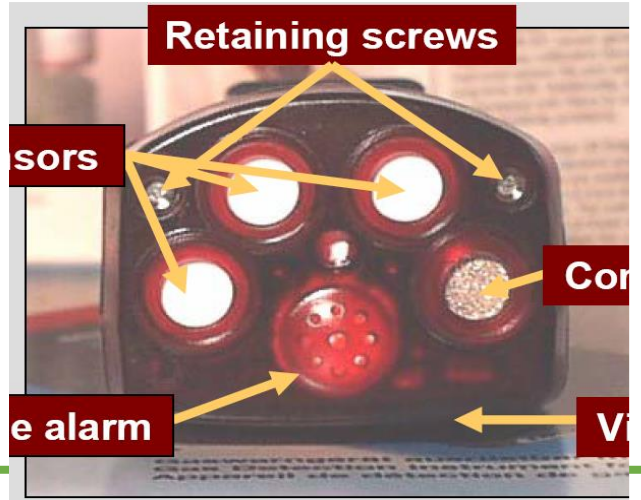
Technical Note TN-106

Considerations and Limitations

- Lamp voltages - UV Lamp of different voltages, have different correct factor for the same chemical.
- Dust-tiny particulates of dust may affect readings
- Humidity-can’t use in rain or high humidity environments without the proper filtration attachment
- radio frequency interference from pulsed DC or AC power lines, transformers, generators, and radio wave transmission may produce an error in response.
- Lamp age - As the lamp ages the intensity of the light decreases
- Range - high concentrations (exceeding the concentration range) , the instrument response can decrease

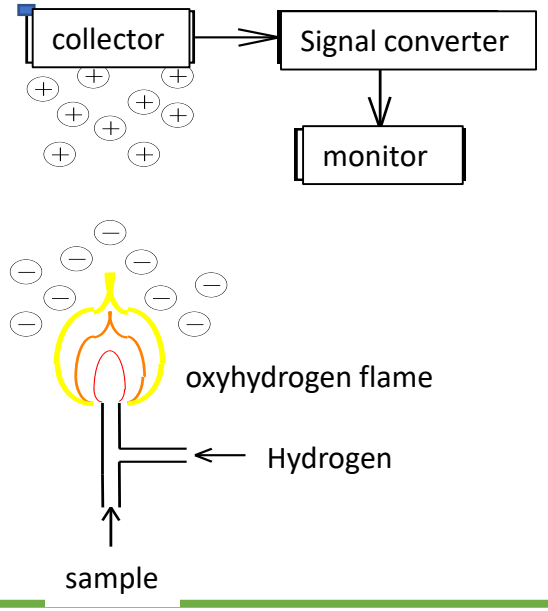
Multi-Gas Detector

- Some monitors may combine these sensors with a CGI and an oxygen sensor to form 2-, 3-,4-. A typical 4-gas monitor will detect LEL, O_2, CO, & H_2S .Some monitors may combine 4-gas monitors with PID to create 5-gas monitors.
- Advantages : Easy to use, easy to carry, and know the concentration of pollutants in a short time.
- Disadvantages: Unknown unsuitable, interferent, expiration date, detection limit (ppm)



Flame ionization detector (FID)

- The sample is brought to the detector via a pumping action, and it is burned in a flame. The flame commonly is generated with hydrogen and air. When a chemical compound is burned, it produces ions and electrons. These electrons are located between two electrodes to which a difference of potential of a few hundred volts is applied. The current signal is proportional to the carbon number of the organic compounds, so the detector is very suitable for organic compounds with CH-based.



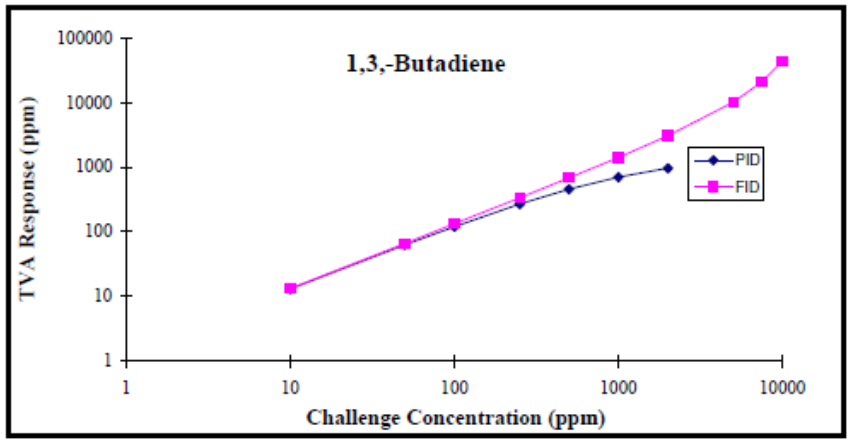
Advantages/Disadvantages/feature

- Advantages
  - Range (0.2~50,000 ppm as CH4)
  - High sensitivity
  - High stability and reproducibility
  - Not affected by CO, CO_2 and H_2O
- Disadvantages
  - Need warming up – 15 mins
  - Destructive and non-selective to the sample
  - Unable to operate under anoxic conditions (17% ignitable, 10% auto-extinguish)
- feature
  - Sensitive to saturated hydrocarbons than PID
  - unsaturated hydrocarbon (benzene) is more sensitive
  - Alcohol and chloride react poorly
  - Inorganic gases (ammonia, chlorine, cyanic acid) do not react

FID-relative factor

1,3,-Butadiene

Challenge Concentration (ppm)	Thermo/TVA-1000A (or equivalent) Relative Response Factor PID	FID	EPA/TVA-1000B (or equivalent) Response Factor Multiplier PID	FID
10	1.281	1.466	0.773	0.758
50	1.243	1.474	0.799	0.756
100	1.198	1.484	0.832	0.754
250	1.082	1.514	0.932	0.746
500	0.931	1.565	1.097	0.732
1000	0.727	1.667	1.428	0.706
2000	0.506	1.871	2.091	0.653
5000		2.482		0.493
7500		2.991		0.360
10000		3.500		0.227



PID Lamp (eV): 10.6

TVA-1000B Response Curve Coefficients:		A	B
	PID	0.77	-6.62
	FID	0.76	0.53

$$Y = \frac{10000AX}{10000 + BX}$$

Y=actual concentration
X=FID reading (TVA1000B)

E.g: FID reading is 100 ppm，actual concentration ?

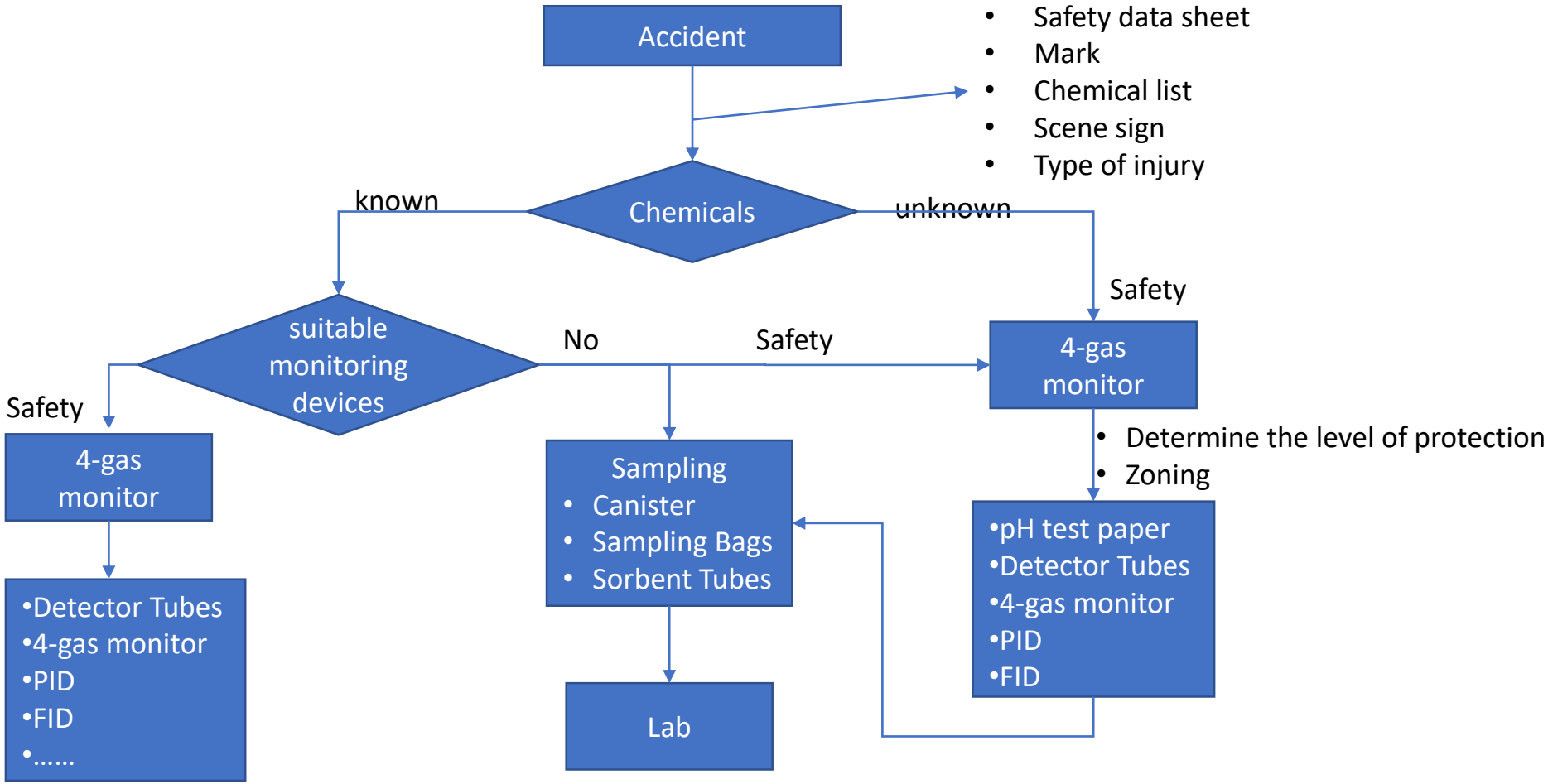
$$Y = \frac{10000 * 0.76 * 100}{10000 + 0.53 * 100}$$

=75.6 ppm

Response Times

- Photoionization = 1-2 seconds
- Flame ionization detector = 3-5 seconds
- LEL with pump = up to 7 seconds
- LEL w/o pump = up to 30 seconds
- CO and H_2S sensors = >20 seconds
- Radiation monitors = up to 1 ½ mins.

Air detection process



Thanks for Your Attention

Wing van truck trailer acid liquid leakage accident

1. Time：2016.07.20

   2017.03.26

2. Location ：Tai No.61 Western Coast Expressway southward 24km。

3. Casualty ：0 dead、0 injured。

   0 dead 、1 person injured

4. Accident type ：Traffic Accident。

5. Chemicals：

   Sulfuric acid (CAS No.:7664-93-9)

- The truck carried 10 barrels of IBC TANK as 96% sulfuric acid
- Turned left onto the Tai No.61 on the flat road.
- By turning too fast results in IBC tank broke Wing van , 9 barrels of TANK accidentally fell on the road surface.

Accident 1

IBC TANK scattered and deformed

IBC TANK crashed into the right wing

Absorbing sulfuric acid with absorbent cotton

Remove IBC TANK

Accident 1

Correcting ISO TANK with a large crane

with a stacke

Absorbing sulfuric acid with absorbent cotton

IBC TANK is placed on the leaking plate to prepare for shifting

Accident 1

Transfer by diaphragm pump

Sprinkle lime on the ground, neutralize sulfuric acid

removed from the field

Remove the ground lime

Collecting waste

Accident 2

The different events
The same locations
The same chemicals
The same causes
The same conditions
The same treatment

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.

Cause analysis

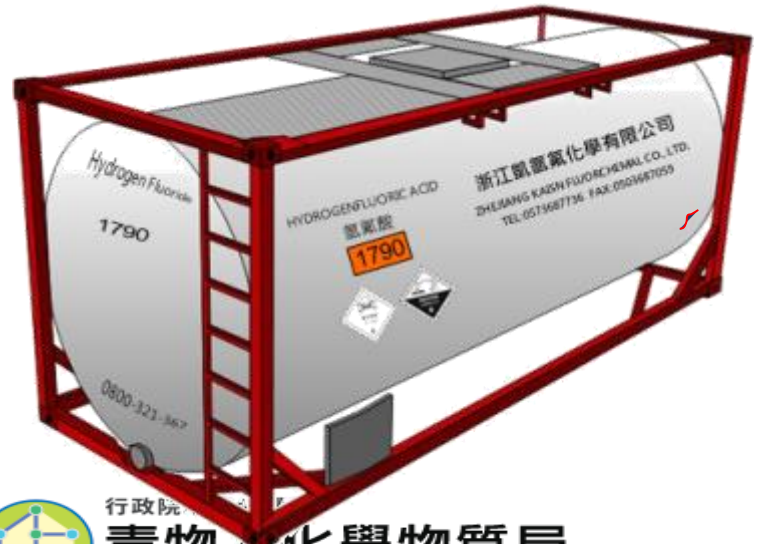
- Immediate cause: The wing roof truck loaded with IBC barrels of sulfuric acid caused the IBC bucket to break open the wing roof when it was bent, and the drop was broken, causing sulfuric acid to leak.
- Indirect cause： The road has a large turning angle, the truck speed is too fast, the IBC barrel is not fixed, and the wing roof has insufficient anti-collision strength.
- Root causes ：
  1. The driver's road safety driving concept is insufficient and the fixed training of loading cargo is insufficient.
  2. The inspection work before the goods leave the factory is insufficient.
  3. The turning angle of this road section is large, and the driving route is modified.
  4. The fixed strength of both sides of the wing roof truck is insufficient to evaluate whether it is suitable for loading dangerous goods.

Intermodal tanks acid liquid leakage accident

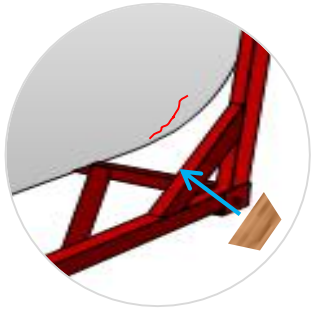
1. Time：2015.02.13
   2015.02.16
2. location ：Keelung Port Container Terminal
3. Casualty ：0 dead、0 injured。
   0 dead 、0 injured
4. Accident type ：Traffic Accident。
5. Chemicals：
   Hydrofluoric acid 49%
   (CAS No.:7664-39-3)

Overview

- Hydrofluoric acid (49%) storage: 20 tons
- Broken hole position: right below the tank
- Broken hole size: 5x0.5 cm (long crack)
- Leakage type: misty eruption
- Total leakage time: about 9 hours
- Total leakage: about 10 tons

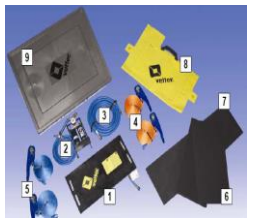


First stop leak (direct fill hole)



Kit AE

The second stop leak (filling between the hole and the frame, stopping the leak)



leak-sealing lance、sealin bag

Third stop leak (filling between the hole and the frame, increasing the thickness)

Modified wood chip + sealin bag

First

The trough is in the middle layer, carrying the Kit AE to stop the ladder

The distance between the tank and the frame is too short to stop leaking.

Second

Try using leak-sealing lance+ liquid absorbent cotton + sealin bag

Thickening the leak stop between the frame and the groove to stop the leak

Third

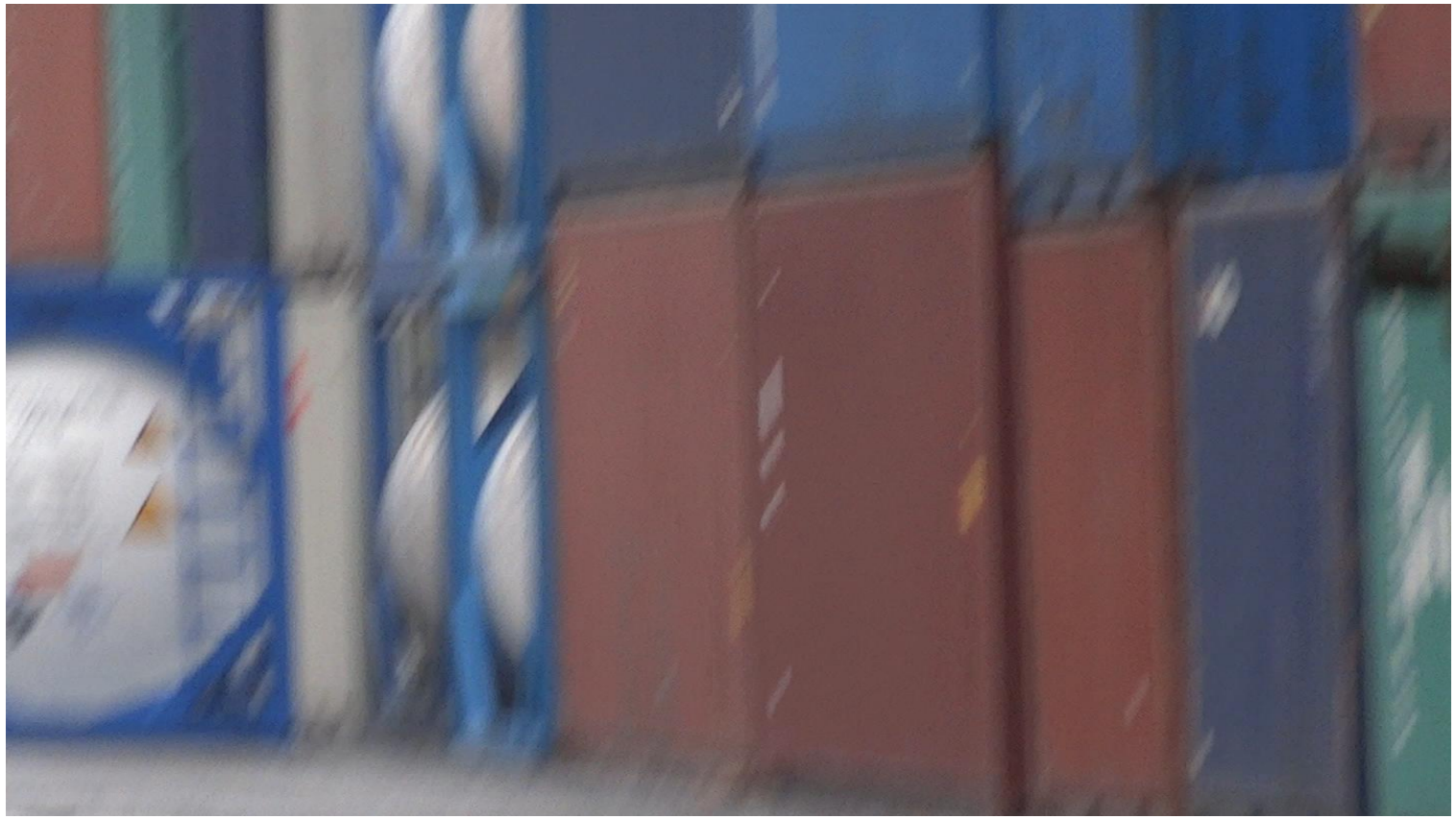
- Modified wood chip + sealin bag
- Thickening between the frame and the groove to complete the leak

Picture

Hydrofluoric acid neutralization

Neutralize HF with calcium chloride (500kg total)

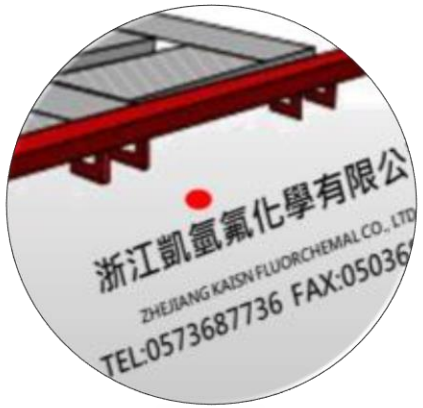
Three days later . . .



Overview

- Hydrofluoric acid (49%) storage: 20 tons
- Broken hole position: above the trough
- Broken hole size: 0.1cm (round hole)
- Leakage type: gas eruption band particles
- Total leakage time: about 3Hr
- Total leakage: <1tons

Stop leaking operation (direct filling of broken holes)



Kit AE

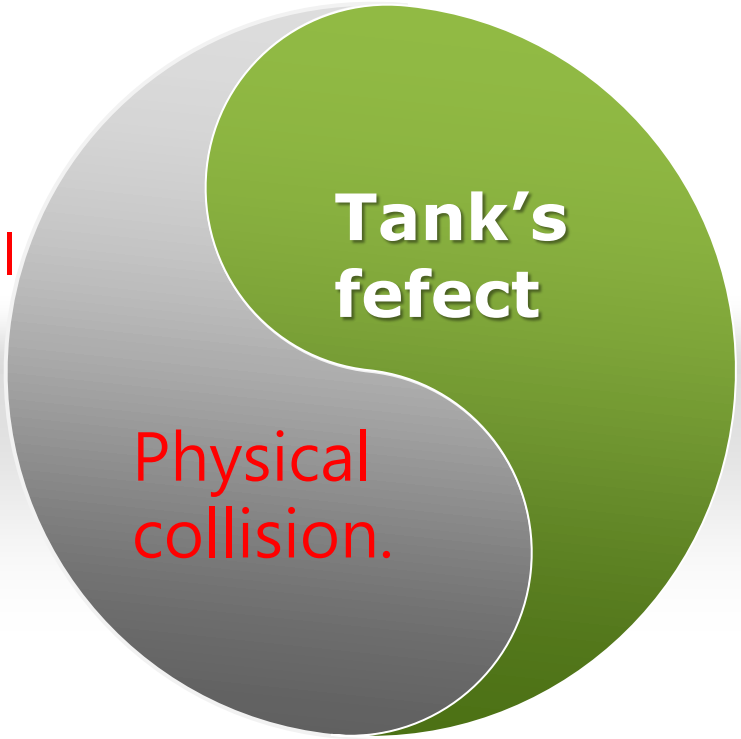
Operation

Stop leaking directly with Kit AE

After reinforcement with anti-chemical tape, inflatable stop film

Cause analysis

From the appearance inspection, there is no damage caused by physical collision.



① Lorry bottom sump design and sputum tube fixing design is unreasonable

② The gap between the liquid sputum tube and the support plate is small

③ The thickness of the liner in the tank is uneven