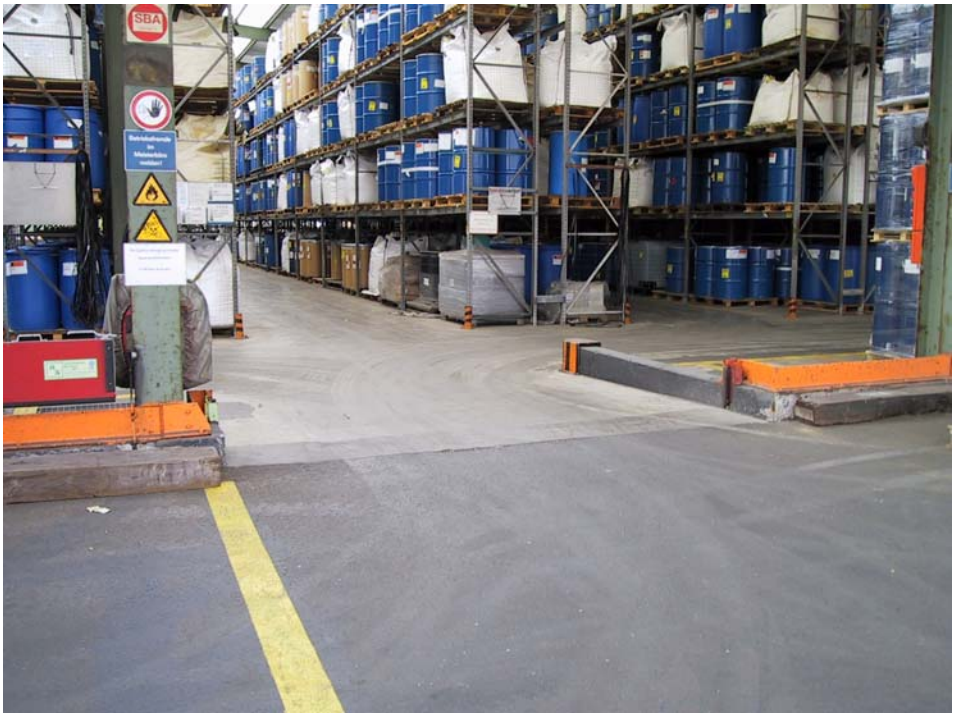
Thai-German Dangerous Goods Project (TG-DGP)

"The Implementation of a System for the Safe Transport and Handling of Dangerous Goods"

Guideline

Safe Storage of Dangerous Goods and Dangerous Substances



NOVEMBER 2002

PN 1995.2501.5-001.00

RESULT 5

Storage, Handling and Safety Management Standards and Procedures for Bangpoo Industrial Estate

Table of Contents

Page

Foreword

This guideline is an overview of all relevant requirements for the safe storage of dangerous goods and dangerous substances based on international regulations and recommendations. The requirements of this guideline should be considered as recommendations for the safe storage. They should not be transferred directly into national regulations. Before implementing regulations for the safe storage, the existing national regulations must be evaluated by the Thai Authorities. For the regulations the Thai Authorities should also consider the equipment of the existing warehouses, to make sure that they can fulfill the requirements by using transitional periods.

If there are stricter national regulations, they must be observed. In such case this part of the guideline does not apply.

The chapters A, B and C should be relevant for all Industrial Estates. This guideline can be used for the whole country. Chapter D is only valid for Bangpoo Industrial Estate Area. If other Industrial Estates will be inventoried, they will get their own chapter D.

A warehouse shall be designed, constructed and maintained in a way that elements of the weather, including precipitation, heat, frost, wind and humidity, have no impact on the capability of the storage facility to guarantee a safe storage of dangerous goods, dangerous substances or dangerous wastes.

During the storage of dangerous goods and dangerous substances several requirements have to be fulfilled to protect the employees or the environment against any kind of risk.

First there are requirements for the construction of the building (for example catch basins, fire walls, fire doors etc.). Another requirement are inventory lists about the goods stored in the warehouse for preparing plans for emergency cases and information of emergency response teams (employees and fire brigade). Furthermore the employees must be trained how to handle the dangerous goods and dangerous substances and how to react in case of emergency.

Another important requirement to be observed during the storage is the segregation of the dangerous goods and dangerous substances. Flammable liquids should not be stored together with toxic substances and oxidizing substances. So that in case of a fire there won't be a release of the toxic substances and to sustain combustion by the oxidizing substances.
Nonetheless complying with the segregation requirements there might be chemical reactions between the substances in the warehouse in case of a spillage or leakage.
For example a release of chlorine might occur if acids react with hypochlorite preparations. Both substances are classified as corrosive and are often stored together. For that reason it is very important to check all the packaging very carefully before they are taken into the warehouse. It is also very important to avoid opening the packagings inside the warehouse to take few quantities out of the packaging for the production process. There might be some residues on the floor of the warehouse, which probably could react with other substances.

In the practise sometimes the segregation requirements are not observed and the construction and equipment of the buildings are not safe enough.

Every person responsible for a storage facility shall ensure that the storage facility is

(a) secured from public entry;
(b) properly identified as a dangerous goods/substances or waste dangerous goods/substances storage facility by using labels/placards prescribed in the Transportation of Dangerous Goods Regulations (Thai Provision Vol. 1) or other information signs which properly describe the dangerous goods/substances or waste dangerous goods/substances contained in the facility, placed on or near each building, room or area where the dangerous goods/substances or dangerous wastes are stored;
(c) equipped with suitable equipment required to handle an emergency related to the dangerous goods/substances or waste dangerous goods/substances stored in the warehouse;
(d) staffed with employees trained to respond to emergencies related to the dangerous goods/substances or waste dangerous goods/substances stored in the warehouse; and
(e) secured to prevent spilled or leaked dangerous goods/substances or dangerous wastes from entering the environment or causing an adverse effect.

All the requirements in this guideline should be fulfilled independent of the number of employee and the quantities of dangerous goods and dangerous substances.

This guideline is based on international regulations for the storage and handling of dangerous goods and dangerous substances. The international regulations which are considered in this guideline are mentioned in the beginning of each chapter.

This guideline also contains detailed figures or numbers for some requirements, for these requirements the annex II states the source of information. In the guideline there will be a number in square brackets ([11]) after the figure. This number can be found in annex II.
For the most of the figures there are only German regulations which give detailed requirements. The German regulations are the basic for EC regulations which are still in discussion.

Data for substances can be found at the following Internet-Domains:

http://www.merck.de/english/services/chemdat/english/index.htm
http://www.sigma-aldrich.com

Other interesting Internet-Domains are only available in German.

A. General requirements for the safe storage of dangerous goods and dangerous substances

A.1 Construction of buildings

Based on the following regulations

European regulations	*1989/654/EC*
German regulations	*MIndBauRl*
U.S. regulations	*40CFR264*

A.1.1 Floor

Based on the following regulations

European regulations	*1989/654/EC Annex I No. 9*
German regulations	*ArbStättV* *ASR 8/1*
U.S. regulations	*29CFR1910, § 1910.22*

The floor of workplaces must have no dangerous bumps, holes or slopes and must be fixed, stable and not slippery.
The material of the floor must be resistant against water and all other chemicals, which are stored in the warehouse. Especially in the waste bundle the floor must be resistant against chemicals. The floor should be conductive (anti-static) in respect of the stored materials.

The surfaces of floors, walls and ceilings in rooms must be such that they can be cleaned or repaired to an appropriate standard of hygiene.

A.1.2 Doors

Based on the following regulations

European regulations	*1989/654/EG Annex I No. 11* *1989/654/EG Annex II No. 9*
German regulations	
U.S. regulations	

The position, number and dimensions of doors and gates, and the materials used in their construction, are determined by the nature and use of the rooms or areas as follows.

A.1.2.1 Doors in general

Transparent doors must be appropriately marked at a conspicuous level.
Swing doors and gates must be transparent or have see-through panels.
If transparent or translucent surfaces in doors and gates are not made of safety material and if there is a danger that workers may be injured if a door or gate should shatter, the surfaces must be protected against breakage.
Sliding doors must be fitted with a safety device to prevent them from being derailed and falling over.
Doors and gates opening upwards must be fitted with a mechanism to secure them against falling back.
Doors along escape routes must be appropriately marked.

It must be possible to open them from the inside at any time without special assistance. Sliding doors are forbidden to use as escape exit.
Doors for pedestrians must be provided in the immediate vicinity of any gates intended essentially for vehicle traffic, unless it is safe for pedestrians to pass through; such doors must be clearly marked and left permanently unobstructed.
Mechanical doors and gates must function in such a way that there is no risk of accident to workers.
They must be fitted with easily identifiable and accessible emergency shutdown devices and, unless they open automatically in the event of a power failure, it must also be possible to open them manually.

A.1.2.2 Fire doors

Based on the following regulations

European regulations	
German regulations	*DIN 4102*
U.S. regulations	

Fire doors are integrated in fire walls to get from one compartment into another. The fire doors must fulfill the same requirements as the fire walls. Fire doors are also distinguished between their resistance against a fire for 30, 60, 90, 120 and 180 minutes. Depending on the material of the fire doors and their thickness, they must be classified by the manufacturer of the door to the type F 30, F 60, F90, F 120 or F 180.

A.1.3 Traffic routes

Based on the following regulations

European regulations	*1989/654/EG Article 6 and 12* *1989/654/EG Annex I No. 12* *1989/654/EG Annex II No. 16*
German regulations	*ArbStättV* *ASR 17/1,2*
U.S. regulations	*29CFR1910, §1910.22*

Traffic routes, including stairs, fixed ladders and loading bays and ramps, must be located and dimensioned to ensure easy, safe and appropriate access for pedestrians or vehicles in such a way as not to endanger workers employed in the vicinity of these traffic routes.
Routes used for pedestrian traffic and/or goods traffic must be dimensioned in accordance with the number of potential users and the type of undertaking.
If means of transport are used on traffic routes, a sufficient safety clearance must be provided for pedestrians.
Sufficient clearance must be allowed between vehicle traffic routes and doors, gates, passages for pedestrians, corridors and staircases.
Where the use and equipment of rooms requires for the protection of workers, traffic routes for vehicles must be clearly identified by continuous stripes in a clearly visible colour, preferably white or yellow, taking into account the colour of the ground. The stripes must be located so as to indicate the necessary safe distance between the vehicles and any object, which may be near by, and between pedestrians and vehicles.
Outdoor and indoor workplaces must be organised in such a way that pedestrians and vehicles can circulate in a safe manner.

Loading bays and ramps must be suitable for the dimensions of the loads to be transported.
Loading bays must have at least one exit point.
Where technically feasible, bays over a certain length must have an exit point at each end.
Loading ramps must as far as possible be safe enough to prevent workers from falling off.

A.1.4 Electrical installations

Based on the following regulations

European regulations	*1989/654/EG Annex I + II No. 3* *1989/654/EG Annex I + II No. 8*
German regulations	*ElexV* *ZH 1/8* *TRGS 514*
U.S. regulations	*29CFR1910, Subpart S*

Electrical installations must be designed and constructed so as not to present a fire or explosion hazard; persons must be adequately protected against the risk of accidents caused by direct or indirect contact.
Electrical installations and protection devices must be appropriate to the voltage, external conditions and the competence of persons with access to parts of the installation. The lamps and electrical installations must be designed in such way that during the storage and unstorage operation no damage can be caused in any kind. The lighting (lamps) of the warehouse must be above the traffic ways and must be at least 0.5 meters [1] above the goods. The lamps must be of such kind and distance that they don't heat the goods.

Workplaces must as far as possible receive sufficient natural light and be equipped with artificial lighting adequate for worker's safety and health.
Workplaces in which workers are especially exposed to risks in the event of failure of artificial lighting must be provided with emergency lighting of adequate intensity.

A.1.5 First aid rooms

Based on the following regulations

European regulations	*89/654/EC Annex I No. 19* *89/654/EC Annex II No. 14* *89/391/EC Article 8*
German regulations	*ArbStättV*
U.S. regulations	

The first aid rooms should be in a separated room outside the warehouse. If the room is located inside the warehouse, it must be separated by fire wall and no direct access to the stored goods should be available.
One or more first aid rooms must be provided where the size of the premises, type of activity being carried out and frequency of accidents so dictate.
First aid rooms must be fitted with essential first aid installations and equipment and easily accessible to stretchers.
They must be signposted in accordance with the international regulations.
In addition, first aid equipment must be available in all places where working conditions require it.
This equipment must be suitably marked and easily accessible.

A.1.6 Walls

A.1.6.1 Walls in general

Based on the following regulations

European regulations	
German regulations	*MIndBauRl*
U.S. regulations	

Walls must be designed in such way that impact neither could from the outside deteriorate the stored goods nor the surroundings (other buildings) could be influenced from the stored goods.

As a general requirement, the walls of the warehouses must withstand a fire of 30 minutes (F 30) [2] It should be a construction of cement blocks. Cement blocks usually withstand a fire for 30 minutes. This time is being considered sufficient for a fire brigade to block a fire of non-combustible material. A tent of plastic materials is not suitable to be used as a permanent warehouse. The walls should be airtight to ensure that no flammable or toxic gases may cause a case of emergency.

A tent can only be used as a temporarily warehouse for almost 3 month.

A.1.6.2 Fire walls

Based on the following regulations

European regulations	
German regulations	*MIndBauRl* *DIN 4102*
U.S. regulations	

There are different types of fire walls. A fire wall is a wall, that consist of non-combustible material and withstands a fire. According to the material and the thickness of the wall, there are 3 main types: F 30, F 60 and F 90 (the two others are F 120 and F 180). The number indicates the number of minutes that the fire wall withstands the fire. A fire wall must be higher than the roof and be longer than the other walls to make sure that a fire can't jump over to another compartment of a building. Fire walls must have a distance of less than 40 meters [3] from each other.

A.1.6.3 Compartment walls

Compartment walls have to be designed to limit the quantity of goods stored. They must be built according to the respective of requirements of the fire walls (A.1.6.2).

A.1.7 Roof

Based on the following regulations

European regulations	*2000/553/EC*
German regulations	*MIndBauRl*
U.S. regulations	

The roof of the warehouse must also withstand a fire of 30 minutes (F 30) [4]. Since, the roofs are normally made of steel constructions with metal sheets; these roofs might get very hot in case of fire. Therefore, the insulation must be made of non-combustible materials. The steel trusses should be protected by non-combustible materials as well.

A.2 Escape ways and exits

Based on the following regulations

European regulations	*1989/654/EG Article 6* *1989/654/EG Annex I + II No. 4*
German regulations	*GefStoffV* *ArbStättV* *ZH 1/265* *MIndBauRl*
U.S. regulations	

In case of an emergency it is very important for the employees to get out of the building to place themselves in safety. For that reason a warehouse needs escape ways.
Emergency routes and exits should remain clear and should lead as directly as possible out of the building to a safe area. The distances between the individual working areas and escape exit must be in accordance with the Thai regulations based on the classes of risks.

In the case of danger, it must be possible for workers to evacuate all workstations quickly and as safely as possible.

An adequate number of escape routes and emergency exits must be available. The number of escape ways and exits depends on the size of the building and its equipment and use.

Emergency exit doors must open outwards.
Sliding or revolving doors are not permitted if they are specifically intended as emergency exits.
Emergency doors should not be locked or fastened in a way that they cannot be easily and immediately opened by any person who may require using them in an emergency. Emergency exits must not be key-locked, so that they can be opened in case of emergency.

Signs must identify specific emergency ways and exits. These signs must be in accordance with the international regulations and must be placed at appropriate points and be made to last.

The emergency ways and exits, and the traffic routes and doors giving access to them, must be free from obstruction so that they can be used at any time without hindrance and obstacles in the way.

Emergency routes and exits requiring illumination must be provided with emergency lighting of adequate intensity in case the lighting fails.

There must be a blueprint showing the emergency exits for the building. For each building the blueprint must be shown inside of the building.

Forklift trucks can only be used on escape ways if there is still enough space to leave the building in case of emergency so that the forklift truck does not block the way.

There must be a meeting point for all employees in case of emergency to check easily if persons are missing.

The escape exits must be placed on two opposite sides of the building. If it is a big building it must be ensured that each 35 meters [5] an escape exit has been placed.
The exit itself must have a width of at least 1.10 metre (minimum) [6]. If more than 50 employees are working in the warehouse, the width of the last escape exit must increase to 1.70 metre, if no other additional escape exit is available.

A.3 Alarm signals

Based on the following regulations

European regulations	
German regulations	*GefStoffV*
U.S. regulations	*29CFR1910, §1910.165*

Two different kinds of alarm signals exist: the fire alarm and the alarm signal for gases.

Acoustic signals must:
(a) have a sound level which is considerably higher than the level of ambient noise, so that it is audible without being excessive or painful;
(b) be easily recognisable, particularly in terms of pulse length and the interval between pulses or groups of pulses, and be clearly distinguished from any other acoustic signal and ambient noises.

If a device can emit an acoustic signal at variable and constant frequencies, the variable frequency should be used to indicate a higher level of danger or a more urgent need for the requested/imposed intervention or action in relation to the stable frequency.
The signal for evacuation must be continuous.

A.3.1 Fire alarm signal

Based on the following regulations

European regulations	*1992/58/EG Annex VII*
German regulations	
U.S. regulations	

The fire alarm is an acoustical signal that can be initiated manually or by smoke detectors. For detailed information about smoke detectors see chapter 4.
For giving an alarm signal manually there must be fire alarm boxes in every warehouse. The fire alarm boxes should be placed at a distance of 30 meters [7], to make it possible for the employees to start the fire alarm signal immediately.
The acoustic alarm should be audible at the entire area of the company, so that everyone is informed.

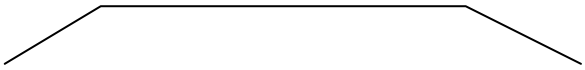
Normally the alarm signal for fire alarm is a one-minute wail.

A.3.2 Signal for gases

Based on the following regulations

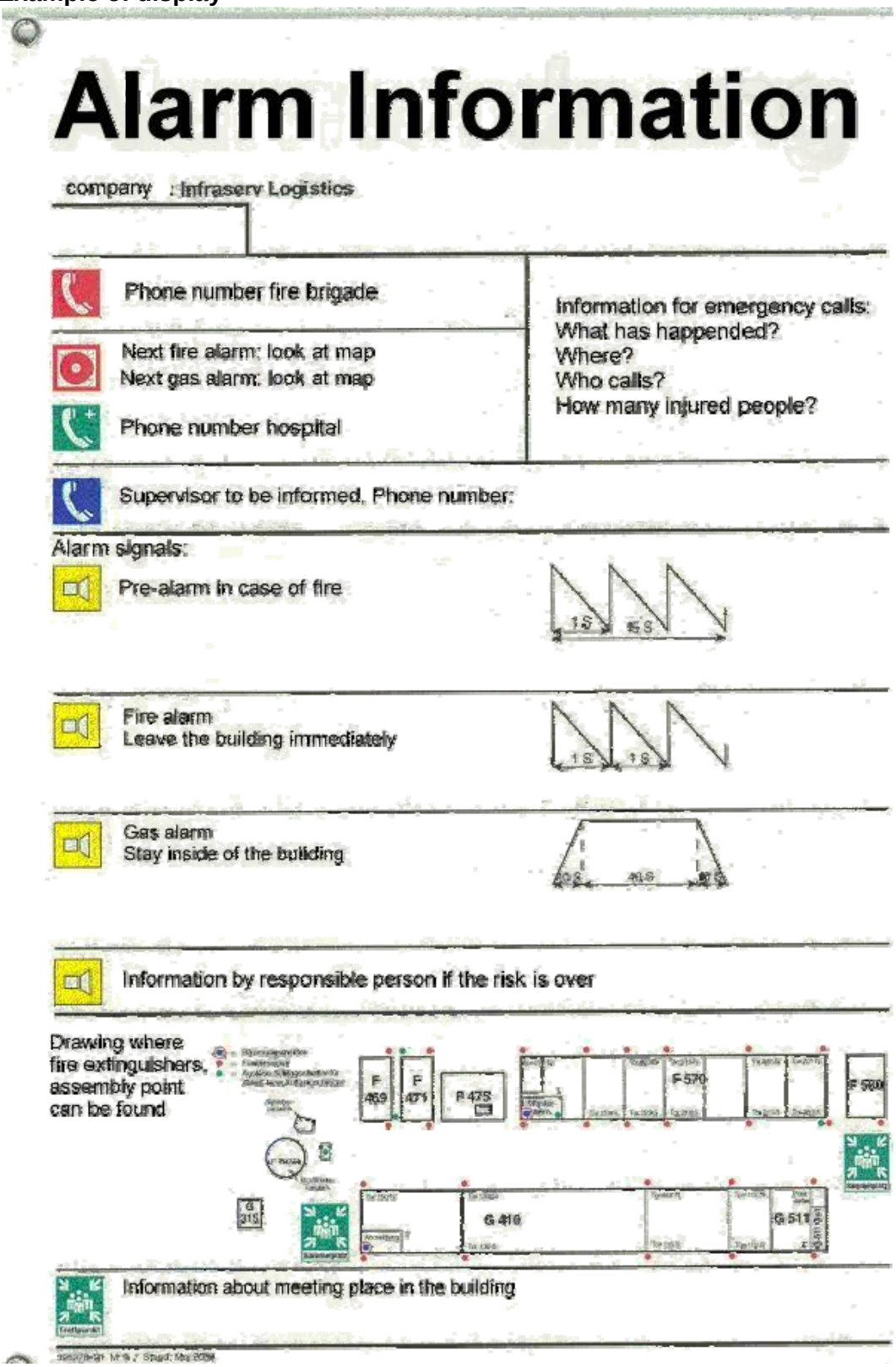
European regulations	*1992/58/EG Annex VII*
German regulations	
U.S. regulations	

For companies who handle dangerous goods and dangerous substances which emit toxic or narcotic gases or gases must have a gas detector in the area where those materials are handled. The gas detector must be suitable for the gases that might be in the air. If the gas detectors realize a certain gas concentration there must be an acoustical alarm to warn the employees so that they can use their personal protective equipment to get out of this area.
The alarm should be audible at the entire area of the company, so that everyone can put on the personal protective equipment.
Normally the alarm signal for gas alarm is an increasing tone, which is constant for one minute at a certain level and decreasing after this time.



All employees must be informed about the different signals and what to do in case of emergency. For that reason the information must be displayed in the warehouse at all exits.

A.3.3 Example of display



General safety precautions

I. Fire, explosion or spillage inside the warehouse

Alert fire brigade
Give information about place of incident

Inform responsible persons of company

Carry out safety measures until fire brigade arrives
Leave unsafe areas
Inform fire brigade at arrival

Get self breathing apparatus ready for use if necessary?
Carry out measures using self - breathing apparatus. Further instructions by supervisor

Rescue injured persons
Beware of own safety

In case of evacuation:

Only use emergency ways and exits

Don't use elevators

Get to the meeting point immediately

Inform the supervisor about missing persons

II. Fire, explosion and spillage of dangerous substances in other buildings or companies

Alert fire brigade

Give information about place of incident

Inform responsible persons of company

Inside the building:
Close doors and windows, switch of ventilation and leave endangered rooms

Go to meeting point inside the building

Get self breathing apparatus ready for use if necessary

Outside of the building:
Get away from gas cloud diagonal to direction of wind
Protect mouth with wet cloth
Go inside of the next building

Adhere strictly to instruction of supervisor or responsible personnel

III. Incident with injured persons

Inform hospital or doctor
Number and kind or injuries

Inform supervisor

Rescue enclosed persons
First aid measures
Beware of your own safety

A.4 Fire fighting and fire extinguishing material

Based on the following regulations

European regulations	
German regulations	*ArbStättV* *ZH 1/201*
U.S. regulations	*29CFR1910, Subpart L* *29CFR1910, §1910.38* *29CFR1910, §1910.157 to 163* *29CFR1910, §1910.164 and §1910.165*

The main reasons for a fire are the handling with potential sources of ignition and flames and the improper handling of flammable substances.

The fire protection consists of two parts:
- Preventive fire protection
- Defensive fire protection

The preventive fire protection consists of
- Construction of the building,
- Number and kind of escape ways and exits
- Fire resistance of the material of the building (a wall of concrete is not flammable but a wall of wood or a plastic tent are flammable)
- Smoke detectors (Detection system smoke)
- Fire extinguishers
- Sprinkling system
- Water hydrants and hoses
- Alarm plan
- Training of employees
- Distance of fire walls (less than 40 metres) [8]

The defensive fire protection consists of
- Emergency response team of employees
- Fire brigade

If the construction of the building doesn't fulfill all requirements for fire protection, there must be measures for minimising the risk in case of fire like smoke detectors or a water sprinkling system. Additionally one person must be responsible (co-ordinator for fire protection) who must check all the requirements (equipment, training), summary of fire protection concept, fire protection plan, maintenance instructions and operating instructions for fire fighting equipment, distances to buildings and traffic ways.

Depending on the dimensions and use of the buildings, the equipment they contain, the physical and chemical properties of the substances and the maximum potential number of employees and other persons, workplaces must be equipped with appropriate fire-fighting equipment and, as necessary, with smoke detectors and alarm systems.

Non-automatic fire-fighting equipment (fire extinguishers, water hydrants and hoses) must be easily accessible and simple to use.
Using a specific colour for the equipment and placing a location signboard, and/or by using a specific colour for the places where such equipment is kept, or their access points must identify fire-fighting equipment. The colour for identifying this equipment is red.

A fast and effective fighting of a rising fire can contribute to minimize the risk of a big fire and safe the building and lives.
The most important measure for fighting of rising fires is the availability of fire extinguishers and trained personnel who can use the fire extinguishers in an effective way. Using the right fire extinguisher (water, powder, and foam) for the dangerous goods and dangerous substances can avoid the spreading of the fire.
The presupposition for a successful fire fighting is the availability of the right fire extinguisher at the site of formation of a fire and the trained personnel, who can use the fire extinguisher in the right way.

A.4.1 Fire extinguishers

Based on the following regulations

European regulations	*89/391/EC Article 8* *89/654/EC Annex I + II No. 5* *EN 3*
German regulations	*ASR 13/1,2*
U.S. regulations	

Suitability of fire extinguishers for each purpose of use

Kind of fire hazard	Kind of substances to be extinguished
A	Fire of solids or glowing forming substances
B	Fire of liquids or liquefaction substances Fire of gases and gases under pressure
C	Electrical installations and devices
D	Fire of combustible metal

These kinds of fire hazards are based on the classification of Thailand and the United States of America.

Please note that, Europe has a different classification, and the gases are assigned to fire hazard C.

Kind of fire extinguishers	A Solids or glowing forming substances	B Liquids or liquefaction substances, gases and gases under pressure	C Electrical installations and devices		D Combustible metals
			Less than 1000 V	More than 1000 V	
Powder extinguisher with ABC powder	yes	yes	yes	yes	no
Powder extinguisher with BC powder	no	yes			no
Powder extinguisher with D powder for combustible metals	no	no			yes
Carbon dioxide extinguisher (CO_2)	no	yes	yes	yes	no
Water fire extinguisher	yes	no	yes from safe distance	no	no
Water fire extinguisher with additives for B	yes	yes for liquids no for gases			no
Foam fire extinguisher	yes	yes for liquids no for gases	no	no	no
Halon	no	yes			no

Fire extinguishers have to be provided by the company in the right number and the right kind with the right capacity.

Fire risks are divided into 3 types: minor risk, moderate risk and major risk [9].
A minor fire risk can be found in warehouses where substances with a low flammability are stored and the local circumstances have a low risk of starting a fire (no sources of ignition and no other material which is flammable). It is also not possible that a fire can expand immediately.
A moderate fire risk can be found in warehouses where flammable substances are stored and the local circumstances have a low risk of starting a fire (no sources of ignition and no other material which is flammable). It is also not possible that a fire can expand immediately.
A major risk can be found in warehouses where flammable substances are stored and the local circumstances have a high risk of starting a fire (sources of ignition and other material which is flammable). It is also possible that a fire can expand immediately.

Minor fire risk	Moderate fire risk	Major fire risk
Dangerous goods and dangerous substances which are **not** flammable and few empty (new) packagings in the warehouse and other materials which are **not** flammable	Dangerous goods and dangerous substances which are flammable and few empty (uncleaned) packagings and other materials which are **not** flammable	Dangerous goods and dangerous substances which are flammable and **large** number of empty (uncleaned) packagings and other materials which are flammable

This risk classes are only considering fire risk, therefore please consider also the segregation and separation requirements (see A.10.) as appropriate.

For the assignment of a warehouse to the applicable fire risk class the following table can be used. The determination of the respective fire risk class could be made by choosing the appropriate constants 1 and 2. The constant number 1 values the different risk classes. The constant number 2 takes the risk sources into account. The numbering is always increasing from low to high.

Class / Criteria	Minor fire risk R1	Moderate fire risk R2	Major fire risk R3	Multiplication constant 2
Constant 1	10	20	30	
Dangerous substances	Non-flammable	Flammable	Flammable	3
Packagings	Empty and clean or uncleaned with non-flammable residues	Empty and clean or uncleaned with non-flammable residues	Uncleaned Packagings with flammable residues	2
Other material	Non-flammable	Non-flammable	Flammable	1

According to the stored substances, the sum of the multiplication of constant 1 and constant 2 will indicate the fire risk class. This calculation has to be made for each criteria and their addition will result to a figure which indicates the fire risk of the warehouse.
These identification figures are:

Minor fire risk (R1):	$x < 80$
Moderate fire risk (R2)	$80 \leq x \leq 120$
Major fire risk (R3)	$120 < x$

<u>Example how to assign a warehouse to a fire risk</u>
In a warehouse are flammable substances, empty and clean packagings and other material which is not flammable.

Flammable substances:	R2 or R3	20 x 3 = 60	or	30 x 3 = 90
Packagings:	R1	10 x 2 = 20		
Other material:	R1	10 x 1 = 10		

The sum of this will be 90 or 120. Both results are in R2 and will lead to a moderate fire risk.

Number of fire extinguishing units [10]

The number of fire extinguishers depends on the fire-extinguishing units. The fire extinguishers have different capacities and different kind of extinguishing materials. For that reason each fire extinguisher has another fire extinguishing unit.

Base area of warehouse (m^2)	Minor fire risk Fire extinguishing units	Moderate fire risk Fire extinguishing units	Major fire risk Fire extinguishing units
50	6	12	18
100	9	18	27
200	12	24	36
300	15	30	45
400	18	36	54
500	21	42	63
600	24	48	72
700	27	54	81
800	30	60	90
900	33	66	99
1000	36	72	108
Each further 250	6	12	18

Depending on the dangerous goods and dangerous substances stored in the warehouse, it is necessary to use different kind of fire extinguishers.

Kind of fire extinguisher	Extinguishing unit per fire extinguisher
6 kg ABC powder	6
12 kg ABC powder	12
6 kg BC powder	6
12 kg BC powder	12
6 kg CO_2	3
Water 10 litre	4
4 kg Halon	For these extinguishers there are other criteria. Expected to be faced out due to environmental and health problems in the next years
6 kg Halon	
12 kg powder for metal	For these extinguishers there are other criteria. The manufacturer of the powder must give detailed information for which capacity/area it can be used.

Example how to calculate for the right number of fire extinguishers

The number of fire extinguishers depends on the kind of the fire extinguisher and the fire risk.

A warehouse of 200 m² with a moderate fire risk needs 24 fire extinguishing units.
There are different opportunities to fulfill the requirements:

a) 6 kg ABC powder (each 6 extinguishing units): 4 fire extinguishers
b) 12 kg ABC powder (each 12 extinguishing units): 2 fire extinguisher
c) 10 L water (each 4 extinguishing units): 6 fire extinguishers
d) combination of all 3 kinds of fire extinguishers mentioned above:
   6 kg ABC powder: 1
   12 kg ABC powder: 1
   10 L water: 2

A.4.2 Water sprinkling system

A water sprinkling system should be installed in warehouses where flammable substances are stored. The sprinklers must be placed in such a way that all goods will be sprinkled with water or the suitable fire-extinguishing material.
In warehouses with shelves the sprinklers must be installed on different heights. At least one sprinkler must be installed for two superimposed cells of a shelf.

A.4.2.1 Water hydrants and hoses

The number of water hydrants and the distances between them depend on the length of the hoses, the pressure of the water and the equipment of the fire brigade.
Normally the water hydrants are placed at a distance of 50 meters. The fire brigade should be equipped with hoses and a nozzle pipe with 3 openings to cover a distance of 45 meters [11].

A.4.2.2 Training of employees concerning fire fighting

To make sure that all the employees react in the proper way in case of fire, they must get a training concerning the

- Use of fire extinguishers
- Use of water sprinkling system
- Evacuation of the building.

These training programmes should be repeated once a year to make sure that every employee is familiar with these procedures.

Additionally there should be an emergency response team who has to fight the fire until the fire brigade arrives. This team should be trained at least once a year by the approved trainers and training program.
There should be test alarms to make sure that in case of emergency the members of the team react in the proper way.

A.4.3 Water supply and water pressure for fire fighting

Based on the following regulations

European regulations	
German regulations	*MIndBauRl*
U.S. regulations	*NFPA 1231*

A fire can only be extinguished, if the water supply is sufficient. It is also very important to ensure that the water pressure is high enough to reach the fire with the water from the hoses with the nozzles.

The quantity of the water must be sufficient to ensure water supply for 2 hours according the size of the warehouse.

There are different methods to calculate the water supply.
According the German regulation a water supply should be at least 96 m³ per hour for a compartment or warehouse up to 2500 m². If the warehouse or the compartments are bigger than 4000 m² the water supply should be at least 192 m³ per hour. Intermediate sizes can be interpolated linear [12].
The insurance companies request a water supply of 3200 litres per minutes for 2 hours.
In the United States the water flow should be 1500 GPM with 20 PSI residual pressure (NFPA 1231).

An adequate fire protection water supply for warehouses without a sprinkler system means an immediately available and accessible water supply, with sufficient volume and/or flow to enable the employees and later on the fire department to use their fire hoses to control fire growth until the building is safely evacuated and search and rescue operations have been completed. The fire protection water supply is also intended to prevent the fire from spreading to adjacent buildings. This water supply should also be sufficient to provide a limited measure of both property protection and protection against fire growth in warehouses with contents that could result in a significant environmental impact.

For warehouses with sprinkler system, an adequate fire protection water supply means a reliable water supply providing sufficient water flow for the sprinkler systems in terms of pressure, volume, and duration to limit fire growth until the fire department arrives to suppress the fire. This automatic protection is expected to provide time for the evacuation of buildings, assist the fire department in preventing fire spread to adjacent buildings, limit the environmental impact of fires, and provide significant property protection.

A properly designed sprinkler system, and especially those using modern technology sprinkler heads, will often extinguish a fire even without additional manual fire fighting intervention.

The test pressure for the hoses should be at least 8 bar [13].

However if the stored goods require stricter safety precautions, then even higher figures are recommended.

A.5 Used fire fighting water

Based on the following regulations

European regulations	*80/86/EEC* *86/280/EEC* *93/67/EEC* *96/61/EC* *96/82/EEC*
German regulations	*LöRüRl* *TRbF 200*
U.S. regulations	

Normally the fire fighting water is contaminated with chemicals after use. Used fire fighting water must not get into the effluent channel and should not be treated in the waste water treatment plant. The used fire fighting water should also not be washed away with water into the khlongs). Otherwise it might pollute the environment. This water can only be treated by chemicals or handled as waste with special treatment.

The used fire fighting water should be captured by catch basins or by retention tank of the fire brigade. After capturing the water must be analysed to find out which chemicals are in the water and what procedures must be taken for the wastewater treatment.
It might also be possible that the wastewater treatment plant gets information about the fire, so that they can collect the water and analyse it. If the used fire fighting water goes directly through the wastewater treatment, the chemicals might destroy the bacteria and all the chemicals will get into the rivers.

The capacity of the retention basins for the used fire fighting water must be sufficient so that no water will be washed away. The capacity depends on the size of the warehouse and the kind of chemicals.

For chemicals which are not hazardous for the environment especially for the water, the following capacities should be available [14].

Size of warehouse in m² (If there are different warehouses, the sizes must be added)	Capacity of retention basin in m³
25	6
50	12
75	18
100	25
150	40
200	55
250	70
300	90
400	125
≥ 500	150

In case of emergency, it might be necessary to pump the water out of the retention basin into a tank container or tank car if they realize that the retention basin is going to overflow.

A.6 Accidental release and spillages

Based on the following regulations

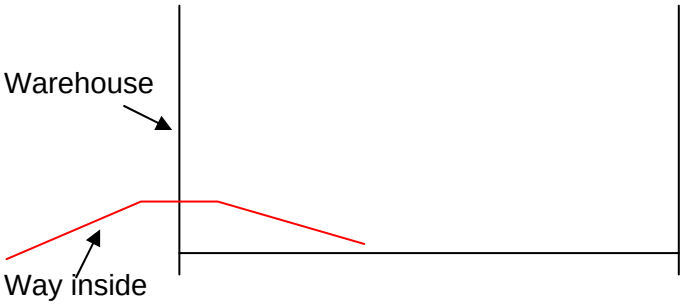
European regulations	
German regulations	*GefStoffV*
U.S. regulations	

It must be ensured that all packagings are proper closed and are not damaged to prevent leakage of dangerous goods and dangerous substances inside the warehouse.

It might be possible that packagings will be damaged during handling. For such emergencies it is necessary to minimise the risk for the employees and the environment.
At first the substance should be absorbed from the floor with binding agents / absorbent chemicals (e.g. dried sand, diatomaceous earth, acid binder, universal binder, sawdust. etc.), which is suitable for the chemicals and does not react with them in a dangerous way.
The next step is to inform the responsible supervisor about the situation to decide which further steps should be taken.
It is important to avoid that the chemical can get into the effluent channel or in the drainage system therefore don't wash the chemical away with water.
The substance with the binding agent must be taken from the floor and packed in a packaging (approved packaging for dangerous goods and dangerous substances) for waste disposal.
The floor must be cleaned to make sure that there are no residues on the floor.

If the packaging gets damaged and a liquid might get into the drainage system or in the effluent channel there must be a barrier against liquids, so that the liquid cannot run away.

It is important that the liquid cannot run out of the warehouse through the doors. For that reason it is important to have barriers against liquids at the doors or elevated entrances to the warehouses.



All the employees must be trained to behave and react right in case of an emergency.
For the bigger spillages there should be an emergency response team. The members should be trained in fighting spillages and using the additional required personal protective equipment.

If there are larger spillages and inadvertent releases of capacities of more than 500 kg or 500 litres or of substances which are toxic by inhalation, the authorized agency must be informed to find out the reason for the release or spillage and to enforce requirements if necessary [15].

A.7 Material safety data sheet

Based on the following regulations

European regulations	*76/769/EEC* *91/155/EEC* *2001/58/EC*
German regulations	*GefStoffV* *TRGS 220*
U.S. regulations	

The material safety data sheet contains all relevant information about the goods and substances.

In particular, the material safety data sheet should enable the employer to determine whether any hazardous chemical agents are present at the workplaces, and to assess any risk to the health and safety of workers arising from their use. It also contains information about the requirements for storage, fire-extinguishing material etc.

The information must be written in a clear and concise manner. The material safety data sheet should be prepared by a competent person who should take into account the specific needs of the user audience, as far as it is known. Persons placing substances and preparations on the market should ensure that competent persons have received appropriate training, including refresher training.

Additional information may be necessary in some cases in view of the wide range of properties of the substances and preparations. If in other cases it emerges that information on certain properties is of no significance or that it is technically impossible to provide, the reasons for this must be clearly stated under each heading. Information must be provided for each hazardous property. If it is stated that a particular hazard does not apply, clearly differentiate between cases where no information is available to the classifier, and cases where negative test results are available.

Give the date of issue of the safety data sheet on the first page.

When a safety data sheet has been revised, the changes should be brought to the attention of the recipient.

The safety data sheet also contains information about the safe storage and handling of dangerous goods and dangerous substances. A safety data sheet must be available for all goods at the warehouse to determine the following aspects for storage:

- Segregation requirements
- Personal protective equipment
- Fire extinguishing material
- Additional requirements for the construction of the building

A.7.1 Structure of the material safety data sheet

1. IDENTIFICATION OF THE SUBSTANCE/PREPARATION AND OF THE COMPANY/UNDERTAKING

1.1. Identification of the substance or preparation
The term used for identification must be identical to that provided on the label of the packaging.

1.2. Use of the substance/preparation
Indicate the intended or recommended uses of the substance or preparation as far as they are known. Where there are many possible uses, only the most important or common uses need be listed. This should include a brief description of what it actually does, e.g. flame retardant, anti-oxidant, etc.

1.3. Company/undertaking identification
Identify the person responsible for placing the substance or preparation on the market within the Community, whether it is the manufacturer, importer or distributor. Give the full address and telephone number of this person.

1.4. Emergency telephone
In addition to the above-mentioned information, supply the emergency telephone number of the company and/or relevant official advisory body.

2. COMPOSITION/INFORMATION ON INGREDIENTS

The information given should enable the recipient to identify readily the hazards of the components of the preparation. The hazards of the preparation itself should be given under heading 3.

2.1. It is not necessary to give the full composition (nature of the ingredients and their concentration), although a general description of the components and their concentrations can be helpful.

2.2. For a preparation classified as dangerous, the following substances shall be indicated, together with their concentration or concentration range:

2.3. For a preparation not classified as dangerous, the following substances shall be indicated, together with their concentration or concentration range, if they are present in an individual concentration of $\geq$ 1 % by weight for non-gaseous preparations and $\geq$ 0.2 % by volume for gaseous preparations:
- substances presenting a health or environmental hazard and
- substances for which there are workplace exposure limits

2.4. The classification of the substances shall be given, including the symbol letters and R phrases which are assigned in accordance with their physicochemical, health and environmental hazards. The R phrases do not need to be written out in full here: reference should be made to heading 16, where the full text of each relevant R phrase shall be listed.

2.5. The name and the CAS number and IUPAC name (if available) may also be helpful. For substances listed by a generic name, a precise chemical identifier is not necessary.

2.6. If the identity of certain substances is to be kept confidential, their chemical nature shall be described in order to ensure safe handling. The name used must be the same as that which derives from the above procedures.

3. HAZARDS IDENTIFICATION

Give here the classification of the substance or preparation, which arises from application of the classification rules in European Community regulations (Directives 67/548/EEC or 1999/45/EC and 2001/59/EC). Indicate clearly and briefly the hazards the substance or preparation presents to man and the environment.

Distinguish clearly between preparations, which are classified as dangerous and preparations which are not classified as dangerous.

Describe the most important adverse physicochemical, human health and environmental effects and symptoms relating to the uses and possible misuses of the substance or preparation that can reasonably be foreseen.

It may be necessary to mention other hazards, such as dustiness, suffocation, freezing or environmental effects such as hazards to soil-dwelling organisms, etc., which do not result in classification but which may contribute to the overall hazards of the material.

The information shown on the label should be given under heading 15.

4. FIRST AID MEASURES

Describe the first-aid measures. Specify first if immediate medical attention is required. The information on first aid must be brief and easy to understand by the victim, bystanders and first-aiders. The symptoms and effects should be briefly summarized. The instructions should indicate what is to be done on the spot in the case of an accident and whether delayed effects can be expected after exposure.

Subdivide the information according to the different routes of exposure, i.e. inhalation, skin and eye contact and ingestion under different subheadings.

Indicate whether professional assistance by a doctor is needed or advisable.

For some substances or preparations it may be important to emphasize that special means to provide specific and immediate treatment must be available at the workplace.

5. FIRE-FIGHTING MEASURES

Refer to requirements for fighting a fire caused by the substance or preparation or arising in its vicinity by indicating:

- suitable extinguishing media.
- extinguishing media which must not be used for safety reasons.
- special exposure hazards arising from the substance or preparation itself, combustion products, resulting gases.
- special protective equipment for fire-fighters.

6. ACCIDENTAL RELEASE MEASURES

Depending on the substance or preparation involved, information may be needed on:

- personal precautions such as:
  removal of ignition sources, provision for sufficient ventilation/respiratory protection, control of dust, prevention of skin and eye contact,
- environmental precaution such as:
  keeping away from drains, surface- and ground-water and soil, possible need to alert the neighbourhood,
- methods for cleaning up such as:
  use of absorbent material (e.g. sand, diatomaceous earth. acid binder, universal binder, sawdust. etc.), reduction of gases/fumes with water, dilution.

Also consider the need for indications such as: "never use, neutralise with ….."

If appropriate refer to headings 8 and 13.

7. HANDLING AND STORAGE

Information in this section should relate to the protection of health, safety and the environment. It should assist the employer in devising suitable working procedures and organisational measures.

7.1. Handling

Specify precautions for safe handling including advice on technical measures such as: containment, local and general ventilation, measures to prevent aerosol and dust generation and fire, measures required to protect the environment (e.g. use of filters or scrubbers on exhaust ventilation, use in a bounded area, measures for collection and disposal of spillages, etc.) and any specific requirements or rules relating to the substance or preparation (e.g. procedures or equipment which are prohibited or recommended) and if possible give a brief description.

7.2. Storage

Specify the conditions for safe storage such as: specific design for storage rooms or vessels (including retention walls and ventilation), incompatible materials, conditions of storage (temperature and humidity limit/range, light, inert gas, etc.) special electrical equipment and prevention of static electricity.

Give advice if relevant on quantity limits under storage conditions. In particular indicate any special requirements such as the type of material used in the packaging/containers of the substance or preparation.

7.3. Specific use(s)

For end products designed for specific use(s), recommendations should refer to the intended use(s) and be detailed and operational. If possible, reference should be made to industry - or sector - specific approved guidance.

8. EXPOSURE CONTROLS / PERSONAL PROTECTION

8.1. Exposure limit values

Specify currently applicable specific control parameters including occupational exposure limit values and/or biological limit values. Values should be given for the country where the substance or preparation is placed on the market. Give information on currently recommended monitoring procedures.

For preparations, it is useful to provide values for those constituent substances which are required to be listed in the material safety data sheet according to heading 2.

8.2. Exposure controls

For the purposes of this document exposure control means the full range of specific protection and prevention measures to be taken during use in order to minimize worker and environmental exposure.

8.2.1. Occupational exposure controls

This information will be taken into account by the employer in carrying out an assessment of risk to the health and safety of workers for the substance or preparation, which requires the design of appropriate work processes and engineering controls, the use of adequate equipment and materials, the application of collective protection measures at source, and finally the use of individual protection measures, such as personal protection equipment. Therefore provide suitable and adequate information on these measures to enable a proper risk assessment. This information should complement that already given under heading 7.1.

Where personal protection is needed, specify in detail which equipment will provide adequate and suitable protection.

8.2.1.1. Respiratory protection
For dangerous gases, vapours or dust, specify the type of protective equipment to be used, such as self-contained breathing apparatus, suitable masks and filters.

8.2.1.2. Hand protection
Specify clearly the type of gloves to be worn when handling the substance or preparation, including:

- the type of material,
- the breakthrough time of the glove material with regard to the amount and duration of dermal exposure.

If necessary indicate any additional hand protection measures.

8.2.1.3. Eye protection
Specify the type of eye protection equipment required such as: safety glasses, safety goggles, face shield.

8.2.1.4. Skin protection
If it is necessary to protect a part of the body other than the hands, specify the type and quality of protection equipment required, such as: apron, boots and full protective suit. If necessary, indicate any additional skin protection measures and specific hygiene measures.

8.2.2. Environmental exposure controls (not applicable in Thailand yet, however needed for the export to Europe and United States, etc.)
Specify the information required by the employer to fulfill his commitments under Community environmental protection legislation.

9. PHYSICAL AND CHEMICAL PROPERTIES

To enable proper control measures to be taken, provide all relevant information on the substance or preparation, particularly the information listed under heading 9.2.

9.1. General information
Appearance
Indicate the physical state (solid, liquid, gas) and the colour of the substance or preparation as supplied.
Odour
If odour is perceptible, give a brief description of it.

9.2. Important health, safety and environmental information
pH
Indicate the pH of the substance or preparation as supplied or of an aqueous solution; in the latter case, indicate the concentration.
Boiling point/boiling range: Flash point:
Flammability (solid, gas); Explosive properties: Oxidising properties: Vapour pressure;
Relative density: Solubility;

- water solubility;
- fat solubility (solvent -oil to be specified);

Partition coefficient; n-octanol/water: Viscosity;
Vapour density;
Evaporation rate:

9.3. Other information
Indicate other important safety parameters, such as, miscibility, conductivity, melting point/melting range, gas group, auto-ignition temperature etc.

10. STABILITY AND REACTIVITY

State the stability of the substance or preparation and the possibility of hazardous reactions occurring under certain conditions of use and also if released into the environment.

10.1. Conditions to avoid

List those conditions such as temperature, pressure, light, shock, etc., which may cause a dangerous reaction and if possible give a brief description.

10.2. Materials to avoid

List materials such as water, air, acids, bases, oxidising agents or any other specific substance which may cause a dangerous reaction and if possible give a brief description.

10.3. Hazardous decomposition products

List hazardous materials produced in dangerous amounts upon decomposition.
Address specifically:

- the need for and the presence of stabilisers,
- the possibility of a hazardous exothermic reaction,
- safety significance, if any, of a change in physical appearance of the substance or preparation,
- hazardous decomposition products. if any, formed upon contact with water.
- possibility of degradation to unstable products.

11. TOXICOLOGICAL INFORMATION

This section deals with the need of a concise but complete and comprehensible description of the various toxicological (health) effects, which can arise if the user gets into contact with the substance or preparation.

Include dangerous-to-health effects from exposure to the substance or preparation, based on both experiences and conclusions from scientific experiments. Include information on the different routes of exposure (inhalation, ingestion, skin and eye contact), and describe the symptoms related to the physical, chemical and toxicological characteristics.

Include known delayed and immediate effects and also chronic effects from short- and long-term exposure: for example sensitisation, narcosis, carcinogenicity, mutagenicity and reproductive toxicity (developmental toxicity and fertility).

Taking into account the information already provided under heading 2, composition/information on ingredients, it might be necessary to make reference to specific health effects of certain components in preparations.

12. ECOLOGICAL INFORMATION

Describe the possible effects, behaviour and environmental fate of the substance or preparation in air, water and/or soil. Where available, give relevant test data (e.g. LC50 fish $\leq$ 1 mg/l).

Describe the most important characteristics likely to have an effect on the environment owing to the nature of the substance or preparation and likely methods of use. Information of the same kind should be supplied for dangerous products arising from the degradation of substances and preparations. This may include the following:

12.1. Ecotoxicity

This should include relevant available data on aquatic toxicity, both acute and chronic for fish, daphnia, algae and other aquatic plant. In addition, toxicity data on soil micro- and macro-organisms and other environmentally relevant organisms, such as birds, bees and plants, should be included when available. Where the substance or preparation has inhibitory effects on the activity of micro organisms, the possible impact on sewage treatment plants should be mentioned.

12.2. Mobility
The potential of the substance or the appropriate constituents of a preparation, if released to the environment, the transport to groundwater or far from the site of release.
Relevant data might include:
- known or predicted distribution or environmental compartments, -surface tension,
- absorption/distraction

For other physicochemical properties see heading 9.

12.3. Persistence and degradability
The potential of the substance or the appropriate constituents of a preparation to degrade in relevant environmental media, either through biodegradation or other processes such as oxidation or hydrolysis. Degradation half lives should be quoted where available. The potential of the substance or appropriate constituents of a preparation to degrade in sewage treatment plants should also be mentioned.

12.4. Bio accumulative potential
The potential of the substance or the appropriate constituents of a preparation to accumulate in biota and pass through the food chain, with reference to the K_{ow} and BCF, if available.

12.5. Other adverse effects
If available, include information on any other adverse effects on the environment, e.g. ozone depletion potential, photochemical ozone creation potential and/or global warming potential.
Remarks
Ensure that information relevant to the environment is provided under other headings of the safety data sheet, especially advice for controlled release, accidental release measures, transport and disposal considerations under headings 6, 7, 13, 14 and 15.

13. DISPOSAL CONSIDERATIONS
If the disposal of the substance or preparation (surplus or waste resulting from the foreseeable use) presents a danger, a description of these residues and information on their safe handling shall be given.
Specify the appropriate methods of disposal of both the substance or preparation and any contaminated packaging (incineration, recycling, and filling, etc.)

14. TRANSPORT INFORMATION
Indicate any special precautions a user needs to be aware of or needs to comply with respect to transport or conveyance either within or outside his premises.
Where relevant, provide information on the transport classification for each of the modal regulations: IMDG (sea), ADR (road), RID (rail), lCAO/IATA (air). This might include inter alia:
- UN number,
- class,
- proper shipping name,
- packing group,
- marine pollutant,
- other applicable information.

15. REGULATORY INFORMATION
Give the health, safety and environmental information shown on the label.
If the substance or preparation covered by this safety data sheet is the subject of specific provisions in relation to protection of man or the environment

Also mention, if possible, the national laws which implement these provisions and any other national measures that may be relevant.

16. OTHER INFORMATION

Indicate any other information, which the supplier assesses as being of importance for the health and safety of the user and for the protection of the environment, for example:

- List of relevant R phrases. Write out the full text of any R phrases referred to under headings 2 and 3 of the safety data sheet,
- Training advice,
- Recommended restrictions on use (i.e. non-statutory recommendations by supplier).
- Further information (written references and/or technical contact point),
- Sources of key data used to compile the data sheet,
- For a revised safety data sheet, indicate clearly the information, which has been added, deleted or revised (unless this has been indicated elsewhere).

A.7.2 Example of material safety data sheet

SIEMENS — **EC safety data sheet**

Trade name: PRO-JET 780 NP — Status: 07.09.01
Product no.: 010906-1Axiva — Version : 1 / D — Date of printing : 07.09.2001

1.) Identification of the substance/preparation and company

Product details

Trade name
PRO-JET 780 NP

Identification of the manufacturer / supplier

Address
Siemens Axiva GmbH & Co. KG
Industriepark Höchst, Pilot Plants, VR I, G831
D-65926 Frankfurt am Main

Telephone no. ++49(0)69-305-6247

Fax no.

Emergency telephone number
069-305-6418

2.) Composition / information on ingredients

Hazardous ingredients
DIMETHYL FORMAMIDE

CAS no.	68-12-2			
Concentration	>= 2	< 5	%-b.w.	
Hazard symbols	T	R phrases	61, 20/21, 36	

p-Tolyldisulfid (Axiva)

Concentration	>= 2	< 10	%-b.w.
Hazard symbols	Xi	R phrases	43

3.) Hazards possibilities

Hazard symbols

T Toxic — Xi Irritant

R phrases

43 May cause sensitization by skin contact.
61 May cause harm to the unborn child.

4.) First aid measures

General Information
By continuous complaints consult a physician. If the patient is likely to become unconscious, place and transport in stable sideways position.

After inhalation
Remove affected person from danger area. Remove the casualty into fresh air and keep him calm. By continuous complaints consult a physician.

After skin contact
Remove contaminated clothes, under clothes and shoes immediately. In case of contact with skin wash off with water. Take for medical treatment.

After eye contact
Separate eyelids, wash the eyes thoroughly with water (15 min.). Begin with medical treatment.

After ingestion
Rinse out mouth and give plenty of water to drink. Do not induce vomiting. Take medical treatment.

SIEMENS — **EC safety data sheet**

Trade name: PRO-JET 780 NP — Status: 07.09.01
Product no.: 010906-1Axiva — Version : 1 / D — Date of printing : 07.09.2001

Advice to doctor

Treatment
Treat symptomatically

5.) Fire-fighting measures

Suitable extinguishing media
Water spray jet; Foam; Dry chemical extinguisher; Carbon dioxide

Special exposure hazards arising from the substance or preparation itself, its combustion products or from resulting gases
In case of combustion evolution of dangerous gases possible.

Special protective equipment for firefighting
Use self-contained breathing apparatus. Wear protective clothing.

Other information (chapter 5.)
Fire residues must be disposed of in a proper manner. Do not whirl around the product.

6.) Accidental release measures

Personal precautions
Wear suitable personal protective equipment. Use breathing apparatus if exposed to vapours/dust/aerosol. Avoid contact with skin and eyes.

Methods for cleaning up/taking up
Avoid raising dust. Dispose of absorbed material in accordance with the regulations. Flush away residues with water.

7.) Handling and storage

Handling

Advice on safe handling
Avoid dust formation. Keep containers tightly closed; Take precautionary measures against electrostatic loading.

Advice on protection against fire and explosion
Take precautionary measures against static charges.

8.) Exposure controls / personal protection

Ingredients with occupational exposure limits to be monitored
DIMETHYL FORMAMIDE

MAK (TRGS 900)				
Value	10	ml/m³	30	mg/m³
Short-term exposure limit	Exceeding factor 4			
Skin resorption / sensibilisation	H			

Personal protective equipment

Respiratory protection
Respiratory protection in case of insufficient exhaust ventilation or prolonged exposure; Breathing apparatus, if measures according to 'Handling and Storage' are not sufficient.

Hand protection
Gloves

Eye protection
safety glasses/face shield

SIEMENS — **EC safety data sheet**

Trade name: PRO-JET 780 NP — Status: 07.09.01
Product no.: 010906-1Axiva — Version : 1 / D — Date of printing : 07.09.2001

Skin protection
protective clothing

General protective and hygiene measures
Do not eat, drink or smoke during work time. Avoid contact with eyes and skin. Remove soiled or soaked clothing immediately and clean thoroughly before using again. Do not inhale vapours or dust

9.) Physical and chemical properties

Appearance

Form	Powder			
Colour	green to black			
Odour	uncharacteristic			

Safety data

Changes in physical state

type	Melting point			
Value		170	- 220	°C

Ignition temperature

Value	>	440		°C
Reference substance	DMF			

Vapour pressure

Value	appr.	5		mbar
Reference temperature		20	°C	
Reference substance	DMF			

Solubility in water
Remarks: insoluble

pH value
Remarks: neutral

Octanol/water partition coefficient (log Pow)

Reference temperature		25	°C
Value		2,6	

10.) Stability and reactivity

11.) Toxicological information

Acute toxicity

Acute oral toxicity

LD50	>	2000	mg/kg
Species	rat		

Acute dermal toxicity

LD50	>	2000	mg/kg
Species	rat		

Experience in practice
Possibility of sensitization through skin contact.

SIEMENS — **EC safety data sheet**

Trade name: PRO-JET 780 NP | Status: 07.09.01
Product no.: 010906-1Axiva | Version : 1 / D | Date of printing : 07.09.2001

12.) Ecological information

Data on elimination (persistence and degradability)

Biodegradability

Value	100	%
Type	DOC decrease	
Duration of exposure	28	day(s)
Method	OECD 301 C	

Ecotoxic effects

Fish toxicity

LC50	0,1	mg/l
Species	rainbow trout	
Duration of exposure	96	h

Daphnia toxicity

LC50	> 0,1	mg/l
Species	Daphnia magna	
Duration of exposure	48	h
NOEC	> 0,1	mg/l
Species	Daphnia magna	
Duration of exposure	48	h

13.) Disposal considerations

Product

Dispose of in accordance with local authority regulations

14.) Transport information

Other information (chapter 14.)

The product does not constitute a hazardous substance in national / international road, rail, sea and air transport.

15.) Regulatory information

Labelling in accordance with EC directives

The product is classified and labelled in accordance with EC directives/GefStoff V (German regulations on dangerous substances).

Hazard symbols

T Toxic Xi Irritant

R phrases

43	May cause sensitization by skin contact.
61	May cause harm to the unborn child.

S phrases

45	In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
24	Avoid contact with skin.
37	Wear suitable gloves.
53	Avoid exposure --- obtain special instructions before use.

16.) Other information

Department issuing safety data sheet

This information is based on our present state of knowledge. However, it should not constitute a

SIEMENS **EC safety data sheet**

Trade name: PRO-JET 780 NP | Status: 07.09.01
Product no.: 010906-1Axiva | Version : 1 / D | Date of printing : 07.09.2001

guarantee for any specific product properties and shall not establish a legally valid relationship.

A.8 Labelling and marking of packagings

Based on the following regulations

European regulations	*2001/58/EC*
German regulations	*GefStoffV*
U.S. regulations	*49CFR*

For the information of the employees and the emergency response teams it is important to get visible information about the properties of the dangerous goods and dangerous substances (including preparations, mixtures and solutions). The dangerous goods must be marked and labelled according to the requirements of the regulations for transport of dangerous goods (Thai Provision 1). The dangerous substances must be marked according the work place requirements. The symbols of both requirements are almost the same.

Once classifications have been obtained, labelling and marking can be prepared. This is an important way of communicating the chemical hazards.
However, before proceeding to discuss them in detail, the following example may prove useful in visualising how they are used.

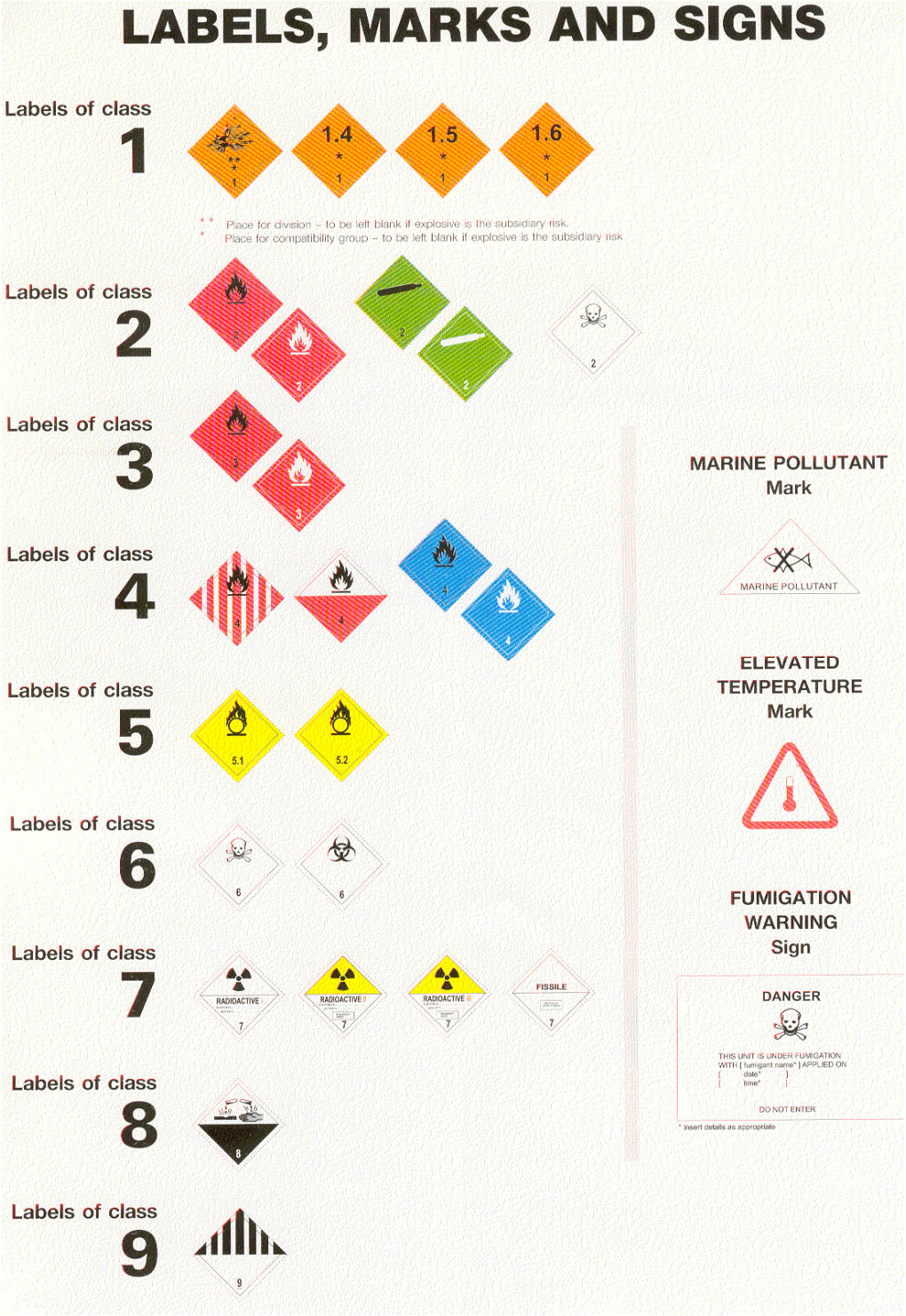
The labelling and marking give information about the hazards of the product. Anyhow there is no information about the degree of danger.
The transport regulations require labels, which must have a size of 10 x 10 cm and be adhered on the peak.


Information for dangerous substances
Information for dangerous goods

A.8.1 Overview of labels (transport)

Based on the following regulations

European regulations	*IMDG-Code Section 5.2* *ADR Section 5.2*
German regulations	
U.S. regulations	*49CFR171*



A.8.2 Overview of symbols

Based on the following regulations

European regulations	
German regulations	*GefStoffV*
U.S. regulations	

F+

Extremely flammable

F

Highly flammable

O

Oxidiser

T+

Very toxic

T

Toxic

Xn

Harmful

C

Corrosive

Xi

Irritating

E

Explosive

N

Toxic for environment

The information for dangerous substances contains more information for the storage and work places.
There is a symbol, which indicates the properties. Additionally there is a text with the R-phrases and the S-phrases. The R-phrases give information about the risks of the chemicals. The S-phrases give advice what has to be done if someone got into contact with the chemicals.

A.8.3 Work place label

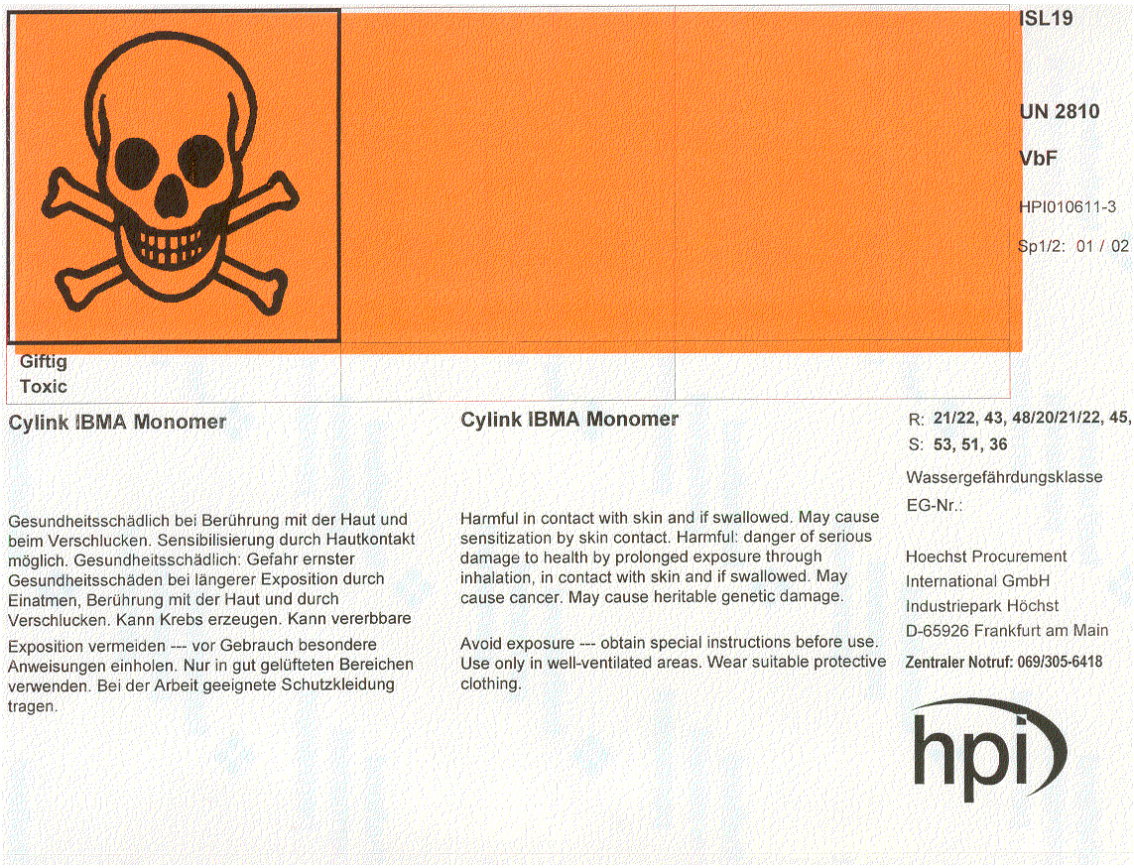
Based on the following regulations

European regulations	*92/32/EEC*
German regulations	*GefStoffV* *TRGS 200* *TRGS 220*
U.S. regulations	

As well as for the transport of the dangerous goods and storage of these materials need some indication and signs. Consequently each package like bottles, drums, bags, cartons, IBC, etc. shall have (besides the transport label and placard) a label which indicates the special hazard for the work place and the people handling these goods.

The work place label is for the information of the employees on the packaging itself. It consists of the symbol which should hint to the dangerous properties, the risk phrases (R-phrases) and the safety phrases (S-phrases). Additionally there should be a telephone number, where additionally information of the substance is available.

Example of work place label



A.8.4 Overview of R-phrases and S-phrases

Based on the following regulations

European regulations	*67/548/EEC* *2001/59/EC* *2001/60/EC* *2001/2455/EC*
German regulations	
U.S. regulations	

The criteria for the classification of the substances according the R-phrases can be found in directive 67/548/EEC and 2001/59/EC.

A.8.4.1 Risk phrases

R1	Explosive when dry.
R2	Risk of explosion by shock, friction, fire or other sources of ignition.
R3	Extreme risk of explosion by shock, friction, fire or other sources of ignition.
R4	Forms very sensitive explosive metallic compounds.
R5	Heating may cause an explosion.
R6	Explosive with or without contact with air.
R7	May cause fire.
R8	Contact with combustible material may cause fire.
R9	Explosive when mixed with combustible material.
R10	Flammable.
R11	Highly flammable.
R12	Extremely flammable.
(R13)	(Extremely flammable liquefied gas.)
R14	Reacts violently with water.
R15	Contact with water liberates highly flammable gases.
R16	Explosive when mixed with oxidizing substances.
R17	Spontaneously flammable in air.
R18	In use, may form flammable/explosive vapour-air mixture.
R19	May form explosive peroxides.
R20	Harmful by inhalation.
R21	Harmful in contact with skin.
R22	Harmful if swallowed.
R23	Toxic by inhalation.
R24	Toxic in contact with skin.
R25	Toxic if swallowed.
R26	Very toxic by inhalation.
R27	Very toxic in contact with skin.
R28	Very toxic if swallowed.
R29	Contact with water liberates toxic gas.
R30	Can become highly flammable in use.
R31	Contact with acids liberates toxic gas.

R32	Contact with acids liberates very toxic gas
R33	Danger of cumulative effects.
R34	Causes burns.
R35	Causes severe burns.
R36	Irritating to eyes.
R37	Irritating to respiratory system.
R38	Irritating to skin.
R39	Danger of very serious irreversible effects.
R40	Possible risks of irreversible effects.
R41	Risk of serious damage to eyes.
R42	May cause sensitisation by inhalation.
R43	May cause sensitisation by skin contact.
R44	Risk of explosion if heated under confinement.
R45	May cause cancer.
R46	May cause heritable genetic damage.
(R47)	(May cause birth defects.)
R48	Danger of serious damage to health by prolonged exposure.
R49	May cause cancer by inhalation.
R50	Very toxic to aquatic organisms.
R51	Toxic to aquatic organisms.
R52	Harmful to aquatic organisms.
R53	May cause long-term adverse effects in the aquatic environment.
R54	Toxic to flora.
R55	Toxic to fauna
R56	Toxic to soil organisms.
R57	Toxic to bees.
R58	May cause long-term adverse effects in the environment.
R59	Dangerous for the ozone layer.
R60	May impair fertility.
R61	May cause harm to the unborn child.
R62	Possible risk of impaired fertility.
R63	Possible risk of harm to the unborn child.
R64	May cause harm to breastfed babies.
R65	Harmful: May cause lung damage if swallowed.

A.8.4.2 Safety phrases

S 1	Keep locked up.
S 2	Keep out of the reach of children.
S 3	Keep in a cool place.
S 4	Keep away from living quarters.
S 5	Keep contents under ... (appropriate liquid to be specified by the manufacturer).
	S 5.1 Keep contents under water. S 5.2 Keep contents under petroleum. S 5.3 Keep contents under paraffin oil.
S 6	Keep under ... (inert gas to be specified by the manufacturer).
	S 6.1 Keep under nitrogen. S 6.2 Keep under argon. S 6.3 Keep under CO_2.
S 7	Keep container tightly closed.
S 8	Keep container dry.
S 9	Keep container in a well-ventilated place.
S 12	Do not keep container sealed.
S 13	Keep away from food, drink and animal feeding stuffs.
S 14	Keep away from ... (incompatible materials to be indicated by the manufacturer).
	S 14.1 Keep away from reducing agents, heavy metal compounds, acids and alkalis. S 14.2 Keep away from oxidizing and acidic substances as well as heavy metal compounds. S 14.3 Keep away from iron. S 14.4 Keep away from water and alkalis. S 14.5 Keep away from acids. S 14.6 Keep away from alkalis. S 14.7 Keep away from metals. S 14.8 Keep away from oxidizing and acidic substances. S 14.9 Keep away from flammable organic substances. S 14.10 Keep away from acids, reducing agents and flammable material. S 14.11 Keep away from flammable material.
S 15	Keep away from heat.
S 16	Keep away from sources of ignition - No smoking.
S 17	Keep away from combustible material.
S 18	Handle and open container with care.
S 20	When using do not eat or drink.
S 21	When using do not smoke.
S 22	Do not breathe dust.
S 23	Do not breathe gas/fumes/vapour/spray (appropriate wording to be specified by the manufacturer).
	S 23.1 Do not breathe gas. S 23.2 Do not breathe vapour. S 23.3 Do not breathe spray. S 23.4 Do not breathe fumes s 23.5 Do not breathe vapour/spray.

S 24	Avoid contact with skin.
S 25	Avoid contact with eyes.
S 26	In case of contact with eyes, rinse immediately with plenty of water and seek medical advice.
S 27	Take off immediately all contaminated clothing.
S 28	After contact with skin, wash immediately with plenty of ... (to be specified by the manufacturer).
	S 28.1 After contact with skin, wash immediately with plenty of water. S 28.2 After contact with skin, wash immediately with plenty of soap and water. S 28.3 After contact with skin, wash immediately with plenty of soap and water, if possible also with polyethylene glycol 400. S 28.4 After contact with skin, wash immediately with plenty of polyethylene glycol 300 and ethanol (2:1) followed by plenty of soap and water. S 28.5 After contact with skin, wash immediately with plenty of polyethylene glycol 400. S 28.6 After contact with skin, wash immediately with plenty of polyethylene glycol 400, then rinse with plenty of water. S 28.7 After contact with skin, wash immediately with plenty of water and acidic soap.
S 29	Do not empty into drains.
S 30	Never add water to this product.
S 33	Take precautionary measures against static discharges.
(**S 34**)	(Avoid shock and friction.)
S 35	This material and its container must be disposed of in a safe way.
S 36	Wear suitable protective clothing.
S 37	Wear suitable gloves.
S 38	In case of insufficient ventilation, wear suitable respiratory equipment.
S 39	Wear eye/face protection.
S 40	To clean the floor and all objects contaminated by this material, use ... (to be specified by the manufacturer).
S 41	In case of fire and/or explosion, do not breathe fumes.
S 42	During fumigation/spraying, wear suitable respiratory equipment (appropriate wording to be specified by the manufacturer).
S 43	In case of fire, use ... (indicate in the space the precise type of fire-fighting equipment. If water increases the risk, add - Never use water).
	S 43.1 In case of fire, use water. S 43.2 In case of fire, use water or powder extinguisher. S 43.3 In case of fire, use powder extinguisher - never use water. S 43.4 In case of fire, use CO_2 - never use water. S 43.6 In case of fire, use sand - never use water. S 43.7 In case of fire, use metal fire powder - never use water. S 43.8 In case of fire, use sand, CO_2 or powder extinguisher - never use water.
(**S 44**)	(If you feel unwell, seek medical advice (show the label where possible).)
S 45	In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
S 46	If swallowed, seek medical advice immediately and show this container or label.

S 47	Keep at temperature not exceeding ...C° (to be specified by the manufacturer).
S 48	Keep wetted with ... (appropriate material to be specified by the manufacturer).
S 49	Keep only in the original container.
S 50	Do not mix with ... (to be specified by the manufacturer).
	S 50.1 Do not mix with acids. S 50.2 Do not mix with alkalis. S 50.3 Do not mix with strong acids, strong bases, non-ferrous metals or their salts.
S 51	Use only in well-ventilated areas.
S 52	Not recommended for interior use on large surface areas.
S 53	Avoid exposure - obtain special instructions before use. - Restricted to professional users -
(**S 54**)	(Obtain the consent of pollution control authorities before discharging to wastewater treatment plants.)
(**S 55**)	(Treat using the best available techniques before discharge into drains or the aquatic environment.)
S 56	Dispose of this material and its container at hazardous or special waste collection point.
S 57	Use appropriate container to avoid environmental contamination.
(**S 58**)	(To be disposed of as hazardous waste.)
S 59	Refer to manufacturer/supplier for information on recovery/recycling.
S 60	This material and its container must be disposed of as hazardous waste.
S 61	Avoid release to the environment. Refer to special instructions/Safety data sheets.
S 62	If swallowed do not induce vomiting: seek medical advice immediately and show this container or label.

A.9 Survey/control of packagings

Based on the following regulations

European regulations	
German regulations	*GefStoffV*
U.S. regulations	*29CFR1926, §1926.64* *29CFR1910, §1910.101* *40CFR300, §300.405*

For safety purposes it is very important to survey and control the packagings in the warehouse to avoid any inadvertent releases or spillages.
There are several opportunities to have a damaged packaging:

- Damaged packaging has already been delivered
- Wrong packaging material so that chemical can damaged packaging (corrosion)
- Improper use of fork lift or other handling equipment inside the warehouse

A.9.1 Main issues for survey/control

There must be two main surveys and controls of the packaging to avoid damages caused by the above-mentioned reasons.

In the first step the packagings must be checked before handled. If there are any damages the packaging can't be taken into stock. There must be a certain place where such packagings can be repacked or packed in salvage packagings. The repacking should not be carried out in the warehouse.

For safety reason and to avoid any damage to the people and environment any spillage has to be removed immediately in a proper way and the residue as well as damaged packaging has to be disposed in accordance with the respective local regulations.

The company must have a material safety data sheet for that chemical to have the right information about this chemical. If it is not available, they have to request for it from the supplier immediately. Appropriate measures like, personal protective equipment and avoiding electrostatic self-charged must be considered for repacking.

If the packagings are loaded on a pallet it must be ensured that the packagings can't fall down from the pallet. This can be achieved by using shrink foil or belt around the packagings.

In the second step all the packagings inside the warehouse must be checked very well to make sure that the chemicals have not weakened the packaging so that after a while there might be a spillage, which is not realised because nobody checked the goods in stock before storing them and while they are stored.
For those chemicals, which are very dangerous (like flammable substances, very toxic substances) the packagings should be checked once a day. For all other goods in the warehouse a survey once a week is sufficient.

If there are any deficiencies, they must be corrected before storing.

A package cannot be stored if:

- There is residue on the exterior of the package.
- The package is deformed because the product has been filled when it was hot.
- The package is deformed because it has dents deeper than 6.5 mm [16]. The dents should not be in the chime.
- The package is rusted.
- There are tears or holes in the bags or boxes.
- The closures are not properly closed.
- The spring closure is not closed or secured.
- The labels are missing, are wrong, are too small or are not identifiable.
- The packages have no UN-code.
- The shrink-wraps or strapping are too loose to secure the packagings on the pallet.

However, damaged packagings cannot be returned to sender/consigner, they have to be repacked. Depending on the toxicity and other risks of the spilled substances, also the immediate consumption could be considered.

If wooden pallets are used there might be nails coming out of the wood, which could damage the packagings.

A.9.2 Examples of damaged packagings

In order to give an idea about the damages which might occur, the following examples show some typical damages of packagings for further considerations:

These plastic bags have not been properly put on the pallet. While placing these pallets in the warehouse the lower bag has been damaged and corrosive material is on the ground of the warehouse and the pallet. These pallets must be repacked before they can be put in the shelves of the warehouse observing the right use of personal protective equipment.

The seam of the drum has been dented and is damaged. The product already got outside and corroded the material of the drum. Such drum can not be stored in the warehouse it must be repacked.

This plastic drum has dents because the product was filled when hot and has already been closed. For that reason there is a vacuum in this drum. It also seems that the drum has not been approved by the competent authority because the marking is fixed by a sticker. The marking must be durable and legible. This drum must be refilled for storing.

Empty unclean packagings still contain residues of the dangerous goods. Some properties get more severe if the packagings are empty and uncleaned.

For example flammable liquids, an empty uncleaned drum contains an explosive atmosphere which only needs an ignition source. A filled drum is not that much dangerous.

For that reason empty uncleaned packagings will be classified with the same class, UN-number and packaging group of the last content. In the documents the words empty uncleaned will be added to the proper shipping name.

The packagings have also to be checked whether there are damages. The closures must be pulled tight.

Some packagings are one-way packagings like bags; they can't be closed again after opening. During the transport everyone can come into contact with the residues of the product. For that reason measures have to be taken like packing the bags in other approved packagings (e.g. flexible IBC's).

The packagings must be marked and labelled in the same way as filled packagings.

A.10 Segregation requirements

Based on the following regulations

European regulations	*94/1/EC* *Guidelines of chemical companies*
German regulations	*ChemG* *GefStoffV* *TRG 100* *TRG 280* *VbF* *TRbF 20* *TRGS 511* *TRGS 514* *TRGS 515* *BGV B4* *SprengV* *SprengLR 340*
U.S. regulations	*29CFR1910, §1910.104, 106 and 109* *49CFR174, §174.102*

In accordance with the international Responsible Care Initiative of the chemical industry, the strategy for the mixed storage of chemicals is intended in co-operation with manufacturers, resellers and users to be instrumental in ensuring the safe storage of products.
This strategy contains rules for the mixed storage of chemicals.
The strategy applies particularly to chemical substances, preparations, products, and any materials (hereafter known as products) if these are stored in packaging and portable containers. If it is intended to store e.g. packagings or technical materials together with chemical products, the strategy must be applied to these accordingly.
The guideline is not applicable to:

- stationary containers, tank farms
- bulk goods warehouses (e.g. loose goods, free-flowing goods)
- intermediate temporary storage areas

Intermediate in this content means a storage which last under normal circumstances not longer than 24 hours or over a weekend [17]. However, the storage time has to be taken in the consideration the danger exposed by and to as well as the quantity.

For reasons of storage safety all products, which need to be stored, should be allocated to storage classes on the basis of their product-specific hazard characteristics. In so doing, the hazardous properties primarily taken into consideration are those that require special fire and explosion prevention measures, e.g. explosive, extremely flammable, highly flammable, flammable or oxidising. Furthermore, hazard characteristics such as very toxic, toxic and corrosive must also be taken into account in the concept of storing hazardous products.
The hazard characteristics irritating, harmful and danger to the environment do not give rise to separate storage classes because they have no bearing on the mixed storage rules. Products with these hazard characteristics and non-hazardous substances are allocated to the corresponding storage classes on the basis of their flammability properties (flammable/non-flammable).
The storage classes can be used as control instruments in storage. This covers both planning (number and size of the storage rooms and technical safety equipment) and the operation of the warehouse (control of transfer to stock).
However the storage classes only have similar criteria as the classes for the transport of dangerous goods. The requirements for a safe storage result to the different criteria (see

A.10.2) as well as to different margins, or figures. Regarding the different margins and figures, an international working group under the guidance of the united nations is working on the subject of harmonizing the classification criteria, labels, and placards (Global Harmonized System – GHS).

A.10.1 Reasons for the formation of storage classes

The following reasons lay behind the introduction of a separate comprehensive classification system for storage:

- The hazardous goods classification system tailored to transport operations does not make adequate allowance for the hazard potential that arises with the substantial quantities of material occurring in storage. Moreover, the hazardous goods classification system does not encompass all products.
- The dangerous goods regulations do not form any classes and similarly do not encompass all products. They identify products by the special hazards they create. In so doing, equal importance is attached to the physical, chemical, toxic and eco-toxicological properties.
- Flammable solids and liquids, as well as non-flammable products that are not included in either transport legislation or dangerous goods legislation, must be included in an overall storage strategy (e.g. can a safety barrier be formed between dangerous products by non-flammable solids or liquids).

A.10.2 Allocation to storage classes

The storage classes have been formed on the basis of the dangerous goods classes of the transport regulations, the hazard characteristics of the dangerous goods regulations and other regulations.

The allocation of a product to a storage class is done by means of available data. Sources of these are primarily the labelling under dangerous goods or transport regulations and data in the material safety data sheet. In the case of non-hazardous products, product information provided by the supplier or knowledge gained from practical experience can be used.

If the supplier of a product provides no details on the storage class, classification can be done independently in accordance with the following rules.

A storage class encompasses products with those hazard characteristics that are regarded as similar and consequently require similar safety measures.

The following rules apply when products are allocated to storage classes: each product is allocated only to one storage class:

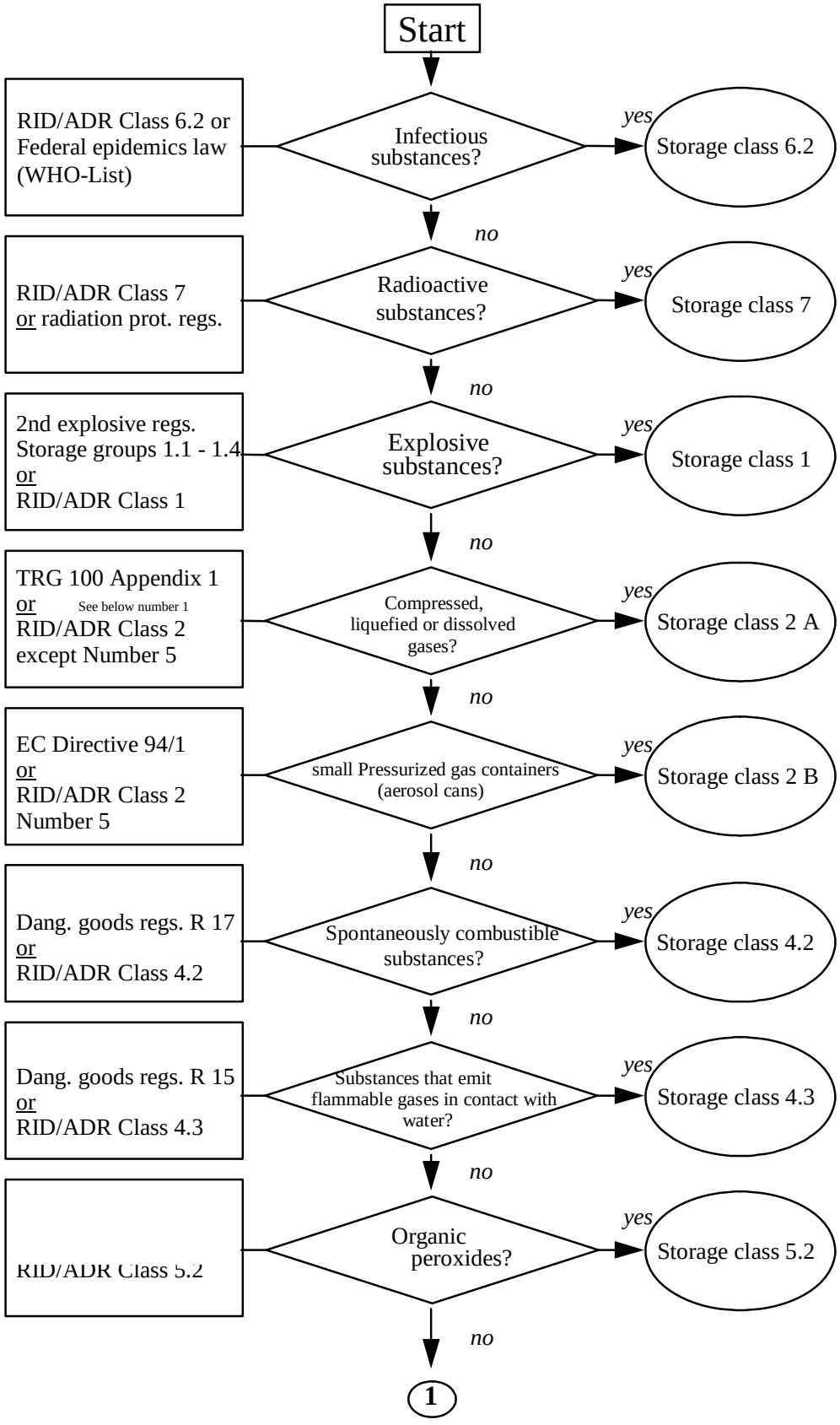
- Explosive, radioactive and infectious products are subject to special statutory storage regulations, which stipulate separate storage for each of these storage classes. They therefore come first.
- Products with physical and chemical hazard characteristics come before those with toxicological hazards.
- Products without hazard characteristics should be regarded as of secondary importance.

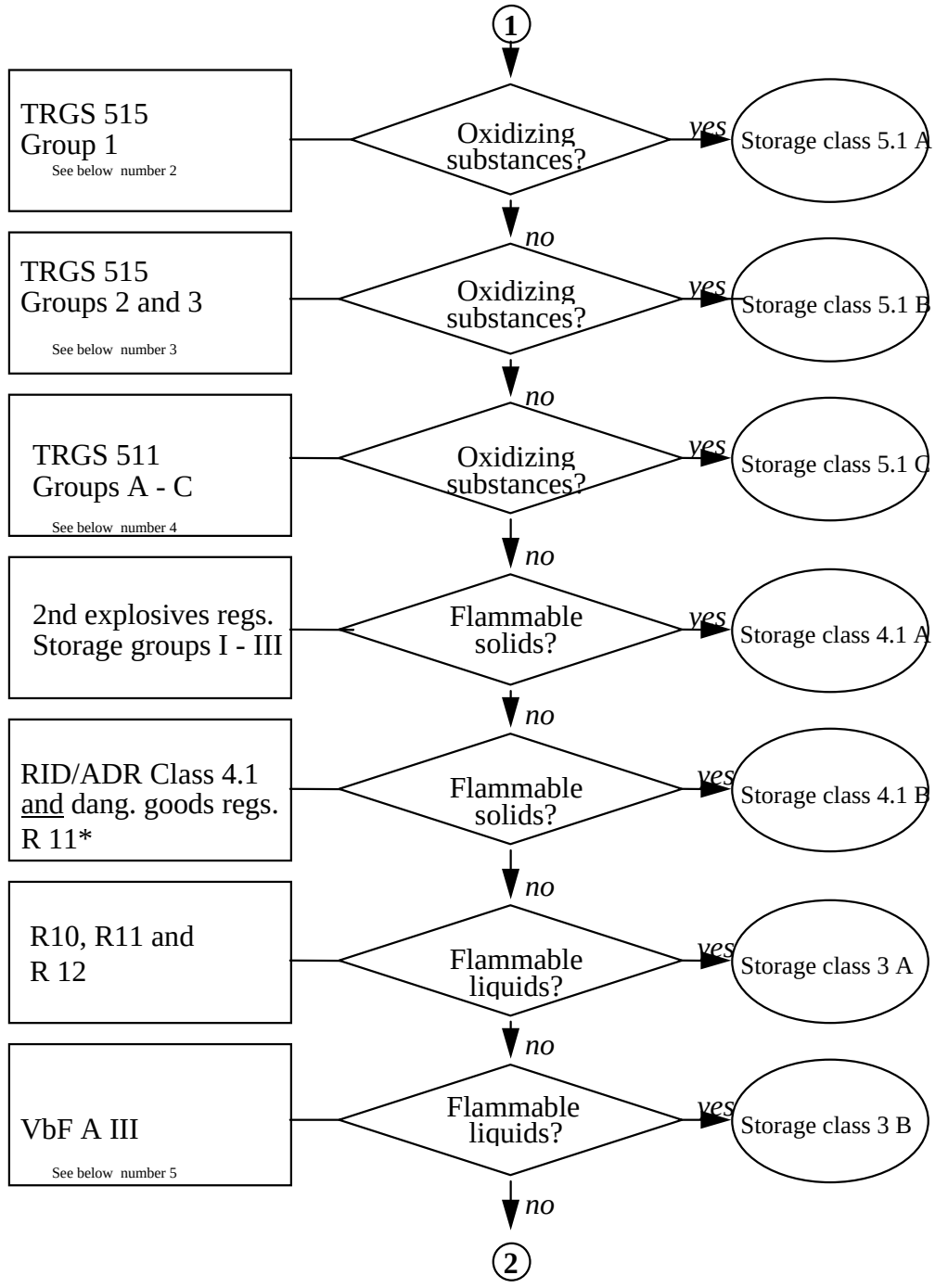
This gives rise to the following order of importance (the corresponding storage classes are given in brackets):

- Infectious substances (6.2)
- Radioactive substances (7)
- Explosive substances (1)
- Compressed, liquefied and dissolved gases and pressurised small gas containers (2 A and 2 B)
- Spontaneously flammable substances (4.2)
- Substances that form flammable gases in contact with water (4.3)

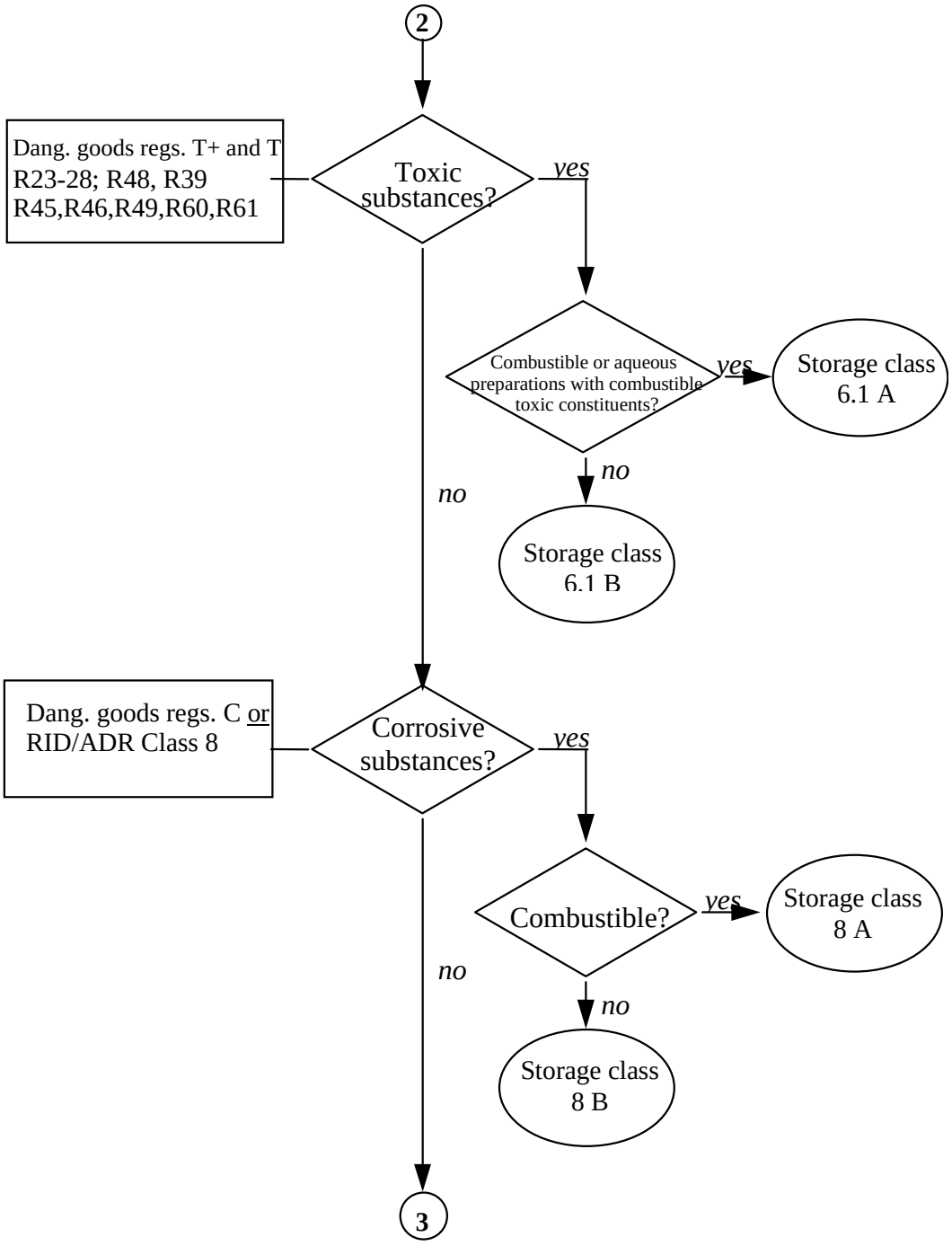
- Organic peroxides (5.2)
- Oxidising substances (5.1 A, 5.1 B and 5.1 C)
- Flammable solids (4.1 A and 4.1 B)
- Flammable liquids (3 A)
- Flammable liquids (3 B)
- Combustible toxic substances (6.1 A)
- Non- combustible toxic substances (6.1 B)
- Combustible corrosive substances (8 A)
- Non- combustible corrosive substances (8 B)
- Combustible liquids, if not classified in 3 A or 3 B (10)
- Combustible solids (11)
- Non- combustible liquids (12)
- Non- combustible solids (13)

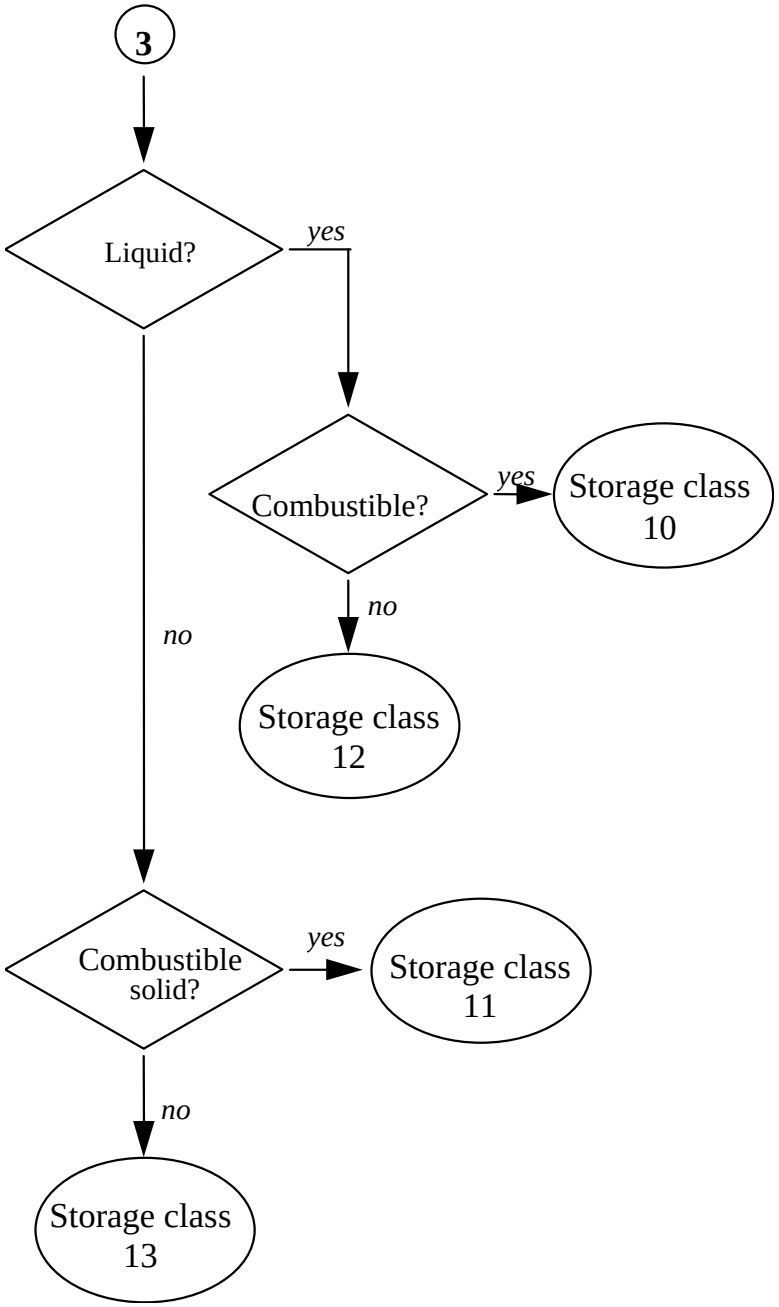
If products with the properties "non- combustible, corrosive", "non- combustible, liquid" or "non- combustible, solid" are packed in such a way that the packaging contributes to spread of a fire, these products must be allocated to storage class 8A, 10 or 11 respectively. This means that allocation in these cases must be specific to the article.
Packaging is understood here to mean the system of storage aids, packages, packaging form and allocation of the packing to the product. Packaging that does not contribute to the spread of fire is that which is not combustible or can be ignited only with difficulty and then continues to burn at a low rate with a constant source of heat. Examples are: metal cans and drums, glass bottles, metal crates, sheet metal containers, free-flowing non-combustible substances in plastic or paper bags, inorganic acids and alkaline solutions in plastic containers.
The storage class can include "S" (for solids) or "L" (for liquids).


Start
RID/ADR Class 6.2 or Federal epidemics law (WHO-List)
Infectious substances?
yes
Storage class 6.2
no
RID/ADR Class 7 or radiation prot. regs.
Radioactive substances?
yes
Storage class 7
no
2nd explosive regs. Storage groups 1.1 - 1.4 or RID/ADR Class 1
Explosive substances?
yes
Storage class 1
no
TRG 100 Appendix 1 or RID/ADR Class 2 except Number 5
See below number 1
Compressed, liquefied or dissolved gases?
yes
Storage class 2 A
no
EC Directive 94/1 or RID/ADR Class 2 Number 5
small Pressurized gas containers (aerosol cans)
yes
Storage class 2 B
no
Dang. goods regs. R 17 or RID/ADR Class 4.2
Spontaneously combustible substances?
yes
Storage class 4.2
no
Dang. goods regs. R 15 or RID/ADR Class 4.3
Substances that emit flammable gases in contact with water?
yes
Storage class 4.3
no
RID/ADR Class 5.2
Organic peroxides?
yes
Storage class 5.2
no
1



* Consider remaining dangerous goods of class 4.1 individually (e.g. self reactive substances)


2
Dang. goods regs. T+ and T
R23-28; R48, R39
R45,R46,R49,R60,R61
Toxic substances?
yes
Combustible or aqueous preparations with combustible toxic constituents?
yes
Storage class 6.1 A
no
Storage class 6.1 B
no
Dang. goods regs. C or RID/ADR Class 8
Corrosive substances?
yes
Combustible?
yes
Storage class 8 A
no
Storage class 8 B
no
3



Number 1 In TRG 100 there is a list of gases. All gases are assigned to this storage class.
Number 2 The substances are listed in storage class 5.1A.
Number 3 The substances are listed in storage class 5.1B.
Number 4 The substances are listed in storage class 5.1C.
Number 5 The substances have a flash point between 55 and 100 °C and are not miscible with water.

A.10.3 Description of the storage classes

The description of the storage classes is based on designations in transport and dangerous goods legislation, technical regulations and general product properties that are used in classification.

Storage class 1: ***Explosive substances***

The criteria of the explosives law and the transport law class 1 UN-Recommendations (Thai Provision 1) are used for classification.
In accordance with the regulations relating to the explosives law these products are classified in storage groups 1.1 to 1.4.

Storage class 2 A: ***Compressed, liquefied and dissolved gases***

Gases that have a vapor pressure of over 300 kPa (3 bar) at 50°C or are completely gaseous at 20°C and the standard pressure of 101.3 kPa.
These include the products that are listed in UN-Recommendations (Thai Provision 1) Class 2, including the gases that are specifically allocated to other classes (e.g. hydrogen fluoride to Class 8). Not included are the compressed gases that are packed in aerosol containers.

Storage class 2 B: ***Pressurized small gas containers (aerosol cans/aerosol containers)***

Aerosol cans are containers made of metal, glass or plastic intended to be used once only, including the compressed, liquefied or dissolved gases with or without liquid, paste or powder, which are equipped with a dispensing device that enables the contents in the form of solid or liquid particles suspended in gas to be released as foam, paste or powder or in liquid form.

Storage class 3 A: ***Flammable liquids***

These include liquid products that have a vapor pressure of max. 3 bar at 50°C, provided they

- have a flash point up to 55°C;
- have a flash point between 21 and 55°C and are miscible with water;
- must be labelled with R phrases 10 (flammable), 11 (highly flammable) and 12 (extremely flammable) in accordance with the dangerous substances regulations;
- have no flash point but do have an ignition range and therefore require explosion protection measures.

Notes:

1. Viscous flammable liquids that are not subject to the flammable liquids regulations cannot automatically be allocated to storage class 3 on the basis of their flash point. Classification e.g. in storage class 3 A or storage class 10 must be decided in each case on the basis of the viscosity, taking into consideration the criteria of spread of fire and formation of an explosive atmosphere.
2. Liquids with R phrases 10 (flammable), 11 (highly flammable) and 12 (extremely flammable) can also be allocated to storage class 4.2 or 4.3 on the basis of additional hazard characteristics.

Storage class 3 B: ***Flammable liquids***

Flammable liquids that have a vapor pressure of maximum 3 bar at 50°C, provided they are not miscible with water and have a flash point between 55°C and 100°C.
(*Note:* water-miscible flammable liquids with a flash point > 55°C are allocated to storage class 10.)

Storage classes 4.1 A and 4.1 B: ***Flammable solids***

Solids that can readily be ignited by brief application of an ignition source and continue to burn at a high rate or glow after its removal, as well as spontaneously decomposing substances in accordance with UN-Recommendations (Thai Provision 1), belong to these storage classes.

Storage class 4.1 A

To this class there are allocated substances that belong to class 4.1 and also have explosive properties according to the dangerous goods regulations, UN-Recommendations and the ADR/RID (Thai Provision 2).

Storage class 4.1 B

This storage class encompasses products that are labelled with R phrase 11 (highly flammable) in accordance with the dangerous substances regulations and (if classified under transport legislation) are allocated to ADR/RID (Thai Provision 2) Class 4.1, but excluding miscellaneous explosive substances in accordance with the explosives classification.

Storage class 4.2: ***Spontaneously combustible substances***

Products that can heat up at normal temperature in air without the supply of energy and then ignite, provided they are labelled with R phrase 17 (Spontaneously flammable in air) in accordance with the dangerous substances regulations or are listed in Class 4.2 of the transport regulations.
The class comprises products that ignite spontaneously in air and those products that can heat up slowly in a fairly large mass under heat accumulation conditions and then ignite.

Storage class 4.3: ***Substances that emit flammable gases in contact with water***

Products that develop dangerous levels of highly flammable gases in contact with water or moist air.
This storage class encompasses those products that are allocated to class 4.3 of the transport regulations.

Storage classes 5.1 A, 5.1 B and 5.1 C: ***Oxidising substances***

Oxidizing products that because of their oxidation potential can raise the burning rate of combustible substances substantially or ignite combustible substances on contact with them.
This storage class encompasses products that are classified in class 5.1 according the UN-Recommendations (Thai Provision 1).

Storage classes 5.1 A

Products that are very reactive belong to this group.

UN-Number	Substance
1445	BARIUM CHLORATE
1447	BARIUM PERCHLORATE
1449	BARIUM PEROXIDE
1450	BROMATES, INORGANIC, N.O.S.
1452	CALCIUM CHLORATE
1453	CALCIUM CHLORITE
1455	CALCIUM PERCHLORATE
1461	CHLORATES, INORGANIC, N.O.S.
1462	CHLORITES, INORGANIC, N.O.S.

UN-Number	Substance
1470	LEAD PERCHLORATE
1471	LITHIUM HYPOCHLORITE, DRY or LITHIUM HYPOCHLORITE-MIXTURES with more than 39 % available Chlorine (8,8 % available Oxygen)
1472	LITHIUM PEROXIDE
1475	MAGNESIUM PERCHLORATE
1479	OXIDIZING SOLID, N.O.S.
1481	PERCHLORATES, INORGANIC, N.O.S.
1483	PEROXIDES, INORGANIC, N.O.S.
1484	POTASSIUM BROMATE
1485	POTASSIUM CHLORATE
1489	POTASSIUM PERCHLORATE
1491	POTASSIUM PEROXIDE
1494	SODIUM BROMATE
1495	SODIUM CHLORATE
1496	SODIUM CHLORITE
1502	SODIUM PERCHLORATE
1504	SODIUM PEROXIDE
1506	STRONTIUM CHLORATE
1508	STRONTIUM PERCHLORATE
1510	TETRANITROMETHANE
1513	ZINC CHLORATE
1745	BROMINE PENTAFLUORIDE
1746	BROMINE TRIFLUORIDE
1748	CALCIUM HYPOCHLORITE, DRY or CALCIUM HYPOCHLORITE-MIXTURES with more than 39 % available Chlorine (8,8 % available Oxygen)
1873	PERCHLORIC ACID with more than 50 % but not more than 72 % acid by mass
2015	HYDROGEN PEROXIDE, STABILIZED or HYDROGEN PEROXIDE, AQUEOUS SOLUTION, STABILIZED, with more than 60 % hydrogen peroxide
2466	POTASSIUM SUPEROXIDE
2495	IODINE PENTAFLUORIDE
2547	SODIUM SUPEROXIDE
2723	MAGNESIUM CHLORATE
2741	BARIUM HYPOCHLORITE with more than 22 % available Chlorine
2880	CALCIUM HYPOCHLORITE, HYDRATED or CALCIUM HYPOCHLORITE, HYDRATED MIXTURE, with not less than 5,5 % but not more than 10 % water
3085	OXIDIZING SOLID, CORROSIVE, N.O.S.
3087	OXIDIZING SOLID, TOXIC, N.O.S.
3098	OXIDIZING LIQUID, CORROSIVE, N.O.S.
3099	OXIDIZING LIQUID, TOXIC, N.O.S.
3212	HYPOCHLORITES, INORGANIC, N.O.S.
-	POTASSIUM METAPERIODATE

UN-Number	Substance
-	SODIUM METAPERIODATE
-	PERIODINE ACID

Storage class 5.1 B

Products that are listed below which have a medium oxidising effect.

UN-Number	Substance
1438	ALUMINIUM NITRATE
1446	BARIUM NITRATE
1448	BARIUM PERMANGANATE
1454	CALCIUM NITRATE
1456	CALCIUM PERMANGANATE
1457	CALCIUM PEROXIDE
1458	CHLORATE AND BORATE, MIXTURE
1459	CHLORATE AND MAGNESIUM CHLORIDE, MIXTURE; SOLUTION
1463	CHROMIUM TRIOXIDE; ANHYDROUS
1469	LEAD NITRATE
1473	MAGNESIUM BROMATE
1476	MAGNESIUM PEROXIDE
1477	NITRATES, INORGANIC, N.O.S.
1479	OXIDIZING SOLID, N.O.S.
1482	PERMANGANATES, INORGANIC, N.O.S.
1486	POTASSIUM NITRATE
1487	POTASSIUM NITRATE AND SODIUM NITRITE, MIXTURE
1488	POTASSIUM NITRITE
1490	POTASSIUM PERMANGANATE
1498	SODIUM NITRATE
1199	SODIUM NITRATE and POTASSIUM NITRATE
1500	SODIUM NITRITE
1503	SODIUM PERMANGANATE
1509	STRONTIUM PEROXIDE
1515	ZINC PERMANGANATE
1516	ZINC PEROXIDE
1796	NITRATING ACID MIXTURE
1802	PERCHLORIC ACID, with not more than 50% acid by mass
1826	NITRATING ACID MIXTURE, SPENT with not more than 50% nitric acid
2014	HYDROGEN PEROXIDE, AQUEOUS SOLUTION, with not less than 20% but not more than 60 % hydrogen peroxide
2032	NITRIC ACID, RED FUMING
2427	POTASSIUM CHLORATE, AQUEOUS SOLUTION

UN-Number	Substance
2428	SODIUM CHLORATE, AQUEOUS SOLUTION
2429	CALCIUM CHLORATE, AQUEOUS SOLUTION
2469	ZINC BROMATE
2573	THALLIUM CHLORATE
2626	CHLORIC ACID; AQUEOUS SOLUTION, with not more than 10% chloric acid
2627	NITRITES, INORGANIC, N.O.S.
2719	BARIUM BROMATE
2721	COPPER CHLORATE
2722	LITHIUM NITRATE
2726	NICKEL NITRITE
2976	THORIUM NITRATE, SOLID
2381	URANYL NITRATE, SOLID
3084	CORROSIVE SOLID; OXIDIZING, N.O.S.
3085	OXIDIZING SOLID, CORROSIVE, N.O.S.
3086	TOXIC SOLID; OXIDIZING; N.O.S.
3087	OXIDIZING SOLID, TOXIC, N.O.S.
3093	CORROSIVE LIQUID; OXIDIZING, N.O.S.
3098	OXIDIZING LIQUID, CORROSIVE, N.O.S.
3099	OXIDIZING LIQUID, TOXIC, N.O.S.
3122	TOXIC LIQUID; OXIDIZING; N.O.S.
3139	OXIDIZING LIQUID, N.O.S.
3210	CHLORATES, INORGANIC, AQUEOUS SOLUTION, N.O.S.
3211	PERCHLORATES, INORGANIC, AQUEOUS SOLUTION, N.O.S.
3213	BROMATES, INORGANIC, AQUEOUS SOLUTION, N.O.S.
3214	PERMANGANATES, INORGANIC, AQUEOUS SOLUTION, N.O.S.
3218	NITRATES, INORGANIC, AQUEOUS SOLUTION, N.O.S.
3219	NITRITES, INORGANIC, AQUEOUS SOLUTION, N.O.S.
3247	SODIUM PEROXOBORATE, ANHYDROUS
-	CHROMYL CHLORIDE
-	POTASSIUM IODATE
-	SODIUM IODATE
1451	CAESIUM NITRATE
1465	DIDYMIUM NITRATE
1466	FERRIC NITRATE
1474	MAGNESIUM NITRATE
1477	NITRATES, INORGANIC, N.O.S.
1479	OXIDIZING SOLID, N.O.S.
1482	PERMANGANATES, INORGANIC, N.O.S.
1492	POTASSIUM PERSULFATE
1493	SILVER NITRATE

UN-Number	Substance
1505	SODIUM PERSULFATE
1507	STRONTIUM NITRATE
1514	ZINC NITRATE
1872	LEAD DIOXIDE
2014	HYDROGEN PEROXIDE, AQUEOUS SOLUTION, with not less than 20% but not more than 40 % hydrogen peroxide
2208	CALCIUM HYPOCHLORITE-MXTURES, DRY with more than 10 %, but not more than 39 % available Chlorine
2464	BERYLLIUM NITRATE
2465	DICHLOROISOCYANURIC ACID, DRY or DICHLOROISOCYANURIC ACID SALTS
2467	SODIUM PERCARBONATE
2468	TRICHLOROISOCYANURIC ACID, DRY
2627	NITRITES, INORGANIC, N.O.S.
2720	CHROMIUM NITRATE
2724	MANGANESE NITRATE
2725	NICKEL NITRATE
2727	THALLIUM NITRATE
2728	ZIRCONIUM NITRATE
3085	OXIDIZING SOLID, CORROSIVE, N.O.S.
3087	OXIDIZING SOLID, TOXIC, N.O.S.
3098	OXIDIZING LIQUID, CORROSIVE, N.O.S.
3099	OXIDIZING LIQUID, TOXIC, N.O.S.
3139	OXIDIZING LIQUID, N.O.S.
3210	CHLORATES, INORGANIC, AQUEOUS SOLUTION, N.O.S.
3211	PERCHLORATES, INORGANIC, AQUEOUS SOLUTION, N.O.S.
3213	BROMATES, INORGANIC, AQUEOUS SOLUTION, N.O.S.
3214	PERMANGANATES, INORGANIC, AQUEOUS SOLUTION, N.O.S.
3215	PERSULFATES, INORGANIC, N.O.S.
3216	PERSULFATES, INORGANIC, AQUEOUS SOLUTION, N.O.S.
3217	PERCARBONATES, INORGANIC, N.O.S.
3218	NITRATES, INORGANIC, AQUEOUS SOLUTION, N.O.S.
3219	NITRITES, INORGANIC, AQUEOUS SOLUTION, N.O.S.
-	SODIUM PERBORATE - MONOHYDRATE
-	IODINE ACID
-	CALCIUM IODATE
-	IODINE PENTOXIDE

Storage class 5.1 C

Ammonium nitrate and preparations with ammonium nitrate

Storage class 5.2: *Organic peroxides*

Products having a peroxide bond and preparations with an organic peroxide content of at least 5 %.
Products of this storage class are listed in UN-Recommendations (Thai Provision 1) class 5.2.

Storage classes 6.1 A and 6.1 B: *Toxic substances*

These storage classes encompass products with the hazard labels "T^+" and "T". These are very toxic and toxic substances that are labelled with the R phrases 23 to 28 (toxic by inhalation, toxic in contact with skin, toxic if swallowed, very toxic by inhalation, very toxic in contact with skin, very toxic if swallowed) and 39 (danger of very serious irreversible effects) or 48 (danger of serious damage to health by prolonged exposure) in accordance with the dangerous substances regulations and/or carcinogenic, mutagenic and fertility-impairing substances, provided they are labelled with the R phrases 45 (may cause cancer), 46 (may cause heritable genetic damage), 49 (may cause cancer by inhalation), 60 (may impair fertility) or 61 (may cause harm to the unborn child) in accordance with the dangerous substances regulations.

Storage class 6.1 A: combustible *toxic substances*

The following very toxic and toxic substances belong to this storage class:

- water-miscible flammable liquids with a flash point > 55°C
- water-immiscible flammable liquids with a flash point > 100°C
- aqueous preparations with combustible toxic substances
- solids with combustion numbers 2, 3, 4 and 5

Storage class 6.1 B: *Non-* combustible *toxic substances*

The following very toxic and toxic substances belong to this storage class:

- non- combustible liquids, except aqueous preparations with combustible toxic substances
- solids with combustion number 1

Storage class 6.2: *Infectious substances*

Infectious substances are those that contain viable micro-organisms that are known or assumed to cause diseases to humans or animals.
The viable micro-organisms include bacteria, viruses, rickettsias, parasites, fungi as well as recombined, hybrid or mutated micro-organisms.
This storage class encompasses the products of class 6.2 of the transport regulations.

Storage class 7: *Radioactive substances*

This storage class encompasses those products classified in class 7 of the UN-Recommendations (Thai Provision 1).

Storage classes 8 A and 8 B: *Corrosive substances*

This storage class encompasses products that are labelled with hazard symbol C and the R phrases 34 (causes burns) or 35 (causes severe burns) in accordance with the dangerous substances regulations. Also included are products that are classified in class 8 in accordance with ADR/RID (Thai Provision 2). It should be noted that a product classified in class 8 in accordance with transport legislation does not automatically have to be allocated to storage class 8 because a flash point may require classification in storage class 3 A or 3 B.
This storage class is subdivided into combustible and non- combustible:

Storage class 8 A: combustible *corrosive substances*

The following corrosive products belong to this storage class:

- water-miscible combustible liquids with a flash point **>** 55°C
- water-immiscible combustible liquids with a flash point > 100°C
- solids with combustion numbers 2, 3, 4 and 5

Storage class 8 B: ***Non-*** **combustible** ***corrosive substances***

The following corrosive products belong to this storage class:

- non- combustible liquids
- solids with combustion number 1

Storage class 9 ***(not used)***

Storage class 10: **Combustible** ***liquids unless classified in storage class 3 A or 3 B***

Combustible liquids which have a vapour pressure of max. 3 bar at 50°C, provided they are

- water-miscible and have a flash point > 55°C;
- water-immiscible and have a flash point > 100°C.

In the case of viscous flammable liquids attention must be paid to the note under storage class 3 A.

These can include substances of class 6.1 (packaging group III) UN-Recommendations (Thai Provisions 1), substances classified under the dangerous substances regulations with hazard symbols Xn (harmful), Xi (irritating) or N (toxic to environment) or substances that are neither regulated nor dangerous goods.

Storage class 11: **Combustible** ***solids***

The criterion for combustible is classification with combustion numbers 2, 3, 4 and 5 (at room temperature). Substances of combustion no. 5 are only assigned to this storage class if they don't fulfill the criteria of storage class 4.1 B.

These can include substances of class 6.1 (packaging group III) ADR/RID (Thai Provisions 2), substances classified under the dangerous goods regulations with hazard symbols Xn (harmful), Xi (irritating) or N (toxic to environment) or substances which are neither regulated nor dangerous goods, provided they are combustible.

Storage class 12: ***Non-*** **combustible** ***liquids***

Products which are not combustible or whose tendency to ignite is so low that they and their packaging present no fire hazard.

These can include substances of class 6.1 (packaging group III) UN-Recommendations (Thai Provisions 1), substances classified under the dangerous substances regulations with hazard symbols Xn (harmful), Xi (irritating) or N (toxic to environment) or substances that are neither regulated nor dangerous goods.

Storage class 13: ***Non-*** **combustible** ***solids***

Products which are not combustible or whose tendency to ignite is so low that they and their packaging present no fire hazard.

These can include substances of class 6.1 (packaging group III) UN-Recommendations (Thai Provisions 1), substances classified under the dangerous substances regulations with hazard symbols Xn (harmful), Xi (irritating) or N (toxic to environment) or substances that are neither regulated nor dangerous goods.

A.10.4 Rules for the mixed storage of products

A.10.4.1 General rules

In the mixed storage table (A.10.4.5) an indication is given for each storage class as to whether storage together with each of the other storage classes is in principle permitted, whether storage together is prohibited (separate storage required) or whether there are restrictions on storage together that have to be observed (segregated storage in the same storage area required).

Mixed storage of products of one or different storage classes are permitted only if certain conditions are met (e.g. identical extinguishing agent for all products, identical temperature conditions).

Mixed storage in this content means the storage of two or more storage classes **without** any other additional infrastructure, operational and technical measures for segregation.

A.10.4.2 Separated storage:

The term separate storage means storage in different storage areas. A storage area is a part of a warehouse which

- in buildings (inside the warehouse) is separated from other rooms by at least fire-resistant walls and ceilings (at least F 90),
- in the open air (outside the warehouse) is separated by appropriate distances (e.g. 5 meters between flammable and non-flammable substances and 10 meters between all others) or by fire-resistant walls (at least F 90).

Separate storage may be necessary to reduce risks during storage, which can arise as a result of risk-increasing contact between products of different storage classes.

A.10.4.3 Segregated storage:

The term segregated storage means storage in the same storage area if products are stored separated from each other by gaps or barriers (e.g. walls, products consisting of non-combustible substances of storage class 12 or 13) or in cabinets made of non-combustible material.

Products of one storage class may in principle be stored together in the same storage area. Exceptions to this are cases where specific storage regulations such as the regulations for explosives, organic peroxides and flammable substances have to be observed.
Segregated storage within a storage area may also be necessary e.g. because of special material properties possessed by certain individual products of the same storage class or by products of other storage classes, for which mixed storage in accordance with the mixed storage table is permitted.

Information on such material properties can be found e.g.

- in the hazard warnings (R phrases) and safety advice (S phrases) for labelling in accordance with the dangerous goods regulations,
- from the product-specific safety information, such as material safety data sheets

A.10.4.4 Exceptions to the mixed storage table

The following exceptions apply to the rules for mixed storage in accordance with

- special rules for the additional storage of small quantities in stores over 5 t and
- special rules for small stores up to 5 t

In these cases it is assumed that mixed storage brings no appreciable increase in risk.

A.10.4.5 Mixed storage table

Mixed storage of products of one or different storage classes are permitted only if certain conditions are met (e.g. identical extinguishing agent for all products, identical temperature conditions).

Storage class		1	2 A	2 B	3 A	3 B	4.1A	4.1B	4.2	4.3	5.1A	5.1B	5.1C	5.2	6.1A	6.1B	6.2	7	8 A	8 B	10	11	12	13
Explosive substances	1	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Compressed, liquefied and dissolved gases	2 A	-	17	4	-	-	-	-	-	-	-	-	10	-	-	-	-	18	5		-	5		
Pressurized small gas containers	2 B	-	4		1	1	-	-	-	-	-	-	10	-	2	2	-	18	4	4	6	6	6	6
Flammable liquids	3 A	-	-	1	17		-	-	-	-	-	-	-	-		-	-	18	9	9		3		
Flammable liquids	3 B	-	-	1			12	4	-	4	-	-	-	7			-	18						
Flammable solids	4.1 A	-	-	-	-	12	17	12	-	-	-	-	-	14	-	-	-	-	12	12	12	12	12	12
	4.1 B	-	-	-	-	4	12		4	4	-		-	13	8	-	-	18						
Spontaneously combustible substances	4.2	-	-	-	-	-	-	4		4	-	-	-	-	-	-	-	18	4	4	4	4		
Substances that form flammable gases in contact with water	4.3	-	-	-	-	4	-	4	4		-	-	-	-	-	-	-	18	4	4	4	4	4	
Oxidizing substances	5.1 A	-	-	-	-	-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-
	5.1 B	-	-	-			-	-	-	-			10	-	15	15	-	18	11		11	11		
	5.1 C	-	10	10	-	-	-	-	-	-	-	10	17	-	-	-	-	18	10	10	10	10	10	10
Organic peroxides	5.2	-	-	-	-	7	14	13	-	-	-	-	-	17	-	-	-	-	-	-	16	16	16	16
Combustible toxic substances	6.1 A	-	-	2			-	8	-	-	-	15	-	-			-	18				3		
Non-combustible toxic substances	6.1 B	-	-	2	-		-	-	-	-	-	15	-	-			-	18				3		
Infectious substances	6.2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-	-	-	-
Radioactive substances	7	-	18	18	18	18	-	18	18	18	-	18	18	-	18	18	-		18	18	18	18	18	18
Combustible corrosive substances	8 A	-	5	4	9		12		4	4	-	-	10	-			-	18						
Non-combustible corrosive substances	8 B	-		4	9		12		4	4	-		10	-			-	18						
Combustible liquids (unless 3 A or 3 B)	10	-	-	6			12		4	4	-		10	16			-	18						
Combustible solids	11	-	5	6	3		12		4	4	-		10	16	3	3	-	18						
Non-combustible liquids	12	-		6			12			4	-		10	16			-	18						
Non-combustible solids	13	-		6			12				-		10	16			-	18						

Mixed storage is permitted in principle — *Number* *Mixed storage is permitted only with restrictions (see number)* — - *Separate storage is required*

Notes to the table:

1. The mixed storage of flammable liquids and pressurized gas containers (aerosols) is permitted under the following conditions:
The compartment must be ventilated and the total number of goods stored should not exceed 60 % of the useable capacity of the warehouse.
The total quantity of flammable liquids and contents of the aerosol dispenser should not exceed 100,000 litres.

2. Pressurized gas containers may be stored together with very toxic and toxic substances under the following conditions:
The size of the fire compartment must be limited to 60 m² and the maximum capacity of the goods is limited to 60 % of the total capacity of the compartment. The temperature of the room should not exceed above 50 °C. The compartment must be ventilated and must have two emergency exits. At each exit a 6 kg fire extinguisher with ABC powder must be available. If the compartment is bigger than 60 m² then these goods have to be segregated by appropriate measures or separated.

3. Materials that cause the rapid start or spread of fire, such as packaging materials, should be separated from toxic substances or flammable liquids.

4. Mixed storage is permitted if the products do not react with each other in the event of an incident. This can be achieved by segregated storage, e.g. physical separation, large gaps, separate containment basins, storage in safety cabinets.

5. In storage halls in which no more than 50 filled pressurized gas cylinders, including not more than 25 pressurized gas cylinders with flammable, oxidizing or very toxic gases, are stored, combustible substances with the exception of flammable liquids may be stored if the storage area for pressurized gas cylinders is separated by a wall at least 2 m high made of non- combustible building materials and between the wall and the combustible substances a distance of at least 5 m is.

6. Mixed storage is permitted if the safety requirements for the entire stock are adapted to meet the requirements of storage class 2B.

7. Mixed storage is permitted for flammable liquids having a flash point above 61 °C provided that the mixed storage will not react in the dangerous way (combustion and/or evolution of considerable heat, evolution of flammable, asphyxiant, and/or toxic gases, formation of corrosive substances, the formation of unstable substances, or dangerous rise in pressure). In such case there must be safety distances (5 metres) between those goods.

8. Flammable toxic substances may be stored together with substances of storage class 4.1B.

9. Where storage of flammable liquids is subject to a permit, corrosive substances in breakable containers must not be stored together with flammable liquids in storage rooms. This does not apply if the goods in the storage room are separated in such a way that they cannot react with each other in the event of an incident

10. Mixed storage is permitted except with flammable gases.

11. Reserved.

12. Substances of storage groups I - III of the 2nd explosives regulations may be stored together with other materials if the safe distances designed to prevent any increase in risk to the surroundings of a warehouse are adequate or are increased. This must be checked in each case.

13. Mixed storage of substances of storage class 5.2 with other highly flammable solids is permitted.

14. Mixed storage with propellants and radical initiators is permitted if these do not contain any heavy metal additives.

15. Oxidizing substances of storage class 5.1B may be stored together with very toxic and toxic substances up to a total quantity of 20 tons, observing the following:
The warehouse must have a fire alarm system, an automatic fire extinguishing system and a company run semi-professional fire brigade (employees only for fire fighting with own engine). Quantities up to 1 ton don't require these additional safety measures.

16. When organic peroxides are stored together with other materials, it is necessary to check in each case whether the safe distances designed to prevent a higher risk for the warehouse surroundings are adequate or need to be increased.

17. The specific statutory storage regulations must be observed.

18. Radioactive material should be considered separately according the IAEA Safety Series and with the approval of the competent authority.

.

A.10.4.6 Special rules for the mixed storage of small quantities of dangerous goods in warehouses

These regulations apply to storage areas with small quantities. They permit the storage of small quantities of specific storage classes together with larger quantities of products of certain other storage classes for which mixed storage is prohibited or restricted. For the storage classes 1, 2A, 4.1A, 4.2, 5.1A, 6.2, and 7 are no exceptions from the mixed storage permissible. For all other storage classes the relevant quantities are given in the table below.

Storage class	Warehouse with capacity Up to 5000 kg	Warehouse with capacity More than 5000 kg
1	-	-
2A	-	-
2B	500 cans	500 cans
3A	100 litres of flammable liquids with flash point below 21 °C 200 litres of flammable liquids with flash point between 21 and 55 °C	100 litres of flammable liquids with flash point below 21 °C 200 litres of flammable liquids with flash point between 21 and 55 °C
3B	less than 5000 kg	5000 kg
4.1A	-	-
4.1B	200 kg	200 kg
4.2	-	-
4.3	200 kg	-
5.1A	-	-
5.1B	200 kg	200 kg
5.1C	100 kg	-
5.2	100 kg (In small packagings with capacity of less than 100 g for solids and 25 ml for liquids only)	-
6.1A	50 kg	50 kg
6.1B	200 kg	200 kg
6.2	-	-
7	-	-
8A	less than 5000 kg	5000 kg
8B	less than 5000 kg	5000 kg
10	less than 5000 kg	5000 kg
11	less than 5000 kg	5000 kg
12	less than 5000 kg	5000 kg
13	less than 5000 kg	5000 kg

Remarks: It must be ensured that the products do not react/spontaneously ignite with each other in an incident. This can be achieved by some safety measures like, safety distance (of at least 3 m.), safety cabinet, separate containment facility, etc.
The quantities permitted for storage class 3 A may be exceeded if the protective measures (e.g. fire and explosion prevention) are adequate.

A.11 Operating Instructions

Based on the following regulations

European regulations	*89/391/EEC* *98/24/EC* *92/58/EC* *2001/58/EC*
German regulations	*GefStoffV* *TRGS 440* *TRGS 555* *ZH 1/124*
U.S. regulations	*29CFR1926, §1926.64*

The employer has to prepare operating instructions for the safe storage and handling of dangerous goods and dangerous substances. For detailed information a third party can be consulted which has the knowledge about the chemicals.

These operating instructions should give information about
- the properties of the dangerous goods and substances
- possible risks
  the risks for human beings
  the risks for the environment
- behaviour in case of leakage
- behaviour in case of fire
- first aid measures
- hygienic measures
- waste disposal

A lot of the information can be found in the material safety data sheets.

A.11.1 Kind of operating instructions

There are two kinds of operating instructions. On one hand there can be operating instructions for each substance (chemical substance or product). On the other hand there might be operating instructions for some substances, which have the same properties.

The operating instructions are binding for each employee how to handle the chemicals.

The operation instructions must be understandable for all employees, which means there must be in English and Thai version and must have illustrations. They must be placed in the warehouses where the employees can take a look at them.
The employees should use the operating instructions for their daily work.

The information in the operating instructions must be precise. The obligations must be expressed by using a sentence with must. All prohibitions must be expressed by the words must not.

A.11.2 Examples of operating instructions

Operating Instruction

Building F 496 and F 471
Storage of packed goods

Workplace: Warehouse

Name of substance

CAS- No.

Flammable liquids and toxic liquids

Risks for humans and environment

- Toxic by inhalation, in contact with skin and if swallowed
- Highly flammable
- Irritating to eyes, to respiratory system and to skin
- Possible risks of irreversible effects
- May cause sensitisation by inhalation and sensitisation by skin contact
- Formation of explosive mixture of gas and air possible
- Toxic to aquatic environment

Safety precautions

- Keep container tightly closed
- Keep container in a well ventilated place
- Wear safety glasses
- Use safety gloves of Poly chloroprene, Nitrile rubber or others
- In case of spillage use self breathing apparatus
- In case of spillage use protective suit
- Keep away from sources of ignition - No smoking
- Do not breathe gas/fumes/vapour/spray
- Avoid contact with skin and eyes
- Take precautionary measures against static discharges
- Avoid exposure - obtain special instructions before use

Behaviour in case of emergency

In case of fire: Start fire fighting with fire extinguisher
Inform supervisor immediately to call fire brigade
Use carbon dioxide or powder for fire fighting
Use respiratory

In case of spillage: Leave area immediately
Inform supervisor
Don't let liquid run into effluent channel

First aid

- Contact first aider immediately
- First aid measures until doctor arrives
- Get injured to fresh air
- Eyes: wash with plenty of water
- Skin: Wash with plenty of water and soap
- Take off immediately all contaminated clothing

Waste disposal

- Dispose spilled goods and binding agent according material safety data sheet
- Don't wash substance in effluent channel or catch basin

A.11.3 Symbols and signs for operating instructions and information

Safety and/or health signs mean signs referring to a specific object, activity or situation and providing information or instructions about safety and/or health at work by means of a colour in combination of a symbol:

(a) prohibition sign means a sign prohibiting behaviour likely to incur or cause danger;
(b) warning sign means a sign giving warning of a hazard or danger;
(c) mandatory sign means a sign prescribing specific behaviour;
(d) emergency escape or first-aid sign means a sign giving information on emergency exits or first-aid or rescue facilities;
(e) information sign means a sign providing information other than that referred to in (a) to (d);
(f) safety colour means a colour to which a specific meaning is assigned;

Employers shall provide safety and/or health signs where hazards cannot be avoided or adequately reduced by techniques for collective protection or measures, methods or procedures used in the organisation of work, or ensure that such signs are in place.
Without prejudice to these requirements, the signs used for road, rail, inland waterway, sea and air transport shall be installed, wherever appropriate for such modes of transport, inside undertakings and/or firms.
The placing of too many signs too close to each other should be avoided.
Areas, rooms or enclosures used for the storage of significant quantities of dangerous substances or preparations must be indicated by a suitable warning sign.

Colour	Meaning or purpose	Instructions and information
Red	Prohibition sign	Dangerous behaviour Danger alarm Stop, shutdown, Emergency cut out devices Evacuate Fire-fighting equipment Identification and location
Yellow or amber	Warning sign	Warning sign Be careful, take precautions Examine
Blue	Specific behaviour or action	Specific behaviour or action Wear personal protective equipment
Green	Emergency escape, first aid sign	Doors, exits, routes, equipment, facilities No danger Return to normal

A.11.4 Prohibition signs

Based on the following regulations

European regulations	
German regulations	
U.S. regulations	*29CFR1910, §1910.144 and §1910.145*

No access

No fire or open flames

No forklift truck

No drinking water

No pedestrians

No smoking

No water for fire extinguishing

A.11.5 Warning signs

Based on the following regulations

European regulations	
German regulations	
U.S. regulations	*29CFR1910, §1910.144 and §1910.145*


Corrosive substances

Explosive atmosphere


Explosive substances


Flammable substances


Forklift trucks


Harmful/irritating substances


Infectious substances


Oxidizing substances


Radioactive material


Toxic substances

A.11.6 Specific behaviour or action signs


Ear protection


Eye protection


Face mask


Pedestrians


Protective clothes


Respirator mask


Safety gloves


Safety helmet


Safety shoes

A.11.7 Emergency escape, first aid signs

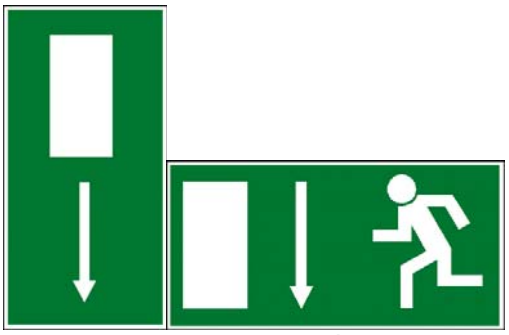

First aid kit


Stretcher


Doctor


Emergency telephone


Escape way


Emergency exit


Assembly point


Eye shower


Emergency shower

A.12 Information and training of employees

Based on the following regulations

European regulations	*89/391/EC Article 6, 10 and 12* *89/654/EC Article 7* *92/58/EC Article 7* *98/24/EC*
German regulations	*GefStoffV* *TRGS 500* *TRGS 555* *ZH 1/7* *ZH 1/554*
U.S. regulations	*29CFR1910, § 1910.38* *29CFR1910, §1910.120* *29CFR1910, § 1910.156* *29CFR1926, §1926.64*

Employees who are informed and well trained can contribute to a safe handling and storage of dangerous goods and dangerous substances.

The management operator of warehouses should also be trained where to get all necessary information about the dangerous goods and the dangerous substances and how to classify them.

The following information should be provided for the employees:

- Properties of dangerous goods and dangerous substances
- What kind of personal protective equipment is available and how to use it
- When personal protective equipment must be replaced by a new one
- How to read operating instructions
- How to react in case of emergency
- How to use a fire extinguisher
- Which information is important for the supervisor or fire brigade in case of emergency

Contents	Repetition
Properties of dangerous goods and dangerous substances	Once a year (If there are new chemicals with other properties, the information must be given immediately)
What kind of personal protective equipment is available and how to use it	Once a year
When personal protective equipment must be replaced by a new one	Once a year
How to read operating instructions	Once a year
How to react in case of emergency	Once a year in combination with emergency training
How to use a fire extinguisher	Once a year
Which information is important for the supervisor or fire brigade in case of emergency	Once a year

Additionally the employees should obtain practical experience for the following:

- How to handle a spillage
- How to fight a fire by using fire extinguishers
- How to react in case of emergency (evacuating the warehouse)
- How to use additional personal protective equipment (respirator etc.)
- Fork lift driver training

Practical training	Repetition
How to handle a spillage	Once a year
How to fight a fire by using fire extinguishers	Once a year
How to react in case of emergency (evacuating the warehouse)	Once a year
How to use additional personal protective equipment (respirator etc.)	Once a year
Fork lift driver training	Once a year

If there is proven evidence of lack of knowledge more frequent trainings are necessary.

A.13 Personal protective equipment

Based on the following regulations

European regulations	*80/1107EEC* *89/391/EC Article 6, 7 and 9* *89/654/EC Article 6* *89/656 EEC* *89/686/EC* *98/24/EC*
German regulations	*GefStoffV* *TRGS 500* *ZH 1/700 to 1/706*
U.S. regulations	*29CFR1910, Subpart I* *29CFR1926, Subpart E*

The personal protective equipment shall protect the employee having direct contact with the dangerous goods or dangerous substances. A contact with those materials may cause illness or diseases.

In the first step the company has to find out, if there are opportunities by using technical equipments, which can protect the employees having direct contact with the chemicals, this equipment has to be installed.

Anyhow, sometimes it is not possible due to the different circumstances to install technical equipment. For that reason it is necessary to wear personal protective equipment.

The basic personal protective equipment should consist of the following equipment:

- Safety shoes

	The main requirements: 1. Upper leather (grain less leather or skivers) 2. Insole (at least 2 mm with layer which is resistant against chemicals, oil and fuel and if necessary also a layer of thin steel) 3. Sole must not be slippery 4. Steel toe cap Details can be found in EN 344 to 347.

Safety shoes must have a steel toe cap, a sole which is resistant against chemicals especially acids and antistatic.
A steel toe cap is necessary to protect the foot. In case heavy things like drums or pallets are falling on the floor or while pushing and turning drums putting the drums on the foot, it will not hurt the foot. A sole must be antistatic to avoid that the sole will be charged electro-static and in case of an explosive atmosphere it will be discharged. The sole must also be resistant against chemicals so that in case of a spillage the shoe will not be destroyed by the chemical and the chemical will not hurt the foot (in case of acid it will cause burns).

- Work wear (safety clothes)

 	The main requirements are: Details can be found in EN 368, 369 and 463 to 468.

Work wear should be resistant against powder and not be easily ignited. The work wear should protect the body, the arms and the legs against the effect of the chemicals. The suitable work wear depends on the kind of risk at the workplace. The material of the cloth depends also on the risk of fire. If there is the risk of ignition the material must withstand a short period the flame. The material of the work wear should also be resistant against liquids, so that the liquid will not be sucked up easily. These properties of the material should be certified by the manufacturer of the work wear.

- Safety helmet

	The main requirements are: 1. Material must withstand hits 2. Suitable for different head sizes and shapes Details can be found in EN 397.

If goods are stored on each other or in shelves, a safety helmet is necessary to protect the head against falling packagings. There are two kinds of safety helmets. There are safety helmets made of plastic materials (poly ethylene) and of carbon fibre. Those of plastic can only be used at the latest for five years. If the plastic material has been weakened by the heat and the sun the helmet should not be used anymore.

- Safety glasses

	The following things should not occur: 1. High weight 2. Insufficient suit 3. Difficult hygiene 4. Derogation from bad sight through glass 5. Limitation of angle of sight 6. Reflection 7. Steam up of glass 8. Glass should not be destroyed by chemicals Details can be found in EN 165 to 172.

Safety glasses are important if dusts can get into the eyes when filling powders or solids. If liquids are filled, a face mask should be used. If corrosive or irritant articles will be filled or refilled a face mask should be also used. Depending on the properties of the chemicals the material of the safety glasses should be resistant.

- Gloves (suitable for normal handling / resistant against the chemicals)

	The main requirements are: 1. Tightness against chemicals 2. Resistance against chemicals Details can be found in EN 374

Gloves should be used to protect the hands. There are different kinds of gloves. For the storage and handling of the packagings there might be the left ones sufficient to protect the fingers from scratching or squeezing and the packagings can not slip out of the hands.

If dangerous gases, vapours or dusts might occur the employees must be equipped with escape masks to get out of the area with the gases safely.

Additionally the company should provide emergency showers and eye showers, where the corrosive substances are stored. The eye shower might also be useful for other substances (information can be found in Material Safety Data Sheet).

A.14 Hygiene measures

A.14.1 Personal Hygiene

Based on the following regulations

European regulations	*98/24/EC*
German regulations	*GefStoffV* *TRGS 500* *ArbStättV* *ASR 34/1-5* *ASR 35/1-4*
U.S. regulations	

Before the employees start working, they have to dress the work wear and have to use their personal protective clothes.

If the employees get in contact with the chemicals and the clothes are contaminated, they have to change their work wear. Don't wash the contaminated/polluted work wear by using a normal washing machine. The water and other clothes could also be contaminated.

Corrosive material might get through the clothes and cause chemical burn. A flammable substance in contact with a source of ignition might start the clothes burn.

During work it's forbidden to eat, to drink or to smoke. If there are chemicals on the hands, they might get into the body with the food, beverages or while smoking.

Before lunch break the employees have to wash their hands very properly. The company has to offer the soap and the skin protection cream.

After finishing work the employees have to change the work wear and need to have the opportunity to take a shower to wash the chemicals off.

For detailed information about the work wear and protective clothes see chapter 13 (personal protective equipment).

A.14.2 Warehouse Hygiene and housekeeping

Based on the following regulations

European regulations	
German regulations	
U.S. regulations	*29CFR1910, §1910.22* *29CFR1910, §1910.176*

The warehouse and service rooms shall be kept clean and orderly and in a sanitary condition.
The floor of every workroom shall be maintained in a clean and a dry condition. Where wet processes are used, drainage shall be maintained, and false floors, platforms, mats, or other dry standing places should be provided where practicable.
To facilitate cleaning, every floor, working place, and passageway shall be kept free from protruding nails, splinters, holes, or loose boards.
The chemical industry in Europe considers it suitable for practical application to have a normal clean up in a warehouse once a week.

The clean up after a spillage has to be carried out immediately. Otherwise the spilled goods could be carried anywhere and the effort to clean up would be bigger. The spilled chemicals also possess a hazard and therefore they should be disposed immediately.

According to their properties the spilled chemicals must be packed according the dangerous goods regulations. These packagings must also be stored according the requirements. Even the empty uncleaned packagings must be tightened as in proper condition or put in a salvage packaging, so that no chemical or vapour can cause any incident.

According to the regulations, the garbage, the waste or the dangerous substances must be disposed off properly.

A.15 Precaution examination of employees

Based on the following regulations

European regulations	*89/391/EEC Article 14* *98/24/EC*
German regulations	*GefStoffV* *ZH 1/7* *ZH 1/600*
U.S. regulations	

A precaution examination is a medical check of the health of the employee. These checks should be carried out before an employee starts working for that company and after certain periods. At first the employer is interested to get a healthy employee, who can carry out the work which is planned to do. If the employees have some diseases, they cannot carry out their job and the employer has to find another work for the employee. Secondly occupational diseases can be prevented. The healthcare helps to avoid occupational diseases and/or screen them at the earliest possible stage. The employees should take advantage of regular medical examinations and consulting. The employees should not get diseases caused by the chemicals stored or handled at the company. The employer must ensure that the employees don't have any kind of diseases (which might also be caused by the chemicals) before they start working for that company. If the employee has been working for other companies where, there the employee might have got into contact with some chemicals which causes diseases like cancer or other long-term effect diseases. These precaution examinations are carried out to make sure that the employee does not have any diseases. Otherwise the employer might be held responsible for that disease.

For that reason all employees should get a precaution examination where the following should be checked [18]:

- Big blood picture (the cells of the blood will be counted and analysed erythrocytes, thrombocytes, leucocytes, hemoglobin, haematocrit, three erythrocytes numbers [MCV, MCH and MCHC] and the spreading of the different kind of leucocytes)
- Urine status
- Ergonometric
- Eye test
- Hearing test
- Test of lung function

Generally, these examinations must be carried out again after 5 year; even stricter regulation can be gained from the table below (This period has been fixed by the employee's insurance. After this period normally the carcinogenic and mutagenic substances can be identified in the body of the employee.).

If the employees must wear respiratory masks they must be of good health.
The check for the employees contains the following [19]:

- X-ray examination of the Thorax
- Spirometry
- Ergometry with incentive condition indication
- Otoscopy, if it is possible that the ears get into contact with gases or vapours

These examinations must be repeated every 3 years (After this period the physical constitution of human being changes. From the age of 40, the employees should go every two years and from the age of fifty yearly) to make sure that the employees are physically able to work with respiratory masks.
There might be additional precaution examinations, if the employees get into contact with substances, which are known to cause diseases (substances which might cause cancer) or might weaken the health (for example Methanol causes eye irritation).
Detailed information about the risks can be found in the material safety data sheets.

For the following substances additional precaution examinations are necessary to be carried out at intervals [20]:

Dangerous good or dangerous substance	First precaution examination (month)	Following precaution examination (month)
Acrylonitrile	12-24	12-24
Antifouling colours	6	12
Aromatic nitro and amino compounds	6-9	6-12
Arsen trioxide and –pentoxide, arsenic acids arsen acid and their salts (arsenites and arsenates	6	12
Asbestos	12-36	12-36
Benzene	2	3-6
Benzo pyrene	24-36	24-36
Lead tetra ethyl	3-6	12-24
Lead tetra methyl	3-6	12-24
Cadmium and cadmium compounds	12-18	12-24
Calcium chromate	6-9	12-24
Chromo III chromate	6-9	12-24
Chromo IV compounds	6-9	12-24
Fluor and inorganic compounds	12	12
Iodine methan	60	60
Isocyanates	3-6	3-6
Methanol	12-18	12-18
Methyl chloride	3-6	12-18
Nickel and compounds and dusts	12-24	12-24
Nitroglycerine and nitroglycol	3-6	6-18
Penta chloro ethane	3-6	6
Phosphorous white	6-9	12-18
Mercury and compounds	3-6	6-12
Carbon disulphide	3-6	6-18
Hydrogen sulphide	6-12	12-24
Strontium chromate	6-9	12-24
Tetra chloro ethan	3-6	6
Tetra chloro ethylene	12-18	12-24
Carbon tetrachloride	3-6	6
Toluene	12-18	12-24
Tri chloro ethylene	12-18	12-24
Vinyl chloride	6-12	12-24
Xylene	12-18	12-24
Carcinogenic substances	60	60

A.16 Restrictions for employment

Based on the following regulations

European regulations	*94/33/EC*
German regulations	*GefStoffV*
U.S. regulations	

Chemicals might have an impact on the health of the employees. Especially substances which may cause cancer, may cause heritable genetic damage, may cause birth defects, have a danger of serious damage to health by prolonged exposure, may cause cancer by inhalation, may impair fertility, may cause harm to the unborn child, have a possible risk of impaired fertility, have a possible risk of harm to the unborn child and may cause harm to breastfed babies.

For that reason no employee should be younger than 18 years. If a female employee is pregnant, she should not get into contact with chemicals at all.

Additionally if such chemicals are stored in the warehouse, the employer must provide the correct personal protective equipment or find other substances, which can be used instead of those chemicals.

A.17 Vehicles used in warehouse

Based on the following regulations

European regulations	
German regulations	*TRbF 20*
U.S. regulations	*29CFR1910, §1910.178*

The vehicles used inside the warehouse should not emit exhaust pollutants.

On one hand there are hand lifts that can be moved by manual or automatically.
The automatically ones are operating battery powered.

On the other hand there are forklift trucks. At first there are those operating by fuel engine with diesel, which emits exhaust pollutants. Second there are forklift trucks operating battery powered.

The forklift trucks, which are operating with diesel engines, should not be used inside the warehouses, if there is no sufficient ventilation inside. On the other hand the engine of the diesel forklift truck has hot surfaces, which might be a source of ignition for flammable substances.
The size of the vehicles must be suitable enough to handle the goods (weight of pallets). Additionally they should not be too big of size so that they don't block the escape ways.

The loading of the batteries for the electrical forklift and hand lift must be carried out in a separate room.

A.18 Environmental protection

Based on the following regulations

European regulations	*76/464/EEC* *96/61/EC*
German regulations	*WHG* *VAwS* *TRGS 514*
U.S. regulations	

Any building used for the storage or processing of chemicals or materials should be deemed to have the potential for significant adverse environmental impact, if a fully developed fire would result in significant contamination of ground or surface water through direct runoff or atmospheric dispersion.

In case of spillage it must be ensured that no chemical can get into the environment.

A.19 Information for emergency response teams (fire brigade etc.)

Based on the following regulations

European regulations	
German regulations	*TRG 280* *TRGS 514* *12. BImSchV*
U.S. regulations	*29CFR1910, §1910.38* *29CFR1910, §1910.120* *29CFR1926, §1926.65*

The fire brigade needs information in case of emergency about the properties of the chemicals and which fire extinguishing material has to be used. For that reason they need the following information:

- Product name and chemical name
- Number and kind of packagings
- Total weight
- Place of storage
- UN-number and classification
- Fire extinguishing agent

All these information could be gained from various chemical handbooks, response databases, product specification, and MSDS as well as the internet etc.

The list of the stored goods/substances must be updated once a week. If there are many changes of the stored goods/substances it must be updated daily.

Additionally the fire brigade needs a blue print of the warehouses where the places of all goods are shown.

A.20 Safety Maintenance Control program for critical function.

Based on the following regulations

European regulations	
German regulations	*Regulations for the technical devices and guidelines of manufacturer*
U.S. regulations	*29CFR1910, §1910.157*

Regular maintenances are required to ensure the proper function of all safety devices. Detailed maintenance plans should be developed based on the recommendation of the producer office devices, the substances stored and the individual circumstances. In particular, the following safety devices must be checked:

- Smoke detector
- Gas detector
- Gas alarm system
- Water sprinkling system
- Fire extinguishers
- Fire alarm system
- Lightning conductor
- Personal protective equipment
- Fork lift
- Emergency exits

B. Additional requirements for certain properties

These requirements must be additionally observed to the general requirements. Each property presents a special risk. Some companies only have a few classes but need to have a special construction of the warehouse to ensure a safe storage or handling.

If all companies should observe these additional requirements it is an investment, which is not necessary.

B.1 Special requirements for explosives

Based on the following regulations

European regulations	
German regulations	*SprengG* *SprengLR 210 to SprengLR 410* *ElexV*
U.S. regulations	

All warehouses where explosives are stored need an approval by the competent authority.

The explosives are divided in storage groups. For each storage group there are different additional requirements laid down. The main differences are the safety distances and the safety equipment of the warehouses. The main reasons for the dividing the storage groups are the fire safety, the deflagration or the detonation.

Storage group 1.1
The substances have a mass explosion hazard. They have an impact on the environment by a blast, flames and parts of the explosive material.

Storage group 1.2
The substances explode in case of a fire separately. During a fire the number of exploding substances increases. The blast limited to the area of the fire.

Storage group 1.3
These substances don't have a mass explosion hazard. They burn very heavy and the fire spreads very fast.

Storage group 1.4
These explosives don't have a big hazard. In case of fire, it is limited on the packaging. Some of the packagings might explode.

B.1.1 Fire protection

Smoking, sparks and open flames are forbidden in this area, some explosives might be ignited.

B.1.2 Construction of the warehouse

- Windows are not allowed (they can be easily destroyed in case of explosion and the splinters can fly for a certain distance and hurt people). However, the ventilation should be sufficient. This can be achieved by air vents in the wall. If the natural ventilation is not sufficient, forced ventilation is allowed provided that electrical installations are explosive proofed.
- The warehouse must have only one floor.
- Walls, floors and roofs must be resistant against explosion.
- The material for walls, floor and roof must be fire resistant of type F 90 (withstand a fire of 90 minutes)
- The floor must have electrical conductivity, be even and plain and be easy to clean.
- The electrical installation must be explosive proofed and checked at least once a year.
- Warehouses for storage group 1.1 must have an embankment of earth with a height of at least 0.6 meters if there are more than 1000 kg gross[21].
- Doors have to be pushed open from inside. The height of the warehouse must be at least 2 meters.
- The warehouse must have lightning conductors, which have to be checked at least once a year (A.20 safety maintenance control program).
- Explosives can only be stored in closed packagings, which are approved for transport.
- There must be one employee responsible for the storage of explosives, who has to check that all requirements are fulfilled.
- At distance of 25 meters from the warehouse there is still a fire protection area, that means in this area smoking and the use of fire and open flames is prohibited.

B.1.3 Safety distances
[22]

Storage group	Safety distance to living areas	Safety distances to traffic routes
1.1	D = 22 x M at least 275 meters	D = 15 x M at least 180 meters
1.2	D = 58 x M at least 135 meters	D = 39 x M at least 90 meters
1.3	D = 6.4 x M at least 60 meters	D = 4.3 x M at least 40 meters
1.4	25 meters	25 meters

D = distance in meters
M = quantity of explosives in total in kg (total net mass of explosive contents)

B.2 Special requirements for gases

Based on the following regulations

European regulations	
German regulations	*TRG 280* *TRG 300* *TRG 301* *ElexV*
U.S. regulations	*29CFR1926, §1926.307*

The gas cylinders and aerosol cans must always have a protection of the valves. This can be achieved by a cap or the construction itself, so that the valve can not be hit.

B.2.1 Storage in warehouses

This part applies to all kind of gases. Aerosol cans must be considered separately.
Ventilation must be 2 air changes (the whole air inside the compartment has to be sucked out of the compartment and fresh air from outside must get in) per hour ventilation. The diameter of the openings for the ventilation must be at least 1/100 of ground area in significant diameter [23].

For example the compartment has a size of 10 meters x 2.5 meters, so the size of this compartment is 25 m^2. Now the result 25 has to be divided by 100 to get the significant diameter of the opening for the ventilation so 1/100 is 0.25. In this case the opening must have a significant diameter of 0.25 meters. It must also be considered if the gases are heavier than air, then the opening must be located close to the floor.

The air should be checked by gas detector to make sure that no toxic gases will be sucked off.

There must be one fire extinguisher. If there are more than 500 receptacles (cylinders, tubes, pressure drums, cryogenic receptacles and bundles of cylinders), the warehouse must have additionally water hydrants [24].

There must be fire walls to the next compartments.

The roof must be resistant against flying sparks.

The floor must be hardly inflammable or non-combustible.

Combustible material like paper, cardboard, saw dust etc. is not allowed to be stored in the same compartment.

If different kinds of gases are mixed in one compartment, there are quantity limitations, the total number of flammable gas cylinders and oxidizing gas cylinders is limited (max) to 150 and the number of toxic gas cylinder is limited to 15. The number of other gases is not limited. The distance between flammable and oxidizing gases must be at least 2 meters. It is recommended having explosive proof gas detection [25].
The electrical installations should be explosive proof if flammable gases are stored.

Each compartment should have a sprinkling system provided that water will not increase the risk.
In each compartment with aerosols the maximum quantities are limited to 60 % of the area [26].

Smoking and open flames are prohibited.

For aerosols the temperature should not be above 50 °C in the warehouse [27].

B.2.2 Storage outside of warehouses

The floor must be plain so that the cylinders cannot tumble and stand in a safe way.

Additionally there must be a safety area, where no other materials are stored, no vehicles are parked and are no traffic routes. The safe area must not contain other land or public routes.

Safety area for flammable or very toxic gases [28]

	Gases	
	lower than air	heavier than air
Height h (m)	1	0.5
Radius r (m)	1	1

The safety area can be limited only on two sides by walls (F30) of a height of at least 2 metres.

There must be safety distances to other buildings of at least 5 metres. These can be replaced by a wall (F30) with a height of at least 2 meters.

The gases must be shaded by a roof from the sunlight.

B.3 Special requirements for flammable substances

Based on the following regulations

European regulations	*94/63IEC*
German regulations	*ElexV* *VbF* *TRbF 20* *ZH 1/75.1*
U.S. regulations	*29CFR1926, §1926.307*

The warehouse where flammable substances are stored must be divided in certain zones depending on the explosive atmosphere.

Classification of zones:

Zone 0: areas in which dangerous explosive atmospheres of gases, vapours or sprays permanently exist or during long periods;
Zone 1: areas in which dangerous explosive atmospheres of gases, vapours or sprays are likely to occur occasionally;
Zone 2: areas in which dangerous explosive atmospheres of gases, vapours or sprays are likely to occur rarely and if so for short periods only [29].

Depending on the zone, which exists in the warehouse, there are different additional requirements for fire protection, construction of the building and ventilation. Normally in a warehouse where the goods are only stored, one will find zone 2.

Repacking and opening of the containments is strongly not recommended to take place inside the warehouse. However, in cases, in which this could not be avoided, ensure that special requirements for zone 1 have to be observed.

The electrical installation must be explosive proof, so that there is no source of ignition in the warehouse. This requirement is also valid for the vehicles used in the warehouse in respect of the different zones.

For fire fighting there must be a water sprinkling system. Additionally water hydrants must be placed in such way and number, to guarantee fire fighting and cooling of other buildings. For high storage in-rack sprinkler is recommended. Foam fire extinguishing system is also recommended.

The building must have a lightning conductor to prevent a fire of the building in case of a thunderstorm.

Warehouses with flammable substances must have a distance of 10 meters to other buildings if they don't have a fire wall, which is resistant for at least 90 minutes.

If there are larger quantities of flammable substances, the management of the warehouse must request for permission for quantity of storage from authorized agencies. The fire brigade must check the measures for protection against fire. There might be additional requirements. The maximum quantity in warehouses is limited to 150,000 litres [30].

Substances	Quantities when authorized agencies must be informed and give permission for storage
Flammable liquids with flash point below 23 °C in fragile packagings	More than 200 litres
Flammable liquids with flash point above 23 °C in fragile packagings	More than 1000 litres
Flammable liquids with flash point below 23 °C in other packagings	More than 1000 litres
Flammable liquids with flash point above 23 °C in other packagings	More than 5000 litres

The storage of combustible material like paper, cardboard, cellulose or empty packagings of these materials is forbidden.

The compartments or warehouses with flammable substances must have fire walls, which are resistant against a fire for 90 minutes provided that with sprinkling system. If there no sprinkling system the walls must be resistant for 180 minutes. The fire compartment walls must be at least 30 cm higher than the roof and the sides. The doors in the compartment walls must be fire doors. In case of emergency, the doors should be automatically closed interlocked with fire alarms.

The floor must be resistant against the chemicals.

The compartments and warehouses must be ventilated. The change of the air must be 5 times the volume of the room per hour. In normal compartments with only up to 1000 litres flammable liquids, it is sufficient to have a change of 2 times the volume per hour.

B.4 Special requirements for oxidizing material

Based on the following regulations

European regulations	
German regulations	*TRGS 515* *BGV B4* *ElexV*
U.S. regulations	

Avoid the use of wooden pallets. Oxidising material might ignite a fire if it gets in contact with wood. New empty packagings of combustible material and empty pallets must be stored in another compartment or warehouse. Combustible material must have at least a distance of 10 meters.

The building should only have one floor.
The walls must be fire walls (F 90). The roof must be resistant against flying sparks.
The walls must be one meter higher than the roof and hang over 0.5 meters to the sides.
The floor must consist of non-combustible material and resistant against the chemicals.

Effluent channels are forbidden.

In addition to the fire extinguishers there must be a water sprinkling system. Water hydrants must be placed outside of the warehouse with suitable hoses [(8 bar working pressure)]. The quantity of fire fighting water must be such that for each 100 m² of the warehouse there are at least 200 litres per minute with a pressure of at least 3 bars. This quantity must be ensured for 2 hours.
The nozzles of the water sprinkling system must be placed in such way that all the goods in stock will be reached. The nozzles must be placed in such way that they won't be damaged while handling the goods.

The warehouse must have a lightning conductor.
The floor must be of such a colour that any leakage can be discovered immediately. It must be resistant against the chemicals.

All packagings must be closed properly. A spillage must be captured properly in a way that no fire can arise. Filling or emptying of packagings is prohibited.

If the company wants to store more than 25 tons, they need the approval of an authorized agency. For the approval the following information must be given to an authorized agency:

- name and address of company
- number and kind of packagings and total quantity
- blueprint of warehouse
- blueprint of company
- blueprint of area with radius of 350 meters around the company

All vehicles used inside the warehouse must be insulated so that the heat of these vehicles won't be a source of ignition.

The fire brigade must have access to the warehouse from two sides.

Oxidising substances should not be stored together with the following substances:

- spontaneous combustible
- substances, which in contact with water, emit flammable gases
- organic peroxides
- gases
- flammable liquids (flash point below 61 °C)
- toxic substances (see more details in A.10.4.5)

The additional personal protective equipment must consist of escape mask, safety shower and eye shower.

B.5 Special requirements for toxic substances

Based on the following regulations

European regulations	
German regulations	*TRGS 514*
U.S. regulations	

Fire fighting must be possible from two sides. If the warehouse has a ground area of more than 1600 m², the fire brigade must have access from all sides.
The lighting (lamps) of the warehouse must be above the traffic ways and must be at least 0.5 meters above the goods.

The floor must be resistant against the chemicals. Spilled goods must be discovered immediately.

Toxic substances must be separated from (in other buildings or other compartments)

- spontaneous combustible substances
- substances, which in contact with water, emit flammable gases
- organic peroxides
- oxidising agents
- gases (storage class 2 A)
- combustible material like paper, cardboard or empty packagings

There must be safety distances to other goods. The distance must be 5 meters to non-combustible goods and 10 meters to other goods.

Different toxic substances and other substances can only be stored in one compartment, if they have the same fire extinguishing material.

The building should only have one floor.
The walls must be fire walls (F 90). The roof must be resistant against flying sparks.
The walls must be one meter higher than the roof and hang over 0.5 meters to the sides.
The floor must consist of non-combustible material and resistant against the chemicals. Effluent channels are forbidden.

The warehouse must have an automatic fire alarm system.
For warehouses with a size of 50 m², there must be two 12 kg fire extinguishers (ABC-powder). For each further 100 m² there must be an additional 12 kg fire extinguisher (ABC-powder). For warehouses with a size of more than 2000 m², there must be a mobile fire extinguisher of 50 kg (ABC-powder).

Additionally to the fire extinguishers there must be a water sprinkling system. Water hydrants must be placed outside the warehouse with suitable hoses (8 bar working pressure). The quantity of fire fighting water must be that for each 100 m² of the warehouse there are at least 200 litres per minute with a pressure of at least 3 bars. This quantity must be ensured for 2 hours. The hoses must have a diameter of at least 50 mm [31].
The nozzles of the water sprinkling system must be placed in such way that all the goods in stock will be reached. The nozzles must be placed in such way that they won't be damaged while handling the goods.
The warehouses must have a lightning conductor. The use of fire or open flames is prohibited.

B.6 Special requirements for corrosive material

Based on the following regulations

European regulations	
German regulations	*ZH 1/229*
U.S. regulations	

The floors must be resistant against the chemicals.
The warehouse must be well ventilated.

The employees should have personal protective equipment, which is resistant to a certain extent against corrosives.

B.7 Special requirements for substances with impact on the environment

Based on the following regulations

European regulations	
German regulations	*ZH 1/229*
U.S. regulations	

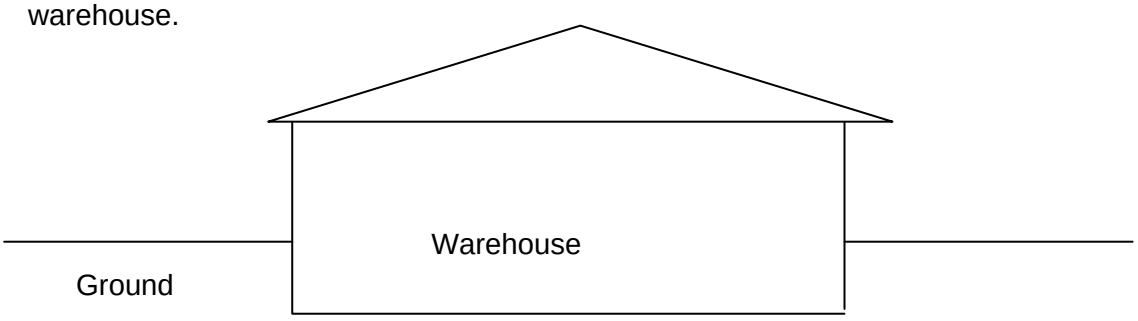
Substances with an impact on the environment are especially substances which are water pollutant. These properties compromises class 9, UN-number 3077 and 3082 and substances which are assigned to risk phrases 50, 51, 52, 53 and 58.

Substances, which have an impact on the environment, must be stored in warehouse where liquids cannot run outside.

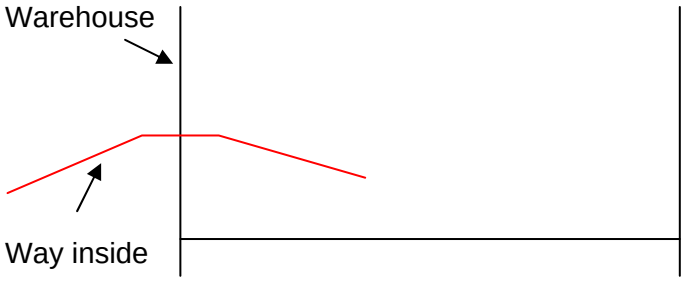
There are two opportunities:

1. This can be achieved with a floor that is lower than the ground. The difference of the height to the ground depends on the quantity of the substances and the size of the warehouse.

   The capacity must be of that size that the half of the quantity can be captured inside the warehouse.



2. The other opportunity is to have ramps at the warehouse, so that the liquid can not flow outside.



The floor of the warehouse and the walls must be coated, so that the liquid can't get through the floor.

C. Additional requirements for the storage of goods in tanks (only partly applicable for tank farms)

Based on the following regulations

European regulations	
German regulations	*WHG* *VAwS* *VbF* *TRbF 20*
U.S. regulations	*40CFR280* *40CFR282*

The following remarks and recommendations are focusing on vertical tanks only because the international regulations do not distinguish between various kinds of tanks available.
Due to the fact that this guideline is only considering packaged dangerous goods and dangerous substances and in Bangpoo Industrial Estate are some companies which have small storage tanks, this part should give some general information about tank storage. For tank farms there are more details which have to be observed.

Storage tanks are a critical part of bulk blending plant operation. They may be used to store base blending components, solvents, additives, acids, caustic, chemicals, or finished products. In addition, they are often used as blending vessels. Storage tanks are expensive to build and they require periodic maintenance to keep them in proper operating condition. For all these reasons, it is important that they are properly sized and utilized to maximize the return on investment.

The design of the tank must be in accordance with the international safety standard and has to consider in particular the material for the shell, its' reaction with the goods to be stored, material coating, as well as the physical and chemical process during the storage period. In case of refill of the tank with another product/substances previously stored a comprehensive check about the design, the fittings, and other safety devices is necessary especially in regard of its' compliance with a new product/substances stored.

The method used for the analysis varies with the intended function of each storage tank.

- Tanks to be used for the storage of raw materials are sized based on the projected daily consumption of the materials to be stored, the receipt parcel size, and the reliability of the supply. The calculation for sizes of each tank to receive the anticipated parcel size, plus sufficient capacity to operate for fixed number of days without going empty.
- Tanks, which will be used to store finished products, can be split into two categories; dedicated and swing. Dedicated tanks are used for finished products, which are packaged or shipped in high frequency, where continuous supply is needed. Since each dedicated tank is used for only one product, a small amount of batch-to-batch residue is normally not a problem. For this reason dedicated tanks are typically designed with flat bottoms. Swing tanks are used for multiple products that are packaged or shipped in lower frequency. Therefore batch-to-batch cross-contamination can be an issue, so swing tanks are typically emptied completely between batches. To accommodate this requirement, they are normally designed with cone or dish bottoms. In both cases (Dedicated or Swing), the size of the tank is based on the size of the finished product batches that it will receive and store.

Typically a range of sizes is used in a tank farm to accommodate a variety of different batch sizes.

Once the tank capacities are determined, the next step is to determine tank diameters. For practical, as well as aesthetic reasons, it is recommended to build tanks of similar heights. Tanks of same height permit easier and less expensive construction of access platforms and catwalks. They are also more efficient in operating, since the operator can move from the top of one tank to another more easily. For this reason, tank heights tend to be standardized in a tank farm and tank diameters differ in their capacity.

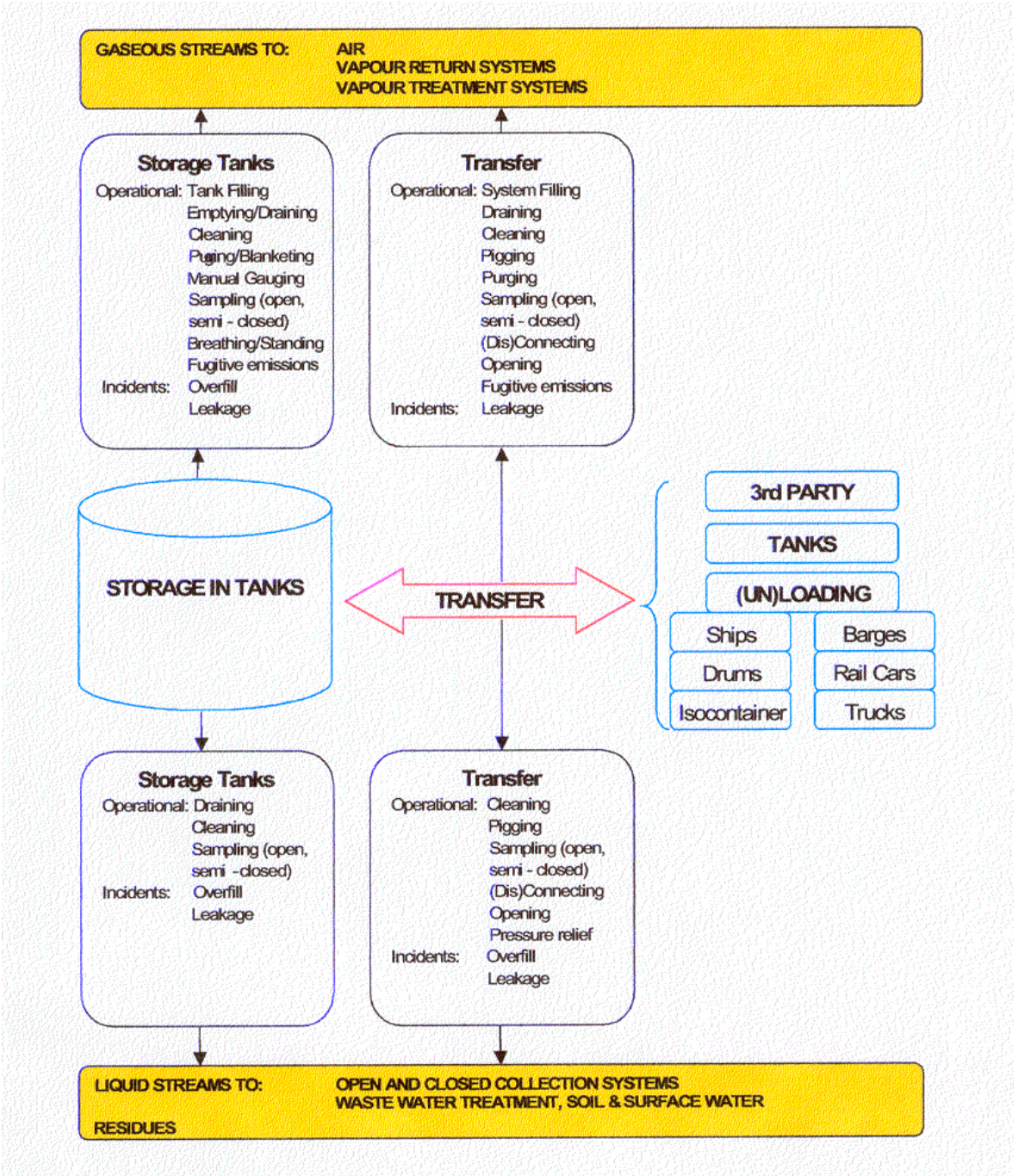
Tank-to-tank separation is important for operations, piping design, and maintenance access. In addition, there are minimum separations that may be required to meet local fire codes and other regulations. Minimum tank separations can differ, depending on the material to be stored in the tank and capacity of the tank.

The drawing on the next page shows the process of tank storage.

On the right side there are the different modes of transport which deliver the goods which should be stored in the tanks. The transfer will be the filling of the tank. There are the operational tasks like filling, draining, sample taking, pigging and purging. For the transfer process there will be one stream of the liquids in the tank and one stream of the vapours out of the tank. For the next step the product will stay in the tank. There might be some sample taking. The next step will be the transfer out of the tank.

From the top to the bottom the drawing starts with the filling and finishes with the emptying of the tank and the various operations which are carried out.

For all activities there is the risk of an overfill or a leakage.


GASEOUS STREAMS TO:
AIR
VAPOUR RETURN SYSTEMS
VAPOUR TREATMENT SYSTEMS
Storage Tanks
Operational: Tank Filling
Emptying/Draining
Cleaning
Purging/Blanketing
Manual Gauging
Sampling (open, semi - closed)
Breathing/Standing
Fugitive emissions
Incidents: Overfill
Leakage
Transfer
Operational: System Filling
Draining
Cleaning
Pigging
Purging
Sampling (open, semi - closed)
(Dis)Connecting
Opening
Fugitive emissions
Incidents: Leakage
STORAGE IN TANKS
TRANSFER
3rd PARTY
TANKS
(UN)LOADING
Ships
Barges
Drums
Rail Cars
Isocontainer
Trucks
Storage Tanks
Operational: Draining
Cleaning
Sampling (open, semi - closed)
Incidents: Overfill
Leakage
Transfer
Operational: Cleaning
Pigging
Sampling (open, semi - closed)
(Dis)Connecting
Opening
Pressure relief
Incidents: Overfill
Leakage
LIQUID STREAMS TO:
OPEN AND CLOSED COLLECTION SYSTEMS
WASTE WATER TREATMENT, SOIL & SURFACE WATER
RESIDUES

C.1 Equipment and kind of storage tanks

The following equipment may be installed on a storage tank, depending on the mode for which it is designed: vents, access hatches (opening or inspection entrances), gauge-float wells, gauge-hatches/sample wells, rim vents, roof drains, roof legs, guide pole wells, and vacuum breakers. These fittings accommodate structural support members or allow operational functions. They can be a source of emissions to air because they require penetrations in the roof.

Fittings for both, internal and external floating roofs are: access hatches, guide- pole wells, roof legs, vacuum breakers, and automatic gauge float wells. Other fittings used on internal floating roof tanks include column wells, ladder wells and stub drains.
The material of the tank and its equipment must be suitable for the chemicals. That means the chemical should not have an impact on the material like corrosion of acid to steel.

C.1.1 External floating roof tanks

Floating roof tanks can be fitted with automatic bleeder vents (also called vacuum breaker) to release air and vapour collected under the floating roof during initial filling. Normally they open automatically before the roof lands on its legs, thus stopping vacuum conditions arising, but under normal circumstances these vents are closed. The size of the bleeder vent/vacuum breaker is based on the product (and hence vapour) flow rate when filling the tank. It is important to have the bleeder vent pipe supports, which open the vent valve, designed in a similar way to the roof support legs i.e. to have an operational and a maintenance setting. The change of roof support leg adjustment always includes a similar change to the bleeder vent support setting.
The rim seal vent is required for seals that have a 'vapour space' under the primary rim seal, for example the vapour mounted seals and the mechanical shoe type seals. The liquid mounted, typical soft/tube type seals do not require a rim vent. The main function of the rim vent(s) is to allow pockets of vapour, which become pressurized, to escape from under the rim seal to the atmosphere. The gas/vapour pockets can form under the floating roof deck and then normally find their way into the rim space. Over-pressure inside the rim space may damage the rim seal material and reduce the efficiency of the seal.

C.1.2 Fixed roof tanks

Pressure Vacuum Relief Valves (PVRV) or vents prevent excessive pressure build-up and vacuum valves prevent the tank collapsing due to a negative pressure in the tank. These functions may be combined in a pressure-vacuum valve (breather valve).

Storage tanks operated without pressure are equipped with air vent valves (free vented tank). The air vent valves are designed so that at the highest volume flow of the pumps and temperature fluctuations in the tank, no dangerous under- or overpressure can be build up. The air vent valves cannot be closed.

C.1.3 Gauging and sampling hatches (for operational control purposes)

Products are usually dipped or ullaged from a gauging or still well. The gauge measures parameters such as: height, mass, temperature, density and/or pressure. To prevent emissions into the air, the gauge or still well is closed with a lid during normal circumstances. Self-closing foot-operated hatches, which are vapour tight, are common practice. Automatic gauging is possible and has the advantage over manual dipping, which allows determination of the quantity of liquid without opening the tank.

Dipsticks are potential sources of ignition, which may produce frictional heating, sparking or static electricity. Normally they are made of non-sparking alloys and are grounded. Dip tapes may be an alternative to measure depth.

Access to the roof itself during operation is not recommended without breathing apparatus and assistance.

C.1.4 Level devices

Level devices are tools to indicate the degree of filling as well as to ensure that no over filling will occur.

A fill level indicator should give information about the degree of filling of the tank. It is a technical device, which measures the height of the liquid inside the tank. So the tank needn't be opened and nobody can get into contact with the substances or inhale the vapours of the liquid.

Never use round bars to check the height of filling in the tank. The round bar is contaminated with the substance and might pollute the chemical in the tank.

C.1.4.1 Design aspects

At least one still well is recommended. If two are used, (one for automatic level gauge, one for manual dipping) they are normally adjacent and fixed to the tank (preferably to the floor) in the same way. If manual and automatic gauging is done from the same still well, then a method of winding the automatic gauge out of the way is necessary to allow for safe sampling and gauging and to minimise the probability of spillage.

C.1.4.2 Operational aspects

During filling procedures, it is generally insufficient to control and record only the filling level. Because there is a danger of overfilling and consequent soil and water pollution, storage tanks are normally equipped with overfill protection which can interrupt filling procedures before the maximum authorized level of liquid is reached. Where the filling procedure is not done automatically, but manually, the tank is normally equipped with an alarm to indicate when the maximum authorized level of liquid is reached. When the alarm signal starts, personnel can stop the filling procedure in time.

C.1.5 Instrumentation

Local or remote instrumentation should be in accordance with appropriate standards.

C.1.6 Flame arrester

As protection from fire and explosion, all openings of the tanks, through which flames can enter, are normally equipped with flame arresters. They are often a technical modification of air vent valves or under-pressure/overpressure valves.

C.1.7 Access hatches

For aboveground vertical tanks, access hatches at the base of the tank should be provided to allow access during a shutdown of the tank and to fulfill gas freeing of the tank. This is also the route where any solids left in the tank are removed during cleaning operations. Tanks greater than 25 meters diameter, requires at least two access hatches.

C.1.8 Drains

Two drain systems are required. The first is to provide drainage for the roof to cater for rain-water. The water is drained via an internal articulated pipe or flexible hose with a valve at the end, at the base of the tank. A non-return valve near the roof end is recommended to prevent any leakage into the drain from the product reaching the roof and evaporating. Normally the roof drain at the base is closed to prevent any product leakage. However, this must be complemented by a programme of regular draining, particularly after rainstorms; otherwise there is a potential serious risk of sinking the roof and causing substantial emissions.
The second type of drain allows draining of water that accumulates at the base of the tank. This is best achieved by an internal water draw-off sump and line leading to an external, valve outlet. In the case of flammable liquids it is common practice to blank off the valves when not in use.

C.1.9 Mixers

Crude tanks are normally fitted with mixers to facilitate sludge removal and to prevent the accumulation of solids in the base of the tank. They should be capable of being maintained without the need to shut down the tank. Consideration should be given to installation of warning devices to indicate failures of bearings or mechanical seals, especially where operation is unattended for long periods. This will ensure that action can be taken quickly in case a problem occurs, which could escalate into a safety or environmental incident.

C.1.10 Heating Systems

For the heating of the products stored in tanks (e.g. to ease pumping for reasons of viscosity), pipe-work is installed inside the tank where steam, heated water or heated oil is pumped for heat exchange.

Normally the outlet pipe is located above the heating coil or element to prevent exposure of any internal heated surface or any temperature control sensor. An alternative is to fit a low liquid level alarm linked to a heater cut-out or an alarm to identify important changes. In any case, a heating system can be equipped with different levels of instrumentation, depending on product specifications and operational requirements.

The temperature and/or the pressure of media stored are monitored when it is necessary because of operating conditions or characteristics of the substances, e. g. with heated tanks or if cover-gas technique is required.

C.1.11 Sealing/gasket elements

Connections and seals of pumps, fittings and pipes (sealing elements) are mounted and installed in a way that during operation they are technically impervious towards the surrounding atmosphere and the seal is not forced out of place.

In selecting an appropriate sealing technique and raw materials, the following should be considered:

- characteristics of the substance (R-phrases)
- the mechanical, thermal and chemical demands
- the stability towards the medium to be transported.

For installations with a high potential for environmental pollution, flanges with tongue and groove or with projection and recess, or special seals such as those with metal or grooved seals, are common practice.

C.2 Labelling and marking of tanks

Tanks must be marked with the chemical name of the contents and be labelled with the enlarged symbol. This might be the symbol for transport or for work places.

Additional information can be affixed on the tank.

C.3 Inspection of tanks

It is common practice to use time-based inspection intervals, related to the stored product (aggressive or non-aggressive) and sometimes also to the geographic location and climate. An international trend is evident towards the replacement of time-based by condition-based inspection. For the latter to be successful it is necessary that comprehensive, accurate, up-to-date records be maintained, starting with the original design and erection data. This is essential for establishing and verifying corrosion rates, for deciding when a tank should be taken out of service for inspection and/or repair and for specifying repair methods and extent.

Inspection can be categorised as regular in-service inspection or as regular out-of-service inspection. An in-service inspection may be a simple, regular walk around the tank using a checklist. Out-of-service inspection is a detailed inspection of the complete tank structure using a standard.

The text below describes an example of a time-based inspection scheme. Tank wall internal inspection of individual (stand-alone) tanks not used for the storage of toxic or odorous K3 products (flammable liquids with a flashpoint of 55 °C or higher, but not above 100 °C) needs to be carried out at least every 15 years. However, due to the weather and other special circumstances (humidity, salinity and corrosivity) even more frequent tank-inspections are recommended. For groups of tanks (tank farms with the same chemicals), only every fourth tank needs to be inspected in accordance with the above-mentioned scheme for individual tanks. For the other tanks the period of 15 years can be extended to 20 years if no important failures are found. But if important failures are discovered, the other tanks in the group need to be inspected as soon as possible.

Individual tanks used for the storage of K1 (flammable liquids with flash point below 21 °C and vapour pressure less than 1 bar) and K2 (flammable liquids with flash point between 21 °C and 55 °C) products or for toxic or odorous K3 (flammable liquids with a flashpoint of 55 °C or higher, but not above 100 °C) products, need to be inspected internally at least every 10 years. For groups of tanks, again, only every fourth tank needs to be inspected every 10 years. For the other tanks in the group, the period of 10 years can be extended to 15 years if no important failures are found, otherwise they need to be inspected as soon as possible.

- External inspection is done by measuring the thickness of walls and fixed roofs of all the tanks, at least every 5 years.
- The minimum required thickness of the steel plates is 2 mm.
- Floating roof seals need to be inspected at least every six months. Regular seal checks and early repairs are recommended.
- Vents need to be externally inspected at least every year for opening, closing and sealing performance.
- Valves, steps, platforms and instruments, need to be inspected regularly (once a month) to ensure good performance.
- Earth wires have to be inspected once a month.
- In this case, a group of tanks is considered to be tanks situated close to each other that are constructed in the same way, store the same product and are used under the same conditions.
- Fire-systems need to be inspected at least every year. This includes tests whether the material is ready for immediate use.

C.3.1 Corrosion protection

Coating: Corrosion is one of the main reasons of equipment failure. It can occur internal and external on any exposed metal surface. Protection may be guaranteed by using paints or other coatings.
Internal corrosion may result from the accumulation of water inside the tank. Auxiliary means to remove such water may be necessary. Corrosion may occur unnoticed under thermal insulation or lagging. Corrosion under lagging has to be addressed as part of the planned preventive maintenance schedule for the tanks.
Cathodic protection is an option to prevent corrosion on the inside of above-ground tanks. Cathodic protection is achieved by placing sacrificial anodes in the tank, which are connected to an impressed current system or by using galvanic anodes in the tank. Internal cathodic protection is no longer used in the petroleum industry, due to corrosion inhibitors, which are found in most refined petroleum products.

C.4 Inspection of hoses and pipes

The hoses and pipes, which are used for filling the tanks or filling the mode of transport, need to be inspected before using them. Additionally, they should withstand a pressure test of 4 bar. This test has to be carried out once a year.

If the hoses and pipes are used for substances with a high pressure, the test pressure must be higher according to the substance.

Additionally the hoses and pipes must be checked visually to make sure that they are not damaged. If they are damaged, they have to be replaced immediately.

The material of the hoses and pipes must be suitable for the dangerous substance that means steel needs a special coating for corrosive substances.

C.5 Protection against overflow

The tanks must have sufficient capacity for the chemicals. Normally a fill level indicator shuts down the filling of the tank.

Sometimes a fill level indicator doesn't work properly. In that case the tanks might overflow. Normally these are large quantities of chemicals. A retention basin around the tank should be available where these quantities can be captured.

C.6 Protection in case of spillage

Spill containment is required for most tank farms, and normally consists of a concrete or earthen dike wall build around the perimeter of the tank farm. The required capacity of the dike wall can vary, but should be at least 110% of the capacity of the largest tank, plus some allowance for rainfall. The dike wall would be four inches higher than the height needed to contain 110% of the largest tank inside. The floor of the tank farm should be constructed of an impermeable substance to prevent any spilled material from leaching into the soil.

For small to medium sized tank farms, this requirement is typically met through the use of concrete or asphalt paving installed from dike wall to dike wall, and between all the tanks. To minimize tank-bottom corrosion from rain water which may be collected inside the containment area, tank foundations are typically designed to elevate the tanks above the floor of the tank farm.

Piping design in the tank farm depends on the intended location of the transfer pumps. If the pumps are located together on a "pump pad" or outside the dike area, then pump suction lines tend to be quite long.

[Blank page]

ANNEX I: ABBREVIATIONS AND GLOSARY

Absolute Pressure	Gauge pressure plus atmospheric pressure, abbreviated kPa (absolute).
Absorbent materials	A material designed to pick up and hold liquid hazardous material to prevent contamination spread. Binding agent to absorb spilled chemicals from the floor like sand, diatomaceous earth, acid binder, universal binder, sawdust. etc., which is suitable for the chemicals and does not react with them in a dangerous way
Access hatches	Type of door: a door cut into the tank. It is lifted to provide access to the area below or above it.
Acute dermal toxicity (LD_{50} in mg/kg)	Severe and of short duration the degree to which something is poisonous located in, or made up of skin or its main layer (dermis) LD_{50} in mg/kg means lethal dose for a fixed period where 50% of the experimental animals will die. It's measured in mg of the substance per kg weight of the experimental animal.
Acute inhalation toxicity (LC_{50} in mg/L)	Severe and of short duration the degree to which something is poisonous inhaled (dusts, vapour and gas) LC_{50} in mg/L means lethal dose for a fixed period where 50% of the experimental animals will die. It's measured in mg of the substance per L of volume of air.
Acute oral toxicity (LD_{50} in mg/kg)	Severe and of short duration the degree to which something is poisonous when it gets in the body through the mouth in the body LD_{50} in mg/kg means lethal dose for a fixed period where 50% of the experimental animals will die. It's measured in mg of the substance per kg weight of the experimental animal.
ADR	Regulations for the transport of dangerous goods by road (Accord d'european de transport internationaux de merchandises dangereuses par route)
ArbStättV	Regulations for workplaces (Arbeitsstättenverordnung)
ASR	Regulations for work places (Arbeitsstättenrichtlinie)
Binding agent	Material to absorb spilled chemicals from the floor like sand, diatomaceous earth, acid binder, universal binder, sawdust. etc., which is suitable for the chemicals and does not react with

	them in a dangerous way
Biodegradability	Able to decompose naturally, substances that will decay relatively quickly as a result of the action of bacteria and break down into elements such as carbon that are recycled naturally
Boiling point	The temperature at which a liquid changes to a vapour state, at a given pressure; usually expressed in degrees Celsius at sea level pressure (760 mm Hg, or one atmosphere). For mixtures, the initial boiling point or the boiling range may be given. Flammable materials with low boiling points generally present extreme fire hazards.
Bunded area	An area where catch basins or sealing measures are used to prevent liquids from running away in the environment (pollution).
CAS number	Chemical abstract service number A number given by the American Chemical Society to identify a chemical
CEFIC	European Chemical Industry (Conceil European Federation Industrie Chemique)
Daphnia toxicity (LC_{50} in mg/L)	Degree to which something is poisonous to Daphnia (water flea: a tiny freshwater flea with a transparent shell and branched antennae for swimming. LC_{50} in mg/L means lethal dose for a fixed period where 50% of the experimental animals will die. It's measured in mg of the substance per L of volume of water.
Deflagration	Burning which takes place at a speed below the speed of sound.
Dermal Toxicity	Adverse effects resulting from skin exposure to a substance.
Detection system	A technical system to detect either gases, smoke or heat
Detonation	An extremely rapid reaction that generates a wave which passes along the body of an explosive, instantaneously producing a violently disruptive effect.
Developmental toxicity and	Damage of the potential of human beings to get children or to cause malformation of children

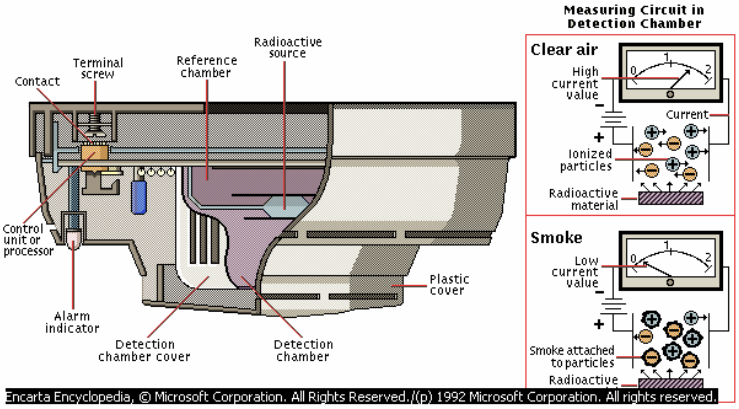
fertility	
Diatomaceous earth	Powdered rock used as nontoxic insecticide: a form of unrefined diatomite that is used as an insecticide. It is used indoors as an alternative to chemical insecticides because it is virtually nontoxic to humans, although it can be a lung irritant if inhaled. For some chemicals it can also be used as binding agent.
Distraction	Desorption: chemically releasing something: the action or process of releasing an absorbed substance from something, for example, gas from rocks
Dustiness	The state of being covered with or containing dust.
EEC	European Economics Community
EC	European Community
EINECS	European Inventory of Existing Chemical Substances
EN	European Norm
Environmental compartment	Parts of the environment like earth, rock, sand, water, air etc.
EWG	European Economics Community
Explosive Limits	All concentrations of a mixture of flammable vapour or gas in air, usually expressed in percent by volume, in which a flash will occur or a flame will travel if the mixture is ignited. (Also known as 'flammable limits').
F30	Fire wall which withstands a fire of 30 minutes.

Flame arrester	Technical device that arrests flames. It stops the flames to get into the tank through the opening 
Fish toxicity (LC_{50} in mg/L)	Degree to which something is poisonous to fish. LC_{50} in mg/L means lethal dose for a fixed period where 50% of the experimental animals will die. It's measured in mg of the substance per L of volume of water.
Form	Appearance of a chemical which might be solid, liquid, gaseous, pasty or viscous
Fire door	Door confining a fire: a fireproof door that is normally kept closed or locked, ensuring that any fire is confined to one area.
Fire walls	Building wall preventing the spread of fire and resistant against fire damage for a certain period of time. A fireproof wall put in place to ensure that if a fire occurs it is confined to one area. Fireproof construction of the walls and prevent the spread of fire. A fire wall consists of nonburning components, such as steel, terra-cotta, plaster, and concrete.
Flash point	The lowest temperature at which a liquid substance gives off flammable vapours sufficient to form an ignitable mixture with air near the surface of the liquid. Combustion is not continuous at the flash point. There are several flash point test methods, and flash points may vary for the same material depending on the method used, so the test method is indicated.
Gauge-float wells	Hole made to draw up gauge.

Gauge pressure	The pressure read on a gauge, which does not take atmospheric pressure into account.
GefStoffV	Regulations for dangerous substances (Gefahrstoffverordnung)
Global warming potential	The potential of the chemicals to contribute to increase the average temperature on earth.
Hazard symbols	Symbols for work place labels to identify the hazard of the product
Ignition sources	Any source which starts the process of igniting; the process of setting something on fire. These can be hot surfaces, electrical installations or engines.
Ignition temperature	The minimum temperature to which a substance must be heated in order to initiate self sustained combustion (burning).
IMDG-Code	International Maritime Dangerous Goods Code
Incompatible	Materials which could cause dangerous reactions from direct contact with one another are described as "incompatible."
IUPAC Nomenclature	International Union of Pure and Applied Chemistry Nomenclature of Organic Chemistry
K_{ow}	Distribution (partition) coefficient in a mixture with Octanol and water.
LC	Lethal Concentration. A concentration of a substance that will kill an animal upon inhalation.
LC_{50}	Lethal Concentration 50%. The concentration of a material in air, which, on the basis of laboratory tests, is expected to kill 50% of a group of test animals when administered as a single exposure (usually one to four hours). The LC_{50} is expressed as parts of material per million parts of air (ppm), by volume for gases and vapours, or as micrograms of material per litre of air (mg/l), or milligrams of material per cubic meter of air (mg/m) for dusts, mists, gases and vapours.

LD	Lethal Dose. A concentration of a substance which will kill an animal by ingestion or skin contact.
LD_{50}	Lethal Dose 50%. A single dose of a material, which, on the basis of laboratory tests, is expected to kill 50% of a group of test animals. The LD50 is expressed as milligrams or grams, or material per kilogram of animal body weight (mg/kg or g/kg).
Material Safety Data Sheets (MSDS)	Documentation provided by manufacturers and compounders of chemicals, mixtures and preparations with minimum information about chemical composition, physical and chemical properties, health and safety hazards, emergency response, and waste disposal.
Melting point	The temperature at which a solid substance changes to a liquid state. For mixtures, the melting "range" may be given.
MIndBauRl	Regulation for the construction of industrial buildings (Muster Industriebau Richtlinie)
Mixed storage	Mixed storage in this content means the storage of two or more classes without any other additional infrastructure, operational and technical measures for segregation.
Octanol water partition coefficient (log P_{OW})	Concentration ratio between solvents: the ratio of the concentrations of a substance dissolved in two immiscible solvents at equilibrium here with water and octanol.
Ozone depletion potential	Potential to destroy the ozone layer in the sky.
Packing group	Grouping of dangerous goods according their risk potential. Each class has own criteria for assigning to packing group. There are three groups: Packing group I: high risk Packing group II: medium risk Packing group III: minor risk
Penetration	The movement of a material through a suit's closures, such as zippers, buttonholes, seams, flaps or other design features of chemical protective clothing, and through punctures, cuts and tears (entering or passing through).

Personal protective equipment	The equipment provided to shield or isolate a person from the chemical, physical and thermal hazards that may be encountered at a hazardous materials incident. Adequate personal protective equipment should protect the respiratory system, skin, eyes, face, hands, feet, head, body and hearing. Personal protective equipment includes both personal protective clothing and respiratory protection.
pH-value	Indication of the acidity or alkalinity of a substance. A *p*H from 1 to 7 is acidic and from 7 to 14, alkaline. A *p*H of 7 is neutral. Technically, *p*H is the logarithm of the reciprocal of the concentration of hydrogen ions in solution. Term indicating the hydrogen ion (positively charged hydrogen atom) concentration of a solution, a measure of the solution's acidity. Hydrogen ions are usually represented by the symbol H+. The term (from French pouvoir hydrogène, "hydrogen power") is defined as the negative logarithm of the concentration of H+ ions: pH = -log10[H+], where [H+] is the concentration of H+ ions in moles per liter (see Mole). Because H+ ions associate with water molecules to form hydronium (H3O+) ions, pH also is often expressed in terms of the concentration of hydronium ions.
Preparations	Mixture of substances which is made for a particular purpose by combining various ingredients.
Proper shipping name	A chemical name or a name that prescribes the properties of the dangerous goods.
Purging	Getting rid of the rests in the hoses, pipelines or tanks by using cleaning agent.
R-phrase	Risk phrase
Rim vents	Vent on the outer edge of a circular tank.
Sample wells	A hole made to draw up fluids: a hole or shaft that is dug or drilled into the ground of the tank in order to obtain a sample of the dangerous substance.

Smoke detector	 Smoke detectors sense the early stages of fire and sound a warning so that the employees of a building may safely escape. They detect smoke and sometimes heat in a variety of ways, in this case by using a detection chamber filled with ionized air. Rays from a radioactive source ionize the atoms of air in the chamber. The charged particles carry current between the top and bottom plates of the detection chamber, which act as electrodes. Smoke entering the chamber attracts the charged particles so that the amount of current passing between the electrodes is reduced (shown on right). When a drop in current is recorded, a message is sent to the control unit, which activates the alarm.
Solubility in water	capacity to dissolve: the extent to which one substance is able to dissolve in water and measure of capacity to dissolve: a measure of one substance's ability to dissolve in a specific amount of water at standard temperature and pressure
S-phrase	Safety phrase
SprengL	Regulations for explosive substances (Sprengstoffrichtline)
Substances	A particular kind of matter or material.
Suffocation	Stop breathing: to deprive somebody of air or prevent somebody from breathing, or to be unable to breathe.
Tank farm	A site with several large storage tanks.
TRB	Regulation for Cylinders and other packagings for gases (Technische Regel Behälter)

TRbF	Regulations for flammable liquids (Technische Regel brennbare Flüssigkeiten)
TRG	Regulations for gases (Technische Regeln Gase)
TRGS	Regulations for dangerous substances (Technische Regel gefährliche Stoffe)
Universal binder	A chemical binder which can absorb many kinds of chemicals. The information of the manufacturer must be observed for which chemicals the binder is suitable.
UN-number	A number of four digits which is place by the UN for dangerous goods. There are four kinds of UN-numbers a) single entries for well-defined substances and articles b) generic entries for well-defined substances and articles c) specific n.o.s. (not otherwise specified) entries covering a group of substances or articles of a particular chemical or technical nature d) general n.o.s. (not otherwise specified) entries covering a group of substances or articles meeting the criteria of one or more classes.
Vacuum breaker	A technical device to avoid vacuums (a space with all the gas removed).
Vapour pressure	Pressure created by the vapour, or gas, of a substance that forms above a liquid or solid of the same substance. All liquids, and even some solids, vaporize continuously. The term vapour pressure usually refers to equilibrium vapour pressure, or the pressure at which the rate that particles (atoms or molecules) leave the substance to form vapour equals the rate that particles re-enter the substance from the vapour. Vapour pressure depends only on the temperature and the type of substance. Scientists usually measure vapour pressure in units of atmospheres (atm), millimetres of mercury (mm Hg), or torr. At 20° C (68° F), water has a vapour pressure of 0.023 atm (17.5 mm Hg). Isopropyl alcohol (rubbing alcohol) has a vapour pressure of 0.043 atm (33 mm Hg) at 20° C. Materials with a higher vapour pressure release more vapour particles and therefore evaporate more quickly than materials with low vapour pressure. A puddle of isopropyl alcohol will disappear more quickly than a water puddle of the same size because the alcohol has a higher vapour pressure than water.

VCI	German Chemical Industry (Verband der Chemischen Industrie)
Vents	An opening for air: a small opening that allows fresh air to enter or stale air, gas, smoke, or steam to escape.
Viscosity	The flow resistance of a liquid. This characteristic increases and decreases with the temperature of the liquid. Low-viscosity liquids have little adhesive qualities and hence flow freely.
WHG	Regulation for water protection (Wasserhaushaltsgesetz)

ANNEX II: REFERENCE TO REGULATIONS

[1]	TRGS 514 3.18 und 3.1.9
[2]	MIndBauRl section 6.1
[3]	IndBauR section 1 and MIndBauR section 6.2
[4]	MIndBauRl section 6.1
[5]	MIndBauRl section 5.3
[6]	Thai regulation
[7]	Practice of chemical industry
[8]	IndBauR section 1 and MIndBauR section 6.2
[9]	ZH 1/201 section 4.4
[10]	ZH 1/201 section 4.5
[11]	Technical guidelines for fire fighting
[12]	MIndBauRl section 5.1
[13]	DIN 14011 and DIN 14811-1
[14]	LöRüRl section 5.3.6 table 2
[15]	12.BImSchV annex III
[16]	49CFR174
[17]	GefStoffV, TRGS 514 und LöRüRl
[18]	ZH 1/600 and VBG 100
[19]	ZH 1/600.26 annex I
[20]	Annex VI of GefStoffV
[21]	SprengLR 210 section 5
[22]	SprengLR 360 section 5
[23]	TRG 280 section 5.2.5

[24]	TRG 280 section 5.1.7
[25]	TRG 280 section 5.2.8
[26]	TRG 300 section 6.2.3
[27]	TRG 300 section 6.1.1.
[28]	TRG 280 section 5.3
[29]	ElexV and VbF annex II
[30]	ZH 1/75.1 § 8
[31]	TRGS 514 section 3.3.6