

DECISION No. 60/2002/QD-BKHCMNT OF AUGUST 7, 2002 PROMULGATING THE
TECHNICAL GUIDANCE ON BURIAL OF HAZARDOUS WASTES

THE MINISTER OF SCIENCE, TECHNOLOGY AND ENVIRONMENT

Pursuant to the 1993 Law on Environmental Protection;

Pursuant to the Government's Decree No. 22/CP of May 22, 1993 defining the tasks, powers and
organizational apparatus of the Ministry of Science, Technology and Environment;

Pursuant to the Prime Minister's Decision No. 155/1999/QD-TTg of July 16, 1999 promulgating the
Regulation on Management of Hazardous Wastes;

After reaching agreement with the Ministry of Construction;

At the proposal of the director of the Environment Department,

DECIDES:

Article 1.- To promulgate together with this Decision the Technical Guidance on Burial of Hazardous
Wastes.

Article 2.- This Decision takes effect 15 days after its signing.

Article 3.- The ministries, branches, People's Committees of the provinces and centrally-run cities and
concerned organizations as well as individuals shall have to implement this Decision.

For the Minister of Science, Technology and Environment
Vice Minister
PHAM KHOI NGUYEN

TECHNICAL GUIDANCE ON BURIAL OF HAZARDOUS WASTES

(Issued together with Decision No. 60/2002/QD-BKHCMNT of the Minister of Science, Technology
and Environment of August 7, 2002)

Part 1

GENERAL INTRODUCTION

1.1. General introduction of the guiding document

Performing its functions and tasks defined in the Government's Decree No.22/CP of May 22, 1993 on
the tasks, powers and organizational apparatus of the Ministry of Science, Technology and
Environment;

In order to satisfy the current urgent demand for designing, construction and operation of hazardous
waste burial sites aiming to limit pollution and protect the environment,

The Ministry of Science, Technology and Environment hereby promulgates the technical guidance on
burial of hazardous wastes, which comprises six parts as follows:

Part 1. General introduction

Part 2. Kinds of hazardous wastes which are not allowed for direct burial into the hazardous waste burial sites.

Part 3. Location selection, designing and construction of hazardous waste burial sites.

Part 4. Operation and observation.

Part 5. The stage of closure and post-closure of hazardous waste burial sites.

Part 6. Contents needed for the implementation of projects on hazardous waste burial sites

This guidance provides the principles; methodology and minimum norms with a view to preventing and minimizing the harms caused by hazardous wastes to the community health and environment; provides overall and flexible approaches to hygienic hazardous waste burial sites according to the technical requirements prescribed in this guidance for application to each specific geographical area of the localities.

1.2. General situation on hazardous waste management system

1.2.1. Management of hazardous wastes:

All stages of the above-mentioned system of hazardous waste management is shown in Figure 1

1.2.2. Adverse impacts on the environment, caused by hazardous waste burial sites (HWBS)

This guiding document largely touches upon Stage 5, the stage of discarding the wastes, more specifically discarding dregs from various treatment processes by the method of burial.

The HWBS's adverse impacts on the environment include:

- Poisonous gases and stinking smells emitting into the environment.
- Dust dispersed in the course of transportation and burial of hazardous wastes into the burial sites.
- Pollution of soil, surface water and underground water due to leakage of garbage water.
- The possibility of direct contacts of workers working at the burial sites.
- Pollution of the environment, laborers in the burial site areas.
- Impacts on environmental landscapes, society.

Particularly, extreme importance should be attached to the study of the potential impacts on community health and environment in order to minimize the danger of leakage of hazardous matters right from the stage of location selection to the stage of designing, construction, operation and closure of burial sites.

Part 2

HAZARDOUS WASTES NOT ALLOWED FOR DIRECT BURIAL INTO HAZARDOUS WASTE BURIAL SITES

Guidance 1 for Part 2:

The hazardous wastes which are allowed to be buried in HWBSs are prescribed in the Regulation on Management of Hazardous Wastes (issued together with Decision No.155/1999/QĐ-TTg of July 16, 1999 of the Prime Minister).

The following wastes are banned from direct burial in the burial sites:

? Liquid solutions or materials.

? Empty packages except when they are pressed, cut to pieces or treated by similar measures to reduce their volumes.

? Explosion-prone substances, flammable solid substances, matters prone to reaction with water, oxidized matters and organic peroxide.

The above-mentioned liquid wastes can be buried only when

? Measures to eliminate the liquid matters from the wastes are applied or the method of solidifying the liquid is used.

? For flammable, explodable wastes, matters which can instantly catch fire or are prone to reaction to water, oxidized matters of organic peroxide, their names and prescribed standards already listed in Vietnam's system of hazardous wastes classification, or in Appendix 1 to Basel Convention (corresponding to waste types coded internationally H1, H3, H4.1, H4.3, H5.1, H5.2) should be consulted

Guidance 2 for Part 2:

? For wastes containing hazardous organic matters, particularly the halogenated organic matters, consideration should be made in order to determine the maximum concentration threshold allowed for direct burial.

? The definition and concentration thresholds of hazardous organic components in wastes regarded as hazardous ones shall be consulted in Vietnam's system of waste classification in the annex section of List A of the classification system, types A3 and A4.

Guidance 3 for Part 2:

- Not to dilute or mix hazardous wastes with other substances only for the purpose of achieving the limited concentration stated in Guidance 2 for Part 2.

- Before their burial, the hazardous wastes must be treated and/or stabilized by the most suitable verified techniques in order to minimize the possibility of leakage of pollutants into the environment or when the safety system of the burial sites is out of order. These managerial and technical solutions include:

+ Reduction of the volume of wastes at their sources through measures of modifying the production process;

+ Recovery, recycling and/or reuse of waste components;

+ Analysis of diluted solid by physio-chemical methods or de-contamination measures;

- + Treatment of organic compounds which are easy to decompose by biological methods;
- + Solidification, stabilization of liquid hazardous wastes into solid hazardous wastes or wastes which cause no reaction to surrounding environment;
- + Thermo-treatment in order to destroy organic wastes.

Recommendations mentioned in the system of hazardous waste classification should be used to select appropriate technological solutions to the treatment of various hazardous wastes. Detailed instructions on the application of these technologies can be consulted in the separate technical guidance on solidification, physio-chemical treatment, biological treatment or burning.

Guidance 4 for Part 2:

Hazardous wastes must be treated with the existing technologies suitable to each type of waste as well as to various burial stages.

Part 3

LOCATION SELECTION, DESIGNING AND CONSTRUCTION OF HAZARDOUS WASTE BURIAL SITES

3.1. Selection of locations for hazardous waste burial sites

3.3.1. Requirements on the selection of locations for hazardous waste burial sites

The selection of locations for hazardous waste burial sites should meet the following requirements:

- The burial locations must be determined on the basis of the construction planning already approved by competent State agencies.
- The burial sites must be large enough in acreage and capacity for burial of the hazardous waste volume arising in the future, possibly the best land area for a site can satisfy the requirement for burial of hazardous wastes for at least 15 - 20 years in the planning region.
- The burial sites must be characterized by appropriate natural conditions for limiting the adverse impacts on the environment in the course of site construction, operation and closure.
- When selecting locations for burial sites, attention should be paid to such elements as natural geography, topographical, hydro-geological, engineering-geological, cultural and social characteristics, local and State law provisions; community opinions; distance for transportation of wastes, historical relics, scenic places, tourist resorts.

Guidance for Clause 3.1.1:

In the course of selecting locations for burial of hazardous wastes, it is necessary to examine and take into account such elements as the land use planning, the size and operation duration of burial sites; geographical, geological, hydro-geological and engineering-geological characteristics; biological, socio-economic elements, the community opinions; waste transportation distance; the elements of landscapes, security and defense.

3.1.2. Selection of burial site models

There are different models for designing and construction of hazardous waste burial sites, possibly including:

- Above-ground burial sites are those built on earth surface in flat-terrain or light-slope areas, the wastes buried according to designs shall create positive terrain.
- Underground burial sites are those where hazardous wastes are buried under the ground surface.
- Above-ground-cum-underground burial sites means those built half underground and half above-ground. Hazardous wastes are buried not only in the underground holes but also above-ground and covered at the designed heights.

Each burial site model has its pluses and minuses, but the selection thereof must be based on the characteristics of each region. Upon the selection of appropriate burial site models, the following factors should be taken into account:

- The type and volume of the hazardous waste.
- Terrain.
- The land area of the permitted location.
- The strata and permeance of soil and rock.
- The depth and descent of the underground water level.
- The availability of rational raw materials.
- The capability to control the risk of waste leakage.
- Surrounding landscape.

Guidance for Clause 3.1.2:

There are now many different HWBS models (the above-ground burial sites, the underground burial sites, the above-ground-cum-underground burial sites). Upon the selection of any burial site model, all the following factors should be taken into account: type and volume of hazardous waste, terrain, the land area of the permitted location, the strata and permeance of soil and rock, the depth and descent of underground water level, the available raw materials, the capability to control the risk of waste leakage and the surrounding landscape.

3.1.3. Section of burial options

For each type of model, the following burial options can be selected:

- The burial compartment option:

The burial sites can be divided into different compartments to store hazardous wastes. The burial compartments may be in square of 1:1 size in length and width. Each compartment can be buried with wastes according to its designed capacity and wastes shall be buried in form of myriapod. The operation duration of each compartment, therefore, shall be shorter than the whole operation duration of the burial site.

- Burial ditch option:

Hazardous wastes shall be buried in ditches with their lengths being bigger than their widths; each ditch can be buried with a volume of waste according to the designed capacity. Unlike burial compartments, the burial ditches constantly develop with activities of opening ditches to dump wastes and closing ditches simultaneously when wastes are buried into ditches. The operation duration of a burial ditch is longer than that of a burial compartment, often lasting for months or for years. The length of a burial ditch is limited by the size of the burial site.

- Burial zone option:

A burial zone means a burial site with its entire existing land area fully developed. The burial zones also develop constantly with activities of opening, waste dumping and closing the burial zones. The burial zones develop along this direction till the entire land areas of the burial sites are used up.

The burial zone-developing option reveals its advantage that its utility area is made fuller use of than burial ditches and compartments, and also its disadvantages that it is more difficult to protect the environment in the process of operating the site and the initial investment is large.

The burial compartment and ditch options are advantageous in making initial investment but disadvantageous in making the fullest use of their land areas. Consequently, the selection and development of any appropriate option depend on the specific requirements of each burial site such as the daily volume of hazardous wastes, the natural conditions (weather, climate, terrain hydro-geology, engineering geology), the technical conditions for environmental protection and initial-investment capability?

Guidance for Clause 3.1.3:

The burial of hazardous wastes at sites can be carried out according to various options such as burial compartments, burial ditches and burial zones. The selection and development of any option shall depend on the specific requirements of each site and the technical conditions.

3.1.4. Scales and areas of burial sites

The scales and areas of HWBSs are determined on the following bases:

- The current and future volume of hazardous wastes.
- The reusability and treatment of hazardous wastes before they are buried.
- The land use planning.

The land area portion for construction of support works such as roads, dikes, storehouses, yards, workshops, water drainage and supply system, buffer zone- protecting belts and other support works often represents 15- 50% of the total acreage of a site.

Guidance for Clause 3.1.4:

The scales and land areas of HWBSs may vary but must ensure that the whole volume of hazardous wastes is fully buried in a given region or area according to the designed capacities. The determination of scale and land area of a HWBS should be based on the current and future volume of hazardous wastes, the reusability and treatment of hazardous wastes before they are discarded, and the land use planning.

3.1.5. Steps for selection of burial sites

The selection of hazardous-waste burial site locations is often carried out in four steps:

- Step 1:

To gather documents on climate, terrain, hydro-geology, engineering geology, infrastructure, as well as information related to the requirements of the hazardous waste burial sites such as types and volume of hazardous wastes at present and in the future; the operation duration of the burial sites; other regulations on the extent of survey on hazardous waste burial sites.

- Step 2:

To analyze relevant documents, consult the central and local plannings on land use, and study then propose a number of suitable locations. To examine relevant factors such as natural geography, hydrogeology, engineering geology, socio-economic situation which require the participation of concerned branches and opinions of the community.

- Step 3:

To conduct topographical, hydro-geological, engineering- geological and other surveys at locations proposed for selection.

- Step 4:

To analyze, evaluate and compare conditions and factors so as to make final decisions on selection of the optimum locations for hazardous waste burial sites.

Guidance for Clause 3.1.5:

The selection of locations for hazardous waste burial sites should abide by those steps from gathering documents to surveying the terrain, hydro-geology, engineering geology and making final decisions. The selected HWBS locations must ensure to the utmost the economic efficiency and safety for human health as well as the environment.

3.2. Designing and construction of HWBS

3.2.1. Examining the designs

Hazardous waste burial sites are the final destruction places; hence they must be designed according to the prescribed standards and in a way convenient for the inspection of all hazardous waste leakage into surrounding environment throughout the process of site operation, closure and post-closure.

At present there are two designing tendencies:

The first tendency is to ensure the environmental safety on the basis of using the natural conditions, namely to choose locations endowed with favorable natural conditions such as the topographical, hydro-geological and engineering geological characteristics, which can best limit the leakage and dispersement of wastes into the environment. So, the expenses for construction of sites shall be reduced and the maintenance of burial sites can be alleviated or eliminated.

The second tendency is to use "prefab burial compartments", meaning to use technical and/or technological measures for construction of compartments to store hazardous wastes, including the

bottom-and wall-lining layers, the system of recovering and gathering leakage water and penetration-detecting system.

Whatever tendency is followed, the important thing is that there must be accurate information on the terrain, hydro-geological and engineering-geological characteristics of the hazardous waste burial sites.

Guidance for Clause 3.2.1:

Upon the examination of designs, it is necessary to compile a report on comprehensive evaluation of the hazardous waste burial site locations (example: terrain, hydro-geological, engineering-geological, climatic? characteristics), including the hazardous waste burial models and options, observation posts in order to control the waste leakage into surrounding environment.

3.2.2. Ground and security

Based on the planning on HWBSs, attention should be paid to such factors on their grounds as terrain, wind direction, surface flow direction, underground flow direction so as to arrange burial compartments, ditches or zones suitable to the calculated acreage, support works: buildings and workshops, storehouses, sanitation area, treatment area, inspection area, operation control area, testing area, protection area; internal roads, lighting system, green-tree system, buffer zone, etc. The area for arrangement of support works may occupy 15- 50% of the total acreage of a HWBS.

All accesses to hazardous waste burial sites must be strictly controlled. Irrelevant persons are not allowed to enter the hazardous waste burial sites. The inbound and outbound roads must run through the only control gate for paper presentation, inspection and other administrative procedures.

It is necessary to install signboards, signal and light systems to guide traffic into and out of the sites.

An appropriate buffer zone around each site's borderline is needed. The buffer zones can be planted with trees or blocking boss which play the role of visibility blocking or sound insulation and also the role of a safety borderline against waste leakage. The width of the buffer zone and blocking shield (visibility blocking/ sound insulation) may vary, depending on the current land use status of the surrounding areas, and at the same time must satisfy the actual role of the buffer zone for hazardous waste burial sites. Trees with big canopy, little deciduousness but evergreen should be selected. The tree height shall be calculated to be at least equal to the height of the burial sites and can block the visibility from the outside into the sites; the width of the buffer zone should not be smaller than 20m.

The hazardous waste burial sites need outside defense system in order to prevent irrelevant persons, cattle or wild animals from entering the sites.

Guidance for Clause 3.2.2:

- When designing grounds for hazardous waste burial sites, attention should be paid to physical factors (terrain, wind direction, current direction, accesses, landscape, etc.)

- Around a hazardous waste burial site, an appropriate buffer zone should be arranged to play its role of preventing the visibility and noises and performing necessary jobs upon the leakage of pollutants. The width of the buffer zone must ensure the performance of the above tasks and not be smaller than 20m.

- An appropriate minimum security system is required. Depending on the safety conditions of each site, appropriate security measures shall be taken.

3.2.3. Project items

The project items and equipment in a hazardous waste burial site shall include:

- + The administrative building.
- + The laboratory.
- + Bathrooms for staff members
- + Lunching hall.
- + Storehouse.
- + Equipment maintenance workshops.
- + Protection fences.
- + Weighing station.
- + Security system.
- + Vehicle-washing station.
- + Internal road system.
- + Waste water and gas-gathering and-treating system.
- + The water supply system.
- + The water drainage system.
- + The information and communication system.
- + Garage and special-use equipment.
- + The green-tree system.
- + Area for storing soil and materials for covering and closing burial compartments.
- + The system for observation and control of garbage water and gas leakage.
- + Entrepots for storing hazardous wastes awaiting the treatment.
- + The burial compartments, ditches or areas.
- + Surface water-preventing system or works.

3.2.3.1. Administrative building.

This building is the working offices of the directorate and administrative staff managing the operation of a hazardous waste burial site, where should be the lunching hall for staff members, clockrooms and bathrooms for personnel.

3.2.3.2. The laboratory

The laboratory is fully capable of analyzing necessary norms of the to-be- buried wastes and also the place where the observation samples are analyzed. The wastes discharged from the laboratory must also be treated like hazardous wastes, unless they are proved not hazardous.

3.2.3.3. Bathroom and toilet area for staff members

This area must be divided into two separate places: The "dirty" place and the "clean" place. By this way, the personnel's dirty clothing shall be kept separately from others. Bath and clothing- washing water shall be separated and treated like hazardous wastes, except where they are proved not hazardous.

3.2.3.4. The lunching hall

The lunching hall must be designed in a way so that all staff members and guests may have their lunches in a clean environment. Workers just returning from the operation areas of the burial site must go through the separate cleansing area before entering the lunching hall for their lunches.

3.2.3.5. Storehouse system

In a HWBS, there is a storehouse system, comprising separate storehouses: fuel depots in service of machinery and equipment operating in the site and transport means as well; equipment and spare part storehouse in service of replacement of broken machinery and equipment.

3.2.3.6. Equipment maintenance workshop

It serves the renovation, maintenance and repair of equipment as well as machinery, which are broken in the course of operation in the burial site. All equipment and facilities, before being brought into the workshop, must be cleanly washed and cleansed.

3.2.3.7. Security system

The security system includes fence walls, fence ditches against animals; signboards and signals, lighting system; fire and explosion prevention and fighting system; security house and station; alarm bells.

3.2.3.8. Vehicle-weighing station

The station is used for weighing trucks in and out to determine the volumes of hazardous wastes buried at the site.

3.2.3.9. Vehicle- washing station

All vehicles, equipment and facilities, which have just worked at operation areas of the HWBS, shall be washed and cleansed before leaving the site. The vehicle-washing water should be treated like hazardous wastes, except when they are proved not hazardous.

3.2.3.10. Intra-HWBS communications system

The communications system in this area must be constructed to ensure that vehicles in the site operate with convenience, easily make turns, give way? The road grade must correspond to types of trucks operating on the site and the impacts of vehicles operating under bad weather conditions must be taken into account. It may be considered to select the option of building with concrete or solidifying routes expected to be used continuously throughout the operation duration of the burial site. There should be signboards and signals for vehicles to run strictly according to prescribed routes.

3.2.3.11. Leaked garbage water-gathering and-treating system.

Garbage water leaking from burial compartments, from the leaked garbage water-gathering and-treating system should be fully collected for conducting to the treatment station. The treatment system can be built inside the burial site or at another appropriate place. The post-treatment water shall be discharged into the outside environment only when its quality reaches the permitted standards or when it proves to be not hazardous. Materials and equipment as well as facilities used for gathering garbage water must be durable for assorted wastes under different weather conditions.

3.2.3.12. Water supply systems

In burial sites, water supply systems must necessarily be built in service of daily life, vehicle washing and other purposes. There should be two separate systems respectively supplying water for daily life and for other purposes. The daily-life water supply system must be designed to avoid all impacts of the hazardous wastes in whatever forms or by whatever way.

The water supply systems can be built independently from or jointly with the urban water supply system. In case of independent water supply, it is best to use underground water from bores (if the local hydro-geological conditions permit), which must be treated to reach the quality standards of daily-life drinking water. Water for production (for washing vehicles, equipment, facilities, irrigation, etc.) can be taken from sources of surface water or rain water, not using daily-water to clean vehicles, yards?

3.2.3.13. Water drainage systems

Systems for draining rain water, daily-life waste water and water discharged from other activities (vehicle washing, garbage water from laboratories, etc.) shall be conducted through separate discharge systems. Each type of water arising from the hazardous waste burial sites shall be carried to different treatment areas according to their respective characteristics (hazardous water to the hazardous waste treatment place; daily-life waste water to the daily-life waste water treatment place, etc.).

3.2.3.14. Information and communications system

The internal information and communications systems must be fully equipped for internal communications and connected to the outside for direction; they must be designed with camera systems connected from the control room to relevant sections for monitoring the process of operating the HWBS, communicating with outside agencies when necessary.

3.2.3.15. Car, equipment, machinery- keeping houses

After each working day, assorted vehicles, equipment, facilities and machinery should be gathered for keeping in a separate building. This building should be partitioned into separate compartments for keeping different kinds of machinery, equipment in order to avoid their misplacement which causes difficulties for subsequent operations.

3.2.3.16. Green-tree system

In hazardous waste burial sites, a certain land area should be arranged for tree planting. The green-tree acreage should concentrate in the administrative area and along the partition lines among different areas in the site. Kinds of tree should be selected to suit the operation conditions of the burial site and weather conditions, and at the same time to increase the beauty of the burial site.

3.2.3.17. Areas for storing soil and materials for covering and closing burial compartments

Depending on the burial mode in each site, the covering soil and material-storing areas shall be arranged to serve the daily or weekly closure of the burial site.

The covering soil and materials must always meet the use demands in time at the site and must strictly comply with the designed standards applicable to the hazardous waste burial sites.

3.2.3.18. Observation system

They include the systems for observation of underground water, surface water, garbage gases and the systems for detection of garbage water leakage. Depending on the concrete terrain, hydro-geological, engineering-geological conditions and structure of each site, these systems shall be arranged in the most rational way to ensure the observation and timely detection of garbage water leakage, the evaporation of toxic gases.

3.2.3.19. Entrepots for storing hazardous wastes awaiting burial (the hazardous waste entrepots in burial sites)

Hazardous waste relay points should be designed and constructed in the burial sites for cases of vehicles carrying "outside" wastes; incidents at the burial sites; these hazardous wastes shall be temporarily kept at entrepots then transported to burial sites by "internal" special-use vehicles. The floors of the storing depots and yards must be built against penetration like the hazardous waste burial sites.

3.2.3.20. Surface water-preventing systems or works

At each burial compartment and the entire burial site, it is necessary to build surface flow-preventing systems or works. These systems can be shield walls, dykes or canals, ditches. Depending on the concrete conditions of each burial compartment and site, appropriate systems shall be constructed.

Guidance for Clause 3.2.3:

- Works and equipment as well as facilities inside a HWBS shall include: the administrative building where locate the office, a laboratory, washing and bathing area for workers, a lunching hall; the green-tree system; the internal-road system; burial compartment- covering and- closing soil and materials storage areas; the hazardous waste entrepots. Other equipment and facilities include the vehicle-weighing station, the vehicle-washing station, the maintenance workshop, storehouses; garbage water-gathering and treating system; water leakage detecting system; water supply and drainage systems; surface water-preventing systems or works; environment observation and supervision systems, information and communications system; machinery, houses for keeping equipment and facilities after each working day and the protection systems.

- There should be regulations and measures to prevent matters already contaminated or in danger of being contaminated from moving outside the burial sites.

- Any liquid substances already contaminated or in danger of being contaminated, which arise from burial sites' operation such as bathing and washing water, vehicle-washing water, waste water from

laboratories, must be separated from one another and managed like hazardous wastes unless they are proved to be not hazardous.

- The internal and external communications systems must be ensured with a view to directing and supervising the site operation process and providing rescue and processing information in time upon the occurrence of any incident at hazardous waste burial sites.

3.2.4. Designing and construction of hazardous waste burial compartments

The hazardous waste burial compartments here are understood as independent burial compartments or part of the hazardous waste burial ditches or zones).

3.2.4.1. General requirements

a) Basic documents when designing hazardous waste burial compartments

Hazardous waste burial compartments constitute the most important works in the hazardous waste burial sites. The hazardous waste burial sites must ensure the absolute safety, limit the leakage of hazardous wastes into the surrounding environment, even at the stage of operation and the site-closing and post-closure stages. The hazardous waste burial compartments, though designed by whatever modes (burial compartments or burial ditches) and in whatever form (underground or underground-cum-above-ground), must be accompanied fully with the following basic documents:

- Topographical documents.

- Documents on climate, particularly the rainfall, rain intensity, the maximum rainfall in a day, wind and wind direction, speed, unexpected weather development (storms, whirlwinds, cyclones?).

- Hydrological documents: surface flow direction, water level, flow rate, flow-appearing time?

- Documents on geological, hydro-geological characteristics such as underground flow direction, the distribution depth of water-holding layers, the water level depth and its seasonal changes, the situation of underground water exploitation and use.

- Documents on engineering-geological characteristics, besides the study of the basic characteristics of soil and rock, it is necessary to determine the water absorbing nature and draw permeant coefficient chart at the depth of the bottom of the hazardous waste burial site, when necessary.

b) Controlling surface water flowing into hazardous waste burial compartments and sites

The rational control of surface water flowing into hazardous waste burial compartments and sites constitutes an important element which should be considered in the designing and construction of hazardous waste burial sites.

Appropriate preventive measures should be worked out to prevent surface water from overflowing into the operation areas of burial sites. Where water overflows outside from the operation areas of burial sites, it should be gathered separately, analyzed and, if necessary, treated and discarded like hazardous wastes.

In hazardous waste burial sites, the systems of canals and ditches around the burial sites should be designed and built to prevent surface water in surrounding areas from flowing into the sites and gather it.

Where the wastes are buried above-ground, there must be surrounding dykes and surface water-gathering systems to prevent them from overflowing outside.

In order to prevent surface water from flowing into burial compartments, measures of building shield walls or dykes around burial compartments can be applied. The dykes and shield walls must be designed to be higher than the possible highest water level and to be strong enough against dyke breaks and the penetration by surface water through the foundations of shield walls and dykes.

Ditches and canals preventing surface water from overflowing into and out of the burial sites must technically ensure that they are capable of draining the biggest rainfall, durable and impenetrable into or from burial compartments.

c) Control of rain water from flowing into burial compartments

At present, weather develops in a complicated manner with the rain fall and rain intensity in Vietnam varying greatly in both space and time. In some areas, the rainfall may reach over 500 mm in a day and may last for many days in a row. Consequently, the limitation of rain water from flowing into burial compartments is extremely important but very difficult and complicated. The volume of rain water falling directly on burial compartments will create a large volume of garbage water which should be gathered and treated.

In order to be able to limit rain water from penetrating into burial compartments, it is necessary to build roofs for all operating burial compartments to ensure their operation in all weathers.

The roofs can be designed and constructed according to different options depending on the specific conditions of each burial site and each burial option already selected.

The roofs can be designed in form of mobile roofs on rails.

d) Controlling underground water from flowing into burial compartments and garbage water from leaking into underground water from burial compartments

Depending on the selected locations, the bottoms of some burial compartments lie below the underground water level, hence the underground water flows into the burial compartments, thus causing difficulties for the process of constructing the burial compartments and possibly increasing the garbage water volume in the compartments. On the contrary, some burial compartments have their bottoms higher than the underground water level, hence the garbage water from the burial compartments may leak into the underground water. It is, therefore, necessary to prevent the penetration of underground water into burial compartments and the leakage of garbage water from burial compartments into underground water.

In order to prevent the penetration of underground water into burial compartments, under the current practical conditions in Vietnam, one of the options can be applied:

- Construction with clay.
- Construction with cement.
- Construction with fence walls (fence ditches).
- Construction with artificial lining layers.

The prevention of leakage of garbage water into underground water strata can be effected with the construction of anti-penetration layers (lining layers) at the bottoms and walls of burial compartments.

e) Engineering geology

In designing the hazardous waste burial sites, the engineering geology principles should be taken into account when building surrounding dykes, shield walls, stable slope, burial compartments, traffic roads and water drainage systems.

The load endurance of earth bottom and walls of burial compartments should be determined through the analysis of engineering-geological elements, sampling, analyzing and testing them in laboratories and in the open air (under the Construction Ministry's guidance on foundation survey). The bottom slope of burial compartments must at least reach 2%.

Guidance for Clause 3.2.4:

- Apart from relevant legal documents, when designing the construction of hazardous waste burial compartments, the following basic documents are also required: the documents on topography, climate, hydrology, geological characteristics, hydro-geology, engineering geology.
- It is necessary to apply all appropriate measures to prevent rain water and surface water from flowing into the operating hazardous waste burial sites. The rain water and surface water inside the hazardous waste burial sites should be gathered through a separate water drainage system and be qualitatively tested regularly, and, if necessary, treated like hazardous wastes to reach the environmental quality standards before being discharged to outside the burial sites.
- It is necessary to apply all appropriate measures to prevent underground water from flowing into hazardous waste burial compartments and garbage water in burial compartments from flowing into underground water.
- It is necessary to apply appropriate engineering-geology principles to the construction of project items of the hazardous waste burial sites such as shield walls, surrounding dykes, slope angles, burial compartments, traffic roads and water drainage systems.

3.2.4.2. Burial compartment structure

The hazardous waste burial compartment is structured to compose of the following:

- Its bottom and walls.
- The surface covering layer.
- The leaked water- gathering system.
- The gas-discharge system.

a) The bottom and wall structure of the burial compartments

The structure of hazardous waste burial compartments greatly varies, depending on the topographical, geomorphic, hydro-geological and engineering- geological conditions of the positions selected for the burial sites. All hazardous waste burial compartments must be perfectly structured in order to get rid off completely the waste leakage into the surrounding environment.

At present, there remain divergent viewpoints on bottom and wall structure of each burial compartment. Each country at each time has its own different requirements and stipulations.

The current practical conditions in Vietnam reveal that the bottoms and walls of the hazardous waste burial compartments should conform to one of the following structures.

In cases where the selected hazardous waste burial sites locate in areas where the bottoms and walls of the burial compartments are over-2 m thick- clay layer with the permeance coefficient $K \leq 1 \times 10^{-7}$ cm/s, the bottoms and walls of the burial compartments are structured only with single layer, concretely:

- The cushion layer of sand of 0.5m thick for gathering leaked water.
- The HDPE anti-penetration layer, 1.5m thick.
- The technical geo-fabric layer.
- The cushion sand layer of 30 cm thick for detecting leaked water.
- The technical geo-fabric layer.
- The natural clay layer with permeance coefficient $K \leq 1 \times 10^{-7}$ cm/s, of over 2 m thick.

Where the bottoms and walls of the burial compartments fail to satisfy the two elements mentioned above (the clay layer is under 2 m thick or the permeance coefficient $K \leq 1 \times 10^{-7}$ cm/s), the bottoms and walls of the burial compartments should be structured with double lining layers, concretely:

- The first cushion layer of sand, 0.5 m thick, for gathering leaked garbage water.
- The first HDPE anti-penetration layer of 1.5 mm thick.
- The technical geo-fabric layer.
- The second cushion layer of sand, 30 cm thick, for gathering leaked garbage water.
- The second HDPE anti-penetration layer, 1.5 mm thick.
- The technical geo-fabric layer.
- The reinforced clay layer, tamped with the minimum thickness of 90 cm and the permeance coefficient $K \leq 1 \times 10^{-7}$ cm/s.

Guidance for Sub-clause 3.2.4.2 (Item a)

- A hazardous waste burial compartment is often structured to compose of the bottom and walls; the surface covering layer; the leaked water gathering and detecting systems and gas-discharge system.
- The burial compartment bottom- and wall-lining system should be properly selected (either single lining or double lining), depending on the specific conditions of each burial site, and comply with one of the structures described in Figures 13 and 14, in order to ensure the prevention of the garbage water leakage from burial sites into the surrounding environment.

b) Lining materials:

There are different kinds of materials which have been used or researched for use as lining layers of burial compartments, including:

- High density polyethylene (HDPE).
- PVC.
- Butyl rubber.
- Neopren (chloropren rubber).
- Other polyethylene (such as chlorinated, chlorosulphonate?).

When considering and selecting lining materials, attention should be paid to the following points:

- Their chemical compatibility with the types of waste to be buried and the garbage water to be possibly leaked out.
- Their durability and inertness to climatic factors.
- Their endurance against physical destruction.
- Their durability against rodents and microbes.
- Their capability to hold their desired properties at all temperatures.
- The quality control and satisfaction at the manufacturing stage and when being placed into the burial compartments.
- The need to have a sand layer of 0.5-1m on the lining layer to gather leaked garbage water and protect the lining layer throughout the process of waste dumping.
- The operation status and longevity.

As compared to other synthetic lining materials, polyethylene at present proves to be most superior. It has high elasticity, endurance, durability against tear, pierce and corrosion by hazardous wastes.

The lining soil layer:

It is the soil layer under the technical geo-fabric lining layer. It is more common and efficient to take advantage of the natural soil layer with structure kept intact as the lining soil layer. Where the natural soil layer at the bottoms of burial compartments fail to satisfy the criteria for hazardous waste burial sites, a lining soil layer should be created. When considering and processing the lining soil layer, attention should be paid to:

- The efficient moisture for tamping.
- The tamping method and techniques.
- The final permeance and depth to be achieved.
- The load endurance against machinery and equipment engaged in burial activities and when fully filled-up hazardous wastes.

- The quality control and satisfaction during the lining process.

Other lining materials:

In addition to the lining membrane (technical geo-fabric) and clay, the following materials can be used as lining layer membrane:

- Bentonite and bentonite compounds

- Cementitious mortar.

- Surfacing materials (asphalt).

The use of these materials should be carefully considered in term of their properties and endurance against the hazardous wastes and weather conditions in Vietnam as well as the construction technical conditions.

Guidance for Sub-clause 3.2.4.2 (Item b):

The selection of materials for lining the bottoms and walls of hazardous waste burial compartments depends on the specific conditions of each site and the nature of to be-buried hazardous wastes. The selected lining materials must ensure their durability and capability against the waste leakage in all weather conditions and throughout the process of construction, operation, closure and post- closure of sites.

c) Leaked garbage water- gathering system (leaked garbage water control)

As usual, the leaked garbage water is gathered mainly on the surface of the lining layer. The leaked water-gathering system comprises ditches, conduits and gathering holes rationally arranged for gathering all the leaked water into the treatment stations. This system is structured with:

- The leaked water- gathering layers at the bottom and walls of the burial compartment and on the anti-penetration lining membrane. The leaked water-gathering layer must have a thickness of at least 50 cm and the following characteristics:

+ Having at least 5% of the grain volume with size of 0.075 mm.

+ Having the minimum permeance coefficient of 1×10^{-2} cm/s.

It is most popular and efficient that the leaked water-gathering layer is structured with sand grains of different sizes, which are arranged in converted filtering layer (the closer to the water-gathering and conducting pipes the bigger the grains' sizes).

- The leaked water-gathering pipe network is placed inside the gathering layer (as described above) and distributed equally on the entire bottom of the burial compartment. This network must satisfy the following requirements:

+ The pipe materials must be compatible with the nature of the hazardous wastes.

+ The pipes' inside walls must be smooth.

+ Having the minimum slanting degree of 1.0%.

+ The pipe network must be designed and constructed with density and with the suitable pipe diameter to gather all leaked garbage water before the surface-covering layer is made.

- The filtering layer around the leaked water-gathering pipes may be a layer of sand grains of which at least 5% have the diameter of 0.075 mm or a synthetic filtering membrane with equivalent efficiency and appropriate materials so as to prevent the movement of too fine grains down into the gathering system while ensuring that the water still runs down into the gathering system.

The leaked water-gathering system must be designed and installed in a way so as to minimize the possible accumulation of water at the bottom of the burial compartments. The materials selected for the construction of the leaked water-gathering system must ensure their chemical and mechanical durability throughout the course of site operation, closure and post-closure.

It's difficult to foresee the characteristics of leaked water in a hazardous waste burial site. The determination of such characteristics can be made only through sample taking and analysis.

Guidance for Sub-clause 3.2.4.2 (Item c):

It is necessary to install the leaked garbage water-gathering and - discarding systems under the burial compartments throughout the process of site operation, closure and post-closure with a view to preventing the garbage water leakage. Moreover, the leaked garbage water gathered, which is hazardous waste, must be treated to reach the Vietnamese standards before being discharged into the environment.

d) The surface-covering layer:

The burial site surface- covering layer has the effect of isolating the hazardous waste from the surface environment; preventing rain water and surface water from penetrating into waste compartments in order to reduce the volume of garbage water arising after closing the burial compartments or sites.

Moreover, the surface-covering layer also controls gases emitted from burial compartments and aims to maintain the development of the vegetation cover thereon and create environmental landscapes.

The surface-covering layer is often structured with the following layers:

- The transitional sand layer of 20-30 cm thick spreading directly on the surface of the last hazardous waste layer.

- The pressed clay layer on the sand layer. The thicker the pressed clay layer the better, which must be at least 0.6 m thick, with the permeance coefficient $K \leq 1 \times 10^{-7}$ cm/s.

- The technical geo-fabric lining membrane layer is 1.0 mm thick, spreading directly on the pressed clay layer.

- The cushion sand layer on the lining membrane layer is at least 0.5m thick. This layer not only has the effect of protecting the lining membrane but also plays the role of gathering rain water and surface water.

- The soil layer with a thickness of not under 30-50 cm.

- The vegetation cover has the effect of combating erosion; it is advisable to grow only grass or polyrhizous plants, but not big tap-root trees, creating conditions for them to destroy the covering layer.

The surface-covering layer must have the minimum slanting degree of 3-5% so that rain water can easily drain from the burial sites. Around the burial sites, the systems of gathering and draining rain water, surface water and water from the burial site surface-covering sand layers must be built. When designing and consolidating the burial site surface-covering layers, attention must be paid to the surface subsidence and other factors such as the exposure to weather conditions, the stability of the slanting degree, etc.

Guidance for Sub-clause 3.2.4.2 (Item d):

It is necessary to design the last covering system for each burial compartment or site in order to isolate hazardous wastes from the surface environment, to combat penetration, combat erosion and control gas emission.

- The anti-penetration layer of the last covering system must be firmly affixed to the outer surface-lining system of the burial compartments. At the same time, the covering system must be thick enough to resist pressure; durable and cohesive enough to avoid slides and sinks which destroy the surface structure.

- The surface-lining layers of hazardous waste burial sites must be designed to be capable of preventing the danger of accumulation of rain water and surface water in burial compartments.

e) Gas - discharging system:

Hazardous wastes contain a low concentration of organic matters, hence the volume of gases emerging in the process of decomposition is inconsiderable. However, gases which may emerge from waste are easy to evaporate due to accidental burial at sites. These gases shall be accumulated beneath the surface-covering layers. Consequently, this issue should be given due attention and settled. In the course of designing and building the burial sites, consideration should be given to the installation of equipment for collecting gases beneath the impenetrable lining layers or in water-gathering ditches in the leaked garbage water-gathering layers. However, these designs may not be necessary if the emitting gas volume is estimated to be very little.

Depending on the nature and volume of emitting gases, a number of handling methods such as burning, if the methane concentration is high, or evaporation, if it is hydrocarbon, can be applied.

Where gases must be recovered, it is necessary to consider the passive gas-discharging systems (applicable to small-sized hazardous waste burial sites) or active gas-gathering system with vertically drilling wells (for medium- and big-sized hazardous waste burial sites). The drilling holes should be placed on the tops of burial compartments, with the minimum depth reaching the cushion layer beneath the impenetrable lining membrane layer of the surface-covering layer. The drilling holes are arranged rationally so as to recover the whole volume of emitted gases. Plastic clay or cement must be stuffed around the gas-recovering drilling holes. Barricades or signboard "restricted areas" must be placed around the waste gas-collecting and treating positions.

Guidance for Sub-clause 3.2.4.2 (e):

It is necessary to determine the danger of gases emitting from hazardous waste burial compartments; if the waste gas volume is big enough, a gas-gathering and treating system must be installed. The gas-gathering systems of burial compartments must be designed and constructed rationally so as to ensure convenience for the control thereof and not to affect the structure of the covering layers and the burial sites.

OPERATION AND OBSERVATION

4.1. General matters

The safe operation of hazardous waste burial sites depends largely on the work of strict control of the operation and observation processes.

In reality, the operation of hazardous waste burial sites is often carried out simultaneously with the construction thereof. As there are many burial compartments in a site, the operation of one compartment proceeds simultaneously with the construction of other compartments, thus being more economical and able to overcome weaknesses and shortcomings in the designing and construction of hazardous waste burial sites. Nevertheless, such operation, either simultaneous or independent, must comply with the regulations on the hazardous waste burial sites. All activities in the hazardous waste burial sites must be guided in detail, in writing. All staff members working in the hazardous waste burial sites must thoroughly understand the regulations or guidance such as:

- The guidance on the transportation of hazardous wastes into burial sites;
- The guidance on sorting out hazardous wastes in the burial sites;
- The guidance on preparation for putting hazardous wastes into burial compartments;
- The guidance on putting hazardous wastes into burial compartments;
- The guidance on reducing volume of hazardous wastes in the burial compartments;
- The guidance on the methods of creating layers to cover hazardous wastes in the burial compartments;
- The guidance on sampling and analysis of assorted samples;
- The guidance on operation and maintenance of equipment;
- The guidance on prevention and handling of incidents which may occur in burial sites;
- The guidance on labor safety in the burial sites;
- The guidance on first aids provided to victims when necessary;
- The guidance on recording work diary, documents, waste delivery-receipt bills and other papers.

Apart from firmly grasping the outlines of the general structure, the organizational structure as well as the modes of management in the burial sites, the instructions on incident prevention and rescue as well as labor safety, each member shall also have to well perform jobs according to his/her responsibility. At the same time, he/she must give comments on and propose amendments and/or supplements to the regulations and guidance, aiming to ensure the absolute safety for environment and the community health.

These should be considered the basic reference documents for activities of operating and maintaining equipment and facilities at the burial sites.

Guidance for Clause 4.1:

- Written guidance should be prepared for activities of operating the hazardous waste burial sites. Such guidance should be disseminated to all staff members of the burial sites and be used as basic reference documents for daily activities of the burial sites.

- It is necessary to establish systems for inventorying hazardous wastes and keeping the results of measurement and general analysis for burial sites and these systems should be strictly complied with by all staff members.

- Plans on maintenance of equipment operating in the hazardous waste burial sites and plans on periodical examination of staff members' health should be worked out so as to early detect incidents for repairs or replacements and to discover ailments for timely treatment; as are the regulations on hygiene, safety and health protection for staff members.

- There should be instructions on prevention, detection and rescue of incidents which occur in the process of operating the burial sites with a view to minimizing risks caused to environment and community health.

4.2. Transportation of hazardous wastes into burial sites

The transportation of hazardous wastes into burial sites can be carried out by hazardous waste-discharging establishments or functional units licensed for such operation by competent State bodies.

Hazardous wastes shall be transported into burial sites by special-use means in strict compliance with the Regulation on Management of Hazardous Wastes, promulgated together with the Prime Minister's Decision No.155/1999/QĐ-TTg of July 16, 1999.

When transporting hazardous wastes into the burial sites, the transport means owners must complete all necessary procedures prescribed for the burial sites? activities, such as checking of hazardous waste volume through weighing, and types?.

4.3. Preparing to put hazardous wastes into burial compartments

According to the Regulation on Management of Hazardous Wastes, the hazardous wastes permitted to be buried must be sorted out and packed right at the places where they have arisen or the units assigned to transport them.

When being transported to the gathering places of the burial sites, the hazardous wastes shall be carried into burial compartments by "internal" means which as specially designed.

4.4. Arrangement of hazardous wastes into burial compartments

The arrangement of hazardous wastes into burial compartments shall be carried out by special-use equipment system, possible through the mobile crane system designed in association to the mobile roof frames. These systems can operate in all weather conditions and minimize the volume of rain water and surface water running into burial compartments.

The hazardous wastes should be tightly pressed by mechanical rollers when they are placed on fork lifts and shall be tamped at the burial compartments into layers by special-use vehicles or tamping machines.

After each day of operation (carrying hazardous wastes into burial compartments) or after each hazardous waste layer reaches the maximum thickness of 2m, the hazardous wastes must be covered with a soil layer with moisture suitable for tamping. This covering soil layer, after being tamped, has

the thickness of 15-20 cm. Such covering aims to isolate the hazardous wastes from the surrounding environment, reduce the leakage of hazardous wastes into environment.

The process of operation at the burial compartments shall go on till the compartments containing hazardous wastes reach the designed thickness before they are covered with the last layers as mentioned in Item d, Clause 3.2.4.2 of the guidance.

Guidance for Clause 4.4.

- Before the hazardous wastes are carried into the burial sites, they must be qualitatively examined and classified according to regulations. Wastes which fail to satisfy the prescribed criteria are not allowed to be put into burial compartments.

- It is necessary to control waste leakage from the operation areas of burial compartments due to wind, wild animals, by spreading the covering materials thereon after each day of operation or after each layer of hazardous wastes reaches its full thickness.

- It is necessary to control direct rain water and surface water running into operation areas of burial compartments. Water overflowing from operation areas of burial compartments should be gathered and treated like the hazardous wastes, unless they are proved to be not hazardous.

- When operating equipment and arranging hazardous wastes into burial compartments, attention should be paid to keeping intact the layers lining the bottoms and walls of burial compartments, without encroaching upon the leaked water-gathering and controlling systems.

- When maintaining equipment and facilities, attention should be paid to dirt accidentally leaking out into the burial sites. All the water used for washing equipment and bathing water used by workers should be separately gathered and treated like hazardous wastes, unless they are proved to be not hazardous.

- The roofs shall be removed only when the burial compartments are fully covered with surface-covering layers as designed, ensuring to prevent rain water and surface water from penetrating into burial compartments.

4.5. Preventive and rescue measures against incidents in hazardous waste burial sites

In the process of operating hazardous waste burial sites, incidents may occur. These incidents may be created by humans or natural elements. Generally speaking, incidents, when occurring, often cause adverse impacts on environment and community health, which can only be overcome with great efforts and much money. Therefore, it is extremely necessary to prevent and timely handle incidents in hazardous waste burial sites. The common incidents are fire, explosion, leakage of pollutants, etc.

4.5.1. Preventive measures

- The incident prevention must be touched upon right at the stage of designing and constructing burial compartments and sites. Actually, right at the time of conducting survey and selection of locations for hazardous waste burial sites, attention must be paid to this question, including the inquiry into topographical, climatic, geological, hydro-geological, engineering-geological characteristics of the areas chosen for the construction of hazardous waste burial sites. In arranging grounds for project items, and in reinforcing cushion layers as well as covering layers of the burial compartments, attention must also be paid to incident prevention.

- To closely supervise the process of building project items, particularly those related to the prevention of waste water from leaking into environment (like the construction of anti-penetration systems, control of overflow, etc.).
- To provide instructions, training for personnel working in the burial sites on possible incidents and measures for the handling thereof.
- To fully provide rescue equipment and means upon the occurrence of incidents.
- To install signboards and signals at necessary and easy-to-spot places.
- To fully provide labor protection devices.
- To work out plans for evacuation of equipment and facilities upon the occurrence of incidents.
- To provide all personnel working in the hazardous waste burial sites with knowledge and drills on first aid to be given to victims upon the incident occurrence.

4.5.2. Coping plans and measures

4.5.2.1. Urgent coping plans

The plans for urgent coping with foreseeable incidents to hazardous waste burial sites which are harmful to environment and human health should be elaborated and regularly updated. The incidents may be fires, explosions, leakage of pollutants at completed burial areas and the emergence of overflowing and/or leaked water sources. An urgent coping plan shall contain:

- Immediate coping measures;
- Names, addresses and telephone numbers of urgent rescue coordinators;
- Names, addresses and telephone numbers or organizations, agencies and individuals that can assist in incident rescue;
- The plan on mobilization of personnel for incident rescue or evacuation of victims.
- Medium- and long-term restoration methods;
- The list of rescue equipment and their locations in the burial sites.
- Form of and procedures for reporting on incidents.

The guidance on the urgent coping plans must be included as part of the training program for all personnel working in waste burial areas. The list of urgent rescue equipment must be always available at the administrative building block.

4.5.2.2. Coping measures:

- + Depending on types of incident, timely alarms at various degrees should be made according to regulations.
- + Notifying responsible and capable establishments and agencies for participation in handling of incidents.

+ Quickly rescuing people and taking equipment and assets not in service of the rescue from incident locations to safe places.

+ Making full use of and mobilizing all means, equipment and facilities to prevent incidents from further development, then seeking measures to overcome the incidents.

In Vietnam, abnormal weather conditions such as rain, storms easily cause incidents to waste burial sites. Each year, Vietnam sees an average of 10 storms entailed with torrential rains. For some days, the rainfall may reach over 1,000 mm, thus creating serious floods. Storms are often accompanied with the wind speed of 60 - 100 km/h which can easily blow away long-span roofs, and with torrential rains which can flood the operating burial compartments and at the same time cause slides of slopes of burial compartments. Such incidents not only obstruct the operation of burial sites but also possibly cause adverse impacts on the environment as the polluted water overflows surrounding areas and flows into surface water currents. Therefore, special attention must be paid to the prevention of and rescue measures for incidents of hazardous waste burial compartments flooded with water. The most effective preventive measure is to keep covering roofs from being blown away, thus preventing rain water from falling into burial compartments. Upon the occurrence of incidents, it is necessary to quickly limit rain water and surface water from running into burial compartments, isolate water in the burial sites from its free flow, then gather and treat it.

Guidance for Clause 4.5.2:

- There must be coping plans and measures to promptly handle incidents at hazardous waste burial sites. The incident coping requires the participation and cooperation of urgent rescue teams of nearby localities and communities.

- There must be plans and measures to prevent incidents at hazardous waste burial sites. These plans and measures must be proposed and considered right from the time of location selection to the time of site operation, closure and post-closure and must be thoroughly informed and trained to every staff of burial sites.

- The incident-preventing and - coping plans and measures should be examined and readjusted annually to suit the actual operation state of burial sites and the subsequent developments.

4.6. Personnel training programs

All personnel working at the hazardous waste burial sites must go through compulsory training courses. After the basic courses, personnel must further attend fostering courses to consolidate the knowledge they have learned and absorb new knowledge. Usually, such courses shall be organized once a year.

The training programs must be effected by experienced and capable specialists.

The training must cover the following subjects:

- Methods and techniques of burying hazardous wastes;
- Regulations on site operation, closure and post-closure;
- Instructions on operation of equipment and on safety manipulations;
- Plans and measures to prevent and cope with incidents;

- The use of protective outfits and devices;
- Proper methods of personal hygiene related to bathing, washing, eating and drinking, clothe washing;
- Methods of maintenance, cleaning equipment, facilities and machinery;
- First-aid methods.

Personnel working at the hazardous waste burial sites should have their health checked regularly and periodically.

The health examination programs must be carried out by specialized physicians who are fully capable and qualified.

Guidance for Clause 4.6:

All personnel working at the hazardous waste burial sites must go through a comprehensive training program as well as periodical health examinations before, during and after the time they have worked at the burial sites.

4.7. Environment observation programs

4.7.1. Overview

The process of operating the hazardous waste burial sites require observations aiming to ensure safety. The observation covers the following contents:

- Observation of physical changes;
- Observation of leaked garbage water;
- Observation of leakage;
- Observation of underground water;
- Observation of garbage gas evaporation;
- General observation.

4.7.2. Observation of physical changes

After the closure of burial compartments or sites, due to various causes such as rain, waste shrinkage, the surface terrain of burial sites may witness such changes as slides, sinks, erosion, cracks, etc. All those phenomena must be early discovered through systematic observations. The observation of topographic changes may be carried out by the method of observing the change of the marker posts implanted on the burial compartments as compared to the fixed checkpoints. It can also be conducted through comparison of the topographic maps drawn after a duration with the topographic maps drawn immediately after the closure of the burial compartments or sites.

Any topographic changes of burial compartments detected in the course of observation must be handled promptly as those changes usually lead to the destruction of the burial compartment surface-covering layers, to the failure in ensuring the absolute isolation of hazardous wastes from the surface environment and often create conditions for rain water to penetrate into burial compartments, thus

increasing the volume of hazardous garbage water. The common handling method is to patch the covering layers.

4.7.3. Observation of garbage water

Garbage water means type of water gathered through systems of gathering water at the bottoms of the burial sites, which must be observed and analyzed in order to find out:

- + The total volume of garbage water to be discharged;
- + The physio-chemical properties of the garbage water.

In order to find out the two above-mentioned elements, it is necessary to qualitatively and quantitatively observe the waste water generated from burial compartments. The water volume shall be measured at the garbage water- gathering places through automatic pumps. The garbage water quality shall be determined by way of sample taking and analysis.

Based on the results of analysis of garbage water components and the changing tendency of garbage water, the changing process of wastes in the burial sites can be considered and studied, thereby finding solutions to the design and construction of observation networks and subsequent waste burial compartments in order to take appropriate measures.

4.7.4. Leakage observation

Upon detecting garbage water leakage, the leaked water volume should be measured, the leakage direction and time should be evaluated and the garbage water composition should be analyzed in order to accurately determine the leaking places and work out effective handling measures.

4.7.5. Underground water observation

Due to the potential danger of garbage water leakage from hazardous waste burial sites into underground water, the observation of underground water sources is an important part of the observation activities at the hazardous waste burial sites. The underground water observation is carried out right from the time of selecting the burial site locations to the time of building, operating, closing and post-closing sites. A comprehensive underground water observation program shall provide reliable data on the burial sites? impacts on the quality of underground water in the areas.

The underground water observation networks are often arranged according to the underground flow direction from upstream to downstream the burial sites. There should be at least 5 observation drilling holes (1 or 2 holes upstream and 3 or 4 holes downstream the burial sites). The observation drilling holes must be arranged at both water-holding layers higher and lower than the bottom of the burial sites.

- The observation elements shall include: The water level, which is monitored by automatic recorders or can be measured directly at drilling holes. In the first year, the water level shall be measured once a month. The measuring results shall be used for making maps on high or constant water pressure. For the subsequent years, it is measured once every three months. Samples shall be taken and analyzed in laboratories at least once every three months in order to determine the physical characters and chemical as well as biological composition of underground water.

- The analysis of changes in the chemical composition of underground water permits the forecast of the infiltration of components arising from the burial sites into water layers. Therefore, in addition to the analysis of components according to regulations (Vietnam Standard TCVN 5944-1995), the

analysis of a number of other polluting components related to the nature of the hazardous waste burial sites is also required.

- The observation activities must begin right from the time of survey, selection, design, construction throughout the process of operating and closing sites and must be maintained for a period of 50 years after the site closure. The 50 year- duration can be shortened if it can be proved that in 5 consecutive years of observation, no pollutants are found in underground water. However, in all circumstances, the observation duration must last at least 20 years after site closure. Due to long observation duration, attention must be paid to the selection of materials for building underground water observation posts so as to ensure their durability and firmness.

- The construction of underground water observation posts shall comply with the current regulations.

- Upon detecting the damage of observation posts, they must be repaired in time or new observation posts shall be built in replacement thereof. The former observation drilling holes must be sealed strictly according to the current regulations.

- Observation documents should be fully recorded and archived continuously after each observation drive and throughout the observation duration.

4.7.6. Emitted gas observation

In the process of operation of burial sites and after the closure of sites, the observation of emitted gases should be carried out.

The gas observation is conducted in the period of survey for selection of burial site locations and also in the period of building, operating and post-closing the sites.

- The documents on observation of air quality, made at the stage of survey for selection of burial site locations are basic reference documents which give observation results in the process of building, operating, closing and post-closing sites. The whole observation duration lasts 50 years after the site closure. The observation duration can be shortened if in 5 consecutive years of observation, no dirty gases are detected as having dispersed into the air.

- In the process of building and operating burial sites, apart from fixed gas observation posts for general evaluation, there must also gas and dust observation points for evaluation of the labor environment quality.

- At the final stage of the operating process as well as during the post-closure period, the gas observation programs should focus on places where gases emit from the mouths of the discharge pipes and the surrounding air spaces. Gas-detecting heads can be used or in some special cases gas-detecting machines shall be installed.

- The observation networks are arranged in a way so as to be able to detect and calculate gases emitting into the environment. A number of observation posts can be arranged around burial sites along the prevailing wind direction (at the head and the end of the wind direction); it can also be arranged one post in the operation areas of the burial site and a number of posts at the discharging heads of the gas-discharge pipes.

- The observation regime (when automatic posts are not yet available) : once a month.

- The observation norms: Apart from norms prescribed under TCVN 5937-1995, a number of other discharge gases which may emerge due to the nature of the hazardous waste burial sites can be measured and determined.

4.7.7. General supervision

Besides the above observations, in the process of building, operating, closing and post-closing sites, it is necessary to supervise the security (the conditions of barricades, signboards, entrance gates, lighting system), the development of the vegetation cover on the surface, the water drainage, garbage water-conduits, weather.?

The units managing the hazardous waste burial sites must report once every six months on the current quality of the environment in the burial sites to the environment State management agencies. The reports shall contain the hydro-geological, engineering-geological measurement and observation results, the detailed explanation of the operation of anti-penetration systems, the plans on gathering leaked water, emitted gas, slanting degree.

The measuring equipment and methods should be uniform. Depending on the scientific and technical advance, the measuring stations can be automated and net-connected with the control rooms of the sites.

Guidance for Clause 4.7:

- Before building a hazardous waste burial site, there should be a report assessing the environmental impacts according to Circular No.490/TT-BKHCMNT of April 29, 1998 of the Ministry of Science, Technology and Environment guiding the elaboration and evaluation of reports on assessment of investment projects' impacts on the environment. This report shall be considered a reference document for subsequent observation activities.

- Owners or managers of burial sites should work out an environment observation program for the whole period of operating and post-closing of sites strictly according to regulations stated in the reports on assessment of environmental impacts. This program shall focus on physical evolution of the burial sites, water leaking from hazardous wastes, gas emission, surface and underground water environment. It is necessary to note and relate all observation data of the period of site operation and post-closure.

- Before operation of site, the observation standards should be considered and set. Where the observation results fail to satisfy these standards, a plan on restoration and overcoming thereof should be deployed as mentioned in the incident-coping plans.

- All the measuring and observations results should be reported regularly and periodically to the environment State management bodies. Apart from the measuring results, there should be the detailed explanation on the operation of the anti-penetration systems, the leaked garbage water-gathering systems, the gas emission.

- The measuring equipment, the observation methods and the observation points must be uniform throughout the observation process. There may be changes unless they are proved to be better.

4.8. Inspection of the quality of construction items in term of environment

The inspection of the quality of construction items in term of environment aims to ensure that the construction of items of the hazardous waste burial sites strictly comply with their designs and the environmental impact assessment, minimize the leakage of hazardous wastes into the outside environment.

The environment inspection should be conducted regularly in the construction, operation, closure and post-closure of hazardous waste burial sites. Among the items subject to environment quality inspection, attention should be paid to the anti-penetration systems, the leaked water-gathering and-treating systems (if installed at sites); gas-discharging systems as well as the whole environment observation networks. The inspection must be conducted in the fields and in the laboratories, for the right items and suited each necessary time point in order to ensure that the materials and equipment being used in the operation areas of the hazardous waste burial sites satisfy the Vietnamese standards on environment.

Professional officials in charge of the environment quality inspection and supervisions should take note of and report in writing on the results thereof after each period of construction investment and operation of items to the environment State management bodies, aiming to detect in time violations of environment standards in the designing, construction, operation and closure of burial sites and map out remedial measures.

Equipment and facilities used for the inspection of environment quality must ensure the national and international standards.

The environment quality inspection must be carried out by specialists having high professional qualifications in that field.

Guidance for Clause 4.8:

It is necessary to strictly implement the work of inspecting the environmental quality of construction items in an objective and independent manner with standard equipment and facilities throughout the process of building, operating and closing the hazardous waste burial sites. The inspection results must be reported regularly after each period, each construction item to the environment State management bodies.

Part 5

THE STAGE OF CLOSURE AND POST-CLOSURE OF HAZARDOUS WASTE BURIAL SITES

5.1. Overview

The closure of hazardous waste burial sites should be effected when:

- The volume of hazardous wastes already buried in the burial sites has reached the largest designed capacity.
- The hazardous waste burial site owner-operators are incapable of continuing to operate their burial sites.
- It is for other special reasons.

In all circumstances, the burial site owner-operators must send written notification on the closure of the burial sites to the environment State management bodies.

As usual, the plans on closure and post-closure of burial sites should be drawn up right from the initial stage of elaborating the plans for the projects. By including the plans on the site closure into the burial site designs right from the beginning. The burial site development plans must be compatible with the requirements of site closure and long-term maintenance when the burial sites are used to the utmost.

Guidance for Clause 5.1.

- The hazardous waste burial sites should be closed when the volume of hazardous wastes reaches the designed capacity, when the site owner-operators are incapable of continuing to operate the burial sites; or when it is for other special reasons. The owner-operators must notify the time and plans for burial site closure to the environment State management bodies.
- The plans on closure and post-closure of hazardous waste burial sites should be prepared and included into the burial site plans and designs right from the beginning. However, these plans should be updated and supplemented to suit changes in the process of building and operating the burial sites.

5.2. Closure of hazardous waste burial sites

The closure of hazardous waste burial sites shall be effected by way of covering the surface of hazardous wastes with soil and other anti-penetration layers as mentioned in Item d of 3.2.4.2 of the Guidance. Where in big burial sites the operation of sites is carried out simultaneously with the construction of new burial compartments, the compartments already filled up with hazardous wastes shall be closed. Therefore, all works must be comply with the provisions on each covering layer as mentioned in the Guidance.

The site closure requirements must ensure that the intactness and safety of the burial sites are maintained for a long time and that the post-closure maintenance shall be minimized.

Upon the completion of the site closure, all equipment used in the operation areas of the burial sites should be washed and cleansed and the water discharged therefrom must be treated like hazardous wastes.

Guidance for Clause 5.2:

- The closure of hazardous waste burial sites should be effected by fully covering the anti-penetration layers and soil layers thereon strictly according to the technical-design requirements as mentioned in Item d of 3.2.4.2 and must ensure to:
 - + Minimize the subsequent maintenance requirements;
 - + Control the leakage of pollutants into the surrounding environment.
- Upon the completion of the site closure, all equipment and facilities used in the burial sites (excluding observation equipment) must be washed and cleansed or discarded in the most appropriate way, and the waste water therefrom must be treated like hazardous wastes.

5.3. Post-site closure maintenance

Within 3- 6 months as from the date of closing the burial sites, the site owner-operators must report to the State management bodies on the present situation of the burial sites. Such a report must be made by an independent professional environment organization, including the following contents:

- The operating state and capability of all works in the hazardous waste burial site, including the anti-penetration systems, the leaked garbage water-gathering and treating systems, the surface water-preventing system, the gas-discharge systems, etc.
- The results of observation of water volume (leaked water, surface water, underground water), gases and other observations.

- The advantages and difficulties and proposals to competent bodies for coordinated settlement.
- After the closure of burial sites, people and animals should not be allowed to enter the burial sites, particularly places where gases or leaked water are gathered. The systems of signboards and safety instructions should be set up in the burial sites.

Guidance for Clause 5.3:

- The post-site closure maintenance programs should cover the following contents:
 - + The maintenance of functions and intactness of the burial site surface-covering layers;
 - + The maintenance and operation of the waste water-or gas- gathering and treating systems, other treating systems;
 - + The protection and maintenance of gas-discharge, surface water or underground water- observation points.
 - + The control of post-site closure entries and exits.
- The hazardous waste burial site owners must make reports on the present situation of the burial sites after their closure. Such reports shall be addressed to the environment State management bodies within 3-6 months after the site closure.

5.4. Archival of documents on hazardous waste burial sites

All documents related to the site survey, design, construction, operation, observation, closure and post-closure, particularly the observation documents, must be kept for an indefinite time. These documents shall serve as basis for handling of burial sites upon the occurrence of incidents or for reuse of land. They shall be duplicated and archived at units operating the hazardous waste burial sites and at the offices of local or central administrations that are responsible for issuing decisions on the operation, closure and post-closure of hazardous waste burial sites.

Guidance for Clause 5.4:

All documents related to the site survey, selection, design, construction, closure and post-closure, particularly documents on environment observation, must be archived at units operating the burial sites and the local or central agencies which are responsible for issuing decisions on the operation and closure of hazardous waste burial sites.

Part 6

CONTENTS NECESSARY FOR IMPLEMENTATION OF HAZARDOUS WASTE BURIAL SITE PROJECTS

1. Determination the volume, composition and nature of hazardous wastes;
2. Determination of treating measures;
3. Evaluation of the garbage volume treated or buried at burial sites;
4. Selection and evaluation of burial site locations (topographic, geological, hydro-geological, engineering-geological, ecological characteristics);

5. Environment observation;
6. Feasibility design/cost estimation; phasing of investment;
7. Determination of organizational structure for implementation;
8. Regulations and standards;
9. Public comments;
10. Environmental impact assessment;
11. Detailed design;
12. Application for construction permit;
13. Construction (of all project items of the hazardous waste burial site simultaneously with the burial compartment by method of myriapod);
14. Quality control and report;
15. Submission to competent bodies and application for operation license;
16. Operation of burial sites;
17. Sending of regular reports to functional State bodies in charge of environmental protection;
18. Closure of burial sites;
19. Post-site closure (including observation and legal responsibility).-