

BS ISO 28901:2011



BSI Standards Publication

# Soil quality — Guidance for burial of animal carcasses to prevent epidemics

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**National foreword**

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**Soil quality — Guidance for burial of  
animal carcasses to prevent epidemics**

*Qualité du sol — Lignes directrices pour l'enfouissement des carcasses  
d'animaux pour éviter une épidémie*





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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 28901 was prepared by Technical Committee ISO/TC 190, *Soil quality*, Subcommittee SC 7, *Soil and site assessment*.

## Introduction

The incidence of livestock epidemics such as bovine spongiform encephalopathy (BSE), swine fever, foot and mouth disease (FMD), Newcastle disease and avian influenza (AI) are becoming increasingly more frequent and geographically widespread. These epidemics spread quickly across country borders due to rapid exchange of people, animals and products between countries. Epidemics threaten the welfare of human beings through secondary infection on other livestock, economic loss and public health. Preventing the spread of epidemics to other areas where livestock are raised is the priority. However, when this fails and the epidemic has spread, rapid and effective action should be taken to prevent the further spread of infection. Slaughter followed by disposal of infected livestock is an essential means of preventing the spread of the epidemic.

Disposal methods for slaughtered livestock include: incineration, rendering, composting and burial. Burial is a method that has long been used, as it is relatively economical and does not require specialized techniques or equipment. However, it does have the potential to contaminate the receiving environment. Leachate from the buried animal carcass can pollute the soil and the surrounding waters (groundwater and surface water), and the gas caused by the decomposition of the carcass produces foul. Despite such drawbacks, burial continues to be used widely, because it can limit the spread of an epidemic when massive amount of carcasses must be disposed rapidly. The objectives of this International Standard are to curtail the spread of the disease, to destroy the causative agents, and to dispose of the carcasses by burial.





# Soil quality — Guidance for burial of animal carcasses to prevent epidemics

## 1 Scope

This International Standard provides guidance on environment-friendly burial methods of animal carcasses to prevent epidemics, to curtail the spread of the disease, to destroy the causative agents, and to dispose of the carcasses.

This International Standard does not apply to the burial of animal carcasses resulting from natural death or by accident.

Other methods of disposal are outside the scope of this International Standard.

**NOTE** In some countries, infected animals or parts of animals cannot be buried on farms due to legislation but are subject to handling by licensed commercial landfills or incinerations.

## 2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10390, *Soil quality — Determination of pH*

ISO 10694, *Soil quality — Determination of organic and total carbon after dry combustion (elementary analysis)*

ISO 11260, *Soil quality — Determination of effective cation exchange capacity and base saturation level using barium chloride solution*

ISO 11272, *Soil quality — Determination of dry bulk density*

ISO 11277, *Soil quality — Determination of particle size distribution in mineral soil material — Method by sieving and sedimentation*

ISO 13536, *Soil quality — Determination of the potential cation exchange capacity and exchangeable cations using barium chloride solution buffered at pH = 8,1*

ISO 14688-2:2004, *Geotechnical investigation and testing — Identification and classification of soil — Part 2: Principles for a classification*

ISO 25177, *Soil quality — Field soil description*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

### 3.1

#### **affected animal**

animal which has been infectious or is at present infectious or is suspected of soon becoming infectious and which is to be killed to prevent epidemics

### 3.2

#### **animal carcass**

dead body of an animal or parts thereof, or products of animal origin

**NOTE** Animal excreta are included in this definition.

- 3.3**  
**burial**  
act of burying an animal carcass
- 3.4**  
**discharge**  
action of releasing a substance such as a liquid or gas; a substance that is expelled from a defined area or location
- 3.5**  
**disposal**  
collective noun for any operation to remove and discard waste
- 3.6**  
**epidemic**  
large number of cases of a particular disease, usually infectious, occurring at the same time in a particular community
- 3.7**  
**infectious waste**  
substance containing viable microorganisms or their toxins which is known or reliably believed to cause disease in man or other living organisms
- [EN 13965-1:2004]
- 3.8**  
**leachate**  
liquid percolated through a soil and containing substances in solution or suspension
- 3.9**  
**livestock**  
domesticated animals, usually kept on a farm
- EXAMPLES    Cattle, sheep, horses, pigs, chickens.
- 3.10**  
**permeability**  
measure of the ease with which gases, liquids, or plant roots penetrate or pass through a bulk mass of soil
- 3.11**  
**quicklime**  
liming material consisting mainly of calcium oxide or a mixture of calcium oxide and possibly magnesium oxide, produced by the calcination of limestone, magnesian limestone or dolomitic limestone
- [EN 12944-3:2001]
- 3.12**  
**soil texture**  
relative proportions of the various particle size fractions (i.e. sand, silt, clay) in a soil according to a soil classification system
- 3.13**  
**wildlife animal**  
all non-domesticated animals
- EXAMPLES    Deer, wild boar, rodents.

## 4 Objectives and constraints

In the event of an epidemic in which an infectious disease either kills animals directly or causes them to be killed, urgent action is required to

- curtail the spread of the disease,

- destroy the causative agents,
- rehabilitate those persons affected by the epidemic,
- return the land to profitable agriculture or other use,
- dispose of the carcasses, and
- dispose of excreta and other obnoxious material.

Four factors will constrain the work:

- a) The need for urgency arises because there will be a multiplicity of pathways by which the causative agents can be transmitted from live or dead animals within the area affected to animals in remote locations. The causative agent can be spread by birds, other wildlife, or transported by wind or wind-blown dust, and water. All of these mechanisms are difficult to control.
- b) In an attempt to arrest some of these pathways, the site shall be quarantined, with movements of people and other animals onsite and offsite being minimized, controlled and disinfected.
- c) As a consequence, the work shall be constrained by what is in hand or can readily be obtained.
- d) Further adaptation should be made to suit local ground conditions.

The number of animals involved shall also be considered.

NOTE For example, in one small outbreak in 2007, over 350 cattle were slaughtered on one day, and 800 pigs and 50 more cattle were slaughtered on the following day.

## 5 Planning of burial programme

### 5.1 Time of burial

Carcasses should be buried as soon as possible after their death. However, it should be noted that postmortem livestock will gas up and increase volume by up to half. Therefore, if they are placed in a burial pit too soon and covered over, the carcasses will subsequently rapidly degas, causing large voids to form and causing cracking of cover material. Therefore, either the stock should not be covered immediately or the carcasses should be pierced to prevent them gassing up.

Once buried, decomposition and degradation processes will intensify after 24 h to 72 h (depending on the ambient temperature), which will pose additional threats to health and the environment.

Each country may have a specified time frame within which carcasses shall be buried.

### 5.2 Consideration of diseases and kind of animal carcasses infected

When livestock are sufficiently believed to be infected by an epidemic, owners of livestock in the area where the epidemic has spread or may spread can be ordered to immediately eradicate the livestock. Livestock eradication requirements can differ on a national scale, depending on the form of the epidemic. Diseases listed by the World Organisation for Animal Health (OIE) are given in Annex B.

#### 5.2.1 Consideration of volume of carcasses to be buried

It might be necessary to bury the following:

- a) carcasses and parts thereof;
- b) excreta, including: urine, dung, sweat, saliva, snot (nasal mucus), tears, earwax, milk, semen, “afterbirth”;
- c) miscellaneous droppings, for example: hair, scurf, skin, blood;

d) infected straw, bedding mixed with dung, farmyard manure (if infected), etc.

Depending on the disease, some or perhaps all of these can transmit viable causative agents.

Burial volume is generally determined by the livestock's species and size. If the burial volume is uncertain, it should be assumed that no more than 300 kg of carcass per 1 m<sup>3</sup> will be permitted. Table 1 gives an indication of average livestock weight.

**Table 1 — Average livestock weight**

Type	Kind of animal	Weight
		kg
Beef cattle	Cows and bulls	550
	Feeder cattle	450
	Replacement heifers	360
	Calves	135
Dairy cattle	Cows and bulls	600
	Replacement heifers	450
	Calves	135
Hog	Boars or sows	150
	Feeder pigs	100
	Weanling pigs	16
Poultry	Hens, cockerels, capons	1,8
	Chicks, broilers	1,5
	Hen turkeys, geese, ducks	8
Sheep		50

### 5.3 Selection of burial site

#### 5.3.1 Deciding between onsite or offsite burial

In general, to avoid further spreading of the disease due to transport and handling, the infected livestock should be buried at the site where they are found.

The principal advantages of burial over incineration are that burial tools are simple, and movements off the site where infected animal carcasses occur are minimized.

When a suitable location for burial is not available on the farm, burial would have to be off the farm.

If the carcasses are buried on the farm, continuing maintenance and monitoring of the burial area are required (in relation to an existing national specification, if available); see also Clause 8. This area should be taken out of production.

NOTE The presence of the pit, even if landscaped, can reduce the value of the land.

#### 5.3.2 Methods of burial

The following methods of burial are distinguished.

Simple burial: The carcasses are laid into a pit and soil is placed directly on top of them, perhaps with the addition of some quicklime. In this method, earth-dwelling worms, insects, and bacteria have direct access to the carcasses and assist in their disintegration. However, large volumes of obnoxious effluent are to be expected, and the causative agents are likely to escape with the effluent, meaning that complete disposal of

the carcasses cannot be assured. Although this method has been used in the past, it should now be regarded as unacceptable.

**Aerobic burial:** Although there appears to be a view that burial under carefully controlled aerobic conditions (presumably without earth-dwelling worms, insects and bacteria) would ensure complete disintegration and disposal of the carcasses, there appears to be little in the way of either scientific evidence or practical experience to support this view.

**Anaerobic burial:** Recent practice seems to have been to envelop the carcasses in impermeable membranes with a view to collecting the leachate. It seems probable that anaerobic conditions have developed in many cases when such systems have been used but there is some doubt as to whether disintegration does occur under anaerobic conditions.

### 5.3.3 Requirements for the burial site

Burial sites are limited to areas where human or livestock access can be controlled, and shall not be in the vicinity of water sources, surface water and principal aquifers, main roads or residential areas. In addition, other aspects, such as environmental designation, archaeological site history, existing underground services, field drains, statutory and legal issues, need to be considered.

When the candidate site is in the vicinity of a principal aquifer, the site should only be used for burial if the results of a trial pit and other investigations show that the site is safe.

The area selected should not be liable to flooding or become submerged during flood events.

Soft ground should be avoided in selecting sites.

Characteristics of the soil of the burial site, such as soil texture, permeability, slope, groundwater depth and its topography, should be taken into consideration. Escarpments and sandy soils shall be avoided.

In selecting a site for burial, soil information obtained from trial pits can be useful. A trial pit is a shallow excavation made to a depth of not greater than 5 m. The trial pit is to be used extensively at the surface for soil sampling and detection of services prior to borehole excavation (see, for example, ISO 10381-4).

**SAFETY PRECAUTIONS — An important safety point to note is that all pits below a depth of 1,2 m shall be supported.**

When preparing a trial pit, a log including such information as soil type, structure and groundwater levels should be made.

The basic characteristic parameters given in Table 2 should be considered to evaluate the potential contamination of soil and groundwater at the burial sites.

NOTE For more information regarding groundwater protection, ISO 15175 can be considered.

**Table 2 — Substances and parameters to be considered in selecting sites for burial**

Substance/parameter	Method	International Standard
Distance to water source	—	—
Distance to main roads	—	—
Distance to residential area	—	—
Depth of groundwater table	—	ISO 25177
Possibility of submergence in case of flooding	—	—
Slope	—	ISO 25177
Soil texture	Sieving, sedimentation	ISO 11277
Permeability	—	—
Bulk density	Direct measurement of undisturbed soil samples estimation from soil water-retention curves	ISO 11272
pH	pH-electrode	ISO 10390
Organic carbon	Dry combustion	ISO 10694
Cation exchange capacity, exchangeable cations	BASCOMP, BaCl <sub>2</sub>	ISO 11260 ISO 13536
Bearing capacity	Cone penetration test	—
Trial pit	—	ISO 14688-2:2004

### 5.3.4 Seasonal high groundwater level

Burial pits should be located on sites with soils having a seasonal high groundwater table not less than 1,5 m below the bottom of the planned burial pit.

Some difficulty will be experienced in establishing the seasonal high groundwater level. Usually, this would require observations to be taken from dip wells or the like, over the course of at least 1 year. However, usually neither is the time available, nor is it advisable to drill holes from severely contaminated land down to the water table. If this information is not already available, it might be possible to obtain a reasonable estimate of seasonal high groundwater level from a desk study or from indirect observations. Otherwise, the best possible estimate should be made and the possibility of error should be accepted.

Because a relatively deep excavation is being made without a thorough investigation, there is a small possibility of breaking into an artesian aquifer. Should this happen, the excavation shall immediately be refilled with compacted soil.

In the worst cases, it will be necessary to exhume the carcasses and start again.

### 5.3.5 Selection of the kind of pit

Usually onsite burial is preferable to offsite burial, given the potential of transmitting infection via transportation. However, site-specific circumstances will usually dictate the best approach.

**NOTE** For example, in an area where a high density of farms has been affected, it might be more appropriate to have one centralized and professionally managed disposal point, with carcasses transported to this point under appropriate conditions. The advantage of this approach is that a more engineered design of the burial pit can be used, together with more stringent monitoring of the disposal process. This approach reduces the number of smaller on-farm burial sites, which for practical and financial reasons are invariably not well engineered or as closely monitored.

### 5.3.6 Design of the burial pit

There is no “one size fits all” design for burial pits. For centralized and professionally managed sites, a landfill-like design (as given in Figure 1) may be appropriate. In contrast, on small and medium-sized individual farms, it is unlikely that this approach can be used.

The design (and later construction) of the burial pit should be supervised by a competent civil engineer.

The depth of the pit should be such that the distance between the top of the carcass (once buried) and the ground surface should be more than 2 m. The sides and the bottom of the pit should be covered with waterproof material such as HDPE (high-density polyethylene) sheet.

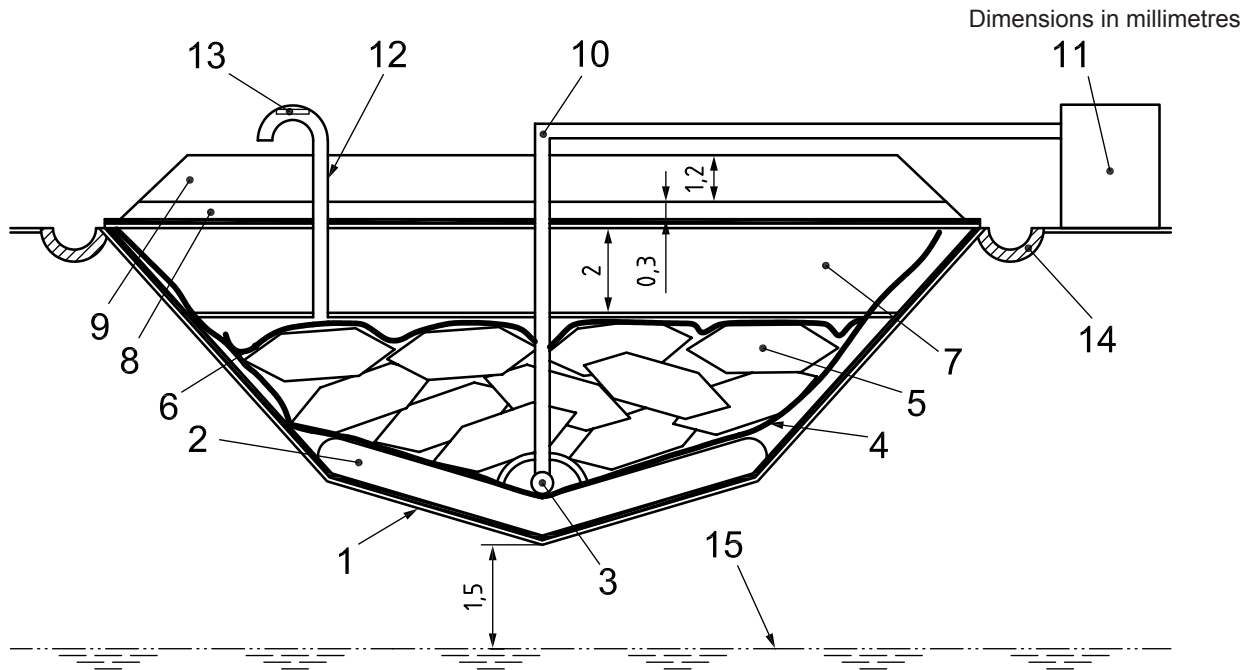
Table 3 indicates the amount by which soil is likely to bulk up; i.e. increase in volume due to its lower compaction.

NOTE Loose soil is unlikely to settle to its original volume. The amount of settlement to be expected when the pit is backfilled will depend, inter alia, on the nature of the soil, the thickness of the soil layer (self-loading), whether any compaction is carried out, the moisture content and the amount of rainfall. Guidance on settlement processes can be found in geotechnical guidance documents.

**Table 3 — Examples of swelling behaviour of different materials**

<b>Material</b>	<b>Swell</b> %
Clay	40
Loam	25
Sand	12
Gravel	12

Where no water courses are located nearby and no underlying aquifers are present, encapsulation with impermeable materials or specialized capping materials may not be required. However, a site-specific assessment of the appropriateness of the burial site would need to be made.



**Key**

- 1 waterproof material: 6.3 Bringing in lining materials and discharge pipes
- 2 soil: 6.2 Execution of the excavation
- 3 perforated pipe: 6.3 Bringing in lining materials and discharge pipes
- 4 quicklime: 5.3.9 Use of lime, 6.2 Execution of the excavation
- 5 carcass: 6.4 Placing of carcasses in the burial pit
- 6 quicklime: 5.3.9 Use of lime, 6.5 Coverage of burial pit after finalization of placement of carcasses
- 7 filling: 6.5 Coverage of burial pit after finalization of placement of carcasses
- 8 bentonite: 6.5 Coverage of burial pit after finalization of placement of carcasses
- 9 soil: 6.5 Coverage of burial pit after finalization of placement of carcasses
- 10 leachate discharge pipe: 5.3.8 Effluent collection, 6.5 Coverage of burial pit after finalization of placement of carcasses
- 11 leachate treatment system: 7.4 Leachate treatment
- 12 gas discharge pipe: 5.3.8 Installation of pipes for gas discharge, 6.5 Coverage of burial pit after finalization of placement of carcasses
- 13 UV lamp: 5.3.8 Installation of pipes for gas discharge
- 14 drainage: 6.5 Coverage of burial pit after finalization of placement of carcasses
- 15 groundwater

**Figure 1 — Schematic diagram of an animal carcass burial pit**

**5.3.7 Leachate collection**

One or more perforated pipes shall be laid along the bottom of the pit to collect and remove leachate from the carcasses, together with any other liquids entering the pit. Care shall be taken to ensure that no leakage can occur at the point or points where such pipes leave the pit.

The top of the perforated pipe(s) should be covered with gravel to prevent their breakage and blockage by leachate and carcass. Examples of the design of protection layers are given in Annex C.

Leachate should be removed and disposed of in a manner in keeping with current appropriate guidance within each country.



### 5.3.8 Installation of pipes for gas discharge

Pipes should be installed to discharge gas produced from carcass decay. The gas discharge pipes should be greater than 100 mm in diameter, perforated and U-shaped and face towards the ground surface in order to reduce stench and to prevent inflow of rainwater. At least 5 pipes should be installed every 90 m<sup>2</sup> of the burial pit. The pipe should be placed on a layer made from gravel to prevent blockage. For reasons of public health and safety a suitable device for gas treatment should be installed at the end of each pipe. For example, a gas sterilization filter (0,2 µm) or solar-cell-operated UV lamp can be used for this purpose.

### 5.3.9 Use of lime

The use of lime in an animal carcass burial site should be decided according to the national and local situation.

The principal reasons for adding lime are as follows:

- a) to mop up excess water by conversion of calcium oxide to calcium hydroxide (i.e. slaked lime); this is sometimes used on construction sites on which the surface soil has become too wet;
- b) to alter the adsorption complex on clay with a view to modifying the behaviour of the clay;
- c) to stabilize clayey soils by reaction with the clay;
- d) to kill bacteria, probably by extracting water from them;
- e) to convert foul-smelling gases to a less obnoxious form; for this to be successful, it is necessary to ensure that the gases passed through the lime rather than escaping along preferential flow paths around it;
- f) to convert foul effluent and leachate to less noxious forms;
- g) to control the pH to promote bacterial and/or chemical disintegration of the carcasses;
- h) to encourage earthworms; this would presumably apply only in cases of simple burial.

The disinfectant used to kill the causative agent for foot-and-mouth disease is acidic. On this basis, there is a fear that the use of lime might help to preserve some causative agents. In addition, the high pH of the leachate collected from the animal carcass burial site where lime is applied may cause problems in treating leachate.

### 5.3.10 Other aspects

When there are several burial pits at a site, the distance between the pits should be more than 6 m to enable the movement of people and equipment.

## 6 Construction of burial pit

### 6.1 Preparation of the site

When the location of the burial pit has been decided, the following actions are desirable.

- a) Exclude animals.
- b) Collect debris and perhaps dung.
- c) Disinfect the working area. This is intended to minimize the chance of survival of causative agents on or in the topsoil.
- d) If the land is arable, compact a strip 1 m wide along the upslope side of the pit to prevent water from flowing through the topsoil and into the pit.
- e) Draw a furrow across the upslope side of the pit to collect runoff.
- f) Strip the topsoil from the area of the pit, and place this soil in a stockpile.

## 6.2 Excavation of the burial site

Take all necessary measures to ensure safe working inside the pit and within close vicinity of the pit.

Excavate the burial pit depending on the size necessary, using suitable equipment and machines.

Place excavated material at a sufficient distance from the excavation to ensure that no material can fall back into the pit.

Whilst digging the pit, rake out any sharp stones protruding from the sides of the pit and inspect the sides in case field drains, mole drains, or other sources of seepage are present. Should any such sources be discovered, they shall be excavated for 0,5 m back from the side of the pit and replaced by well-rammed soil. In severe cases, arrangements to intercept and divert the water will be required. In extreme cases, a new location for the pit must be found.

If the material underlying the bottom of the pit appears to be permeable, remove another 0,6 m of material and replace this with clay or such fine-grained material as can be found. In some cases, adding small quantities of bentonite or cement to the material which has been excavated will be sufficient. This underlay shall be heavily compacted whilst in a moist condition with a view to leaving it in an impermeable state (in civil engineering terms, the material should be a few percent wet of optimum, but it is unlikely that there will be time to perform compaction tests). It will be necessary to compact the underlay in a number of "lifts" (i.e. sub-layers), probably 2, 3 or 4, depending upon the type of machine used.

If the material underlying the bottom of the pit contains sharp stones or is in fact rock, it shall be covered with a 150 mm layer of stone-free soil whose function is to protect the overlying impermeable membrane which will be placed upon it. This layer of soil shall be given such compaction as seems necessary to stabilize it. Its moisture content is unlikely to be critical but, if it seems to be too wet, adding a small quantity of quicklime may dry it sufficiently.

The bottom of the burial site should be slanted to prevent leachate from collecting at the bottom of the pit. There should be at least a 2 % slope to the perforated pipe where leachate is drained.

On top of the waterproof material, the pit shall be filled with a 1 m layer of soil. Then apply a layer made of 3 cm of quicklime to prevent groundwater pollution from percolating leachate.

## 6.3 Placement of lining materials and discharge pipes

The bottom and sides of the pit shall be lined with heavy-duty impermeable material, such as high-density polyethylene (HDPE) sheet. The joins between separate pieces of this material shall be made watertight.

Lay out one or more perforated pipes at the bottom of the pit, taking care to ensure that no leakage can occur at the point or points where the pipes leave the pit. When the conceptual design calls for only one pipe, it will often be prudent to lay a pair of pipes very close together.

**NOTE** Should a single perforated pipe become blocked, it would be difficult to clear. The reason for laying two pipes is therefore that fluid in the blocked pipe could escape from one pipe into the other.

In order to protect the perforated pipes and the impermeable membrane at the bottom of the pit from traffic within the pit, and to help to provide drainage paths from the carcasses to the perforated pipes, a bottom layer of at least 0,6 m thickness shall be constructed. Three designs for this layer are suggested below.

- a) Lay a thick permeable plastic layer over the impermeable layer at the bottom of the pit (the main purpose of this is to protect the impermeable layer). Add 250 mm of lightly compacted gravel to provide cross-drainage. Add 200 mm of moderately compacted sand to provide vertical drainage and to act as a graded filter to keep material from the next layer out of the gravel. Add 150 mm of soil to filter out solid debris. If necessary, add quicklime to reduce the moisture content and help to preserve any small soil aggregates (i.e. crumbs) present. Compact this layer of soil sufficiently, so that serious rutting will not be caused by a farm tractor when carrying a carcass. If necessary, protect the sand layer from disturbance by adding another layer of soil.

- b) Before the perforated pipes are laid, construct the entire bottom layer using 2, 3 or 4 sub-layers of soil. Each layer shall be compacted sufficiently to prevent serious rutting (as described above). To prevent puddling and to improve the permeability, the soil should be moderately dry. Quicklime may be added to reduce the water content. If the soil is clayey, quicklime may be mixed in with it to improve the structure and the permeability of the soil. Quicklime reacts with clay to form cement. This reaction takes some time so care will be required to avoid over-compacting the mixture. A rough guide is to add between 0,5 % and 1,0 % lime per 10 % clay. To improve passage of fluids from one sub-layer to the next, it will probably be necessary to loosen the surface of each sub-layer before the next is added. When all of the soil is in place, excavate trenches for the perforated pipes, lay the pipes, and backfill with gravel.
- c) If no gravel is to hand, proceed as in b) above, taking extra care to make the layers as permeable as possible. Then lay several permeable pipes at no more than 2 m apart, and backfill with lightly compacted soil or turf.

Using plastic pipe enveloped in plastic filter material might be preferable to using gravel, especially if this helped to minimize the number of movements onto and off the site. However, allowing either method to be used would minimize delays if a difficulty in procurement arose.

#### **6.4 Placing of carcasses in the burial pit**

Carcasses of large animals shall be laid in an orderly fashion, to facilitate their exhumation if this becomes necessary. The carcasses, especially of ruminants, will gas up and increase in volume. They are liable to subsequently degas rapidly, leading to formation of large voids and the cracking of cover material. Thus, the carcasses should be pierced to prevent gassing up, provided appropriate guidance is available on how to do this. Regardless of the size of the animals, care shall be taken that the impermeable membrane at the side of the pit is not pierced. Where applicable, consideration should be given to removing antlers, horns and tusks from the carcasses. When the sides of the pit are sloping, the carcasses at the sides of the pit shall be laid no closer to the original ground surface than 2 m. Carcasses in the centre of the pit may be laid at a higher level based on an assumption of 20 % settlement, for example, except that no carcasses shall be closer to the original ground surface than 2 m.

#### **6.5 Coverage of burial pit after finalization of placement of carcasses**

After burying the carcass, apply a 2 cm thick layer of quicklime to the surface to reduce leachate drainage and prevent stench.

Other than the situation of conventional landfill, heavy compaction would be difficult and undesirable here. Soil should not be used to fill the gaps between the carcasses. If exhumation becomes necessary, all that soil becomes “infectious material requiring special treatment”.

Lay a heavy-duty permeable membrane over the carcasses with a view to enabling gases to move upwards and to prevent soil from moving downwards. It will be necessary to cut holes in this membrane for the gas and leachate discharge pipes. This should be done carefully, but a watertight and gastight seal is not required.

Backfill the previously excavated material to the pit about 2 m to reach surface level. On the surface, establish a mound composed of 30 cm of bentonite and more than 1,2 m of soil to prevent rainfall infiltration, leachate drainage and carcass damage by wild animals.

Complete the construction of the gas and leachate discharge pipes.

Spread the topsoil (which was excavated when the pit was dug) over the mound.

Disinfect the entire area.

Unless the topsoil consists mainly of viable turf, broadcast grass or “pasture-mixture” seeds over all bare patches of soil as soon as the climatic conditions permit.

## **7 Maintenance after burial**

### **7.1 Safety measures**

A suitable warning sign with information on the buried carcass, such as the disease, species, number, burial date and the possible date for excavation, should be erected at the site.

### **7.2 Odour treatment**

Scatter deodorizer to eliminate stench from leachate and gas. Scatter sawdust in the ditch to absorb leachate, and collect and dispose it regularly. Disinfect with quicklime.

### **7.3 Gas discharge**

Install more gas discharge pipes where there is excess gas or leachate production. Where there is little or no production of gas, reduce or eliminate the pipes.

### **7.4 Leachate treatment**

In areas where heavy rainfall may occur very frequently, the site should be covered with material such as HDPE sheet to prevent soil cover from being washed away or collapsing. Build a mound around the ditch to prevent leachate overflow. The quantity of leachate will generally increase temporarily in case of rainfall, and the quantity will depend on the amount of rainfall at the beginning. The amount of discharge will become constant over time, with the carcass acting as a buffer. The collected leachate should be sterilized by using treatment systems, such as sterilization by autoclaving, ionizing radiation, filtration and chemical treatment with sterilizing agents. Leachate-treatment systems should be designed to accommodate daily changes in quantity and quality accordingly.

### **7.5 Surface regrading**

The surface of the mound of the burial pit can become undulated due to irregular collapse of the burial pit. In that case, regrade the surface of the mound with the soil collected around the pit.

## **8 Monitoring**

A monitoring program should be established according to national or international regulations to look for, and then prevent or control evidence of protrusion, rupture or sinking due to a decaying carcass or gas.

After the site has been declared to be free from disease contamination (and after a minimum period of 6 months), construct dip wells and start to monitor the groundwater release of any contaminants from the pit. The delay is intended to reduce the risk of viable causative agents being washed from the soil into the groundwater from the construction of wells. It is recommended to install one dip well for every 100 m length of pit, one for every pit less than 100 m in length and one for each group of pits. For this purpose, the length of a pit is to be taken to include the carcasses and the cess pit, but excluding any ramps or slopes at the ends of the pit. For very wide pits, measure in the direction which gives the largest dimension.

## **9 Reuse of burial sites**

For small on-farm sites, given the dominant use for agriculture, it is important that the pits be properly designed and the land restored to a suitable standard. This includes reconnecting any severed field drains, provided that the burial is deeper than agricultural operations (typically at least 1 m of topsoil and subsoil is required in agricultural restorations following open-cast operations). It is also important when excavating the pits that soil layers be carefully separated to allow for correct reinstatement of soil horizons. In many cases, topsoil has been buried with the livestock and rocky subsoil left on the surface, causing restoration problems.

## 10 Report and record keeping

The burial report shall include the following information:

- a) a reference to this International Standard;
- b) all information necessary for identification of the site;
- c) complete information concerning the animal carcass and accompanying diseases;
- d) a reference to the method used for burial;
- e) any unusual features noted during the burial.

## Annex A (informative)

### Examples of national specifications regarding burial of animal carcasses

#### A.1 Introduction

Many jurisdictions have produced guidance on the burial of animal carcasses. Although these differ at a detailed level, they are similar in setting basic requirements relating to the surrounding environment and public health, such as the distance from a water source (e.g. river, pond, lake, groundwater well), residential areas and roads, and the depth to groundwater specified.

#### A.2 Examples

##### A.2.1 US EPA (Environmental Protection Agency)

Source	Profile of the Agricultural Livestock Production Industry. Summary of operations, impacts and pollution prevention opportunities for the agricultural livestock production industry, Section D: Managing animal waste
Content	<ul style="list-style-type: none"> <li>— The impact of burying carcasses can be minimized by burying them deep below the surface of the ground, well away and downgrade from any source of drinking water.</li> <li>— Cover with a generous supply of quicklime to reduce soil pH before fill dirt is added.</li> <li>— If the carcasses must be disposed of on-site, it is preferable to have:             <ul style="list-style-type: none"> <li>— a burial area at least 100 m away from houses and watercourses;</li> <li>— the pit base at least 38 inches above the level of the water table;</li> <li>— heavy soil of low permeability and good stability;</li> <li>— good access to the site for earthmoving machinery and stock transport unless the stock are to be walked in for slaughter;</li> </ul> </li> <li>— It is important to avoid sites sloping toward watercourses and areas that are likely to drain to surface water.</li> <li>— Many states may have more strict statutes regulating the burial of dead animals.</li> </ul>

### A.2.2 Michigan, USA

Source	State of Michigan, Department of Agriculture, Animal Industry Division, Bodies of dead animals, R 287.652: Disposal of animal carcasses and disposal of residue from burning process of carcasses.
Content	<ul style="list-style-type: none"> <li>— Animal carcasses, excluding restaurant grease, buried in individual graves shall be in compliance with all of the following requirements: <ul style="list-style-type: none"> <li>— The carcass shall not come in contact with waters of the state.</li> <li>— The number of individual graves per acre shall not be more than 100 and the total combined animal weight shall not be more than 5 tons per acre.</li> <li>— Individual graves shall be separated by a minimum of 2,5 feet.</li> <li>— A grave shall not be located within 200 feet of any existing groundwater well that is used to supply potable drinking water.</li> <li>— The owner of the land has authorized the placement of the carcass.</li> </ul> </li> <li>— Animal carcasses, excluding restaurant grease, buried in a common grave shall be in compliance with all of the following requirements: <ul style="list-style-type: none"> <li>— Carcasses in a common grave shall be covered with at least 1 foot of soil within 24 h of burial.</li> <li>— A common grave shall not remain open for more than 30 days and shall receive not less than 2 feet of soil as final cover.</li> <li>— Carcasses shall not come into contact with waters of the state.</li> <li>— The total carcass weight in common graves shall not be more than 5 000 pounds per acre.</li> <li>— If there is more than 1 common grave per acre, each common grave within that acre shall be separated by a minimum of 100 feet.</li> <li>— A common grave shall be located not less than 200 feet from any existing groundwater well that is used to supply potable drinking water.</li> <li>— The owner of the land has authorized the placement of the carcasses.</li> </ul> </li> </ul>

### A.2.3 Georgia, USA

Source	Georgia General Assembly Unannotated Code, 4-5-5
Content	<ul style="list-style-type: none"> <li>— Disposal of dead animals by any of the approved methods shall be completed within 24 h after death or discovery.</li> <li>— Dead animals that are buried must be buried at least 3 feet below the ground level and have not less than 3 feet of earth over the carcass.</li> <li>— Livestock mortality must not contaminate groundwater or surface water.</li> </ul>

#### A.2.4 Illinois, USA

Source	Illinois Administrative Code, Title 8: Agriculture and animals, Chapter: Department of Agriculture, Part 90: Illinois Dead Animal Disposal Act, Section 90.110: On-the-farm disposal
Content	<ul style="list-style-type: none"> <li>— Burial shall be on the premises owned or operated by the owner of the dead animal.</li> <li>— Location shall be in an area where runoff will not contaminate water supplies or allow leachate to discharge into streams, ponds or lakes.</li> <li>— Dead animals shall not be buried less than 200 feet from a stream, private potable water supply well, or any other potable water supply source.</li> <li>— Dead animals shall not be buried within the applicable 200 or 400 foot minimum setback zone of an existing community water supply well.</li> <li>— Dead animals shall not be buried less than 200 feet from any existing residence not owned or occupied by the owner of the animal.</li> <li>— No more than a ratio of 1 pound of dead animals per 1 square foot of surface area shall be buried on an annual basis.</li> <li>— No more than 3 000 pounds of dead animals shall be buried in each site location, and the same site shall not be used more frequently than once every two years for burial purposes.</li> <li>— There shall be no more than three site locations within a radius of 120 feet.</li> <li>— Burial depth shall be sufficient to provide at least a 6 inch compacted soil cover over the uppermost part of the carcass. Precautions shall be taken to minimize soil erosion.</li> <li>— The abdominal cavity of large carcasses shall be punctured to allow escape of putrefactive gases.</li> <li>— Lime or other chemical agent shall not be used to prevent decomposition.</li> <li>— Precautions shall be taken at the site of burial necessary to prevent any disturbance by animal or mechanical means.</li> <li>— Disease and nuisance vectors are to be minimized and controlled.</li> <li>— Final cover or settling shall be limited to a 5 % or less slope differential from the normal gradient of its general surroundings.</li> <li>— Burial site locations shall be available for inspection by department personnel during normal working hours.</li> </ul>

#### A.2.5 Oregon, USA

Source	Oregon Revised Statutes, Chapter 601: Dead animals, 601.090 & 601.140
Content	<ul style="list-style-type: none"> <li>— They shall be buried to such a depth that no part of any such body, carcass or part of an animal shall be nearer than 4 feet to the natural surface of the ground and every part of such body, carcass or part of an animal shall be covered with quicklime and by at least 4 feet of earth.</li> <li>— No person shall knowingly leave the carcass of any domestic animal which the person has owned or had in charge within 0,5 miles of any dwelling or within 0,25 miles of any running stream of water for longer than 15 h without burying or burning it.</li> </ul>



### A.2.6 Idaho, USA

Source	Rules governing dead animal movement and disposal (02.04.17), 030, Disposal of dead animals
Content	<ul style="list-style-type: none"> <li>— Dead animals shall be buried to such a depth that no part of the dead animal shall be nearer than 3 feet to the natural surface of the ground.</li> <li>— Every part of the dead animal shall be covered with at least 3 feet of earth. The location of a burial site shall be: <ul style="list-style-type: none"> <li>— at least 300 feet from any wells, surface water intake structures, and public or private drinking water supply lakes or springs;</li> <li>— at least 300 feet from any existing residences;</li> <li>— at least 50 feet from property lines;</li> <li>— at least 100 feet from public roadways;</li> <li>— at least 200 feet from any body of surface water such as a river, stream, lake, pond, intermittent stream, or sinkhole.</li> </ul> </li> <li>— Burial sites shall not be located in low-lying areas subject to flooding, or in areas with a high water table where the seasonal high water level may contact the burial pit.</li> </ul>

### A.2.7 Manitoba, Canada

Source	Environment Act: Livestock Manure and Mortalities Management Regulation, Disposal of mortalities
Content	<ul style="list-style-type: none"> <li>— The disposal does not cause pollution of surface water, groundwater or soil. <ul style="list-style-type: none"> <li>— Where disposal is by burial, the operation has less than 300 animal units.</li> <li>— Mortalities in a burial pit are covered with a minimum of 1 m of soil.</li> </ul> </li> <li>— The disposal site is located at least 100 m from any surface watercourse, sinkhole, spring or well and from the operation's boundaries.</li> <li>— The disposal site is constructed so as to prevent the escape of any decomposition products of the mortalities that cause or may cause pollution of surface water, groundwater or soil, and pit.</li> </ul>

### A.2.8 British Columbia, Canada

Source	Environmental Management Act, Health Act, Agricultural Waste Control Regulation
Content	<ul style="list-style-type: none"> <li>— Mortalities may be disposed of on-farm by burial or incineration if: <ul style="list-style-type: none"> <li>— the mortalities are livestock, poultry or farmed game disposed of on the farm where they died;</li> <li>— the disposal does not cause pollution;</li> <li>— where disposal is to land, the burial pits are covered, located at least 30 m from any source of water used for domestic purposes and constructed to prevent the escape of any agricultural waste that causes pollution.</li> </ul> </li> </ul>

**A.2.9 Alberta, Canada**

Source	Livestock Diseases Act, Destruction and Disposal of Dead Animals Regulation
Content	<ul style="list-style-type: none"> <li>— The owner of a dead animal shall dispose of the animal within 48 h of its death in accordance with this section.</li> <li>— Where because of flood, fire, starvation or other similar disaster there are multiple deaths of animals and the weight of the dead animals exceeds 2 500 kg.</li> <li>— The pit is:           <ul style="list-style-type: none"> <li>— at least 100 m from wells or other domestic water intakes, streams, creeks, ponds, springs and high water marks of lakes and at least 25 m from the edge of a coulee, major cut or embankment;</li> <li>— at least 100 m from any residences;</li> <li>— at least 100 m from any livestock facilities, including pastures, situated on land owned or leased by another person;</li> <li>— at least 300 m from a primary highway;</li> <li>— at least 100 m from a secondary highway;</li> <li>— at least 50 m from any other road allowance.</li> </ul> </li> <li>— The pit is covered with:           <ul style="list-style-type: none"> <li>— a minimum of 1 m of compacted soil; or</li> <li>— a wooden or metal lid that is designed to exclude scavengers, if quicklime is applied to the dead animal in sufficient quantities to control flies and odour.</li> </ul> </li> <li>— The bottom of the pit is at least 1 m above the seasonal high water table.</li> </ul>

**A.2.10 US Department of Agriculture (USDA)/Natural Resources Conservation Service (NRCS)**

Source	Natural Resources Conservation Service, Conservation Practice Standard, Animal mortality facility code 316
Content	<ul style="list-style-type: none"> <li>— General <ul style="list-style-type: none"> <li>— Catastrophic mortality resulting from natural conditions such as temperature extremes shall be buried on-site or as otherwise directed by state and local regulatory agencies.</li> <li>— Burial of catastrophic mortality shall be timed to minimize the effects of mortality expansion during early stages of the decay process.</li> <li>— Where possible and permitted by state law, mortality shall remain uncovered or lightly covered until bloating has occurred, or methods employed to reduce or eliminate bloating.</li> <li>— Topsoil shall be retained to regrade the disposal site after the ground has settled as the decay process is completed.</li> <li>— Stockpiled soil shall be no closer than 20 feet from the edge of the burial pit.</li> </ul> </li> <li>Table 4 — Size and capacity <ul style="list-style-type: none"> <li>— Pits shall be sized to accommodate catastrophic mortality using appropriate weight to volume conversions.</li> <li>— The burial pit shall be a minimum of 4 feet wide with length necessary to accommodate mortality.</li> <li>— Depth shall accommodate a minimum of 2 feet of cover over the mortality.</li> <li>— Pit bottoms shall be relatively level.</li> <li>— Lengths may be limited by soil suitability and slope.</li> <li>— If more than one pit is required, they shall be separated by a minimum of 3 feet of undisturbed or compacted soil.</li> <li>— The burial site shall be of sufficient volume to contain the mortality with a minimum of 2 feet of soil cover.</li> <li>— The burial site shall be finish graded to slightly above natural ground elevation to accommodate settling.</li> </ul> </li> <li>— Structural loading and design <ul style="list-style-type: none"> <li>— Vehicular traffic shall not be allowed within 4 feet of the pit edge.</li> <li>— For pits that are 4 to 5 feet deep, a step or bench 18 inches wide and 1 foot deep will be dug around the perimeter of the main pit so the remaining vertical wall will not exceed 4 feet.</li> <li>— For pits greater than 5 feet deep, the earthen wall shall be sloped back at 1 1/2 horizontal and 1 vertical or flatter.</li> </ul> </li> </ul>

### A.2.11 European Union (EU)

Source	European Union law, Commission Regulation (EC) No. 811/2003 of 12 May 2003
Content	<p>Disposal of animal by-products in the event of an outbreak of disease</p> <ul style="list-style-type: none"> <li>— The competent authority must supervise the burial of animal by-products and take the measures necessary to ensure that they are buried:           <ul style="list-style-type: none"> <li>— in such a way that carnivorous animals cannot gain access to them; and</li> <li>— in a landfill site approved under Directive 1999/31/EC; or</li> <li>— in another site without endangering human health.</li> </ul> </li> <li>— In the case of burial at a site other than an approved landfill, the competent authority must take the necessary measures to ensure that the animal by-products are buried without using processes or methods which could harm the environment, taking account of Community and national environmental and public health legislation and guidance to minimize to the extent compatible with public order consideration:           <ul style="list-style-type: none"> <li>— risk to water, air, soil and plants and animals;</li> <li>— causing a nuisance through noise or odours; and</li> <li>— adversely affecting the countryside or places of special interest.</li> </ul> </li> </ul>

### A.2.12 Japan

Source	Regulations on Prevention of Livestock Epidemics, Article 29, Annex 2
Content	<ul style="list-style-type: none"> <li>— Requirements for burial site:           <ul style="list-style-type: none"> <li>— Distance from houses, drinking water (well), river, road;</li> <li>— No possible effect on water sources;</li> <li>— Allows 4 m minimum digging;</li> <li>— No possibility of excavating for 3 years after burial;</li> <li>— Easy to bring in equipments and materials.</li> </ul> </li> <li>— Burial methods:           <ul style="list-style-type: none"> <li>— Pit depth of 4 m to 5 m. Pit sides are covered with impermeable sheet.</li> <li>— 2 m of soil from the top of the carcass to surface. Bury carcass in long narrow rows, the ground shape permitting.</li> <li>— Scatter lime powder on top of buried carcass. Then cover with earth and sand, and again scatter lime powder on top.</li> <li>— In case of 20 fully-grown cows or 60 pigs or sheep, approximately 10 m is required.</li> <li>— When burial is completed, put up a warning sign indicating the burial date and the 3 year excavation prohibition.</li> </ul> </li> </ul>

### A.2.13 Republic of South Korea

Source	Enforcement Regulation of the Act on the Prevention of Livestock Epidemics
Content	<ul style="list-style-type: none"> <li>— The location of a burial pit:               <ul style="list-style-type: none"> <li>— shall be at least 1 m above groundwater;</li> <li>— shall be at least 30 m from water source and surface water; and</li> <li>— shall not be in the vicinity of main road and residential areas.</li> </ul> </li> <li>— Things to be considered in estimating the volume of burial pit:               <ul style="list-style-type: none"> <li>— Number of carcasses;</li> <li>— Dimension of the burial pit: 4 m to 5 m (bottom width) × 5 m to 6 m (top width) × 5 m (depth) × 10 m (length).</li> </ul> </li> <li>— Burial methods:               <ul style="list-style-type: none"> <li>— The bottom of the burial pit should be slanted (at least 2 % slope) to facilitate leachate collection at the bottom of the pit.</li> <li>— The sides and the bottom of the pit should be covered with a mixed soil and waterproof material.</li> <li>— Perforated pipe is used for leachate collection.</li> <li>— Fill the pit with 1 m high soil on top of the waterproof material.</li> <li>— Bury the carcass (2 m) and apply 40 cm soil and 5 cm quicklime.</li> <li>— Install pipe to discharge gas produced from carcass decay on top of the carcass.</li> <li>— Fill up the pit with soil (at least 2 m).</li> <li>— Establish a mound (more than 1,5 m) over the surface of the burial pit.</li> <li>— Make ditch around the burial pit.</li> <li>— Spread quicklime on the surface and around the burial site.</li> <li>— Post a warning sign.</li> <li>— Prepare a monitoring programme.</li> </ul> </li> </ul>

## Annex B (informative)

### Diseases listed by the World Organisation for Animal Health (OIE)

**Table B.1 — Diseases listed by the World Organisation for Animal Health for domestic animals**

Livestock	Disease
Multiple species	— Anthrax
	— Aujeszky's disease
	— Bluetongue
	— Brucellosis ( <i>Brucella abortus</i> )
	— Brucellosis ( <i>Brucella melitensis</i> )
	— Brucellosis ( <i>Brucella suis</i> )
	— Crimean Congo haemorrhagic fever
	— Echinococcosis/hydatidosis
	— Epizootic haemorrhagic disease
	— Equine encephalomyelitis (Eastern)
	— Foot and mouth disease
	— Heartwater
	— Japanese encephalitis
	— Leptospirosis
	— New world screwworm ( <i>Cochliomyia hominivorax</i> )
	— Old world screwworm ( <i>Chrysomya bezziana</i> )
	— Paratuberculosis
	— Q fever
	— Rabies
	— Rift Valley fever
— Rinderpest	
— Surra ( <i>Trypanosoma evansi</i> )	
— Trichinellosis	
— Tularemia	
— Vesicular stomatitis	
— West Nile fever	

Table B.1

Livestock	Disease
Cattle	<ul style="list-style-type: none"> <li>— Bovine anaplasmosis</li> <li>— Bovine babesiosis</li> <li>— Bovine genital campylobacteriosis</li> <li>— Bovine spongiform encephalopathy</li> <li>— Bovine tuberculosis</li> <li>— Bovine viral diarrhoea</li> <li>— Contagious bovine pleuropneumonia</li> <li>— Enzootic bovine leukosis</li> <li>— Haemorrhagic septicaemia</li> <li>— Infectious bovine rhinotracheitis/infectious pustular vulvovaginitis</li> <li>— Lumpy skin disease</li> <li>— Theileriosis</li> <li>— Trichomonosis</li> <li>— Trypanosomosis (tsetse-transmitted)</li> </ul>
Sheep and goat	<ul style="list-style-type: none"> <li>— Caprine arthritis/encephalitis</li> <li>— Contagious agalactia</li> <li>— Contagious caprine pleuropneumonia</li> <li>— Enzootic abortion of ewes (ovine chlamydiosis)</li> <li>— Maedi-visna</li> <li>— Nairobi sheep disease</li> <li>— Ovine epididymitis (<i>Brucella ovis</i>)</li> <li>— Peste des petits ruminants</li> <li>— Salmonellosis (<i>S. abortusovis</i>)</li> <li>— Scrapie</li> <li>— Sheep pox and goat pox</li> </ul>

Table B.1

Livestock	Disease
Equine	<ul style="list-style-type: none"> <li>— African horse sickness</li> <li>— Contagious equine metritis</li> <li>— Dourine</li> <li>— Equine encephalomyelitis (Western)</li> <li>— Equine infectious anaemia</li> <li>— Equine influenza</li> <li>— Equine piroplasmiasis</li> <li>— Equine rhinopneumonitis</li> <li>— Equine viral arteritis</li> <li>— Glanders</li> <li>— Venezuelan equine encephalomyelitis</li> </ul>
Swine	<ul style="list-style-type: none"> <li>— African swine fever</li> <li>— Classical swine fever</li> <li>— Nipah virus encephalitis</li> <li>— Porcine cysticercosis</li> <li>— Porcine reproductive and respiratory syndrome</li> <li>— Swine vesicular disease</li> <li>— Transmissible gastroenteritis</li> </ul>
Avian	<ul style="list-style-type: none"> <li>— Avian chlamydiosis</li> <li>— Avian infectious bronchitis</li> <li>— Avian infectious laryngotracheitis</li> <li>— Avian mycoplasmosis (<i>Mycoplasma gallisepticum</i>)</li> <li>— Avian mycoplasmosis (<i>Mycoplasma synoviae</i>)</li> <li>— Duck virus hepatitis</li> <li>— Fowl cholera</li> <li>— Fowl typhoid</li> <li>— Highly pathogenic avian influenza</li> <li>— Infectious bursal disease (Gumboro disease)</li> <li>— Marek's disease</li> <li>— Newcastle disease</li> <li>— Pullorum disease</li> <li>— Turkey rhinotracheitis</li> </ul>



Table B.1

Livestock	Disease
Lagomorph	— Myxomatosis — Rabbit haemorrhagic disease
Other species	— Camel pox — Leishmaniasis

## Annex C (informative)

### Examples of the design of protection layers for perforated drainage pipes

#### C.1 Protection-applying plastic layers

Lay a thick permeable plastic layer over the impermeable layer at the bottom of the pit (the main purpose of this is to protect the impermeable layer). Add 250 mm of lightly compacted gravel to provide cross-drainage. Add 200 mm of moderately compacted sand to provide vertical drainage and to act as a graded filter to keep material from the next layer out of the gravel. Add 150 mm of soil to filter out solid debris. If necessary, add quicklime to reduce the moisture content and help to preserve any small aggregates (e.g. crumbs) present. Compact this layer of soil sufficiently, so that serious rutting will not be caused by a farm tractor when carrying a carcass. If necessary to protect the sand layer from disturbance, add another layer of soil.

#### C.2 Protection-applying quicklime

Before the perforated pipes are laid, construct the whole of the bottom layer using 2, 3 or 4 sub-layers of soil. Each layer shall be compacted sufficiently to prevent serious rutting as described above. To prevent puddling and to improve the permeability, the soil should be moderately dry. Quicklime may be added to reduce the water content. If the soil is clayey, quicklime may be mixed in to improve the structure and the permeability of the soil. Quicklime reacts with clay to form a cement; this reaction takes some time, so care will be required to avoid overcompacting the mixture. A rough guide is to add between 0,5 % and 1,0 % lime per 10 % clay. To improve passage of fluids from one sub-layer to the next, it will probably be necessary to loosen the surface of each sub-layer before the next is added. When all of the soil is in place, excavate trenches for the perforated pipes, lay the pipes, and backfill with gravel.

#### C.3 Protection when no gravel is readily available

If no gravel is available, proceed as in C.2, taking extra care to make the layers as permeable as possible. Then lay several permeable pipes no more than 2 m apart and backfill with lightly compacted soil or turf.

NOTE Using plastic pipe enveloped in plastic filter material might be preferable to using gravel, especially if this helped to minimize the number of movements onto and off the site. However, permitting either method to be used would minimize delays if a difficulty in procurement arose.

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