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European IPPC Bureau

Integrated Pollution Prevention and Control (IPPC)

Draft Reference Document on Best Available Techniques on Emissions from Storage

Draft dated September 2001

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PREFACE

1. Status of this document

Unless otherwise stated, references to “the Directive” in this document means the Council Directive 96/61/EC on integrated pollution prevention and control.
This document is a working draft of the European IPPC Bureau. It is not an official publication of the European Communities and does not necessarily reflect the position of the European Commission.

2. Relevant legal obligations of the IPPC Directive and the definition of BAT

In order to help the reader understand the legal context in which this document has been drafted, some of the most relevant provisions of the IPPC Directive, including the definition of the term “best available techniques”, are described in this preface. This description is inevitably incomplete and is given for information only. It has no legal value and does not in any way alter or prejudice the actual provisions of the Directive.

The purpose of the Directive is to achieve integrated prevention and control of pollution arising from the activities listed in its Annex I, leading to a high level of protection of the environment as a whole. The legal basis of the Directive relates to environmental protection. Its implementation should also take account of other Community objectives such as the competitiveness of the Community’s industry thereby contributing to sustainable development.

More specifically, it provides for a permitting system for certain categories of industrial installations requiring both operators and regulators to take an integrated, overall look at the polluting and consuming potential of the installation. The overall aim of such an integrated approach must be to improve the management and control of industrial processes so as to ensure a high level of protection for the environment as a whole. Central to this approach is the general principle given in Article 3 that operators should take all appropriate preventative measures against pollution, in particular through the application of best available techniques enabling them to improve their environmental performance.

The term “best available techniques” is defined in Article 2(11) of the Directive as “the most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole.” Article 2(11) goes on to clarify further this definition as follows:

“techniques” includes both the technology used and the way in which the installation is designed, built, maintained, operated and decommissioned;

“available” techniques are those developed on a scale which allows implementation in the relevant industrial sector, under economically and technically viable conditions, taking into consideration the costs and advantages, whether or not the techniques are used or produced inside the Member State in question, as long as they are reasonably accessible to the operator;

“best” means most effective in achieving a high general level of protection of the environment as a whole.

Furthermore, Annex IV of the Directive contains a list of “considerations to be taken into account generally or in specific cases when determining best available techniques ... bearing in mind the likely costs and benefits of a measure and the principles of precaution and prevention”. These considerations include the information published by the Commission pursuant to Article 16(2).

Competent authorities responsible for issuing permits are required to take account of the general principles set out in Article 3 when determining the conditions of the permit. These conditions must include emission limit values, supplemented or replaced where appropriate by equivalent parameters or technical measures. According to Article 9(4) of the Directive, these emission limit values, equivalent parameters and technical measures must, without prejudice to compliance with environmental quality standards, be based on the best available techniques, without prescribing the use of any technique or specific technology, but taking into account the technical characteristics of the installation concerned, its geographical location and the local environmental conditions. In all circumstances, the conditions of the permit must include provisions on the minimisation of long-distance or transboundary pollution and must ensure a high level of protection for the environment as a whole.

Member States have the obligation, according to Article 11 of the Directive, to ensure that competent authorities follow or are informed of developments in best available techniques.

3. Objective of this Document

Article 16(2) of the Directive requires the Commission to organise "an exchange of information between Member States and the industries concerned on best available techniques, associated monitoring and developments in them", and to publish the results of the exchange.

The purpose of the information exchange is given in recital 25 of the Directive, which states that "the development and exchange of information at Community level about best available techniques will help to redress the technological imbalances in the Community, will promote the world-wide dissemination of limit values and techniques used in the Community and will help the Member States in the efficient implementation of this Directive."

The Commission (Environment DG) established an information exchange forum (IEF) to assist the work under Article 16(2) and a number of technical working groups have been established under the umbrella of the IEF. Both IEF and the technical working groups include representation from Member States and industry as required in Article 16(2).

The aim of this series of documents is to reflect accurately the exchange of information which has taken place as required by Article 16(2) and to provide reference information for the permitting authority to take into account when determining permit conditions. By providing relevant information concerning best available techniques, these documents should act as valuable tools to drive environmental performance.

4. Information Sources

This document represents a summary of information collected from a number of sources, including in particular the expertise of the groups established to assist the Commission in its work, and verified by the Commission services. All contributions are gratefully acknowledged.

5. How to understand and use this document

The information provided in this document is intended to be used as an input to the determination of BAT in specific cases. When determining BAT and setting BAT-based permit conditions, account should always be taken of the overall goal to achieve a high level of protection for the environment as a whole.

The rest of this section describes the type of information that is provided in each section of the document.

Chapters 1 provides information on the storage and handling of bulk and dangerous substances and on the horizontal approach taken to present BAT.

Chapter 2 addresses the relevant classification of substances such as toxicity, flammability and harmfulness for the environment. For solids in bulk it also addresses the dispersiveness class.

Chapter 3 describes the various modes used to store liquids and gases as well as possible emissions resulting from storage and transfer facilities both above and below ground. For each storage and transfer category, relevant operational activities and possible events/incidents are listed. The emission scorecards show which emissions are relevant and are going to be discussed in more detail.

This chapter also describes storage and handling of solids in bulk. Heaps of bulk material such as cereals and coals in the open air are a potential source of dust emissions. Different types of heaps are described. Because the handling of solid bulk material is another potential source of dust emissions, several loading, unloading and conveying techniques are described.

Chapter 4 provides basic information on the possible Emission Control Measures (the so-called ECMs) which, for liquids and gases, includes an assessment of relevant safety and operational aspects and economic considerations. ECMs for preventing dust emissions from storing and handling solids are also described and assessed, but this assessment is less comprehensive than for liquids and gases.

Chapter 5 focuses on the selection and description of BAT. This is done via the provision of a general methodology for making the appropriate assessment for specific cases (specific product and storage mode) and providing a number of case studies. The purpose is thus to provide a general methodology to be applied to the storage and handling of substances to assist in the determination of BAT-based permit conditions or for the establishment of general binding rules under Article 9(8). It should be stressed, however, that this document does not propose emission limit values. The determination of appropriate permit conditions will involve taking account of local, site-specific factors such as the technical characteristics of the installation concerned, its geographical location and the local environmental conditions. In the case of existing installations, the economic and technical viability of upgrading them also needs to be taken into account. Even the single objective of ensuring a high level of protection for the environment as a whole will often involve making trade-off judgements between different types of environmental impact, and these judgements will often be influenced by local considerations.

Although an attempt is made to address some of these issues, it is not possible for them to be considered fully in this document. The methodology presented in chapter 5 will therefore not necessarily be appropriate for all installations.

Since the best available techniques change over time, this document will be reviewed and updated as appropriate. All comments and suggestions should be made to the European IPPC Bureau at the Institute for Prospective Technological Studies at the following address:

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Draft Reference Document on Best Available Techniques on Emissions from Storage

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1 GENERAL INFORMATION

1.1 Background / Problems with storage and handling of solid bulk materials

The following categories of emissions from dusty bulk materials may be distinguished:

- Emissions during loading of the material
- Emissions during discharge of the material
- Emissions during conveyance of the material
- Emissions during storage of the material.

Generally we are dealing with diffuse dust emissions, i.e. unconfined sources.

Moreover the subject must be approached from the following perspectives:

- dusty bulk materials are to be assigned to one of the following categories: coal, ores, grains, stone, earth and fertilisers
- bulk materials vary in their tendency to generate dust not only according to category but also according to the form in which they are handled
- furthermore, the various storage, conveyance and handling processes are not equally suitable for each bulk material. The suitability of processes and the specific emissions of the individual bulk materials must hence be analysed
- the same applies to integrated or downstream dust reduction measures.

Conclusion: the most appropriate techniques for storing and loading bulk can only be recommended in relation to each specific material. [UBA, 2001, 17]

2 SUBSTANCES AND CLASSIFICATION

2.1 General

2.1.1 Nature and classification of dangerous materials

The classification of dangerous substances is the process of identifying their hazardous properties by using appropriate test methods and allocating them to one or more hazard classes by comparing the results of the tests with the classification criteria. Preparations or mixtures may be classified either by testing or by applying calculation methods based upon the concentration of their hazardous components. [TETSP, 2001, 84]

The list in Table 2.1 shows an overview of the relevant categories of substances with their danger characteristics and hazard symbols. Furthermore, the R-Phrases can appear separately or in combination.

Hazard	Symbol	R-Phrases
explosive	E	1,2,3
oxidising:	O	7,8,9
extremely flammable:	F+	12
highly flammable:	F	11
flammable:	-	10
reacts strongly with water	-	14
reacts strongly with water producing extremely flammable gases	-	15
forms poisonous gases in contact with water	-	29
very toxic	T+	26,27,28 (-39)
toxic	T	23,24,25 (-39,-48)
harmful	Xn	20,21,22, 65 (-48)
corrosive	C	34,35,36
irritant	Xi	36,37,38
sensitising	-	42,43
carcinogenic	-	40,45,49
toxic for reproduction	-	60,61,62,63,64
mutagenic	-	46
dangerous for the environment	N	50,51,52,53,58,59
VOC[1)]	-	-
Dust[1)]	-	-
[1)] **Dangerous according to Annex 3 of the IPPC Directive**		

Table 2.1: Categories of dangerous substance
[Germany, 1999 #18]

The following subjects are addressed in detail in Annex II.1 Dangerous substances and classification: [TETSP, 2001, 84].

- Regulatory Classification Systems (European Union Supply Legislation; Transport Legislation)
- Scope of Regulatory Classification Systems (European Supply System; UN RTDG Transport System)

- Hazard Communication within Regulatory Classification Systems
- Physico-Chemical Hazards
  - Explosive Hazards (EU System; UN RTDG Transport System)
  - Oxidising and Organic Peroxide Hazards (EU System; UN RTDG Transport System)
  - Flammability Hazards
  - EU System (Liquids; Solids; Gases; Pyrophoric/Self Heating; Water Reactive evolving Flammable Gases; Other Physico-Chemical Properties
  - UN RTDG Transport System (Liquids; Solids; Gases; Self-Reactive and Related Substances; Desensitised Explosives; Pyrophoric/Self Heating; Water Reactive evolving Flammable Gases)
  - Physico-Chemical Properties (EU System; UN RTDG Transport System)

- Health Hazards
  - Acute toxicity (EU System; UN RTGD Transport System)
  - Sub-Acute, Sub-Chronic or Chronic Toxicity (Very Serious Irreversible Effects by a Single Exposure; Very Serious Irreversible Effects by Repeated or Prolonged Exposure)
  - Corrisive and Irritant (EU System – Corrosive; UN RTDG Transport System; EU System – Irritant)
  - Sensitisation
  - Specific Effects on Health
  - Other Health Effects (EU System; UN RTDG Transport System)

- Environmental Hazards (EU System; UN RTDG Transport System)

It should be noted that the classification systems described in detail in Annex II.1 Dangerous substances and classification do not necessarily cover all the criteria required for dangerous goods storage legislation in all Member States of the European Union. For example, in parts of Belgium, storage legislation covers flash points up to 250°C. [TETSP, 2001, 84]

Classification leads to hazard communication, of which there are two forms; the immediate information on the label of packaging containing the dangerous goods and more detailed information on, for example, a safety data sheet. [TETSP, 2001, 84]

2.1.2 Nature and classification of other materials

In this document 'other materials' are regarded as not harmful for the environment or for living beings under normal circumstances. 'Other materials' such as liquid or solid foodstuffs, are regarded in this category.

Although this category covers materials that are harmless under normal circumstances, they can cause much damage to the environment when e.g. a large amount is discharged into the aquatic environment. Milk discharged into a little river can, because of the high oxygen demand, destroy the aquatic environment completely.
(to be completed)

2.1.3 How to use classification systems in this document

The classification systems described in Sections 2.1.1 and 2.1.2 are very comprehensive and rather complex, but only part of the hazardous properties (e.g. flammability) really influences the design mode and the operation of a storage unit. Conversely some properties are ignored or almost ignored by the classification system although they have a major influence on the design and operation of storage unit; examples in this are the freezing and boiling points, vapour pressure and data on suitable construction materials. This is because the classification criteria of the dangerous substances are based on their intrinsically hazardous properties and are not based on risk. [TETSP, 2001, 84].

The IPPC Directive clearly promotes a balanced approach where simultaneous considerations are given to some intrinsically dangerous properties (e.g. acute toxicity), the exposure probability (which depends on e.g. the substance volatility) and the costs. [TETSP, 2001, 84].

The classification system by itself does not include all data necessary to define BAT for the storage of a given substance, but includes hazardous properties data which is necessary to perform a risk analysis, the classification data of a given substance are therefore a useful tool to approach BAT. [TETSP].

2.2 Classification of liquids concerning storage and handling

When considering storage and handling of the materials in the liquefied phase mentioned in Section 2.1, there is no need for such detailed classification. The eighteen classes mentioned above are reduced to five categories, containing all the relevant substances regarding the emissions, the prevention of emissions and major accidents. Those categories are: [Mueller-Witte, 2000, 85]

- corrosive liquids
- flammable liquids
- explosive liquids
- toxic liquids
- others.

The following paragraphs will discuss the special storage and handling characteristics of those categories. Examples are also given of which materials fall under which specific category and which industries are involved.

2.2.1 Corrosive liquids

2.2.2 Flammable liquids

2.2.3 Explosive liquids

2.2.4 Toxic liquids

Aquatoxic liquids
Toxic concerning health

2.2.5 Others

2.3 Classification of gases

2.4 Classification of solids

[InfoMil, 1992, 15]
The following classification, based on the susceptibility of a material to be dispersed and the possibility of dealing with the problem by wetting, is used for non-reactive products:

S1: highly drift sensitive, not wettable
S2: highly drift sensitive, wettable
S3 moderately drift sensitive, not wettable
S4 moderately drift sensitive, wettable
S5 not or very slightly drift sensitive.

Annex II.2 Dispersiveness classes of solid bulk materials, shows a long list of different solid materials and their respective dispersiveness class. *(Note that most of the substances are still in Dutch)*

The storage and transfer of toxic and/or reactive products is disregarded here because, when these products are loaded for transport or storage in bulk, they are handled in closed systems or in packaged form and not as loose material.

3 APPLIED STORAGE AND HANDLING TECHNIQUES

This chapter describes applied storage and handling techniques for liquids, gases and solids. The table below shows in detail which storage modes and handling techniques are considered with reference to the specific section.

The storage of liquids and liquefied gases is described in Section 3.1 and the following storage modes are considered:

Above-ground/ underground storage	Type of storage mode	Atmospheric, pressurised, refrigerated	Sections and page
Above-ground	External floating roof tanks	Atmospheric	Section 3.1.1 page 11
	(Vertical) fixed roof tanks	"	Section 3.1.2 page 13
	Horizontal storage tanks	"	Section 3.1.3 page 15
	Lifter roof tanks		Section 3.1.8 page 20
	Spheres	Pressurised	Section 3.1.6 page 17
	Horizontal storage tanks	"	Section 3.1.4 page 16
	Vertical cylindrical tanks	"	Section 3.1.5 page 17
	Mounded storage	"	Section 3.1.7 page 17
	Refrigerated storage tanks	Refrigerated	Section 3.1.9 page 21
Underground	Horizontal storage tanks	Atmospheric	Section 3.1.10 page 24
	Fixed storage tank in a cave	"	
	Caverns	"	Section 3.1.19 page 31
	Salt domes	"	
	Mounded storage	Pressurised	Section 3.1.7 page 17
	Caverns	"	Section 3.1.19 page 31
Other storage	Warehouses	Atmospheric	Section 3.1.16 page 30
	Basins	"	Section 3.1.17 page 31
	Lagoon	"	Section 3.1.18 page 31
	Floating storage	"	

Table 3.1: Cross-references of storage modes for liquids

The handling of liquids is described in Section 3.2 and the following handling and transfer techniques are considered:

The storage of gas that is stored mainly in the gas phase is described in Section 3.3 and the following storage modes are considered:

Above-ground/ underground storage	Type of storage mode		Sections
		"	
		"	

The handling of gases is described in Section 3.4 and the following handling and transfer techniques are considered:

The storage of solids is described in Section 3.5 and the following storage modes are considered:

The handling of solids is described in Section 3.6 and the following handling and transfer techniques are considered:

3.1 Storage of liquids

The flow chart in Figure 3.1 identifies the possible gaseous and liquid emissions and residues, resulting from the storage and transfer of liquid materials. For each storage and transfer category, the relevant operational activities and possible events/incidents which can result in an emission are listed. This will then form the basis for describing the possible emissions by mode and activities.

The types of tanks are described in the sections as shown in Table 3.1. To prevent repetition, all the common technical issues, such as commissioning, decommissioning and equipment, are described in separate sections. Where relevant cross-referencing, as an instrument to link the related issues, is used to ease the search for those related issues. Other storage modes as e.g. warehouses, basins, lagoons and caverns have less or no common technical issues and are therefore only described in separate sections.

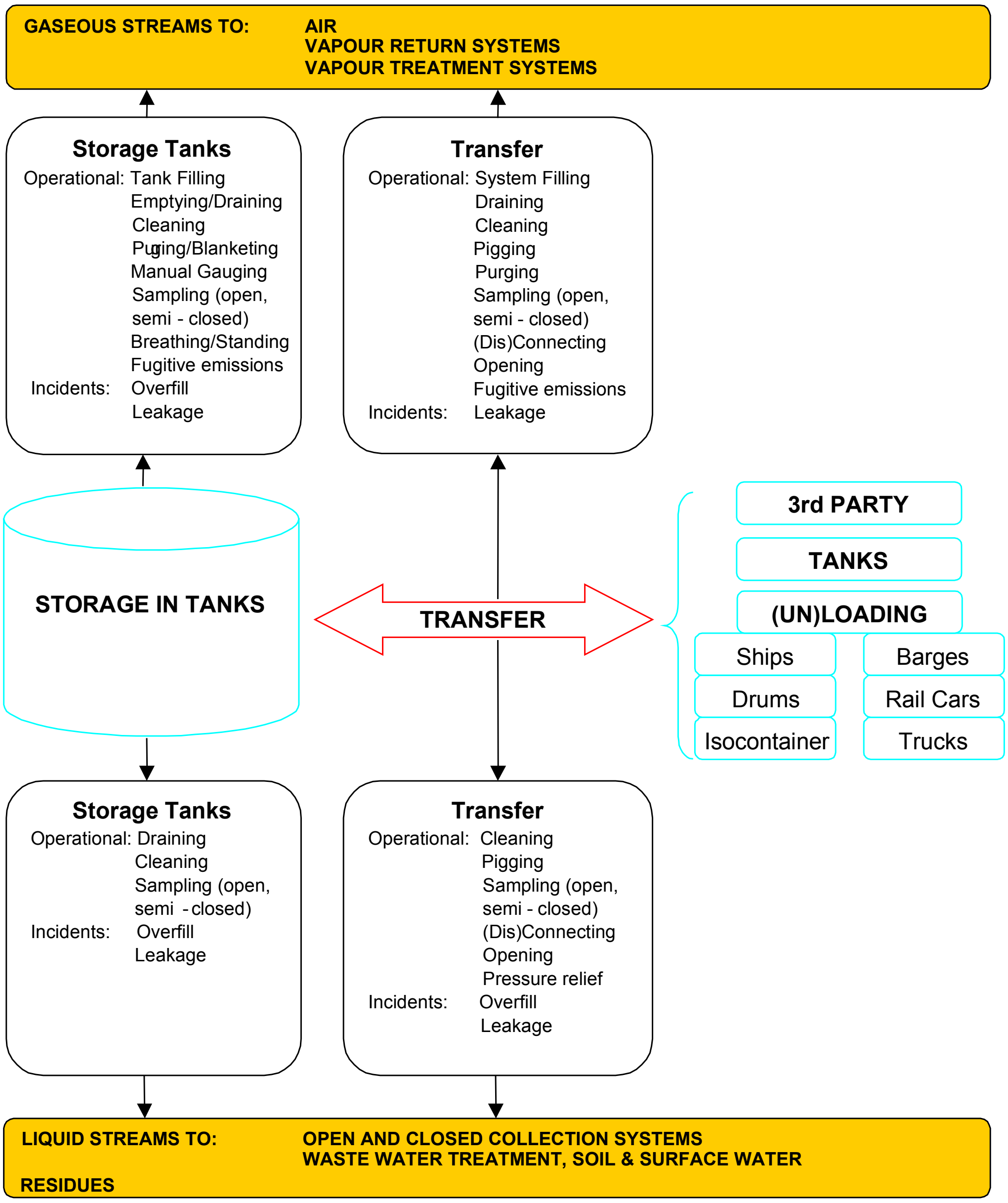


Figure 3.1: Flow chart with potential emissions resulting from above-ground and underground storage and transfer facilities

The following storage modes are considered in this section:

Above-ground/ underground storage	Type of storage mode	Atmospheric, pressurised, refrigerated	Sections and page
Above-ground	External floating roof tanks	Atmospheric	Section 3.1.1 page 11
	(Vertical) fixed roof tanks	"	Section 3.1.2 page 13
	Horizontal storage tanks	"	Section 3.1.3 page 15
	Lifter roof tanks		Section 3.1.8 page 20
	Spheres	Pressurised	Section 3.1.6 page 17
	Horizontal storage tanks	"	Section 3.1.4 page 16
	Vertical cylindrical tanks	"	Section 3.1.5 page 17
	Mounded storage	"	Section 3.1.7 page 17
	Refrigerated storage tanks	Refrigerated	Section 3.1.9 page 21
Underground	Horizontal storage tanks	Atmospheric	Section 3.1.10 page 24
	Fixed storage tank in a cave	"	
	Caverns	"	Section 3.1.19 page 31
	Salt domes	"	
	Mounded storage	Pressurised	Section 3.1.7 page 17
	Caverns	"	Section 3.1.19 page 31
Other storage	Warehouses	"	Section 3.1.16 page 30
	Basins		Section 3.1.17 page 31
	Lagoon	Atmospheric	Section 3.1.18 page 31
	Floating storage	"	

Table 3.2: Storage modes for liquids and reference to the sections

The possible emission sources from storage operations are selected for further analyses, using a risk matrix approach.

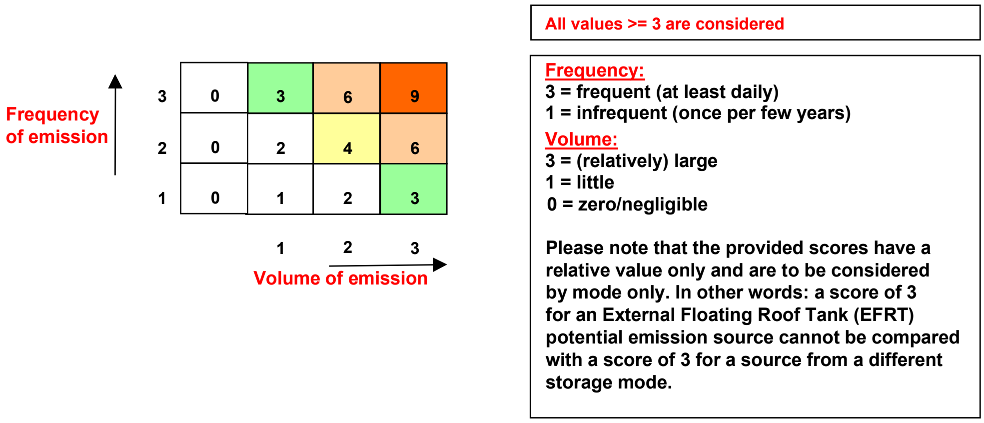


Figure 3.2: Risk matrix for emissions from liquid storage

Remarks:

1. **Please note that the provided scores have a relative value only and are to be considered by mode only. In other words, a score of 3 for an EFRT potential emission source cannot be compared with a score of 3 for a similar source from a different storage mode.**
2. **The classification term N/A (Not Applicable) indicates that a particular emission source will not be considered (not applicable or not relevant etc.) due to the specific nature of the storage mode described.**
3. **A clear distinction will be made between emissions from "operational sources" and emission from "incidents".**
4. **The emission scores (from "operational sources") are calculated by multiplying emission frequency by emission volume. This methodology is commonly applied in Risk Assessment approaches such as the one used for Risk Based Inspection (as will be further explained in the BREF). All scores above 3 are considered: e.g. all 'high' frequencies (score = 3), 'large' volumes (score = 3) and the 'medium/medium' frequency/volume emission sources (where frequency & volume both score 2).**

3.1.1 External floating roof tanks (EFRT)

A. Description

A typical EFRT consists of an open-topped cylindrical steel shell equipped with a roof that floats on the surface of the stored liquid. The floating roof consists of a deck, fittings, and rim seal system. With all types of EFRT, the roof rises and falls with the liquid level in the tank. External floating decks are equipped with a rim seal system, which is attached to the deck perimeter and contacts the tank wall. The purpose of the floating roof and rim seal system is to reduce emissions to air (and loss of product) of the stored liquid. The seal system slides against the tank wall as the roof is raised and lowered. The floating deck is also equipped with fittings that penetrate the deck and serve operational functions. The external floating roof design is such that evaporative losses from the stored liquid are limited to losses from the rim seal system and deck fittings (standing storage loss) and from any liquid left on the inner tank shell as the roof falls (withdrawal loss).

An EFRT can be fitted with a geodesic dome roof. These dome roofs are primarily installed to prevent water ingress to the product or reduce snow load on the floating roof. A domed roof, however, reduces the wind effects on the roof seals system and thus reduces emissions. A domed roof is thus an emission control device and is described in Chapter 4, Section 4.1.4.1.

There are three main types of floating roof:

1. Pontoon-type floating roofs

For these roofs, the buoyancy is supplied by an annular pontoon that covers approximately 20 to 25 % of the total roof area. The centre deck is able to carry about 250 mm rainfall over the total roof area. The annular pontoon is compartmentalised and the flotation designed so that the roof will still float if two adjacent pontoon compartments and the centre deck are punctured.

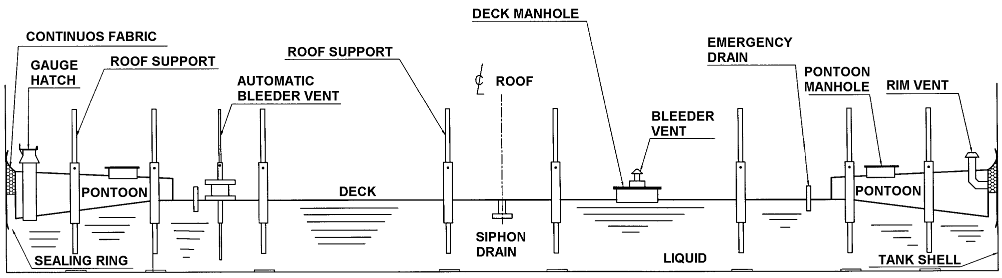


Figure 3.3: Typical floating roof tank with pontoon floating roof [draft EEMUA Pub 159]

2. Double-deck floating roofs

For these roofs the entire roof area is provided with a double deck, making the roof more rigid than the pontoon roof. Water does not accumulate on the upper deck, which is above the level of the stored product; it is immediately discharged via the roof drain (via drain or hose system and via a ground level shell drain valve). Double-deck roofs can be fitted with emergency drains, which discharge any accumulation into the stored product. Double-deck roofs are generally fitted to large diameter tanks (e.g. > 50 m diameter). They are structurally stronger and prevent wind problems, which occur in the centre decks of large pontoon roofs.

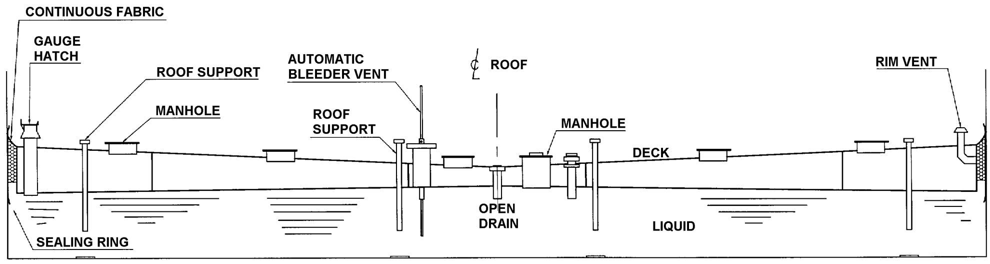


Figure 3.4: Typical floating roof tank with double-deck floating roof
[draft EEMUA Pub 159]

3. Special buoy-type and radially reinforced roofs:

The buoy-type roof is a pontoon roof with a relatively small annular pontoon, but has in addition a number of small-diameter circular buoys spread over the centre deck to provide additional buoyancy. Radially reinforced roofs have a pontoon ring and a buoy in the middle of the centre deck. These roofs are built with a certain slope to force rainwater to the drains at the centre of the deck, thus preventing water accumulation. Radial stiffeners are applied to maintain the slope when the roof floats. These roofs are vulnerable to collapse when landing on the support legs. These types of roof are mainly applied for large diameter roofs. They are hardly built nowadays, because double-deck roofs perform much better in large diameter tanks.

Reference: [TETSP, 2001, 84] [Concawe, 1999, 41], [EPA, 1997, 66],

B. Relevant tank equipment, fittings etc,

Figures	Seals Vents	Figure …. Figure:…
Equipment and fittings		
3.1.15 Equipment for tanks	Vents Gauging and sample hatches Still wells Instrumentation etc.	3.1.15.1 3.1.15.2 3.1.15.3 3.1.15.4
Design and construction requirements		
Refer to General section and Annex *To be completed.*		
Commissioning and decommissioning aspects		
3.1.13 Commissioning of tanks 3.1.14 Decommissioning and demolisition of tanks *To be completed.*		

Table 3.3: Cross-references for EFRT

C. Possible emission sources (EFRT)

Table 3.4 and Table 3.5 show the emission score for the potential emission sources for EFRT. Section 3.1, Figure 3.2 explains the methodology for calculating the emission score. The sources with an emission score of 3 and more will be addressed in Chapter 4.

It should be noted that the scores have a relative value and should only be considered for each storage mode in isolation – see Figure 3.2.

Potential source of emissions to air	Emission frequency	Emission volume	Emission score
Standing	3	1	3
Filling	2	1	2
Emptying (shell film)	2	1	2
Emptying (roof landing)	1	3	3
Cleaning	1	2	2
Manual gauging	2	1	2
Sampling	2	1	2
Fugitive	3	1	3
Draining	2	1	2

Table 3.4: Possible emissions to air from "operational sources" with EFRT [TETSP, 2001, 84]

Potential source of liquid emissions to water or waste	Emission frequency	Emission volume	Emission score
Draining	2	1	2
Roof draining	2	0	0
Cleaning	1	3	3
Sampling	2	0	0

Table 3.5: Possible liquid emissions to water or waste from "operational sources" with EFRT [TETSP, 2001, 84]

Apart from operational losses, emissions also occur from incidents such as overfill and leakages. These emissions will also be addressed in Chapter 4.

3.1.2 (Vertical) fixed roof tanks (FRT)

A. Description

Fixed roof tanks are designed as atmospheric tanks (free vented), low-pressure tanks (to approx. 20 mbar internal pressure) or – so-called – "high-pressure" tanks (to approx. 56 mbar internal pressure). Non-pressure fixed roof tanks are suitable for storage at atmospheric pressure and are therefore provided with open vents (although designed to withstand internal pressure up to 7.5 mbar and vacuum of 2.5 mbar). Both low-pressure and high-pressure fixed roof tanks are provided with pressure/vacuum relieve valves (PVRV) set to be fully open at the design pressure/vacuum. All of these tank types must meet additional requirements such as stability. Anchor systems may be necessary to prevent uplifting of the tank near the periphery due to the combined load of internal pressure and wind loads. [TETSP, 2001, 84]

Annex III.1, Figure III - 1 shows a flat-bottomed tank complete with equipment [Germany, 1999 #18]

Figure 3.5 shows a conical shaped roof, which is typical for larger diameter fixed roof tanks. The roof has a roof support structure, which may be constructed from beams, trusses or rafters. Self-supporting roofs can be of conical or dome shape but these are generally used only for smaller diameter tanks. [TETSP, 2001, 84]

A fixed roof tank can be fitted with an internal floating roof to reduce emissions.

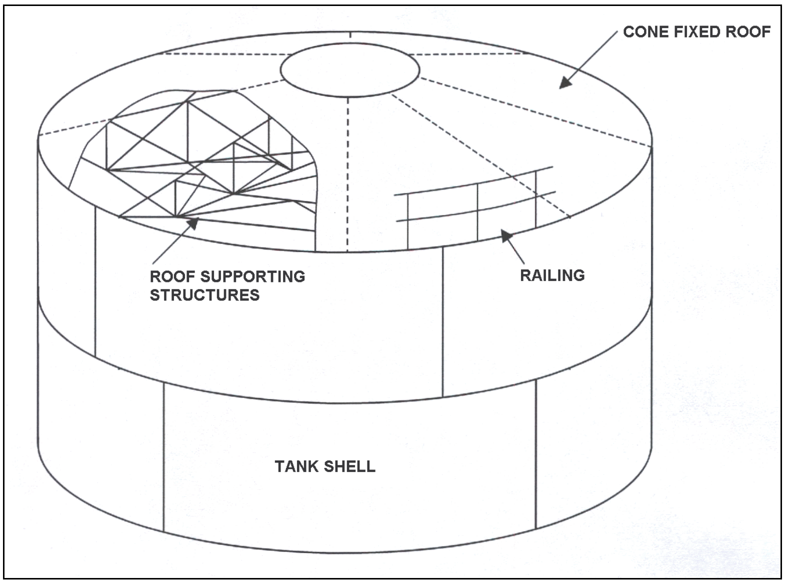


Figure 3.5: Typical example of a fixed roof tank
[draft EEMUA Pub159]

Figure 3.6 shows the different design ratings and P/V relieve valve settings. [TETSP,°2001°#84]

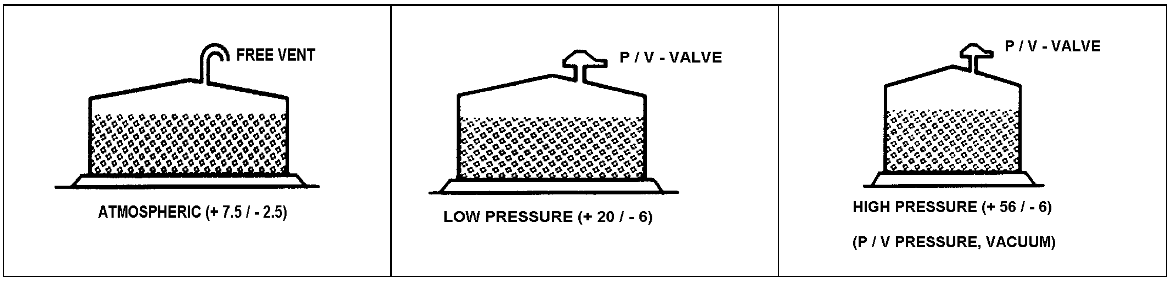


Figure 3.6: Types of fixed roof tanks
[draft EEMUA Pub 159]

B. Relevant tank equipment, fittings etc.

Figures in Annex…	Seals Vents	Figure Figure:…
Equipment and fittings		
3.1.15 Equipment for tanks	Vents Gauging and sample hatches Still-wells Instrumentation etc.	3.1.15.1 3.1.15.2 3.1.15.3 3.1.15.4
Design and construction requirements		
Refer to General section and Annex *To be completed.*		
Commissioning and decommissioning aspects		
3.1.13 Commissioning of tanks 3.1.14 Decommissioning and demolition of tanks *To be completed.*		

Table 3.6: Cross-references for FRT

C. Possible emission sources (FRT)

Table 3.7 and Table 3.8 show the emission score for the potential emission sources for FRT. Section 3.1, Figure 3.2 explains the methodology for calculating the emission score. The sources with an emission score of 3 and more will be addressed in Chapter 4.

It should be noted that the scores have a relative value and should only be considered for each storage mode in isolation – see Figure 3.2.

Potential source of emissions to air	Emission frequency	Emission volume	Emission score
Breathing	3	2	6
Filling	2	3	6
Emptying/draining	2	1	2
Cleaning	1	2	2
Blanketing	3	2	6
Manual gauging	2	1	2
Sampling	2	1	2
Fugitive	3	1	3

Table 3.7: Possible emissions to air from "operational sources" with FRT
[TETSP, 2001, 84]

Potential source of liquid emissions to water or waste	Emission frequency	Emission volume	Emission score
Draining	2	1	2
Cleaning	1	3	3
Sampling	2	0	0

Table 3.8: Possible liquid emissions to water or waste from "operational sources" with FRT
[TETSP, 2001, 84]

3.1.3 Above-ground horizontal storage tanks (atmospheric)

A. Description

Horizontal fixed roof tanks are constructed for both above-ground and underground service and generally have a capacity of less than 150 m^3. Horizontal tanks are usually equipped with pressure-vacuum relieve vents, gauge hatches, sample wells and manholes to provide access. [EPA, 1997, 66]. The maximum diameter is usually determined by factors such as design pressure, fabrication possibilities, post-weld heat treatment requirements, transport limitations, foundation criteria and economy of design. The maximum allowable length is usually determined by the support structure, foundation criteria, size of available site and economy of design. [TETSP, 2001, 84].

The material may be steel, steel with a fibreglass overlay, or fibreglass-reinforced polyester. Older tanks may be of riveted or bolted construction and are designed to be both liquid and vapour tight. [EPA, 1997, 66]

Annex III.1 shows in Figure III - 1 a typical above-ground horizontal storage tank with equipment. [Germany, 1999 #18]

Details of underground horizontal storage tanks are given in Section 3.1.10.

C. Possible emission sources (above-ground horizontal storage tanks)

Table 3.9 and Table 3.10 show the emission score for the potential emission sources for the above-ground horizontal storage tank. Section 3.1, Figure 3.2 explains the methodology for calculating the emission score. The sources with an emission score of 3 and more will be addressed in Chapter 4.

It should be noted that the scores have a relative value and should only be considered for each storage mode in isolation – see Figure 3.2.

Potential source of emissions to air	Emission frequency	Emission volume	Emission score

Table 3.9: Possible emissions to air from "operational sources" with above-ground horizontal storage tanks
[TETSP, 2001, 84]

Potential source for liquid emissions to water or waste	Emission frequency	Emission volume	Emission score
Draining			
Cleaning			
Sampling			

Table 3.10: Possible liquid emissions to water or waste from "operational sources" with above-ground horizontal storage tanks
[TETSP, 2001, 84]

3.1.4 Horizontal storage tanks (pressurised)

Description See Annex III.2 Storage modes and equipment for gassesFigure III - 6.
Two classes of pressure tanks are in general use: low-pressure (2.5 to 15 psig) and high-pressure (higher than 15 psig). Pressure tanks are generally used for storing organic liquids and gases with high vapour pressures and are found in many sizes and shapes, depending on the operating pressure of the tank. Generally they are horizontally oriented and "bullet" or spherically shaped (see Section 3.1.6) to maintain structural integrity at high pressure. High-pressure storage tanks can be operated so that virtually no evaporative or working losses occur. [EPA, 1997, 66].

C. Possible emission sources (horizontal storage tanks (pressurised))

Table 3.11 and Table 3.12 show the emission score for the potential emission sources for pressurised horizontal storage tanks. Section 3.1, Figure 3.2 explains the methodology for calculating the emission score. The sources with an emission score of 3 and more will be addressed in Chapter 4.

It should be noted that the scores have a relative value and should only be considered for each storage mode in isolation; see Figure 3.2.

Potential source of emissions to air	Emission frequency	Emission volume	Emission score

Table 3.11: Possible emissions to air from "operational sources" with horizontal storage tanks (pressurised)
[TETSP, 2001, 84]

Potential source of liquid emissions to water or waste	Emission frequency	Emission volume	Emission score
Draining			
Cleaning			
Sampling			

Table 3.12: Possible liquid emissions to water or waste from "operational sources" with horizontal storage tanks (pressurised)
[TETSP, 2001, 84]

3.1.5 Vertical storage tanks (pressurised)

A. Description: See Annex III.2 Storage modes and equipment for gasses, Figure III - 7.

3.1.6 Spheres (pressurised)

3.1.7 Mounded storage (pressurised)

A. Description (Figure 3.7**)**
Mounded storage is the term given to the pressurised storage at ambient temperatures of liquefied petroleum gases in horizontal cylindrical vessels placed at or just below ground level and completely covered with suitable backfill. Several vessels may be placed side-by-side under one 'mound'. Vessels in open underground vaults and excavations are normally not considered to be 'mounded storage'. [TETSP, 2001, 84]

The design aspects of mounded storage projects are in general more complicated than those for above ground spheres or bullets. Attention should be paid to the interaction between vessel and soil, and to corrosion protection. As it is not intended that mounded vessels be externally inspected during their lifetimes, attention needs to be given to external coating and a cathodic protection system to minimise the risk of (undetectable) corrosion. Depending on site conditions, ground-water level and operational requirements, the vessels may be installed either at grade level or in an excavation. Vessels need to be installed above the highest known water table level, and the soil cover therefore usually protrudes above grade as an earth mound – hence the term 'mounded storage' –. [TETSP, 2001, 84]

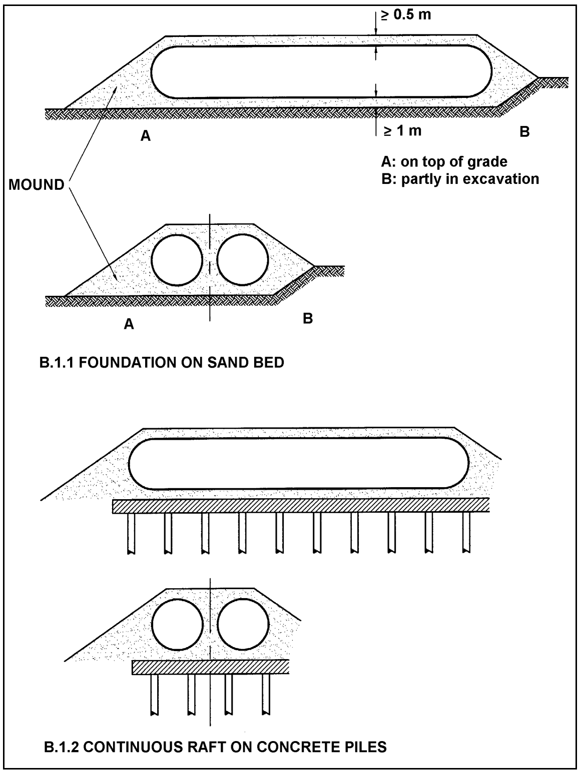


Figure 3.7: Mounded storage
[EEMUA Pub 190]

If more than one vessel is placed in a single mound, then the minimum distance between the vessels depends on construction activities such as welding, coating, backfilling and compaction of the backfill material. A distance of 1 m is considered to be a practical minimum. [TETSP, 2001, 84]

The maximum diameter is usually determined by factors such as design pressure, fabrication possibilities, post-weld heat treatment requirements, transport limitations, subsoil conditions and economy of design (8 m may be regarded as a practical upper limit). The maximum allowable length is usually determined by the support structure and/or subsoil conditions (especially if differential settlement is expected), size of available site and economy of the design. For vessels which are founded on a sand-bed, the length of the vessel is generally no more than eight times the diameter in order to prevent the design shell thickness being governed by longitudinal bending of the vessel due to possible differential settlement or construction tolerances of vessels and foundations. The maximum volume of a vessel is normally approximately 3500 m^3 gross; there is no minimum size of vessel, except for practical considerations. [TETSP, 2001, 84].

B. Relevant tank equipment, fittings etc.

Figures in Annex…	Seals Vents	Figure Figure:…
Equipment and fittings		
3.1.15 Equipment for tanks	Vents Gauging and sample hatches Still-wells Instrumentation etc.	3.1.15.1 3.1.15.2 3.1.15.3 3.1.15.4
Design and construction requirements		
Refer to General section and Annex *To be completed.*		
Commissioning and decommissioning aspects		
3.1.13 Commissioning of tanks 3.1.14 Decommissioning and demolition of tanks *To be completed.*		

Table 3.13: Cross-references for mounded storage

C. Possible emission sources (mounded storage/pressurised)

Table 3.14 and Table 3.15 show the emission score for the potential emission sources for mounded storage. Section 3.1, Figure 3.2 explains the methodology for calculating the emission score. The sources with an emission score of 3 and more will be addressed in Chapter°4.

It should be noted that the scores have a relative value and should only be considered for each storage mode in isolation; see Figure 3.2.

Potential source of emissions to air	Emission frequency	Emission volume	Emission score
Breathing			N/A
Filling	2	1	2
Emptying			N/A
Blanketing	2	1	2
Cleaning	1	2	2
Manual gauging			N/A
Sampling	2	1	2
Fugitive	3	1	3
Draining	2	2	4

Table 3.14: Possible emissions to air from "operational sources" with pressurised mounded storage [TETSP, 2001, 84]

Potential source of liquid emissions to water or waste	Emission frequency	Emission volume	Emission score
Draining	2	0	0
Cleaning	1	1	1
Sampling	2	0	0

Table 3.15: Possible liquid emissions to water or waste from "operational sources" with pressurised mounded storage
[TETSP, 2001, 84]

Apart from operational losses, emissions also occur from incidents such as overfill and leakages. These emissions will also be addressed in Chapter 4.

3.1.8 Lifter roof (variable vapour space) tanks

A. Description
Variable vapour space tanks are equipped with expandable vapour reservoirs to accommodate vapour volume fluctuations attributable to temperature and barometric pressure changes. The two most common types of variable vapour space tanks are lifter roof tanks and flexible diaphragm tanks. [EPA, 1997, 66]. The latter are usually connected to a number of tanks to reduce breathing emissions and thus are an emission control measure (ECM). [TETSP,°2001°#84].

Lifter roof tanks have a telescoping roof that fits loosely around the outside of the main tank wall. The space between the roof and the wall is closed by either a wet seal, which is a trough filled with liquid, or a dry seal, which uses a flexible coated fabric. [EPA, 1997, 66].

Variable vapour space tank losses occur during tank filling when vapour is displaced by liquid. Loss of vapour occurs only when the tank's vapour storage capacity is exceeded. [EPA,°1997°#66].

Reference: [EPA, 1997, 66], [TETSP, 2001, 84]

B. Relevant tank equipment, fittings etc.

Figures in Annex…	Seals Vents	Figure Figure:…
Equipment and fittings		
3.1.15 Equipment for tanks	Vents Gauging and sample hatches Still-wells Instrumentation etc.	3.1.15.1 3.1.15.2 3.1.15.3 3.1.15.4
Design and construction requirements		
Refer to General section and Annex *To be completed.*		
Commissioning and decommissioning aspects		
3.1.13 Commissioning of tanks 3.1.14 Decommissioning and demolition of tanks *To be completed.*		

Table 3.16: Cross-references for lifter roof tanks

C. Possible emission sources (lifter roof tank)

Table 3.17 and Table 3.18 show the emission score for the potential emission sources for mounded storage. Section 3.1, Figure 3.2 explains the methodology for calculating the emission scor. The sources with an emission score of 3 and more will be addressed in Chapter 4.

It should be noted that the scores have a relative value and should only be considered for each storage mode in isolation; see Figure 3.2.

Potential source of emissions to air	Emission frequency	Emission volume	Emission score
Breathing	3	0	0
Filling	2	3	6
Emptying	2	1	2
Blanketing	3	2	6
Cleaning	1	2	2
Manual gauging	2	1	2
Sampling	2	1	2
Fugitive	3	1	3
Draining	2	1	2

Table 3.17: Possible emissions to air from "operational sources" with lifter roof tanks [TETSP, 2001, 87]

Potential source of liquid emissions to water or waste	Emission frequency	Emission volume	Emission score
Draining	2	1	2
Cleaning	1	3	3
Sampling	2	0	0

Table 3.18: Possible emissions to water or waste from "operational sources" with lifter roof tanks [TETSP, 2001, 87]

3.1.9 Refrigerated storage tanks

A. Description

There are three types of refrigerated storage systems: [TETSP, 2001, 84]

1) single containment
2) double containment
3) full containment.

The selection of the type of storage system will be considerably influenced by the location, the operational conditions, the adjacent installations, loadings and environmental considerations.

1) Single Containment: Either a single or double wall tank designed and constructed so that only the containing element in contact with the refrigerated product is required to meet the low temperature ductility requirements for storage of the product. The outer wall (if any) of a single containment storage system is primarily for the retention and protection of insulation and is not designed to contain liquid in the event of product leakage from the inner container. A single containment tank will be surrounded by a traditional low bund wall to contain any leakage.

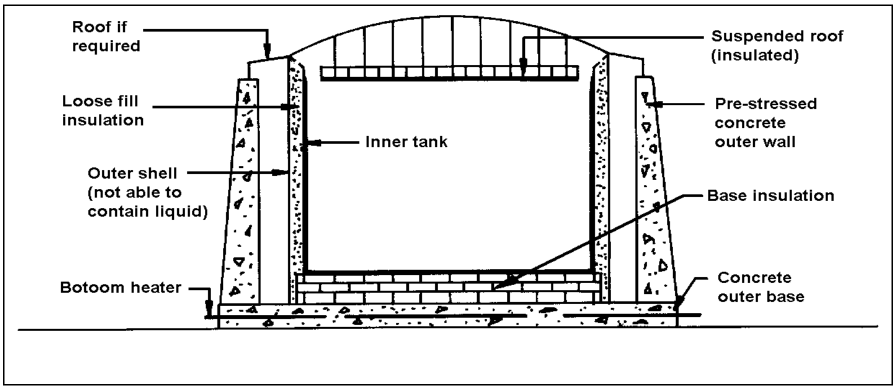


Figure 3.8: Typical example of a single containment refrigerated tank [EEMUA Pub 147]

2) Double Containment: A double-wall tank designed and constructed so that both inner and outer walls are capable of containing the refrigerated liquid stored. The inner tank stores the refrigerated liquid under normal operating conditions. The outer tank is able to contain any refrigerated liquid product leakage from the inner tank. The outer tank is not designed to contain vapour released due to product leakage from the inner tank.

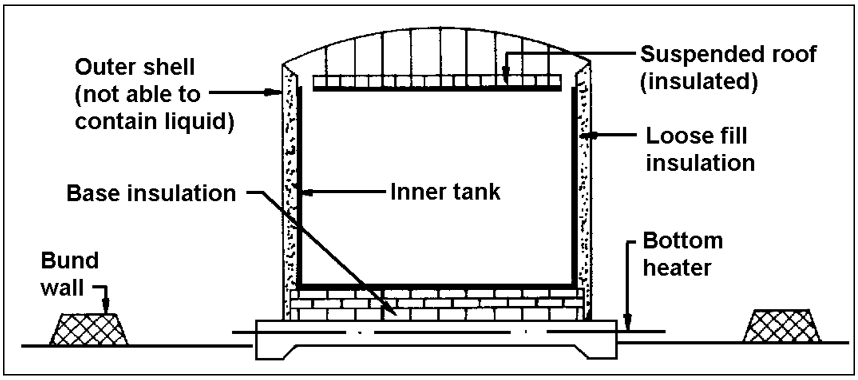


Figure 3.9: Typical example of a double containment refrigerated tank
[EEMUA Pub 147]

3) Full Containment: A double-wall tank designed and constructed so that both inner and outer tanks are capable of containing the refrigerated liquid stored. The outer wall is approximately 1 to 2 metres distant from the inner wall. The inner tank stores the refrigerated liquid under normal operating conditions. The outer roof is supported by the outer wall. The outer tank is capable of containing the refrigerated liquid and vapour resulting from product leakage from the inner tank. [TETSP, 2001, 84]

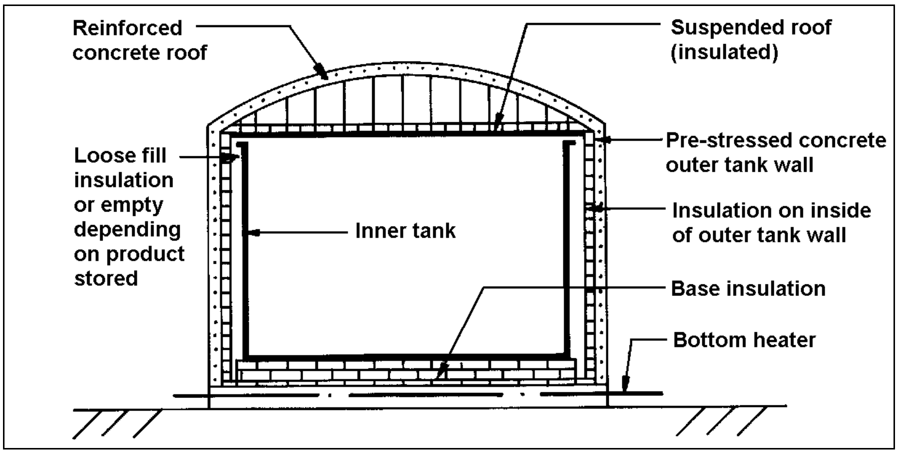


Figure 3.10: Typical example of a full containment refrigerated tank
[EEMUA Pub 147]

B. Relevant tank equipment, fittings etc

Figures …	Seals Vents	Figure Figure:…
Equipment and fittings		
3.1.15 Equipment for tanks	Vents Gauging and sample hatches Still-wells Instrumentation etc.	3.1.15.1 3.1.15.2 3.1.15.3 3.1.15.4
Design and construction requirements		
Refer to General section and Annex *To be completed.*		
Commissioning and decommissioning aspects		
3.1.13 Commissioning of tanks 3.1.14 Decommissioning and demolition of tanks *To be completed.*		

Table 3.19: Cross-references for above-ground refrigerated storage tanks

C. Possible emission sources (above-ground refrigerated storage tank)

Table 3.20 and Table 3.21 show the emission score for the potential emission sources for above-ground refrigerated storage. Section 3.1, Figure 3.2 explains the methodology for calculating the emission score. The sources with an emission score of 3 and more will be addressed in Chapter 4.

It should be noted that the scores have a relative value and should only be considered for each storage mode inisolation – see Figure 3.2.

Potential source of emissions to air	Emission frequency	Emission volume	Emission score
Breathing			N/A
Filling	2	1	2
Emptying/Draining			N/A
Cleaning	1	2	2
Blanketing	2	1	2
Manual gauging			N/A
Sampling	2	1	2
Fugitive	2	1	2

Table 3.20: Possible emissions to air from "operational sources" with above-ground refrigerated storage
[TETSP, 2001, 84]

Potential source of liquid emissions to water or waste	Emission frequency	Emission volume	Emission score
Draining			N/A
Cleaning			N/A
Sampling			N/A

Table 3.21: Possible liquid emissions to water or waste from "operational sources" with above-ground refrigerated storage
[TETSP, 2001, 84]

Apart from operational losses, emissions also occur from incidents such as overfill and leakages. These emissions will also be addressed in Chapter 4.

3.1.10 Underground horizontal storage tanks

A. Description

See Section 3.1.3 for the general description of horizontal tanks. In addition, underground tanks may be cathodically protected to prevent corrosion of the tank shell. [EPA, 1997, 66]

Annex II.1, Figure III - 1 shows a typical underground horizontal storage tank with equipment. [Germany, 1999 #18]

B. Relevant tank equipment, fittings etc

Figures …	Seals Vents	Figure Figure:…
Equipment and fittings		
3.1.15 Equipment for tanks	Vents Gauging and sample hatches Still-wells Instrumentation etc.	3.1.15.1 3.1.15.2 3.1.15.3 3.1.15.4
Design and construction requirements		
Refer to General section and Annex *To be completed.*		
Commissioning and decommissioning aspects		
3.1.13 Commissioning of tanks 3.1.14 Decommissioning and demolition of tanks *To be completed.*		

Table 3.22: Cross-references for underground horizontal storage tanks

C. Possible emission sources (underground horizontal storage tank)

Table 3.20 and Table 3.21 show the emission score for the potential emission sources for underground horizontal storage tanks. Section 3.1, Figure 3.2 explains the methodology for calculating the emission score. The sources with an emission score of 3 and more will be addressed in Chapter 4.

It should be noted that the scores have a relative value and should only be considered for each storage mode in isolation – see Figure 3.2.

Potential source of emissions to air	Emission frequency	Emission volume	Emission score
Breathing			N/A
Filling	2	1	2
Emptying/Draining			N/A
Cleaning	1	2	2
Blanketing	2	1	2
Manual gauging			N/A
Sampling	2	1	2
Fugitive	2	1	2

Table 3.23: Possible emissions to air from "operational sources" with underground horizontal storage
[TETSP, 2001, 84]

Potential source of liquid emissions to water or waste	Emission frequency	Emission volume	Emission score
Draining			N/A
Cleaning			N/A
Sampling			N/A

Table 3.24: Possible liquid emissions to water or waste from "operational sources" with underground horizontal storage
[TETSP, 2001, 84]

Apart from operational losses, emissions also occur from incidents such as overfill and leakages. These emissions will also be addressed in Chapter 4.

3.1.11 Economics of tanks

3.1.12 Design and construction of tanks

Description
The storage facilities are constructed in such a way so that any geological features which could pose a risk to the safety and integrity of the installation, are catered for. A detailed soil investigation will be necessary at the design stage. [Concawe, 1999, 41]. The investigation aims to give information about the structure and horizontal and vertical permeability of the soil-layers and information about the expected rate of subsidence. [CPR9-3, 1984 #3]

The type of foundation will very from site to site and will be for local consideration. Types include:

- reinforced concrete slabs on piles
- a reinforced concrete ring wall with a fill
- a compacted fill. [Concawe, 1999, 41]

Common practice is that a top surface is applied to the foundation to help prevent corrosion of the underside of the tank bottom. A foundation that is slightly raised from the bund floor ensures that the tank is not standing in rainwater.[Concawe, 1999, 41]

The material of the whole tank normally meets one of the following international recognised standards: API 650, BS 2654, DIN 4119, NEN 3850[1]. [CPR9-3, 1984, 3], BS 2594 or BS 4994 or any other national or international standard that provides an equivalent level of safety. (See Annex I. International Codes, for an overview of the standards). Furthermore, the constructed facilities, including tanks and foundations, are constructed in such a way that displacements and slopes, which pose a danger to the safety and tightness of the installation, are normally excluded. The raw materials, production, dimension, monitoring and quality-proofing of the tanks and all their equipment are appropriate for the technical purpose. [Germany, 1999 #18].

Tanks with a fixed roof are constructed is in such a way that, in the event of an explosion, the roof will tear at the top of the tank. The weld between the roof and the tank-wall is therefore weaker than the weld between the bottom and the tank-wall. [CPR9-3, 1984, 3].

Approach roads are provided to allow for swift intervention by the fire brigade and rescue services in case of damage or injury. [Germany, 1999 #18].

[1] In cases when the liquid stored has a specific gravity ≤ 1 and the pressure above the liquid is more or less equal to atmospheric pressure.

The distances between tanks and from the tanks to walls and other construction components are sufficient to allow malfunctions to be detected and fires to be contained. These distances are kept or protective walls are constructed to minimize danger from neighbouring facilities or buildings. [Germany, 1999 #18].

There is also a threat to depot installations from vehicles colliding with them. Vulnerable tank installations are therefore protected by crash barriers. [Germany, 1999 #18].

3.1.13 Commissioning of tanks

3.1.14 Decommissioning and demolition of tanks

Decommissioning. Tanks which are to be taken out of service are made safe. The method will vary with the location of the tank, the product it has contained and whether it is to be taken out of use permanently or temporarily. Common practice is that a risk assessment is carried out at the planning stage to identify any hazards that decommissioning may introduce. The preliminary steps in the decommissioning process (which apply also to pipework) are:

- Isolation of the tanks from any process, plant or storage vessel by either removing pipe sections or fitting spade pieces. Shut-off valves by themselves are not adequate;
- Emptying the tanks as much as possible;
- Opening access hatches to assist venting.

Tanks which are being decommissioned permanently are made safe by thorough cleaning and gas freeing. Tanks that are being decommissioned temporarily are made safe by thorough cleaning as above or by filling with water or an inert gas such as nitrogen. If inert gas is used, the tank is labelled to make it clear that it contains a gas which could cause suffocation if the tank is entered. Regular inspection ensures that the tanks remain in a safe condition.

In the UK and other Member States, the work needs to be covered by a permit-to-work or similar authorisation procedure. Such a permit specifies:

- the area to which the permit applies
- the work to be done and the method to be used
- the time limit on the permit
- the precautions to ensure that all flammable materials have been removed and cannot be accidentally reintroduced.

Demolition of tanks that have contained flammable liquids is potentially (very) hazardous. Hot work might cause an explosion if undertaken before the tanks and pipework have been adequately drained and cleaned. Tanks that have contained flammable liquids need special preparation to remove flammable vapours or associated liquids and sludges. Residues that can emit flammable vapours when heated may be present on the walls and underside of the roof. It may be advisable to use a special tank demolition company with the relevant expertise and equipment.

Reference: [HSE, 1998, 37]

3.1.15 Equipment for tanks

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

Fittings for both internal floating roofs and external floating roofs are: access hatches, guide-pole wells, roof legs, vacuum breakers, and automatic gauge float wells. Other fittings used on internal floating roof tanks include column wells, ladder wells and stub drains.

Reference: [O. Rentz, 1998, 67]

3.1.15.1 Vents

Normal relief:

External floating roof tanks:
Floating roof tanks can be fitted with automatic bleeder vents (also called vacuum breaker) to release air and vapour from under the floating roof during initial filling. Normally they open automatically before the roof lands on its legs, thus stopping vacuum conditions arising, but under normal circumstances these vents are closed. [Concawe, 1999, 41]. The size of the bleeder vent/vacuum breaker is based on the product (and hence vapour) flow rate when filling the tank. It is important to have the bleeder vent pipe supports, which open the vent valve, designed in a similar way to the roof support legs i.e. to have an operational and a maintenance setting. The change of roof support leg adjustment always includes a similar change to the bleeder vent support setting. [TETSP, 2001, 84].

The rim seal vent is required for seals that have a ‘vapour space’ under the primary rim seal, for example the vapour mounted seals and the mechanical shoe type seals. The liquid mounted, typical soft/tube type seals do not require a rim vent. The main function of the rim vent(s) is to allow pockets of vapour, which become pressurised, to escape from under the rim seal to the atmosphere. The gas/vapour pockets can form under the floating roof deck and then normally find their way into the rim space. Over-pressure inside the rim space may damage the rim seal material and hence reduce the efficiency of the seal. [TETSP, 2001, 84].

Fixed roof tanks:
Pressure vacuum relief valves or vents (PVRV) prevent excessive pressure build-up and vacuum valves prevent the tank collapsing due to a negative pressure in the tank. These functions may be combined in a pressure-vacuum valve (breather valve). In standard BS 2654 (Annex I. International Codes), these valves are recommended for use on atmospheric fixed roof tanks in which a product with a flashpoint below 38°C is stored and for use on tanks containing product that is heated above its flashpoint. [HSE, 1998 #37]. See Figure 3.6, which shows the 3 basic types of tanks with PVRV settings.

Storage tanks operated without pressure are equipped with air vent valves (free vented tank). The air vent valves are designed so that at the highest volume flow of the pumps and temperature fluctuations in the tank, no dangerous under- or overpressure can be caused. The air vent valves cannot be shut. [Germany, 1999 #18].

Emergency relief:

This may be provided by:

- larger or additional vents
- access hatches or hatch covers which lift under abnormal internal pressure
- a weak wall-to-roof joint
- purpose-built relief devices.

3.1.15.2 Gauging and sample hatches

Products are usually dipped or ullaged from a gauging or still well. The gauge measures parameters such as: height, mass, temperature, density and/or pressure. [HSE, 1998, 37]. To prevent emissions to air the gauge or still well is closed with a lid during normal circumstances. Self-closing foot-operated hatches that are vapour tight are common practice. [Concawe, 1999 #41][CPR, 1984 #3]. Automatic gauging is possible and has the advantage over manual dipping that it allows determination of the quantity of liquid without opening the tank. [HSE, 1998, 37].

Dipsticks are potential sources of ignition in that they may produce frictional heating, sparking or static electricity. Normally they are made of non-sparking alloys and are earthed as described e.g. in BS 5958 (Annex I. International Codes). Dip tapes may be an alternative to measure depth. [HSE, 1998 #37].

For EFRT, access to the roof itself during operation is not recommended without breathing apparatus and assistance. [Concawe, 1999, 41].

Reference:

3.1.15.3 Still-wells

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

Reference: [Concawe, 1999, 41]

3.1.15.4 Instrumentation

Local or remote instrumentation should be in accordance with appropriate standards; the Institute of Petroleum (IP) Petroleum Measurement Manual and IP Electrical Safety Code will provide specific advice, as well as other codes, standards and guidelines in this field; see Annex I. International Codes. Consideration should always be given to fitting of high-level alarms to prevent environmental incidents by overfilling. [Concawe, 1999, 41]

Level control and overfill protection:
During filling procedures, it is generally insufficient to control and record only the filling level. Because there is a danger of overfilling and consequent soil and water pollution, storage tanks are normally equipped with overfill protection which can interrupt filling procedures before the maximum authorised level of liquid is reached. [Germany, 1999 #18]. Where the filling procedure is not done automatically, but manually, the tank is normally equipped with an alarm to indicate when the maximum authorised level of liquid is reached. When the alarm goes off, personnel can stop the filling procedure in time. [CPR9-3, 1984, 3].

An electronic sensor for overfill protection costs EUR 500 to 2000. It is possible to have alternative sensors with the same measuring principle and comparable environment protection capacity. The costs do not differ considerably. [Germany, 1999 #18].

Flame arrester
As protection from fires and explosions, openings in the tanks, through which flames can enter, are normally equipped with flame arresters. They are often a technical modification of air vent valves or underpressure/overpressure valves. [Germany, 1999 #18].

3.1.15.5 Access hatches

For above-ground vertical tanks, access hatches at the base of the tank should be provided to allow access during a shut-down of the tank and to fulfil gas freeing of the tank. This is also the route where any solids left in the tank are removed during cleaning operations. Tanks greater than 25 metres diameter require at least two access hatches. [Concawe, 1999, 41]

3.1.15.6 Drains

EFRTs require two drain systems. The first is to provide drainage for the roof to cater for rain-water. The water is drained via an internal articulated pipe or flexible hose with a valve at the end, at the base of the tank. A non-return valve near the roof end is recommended to prevent any leakage into the drain from the product reaching the roof and evaporating. Normally the roof drain at the base is closed to prevent any product leakage. However, this must be complemented by a programme of regular draining, particularly after rainstorms, otherwise there is a potential serious risk of sinking the roof and causing substantial emissions. [Concawe, 1999 #41]. Reference [CPR9-3, 1984, 3, p44], however, states that the drain should always be opened.

The second type of drain, which is also applicable to FRT, allows draining of water that accumulates at the base of the tank. This is best achieved by an internal water draw-off sump and line leading to an external, valved outlet. [Concawe, 1999, 41]. In the case of flammable liquids it is common practice to blank off the valves when not in use. [HSE, 1998, 37].

3.1.15.7 Mixers

Crude tanks are normally fitted with mixers to facilitate sludge removal and to prevent the accumulation of solids in the base of the tank. They should be capable of being maintained without the need to shut down the tank. Consideration should be given to installation of warning devices to indicate failures of bearings or mechanical seals, especially where operation is unattended for long periods. This will ensure action can be taken quickly for a problem that could escalate into a safety or environmental incident. [Concawe, 1999, 41]

3.1.15.8 Heating systems

For the heating of the products stored in tanks (e.g to ease pumping for reasons of viscosity), pipe-work is installed inside the tank through which steam, heated water or heated oil is pumped for heat exchange. [CPR9-3, 1984, 3]. Standards for the construction of heated tanks and their associated heating equipment are e.g.: BS 799, BS 5410 or BS 806 (See Annex I. International Codes). [HSE, 1998, 37].

Normally the outlet pipe is located above the heating coil or element to prevent exposure of any internal heated surface or any temperature control sensor. A second drain pipe is fitted at a lower level so that the tank can be completely emptied when necessary. A closed valve and a blank flange will prevent this drain pipe from being used during normal operations. [HSE, 1998, 37]. An alternative is to fit a low liquid level alarm linked to a heater cut-out [HSE, 1998, 37] or an alarm to identify important changes [CPR9-3, 1984, 3]. In any event, a heating system can be equipped with different levels of instrumentation, dependent upon product specifications and operational requirements. [TETSP].

The temperature and/or the pressure of media stored is monitored when it is necessary because of operating conditions or characteristics of the substances, e. g. with heated tanks or if cover-gas technique is required. [Germany, 1999 #18].

3.1.15.9 Sealing elements

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

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

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

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

Reference: [Germany, 1999 #18]

3.1.16 Chemical warehouses

Description
For the majority of warehouses storing hazardous substances, there are four main events which individually or jointly have the potential to cause harm or damage;

- fire
- explosion
- release of a toxic substance
- release of a corrosive substance.

A risk assessment is a helpful instrument to consider how these events could occur. The precaustions needed to prevent those events, not only include building and engineering design and installation standards, but also good management practices and operational procedures. [HSE, 1998, 35].

3.1.16.1 Management control

3.1.16.2 Construction

3.1.17 Basin

Description:

Construction

Economics

Cross-media effects

3.1.18 Lagoon

Description

Construction

Economics

Cross-media effects

3.1.19 Caverns

In building a rock cavern, there are three main factors to be taken into account:

1. the oil stored must be lighter than water
2. the bedrock must be sufficiently hard and homogenous
3. rock caverns must be excavated below the groundwater level to a depth were groundwater pressure around the cavern is higher than any pressure inside the cavern.

The difference in specific gravity between the oil stored and water, and the location of caverns below the groundwater table, ensure that the hydrostatic pressure of the groundwater surrounding the rock cavern is greater than that of the stored oil, preventing the oil and the gas from escaping. Seepage water, entering the cavern through fractures and joints in the rock mass, collects in the water-bed and is pumped out. There are several alternative varieties of acceptable bedrock, including intrusive rocks, metamorphic rocks, limestone, certain sedimentary rocks and even in some cases volcanic rocks. [Neste, 1996, 81]

Description [Neste, 1996, 81]
There are two main types of storage principles,

Caverns with a fixed water-bed. A layer of water, usually less than a metre deep, is maintained at the bottom of the cavern. The water level is kept constant with a pump pit weir.

Caverns with a fluctuating water-bed. In this type of rock cavern, the level of the product stored is kept at a nearly constant height by varying the depth of the water layer. The cavern is always full and the amount of water is at a minimum when oil fills the cavern. When there is no oil in the cavern, it is full of water.

Caverns built on the fixed water-bed principle can store, for example, crude oil, LPG, gasoline, diesel fuel, light fuel oil and heavy fuel oil. Caverns constructed with a fluctuating water-bed are used for storing gasoline, for example. Heavy oils to be stored at elevated temperatures, and other products requiring great outlet pumping capacity, are also stored in caverns utilizing a dry pump room at the bottom level of one or more caverns.

The volume of the caverns at Porvoo Refinery in Finland, ranges from 50000 m^3 to 580000 m^3. Porvoo only uses caverns of the fixed water-bed type because they need less water and thus less water treatment. The depth where a cavern is situated differs; at Porvoo Refinery, for example, a pressurized cavern containing LPG is situated 140 metres below the groundwater level.

Construction [Neste, 1996, 81]
The construction of economically viable rock caverns is highly dependent on favourable rock and groundwater conditions. Site studies are made to determine rock quality, solidity, discontinuities, direction of schistosity and other valuable information for excavation plans are collected. Bedrock structure is studied by means of outcrop mapping, seismic refraction soundings, percussion drilling and diamond core drilling. In certain cases, the initial stress of the bedrock is measured. Groundwater conditions are studied by well observations and pumping tests. After this study, the exact location and the longitudinal direction of the caverns can be chosen.

Economics [Neste, 1996, 81]
Major factors affecting construction costs are:

- the quality of the bedrock
- the groundwater conditions
- the size and dimensions of storage caverns
- the number of storage units and the total volume of the project
- the type of oil to be stored and the method of storage
- the amount of reinforcing and grouting needed
- requirements for purifying seepage water and the need to replace groundwater
- design loads of concrete structures
- types of inlet and discharge facilities
- the equipment and degree of automatic and remote control
- value of the excavated stone, which can be used for levelling and road construction, e.g.

The largest cost item is excavating the cavern out of the rock, amounting to at least half of total investment costs. Installation costs, reinforcement and concrete structures are in the range of 10 % each. All costs depend greatly on local conditions.

The cost of a rock cavern increases very slowly in relation to volume, favouring the storage of large quantities of oil. In cost comparisons with above-ground steel tanks, the break-even point in Finland is generally 50000 m^3. For LPG the figure is considerably lower. Figure… shows the relative investment costs for oil storage in surface tanks and ulined rock caverns in Finnish conditions. Figure… shows the relative investment costs for LPG storage alternatives in Finnish conditions. ***Figures are not added yet.***

The operation and maintenance costs at Porvoo Refinery for the underground caverns are no more than one-sixth of those for steel tanks on the surface. This figure is based on daily operations of 5 million m^3 of underground caverns and 2 million m^3 of above-ground steel tanks.

Cross-media effects [Neste, 1996, 81]
An underground storage unit is protected against external forces and threats. The risk of gas explosions is minimal and under no circumstances can the oil catch fire. Emissions to air are low, due to stable temperature and the possibility of storing oil under pressure. Since the entire storage cavern is practically invisible, the landscape above remains untouched and free for other industrial purposes.

A disadvantage of caverns in general is the oily seepage water, which is pumped out and is treated in a waste water treatment plant.

Caverns of the fixed water-bed type need less water (and thus less water treatment) than the caverns of the fluctuating water-bed type.

Equipment [Neste, 1996, 81]
The pipes and instruments of an underground cavern are generally installed in a vertical shaft constructed from the cavern to the surface. Caverns are mostly equipped with complete instrumentation to control pressure, surface levels and temperature and to check the operation of the equipment.

In general the pumps used in caverns are submersible motor pumps suspended (hanging) from discharge pipes, located in the vertical shaft leading to the cavern. Pumps can also be installed in a dry pump room located at the bottom level of the cavern and seperated from it. Conventional centrifugal pumps are used in this type of design.

Generally the control and operation of cavern storage facilities are carried out in a remote control room. Due to their remote and partly automatic operation, cavern sites are unmanned.

3.1.19.1 Emissions to air: prevention techniques for caverns

Emissions from displaced air when filling a cavern do not occur because generally all the caverns on a site are connected with each other.

3.1.19.2 Emissions to soil: prevention techniques for caverns

For preventing the stored product from escaping out of the cavern the hydrostatic pressure of the groundwater, surrounding the cavern, must be greater than that of the stored product.

It is common practice to install an interlock-system against overfilling; this system closes the inlet line valve if the level in the cavern is too high. [Neste, 1996, 81]

3.1.19.3 Emissions to water: prevention techniques for caverns

Cement injection of the roof and walls of caverns help to minimize the amount of seepage water.

The seepage water entering the cavern is pumped out and treated in a waste water treatment system. Porvoo Refinery has two waste water treatment plants; an active sludge plant (chemical and biological treatment) and an active carbon plant (adsorption/regeneration sections), which both suit well for oily waters. At Porvoo Refinery the amount of waste water discharged is about 1 m^3/day concerning a volume of 5000 m^3 oil, this equals 6 - 8 litres of seepage water / m^3 of cavern volume / year. The achieved emission level of VOC in the treated waste water that is discharged into the sea is typically below 1 mg/l. [Neste, 1996, 81]

3.1.19.4 Waste: prevention techniques for caverns

There might be some sediment accumulation at the bottom of the caverns where crude is stored, but at Porvoo Refinery there is, in the 30 years of exploiting the caverns, no wastes taken from the caverns. The only wastes that arise are the spare parts of the pumps which have to be changed in case of malfunction and maintenance.

3.1.19.5 Energy: reduction techniques for caverns

The main consumers of energy are the pumps used for filling and emptying the caverns. The energy consumption for filling and emptying above-ground storage tanks is lower than that for filling and emptying caverns. On the other hand, under Finnish climate conditions, the energy consumption for heating certain types of substances in above-ground storage tanks is higher compared with storage in caverns. [Neste, 1996, 81]

3.1.19.6 (Major) accidents: prevention techniques for caverns

Nitrogen blanketing is used to make absolutely sure that no ignition is possible inside of the cavern. [Neste, 1996, 81]

3.2 Handling of liquids

3.2.1 Loading and unloading

3.2.1.1 Supply of products

The means of transport for loading and unloading dangerous packaged substances (stacker) must be designed to suit the characteristics of the substances. If, e. g., highly flammable liquids are also loaded and unloaded an explosion-prevention design is necessary. Nowadays in most storage installations electrically-operated vehicles are used. Where vehicles with diesel engines are used their emission should be limited to protect the employees. Stacker drivers must be carefully selected and trained in order to avoid accidents. [Germany, 1999 #18].

3.2.1.2 Withdrawal of products

3.2.1.3 Transfer and blending

3.2.2 Transport in pipes; sealing systems

3.2.2.1 Pumps

3.2.2.2 Shut-off and control fittings

Valves:
It is common practice that valves (fittings) are easily accessible and operated and that they are, with respect to raw materials, production, dimension, monitoring and proof of quality, appropriate for the technical purpose. The casing of valves consists of tough raw materials. Valves underneath the level of the liquids can, in special cases, be designed "fire-safe" to delay failure in case of a fire. [Germany,°1999°#18].

3.2.2.3 Flange connections

3.3 Storage of gas

3.4 Handling of gas

3.5 Storage of solids

The different modes of storing solids are described in the sections as shown in Table 3.25.

Type of storage mode	Sections and page
Heaps	Section 3.5.1 page 36
Sacks and bulk bags	Section 3.5.2 page 37
Silos and bunkers	Section 3.5.3 page 37

Table 3.25: Storage modes for solids and reference to the sections

3.5.1 Heaps

Storage in heaps outdoors or in buildings is used for greater quantities of bulk materials. It serves: [Germany, 2001 #17]

- for stockpiling between the place of extraction and the processing plant
- as a buffer between different operations, which work at different times or with different amounts of the material
- for mixing of different bulk materials
- for homogenisation of the mass flow
- as a means of transfer from continuous to discontinuous conveying systems and vice versa.

Outdoor storage is suitable for bulk materials such as coal, ore, scrap and sand because these are not seriously affected by the weather. The bottom of the storage area can be sealed to protect the material against dirt. In most cases concrete is used. [Germany, 2001 #17]. When solid fuels are stored, the support surface is normally waterproof. An outdoor storage facility for limestone (calcium carbonate) is normally fitted with a rainwater collection system. [Salzano, 2000, 89].

Description: In general there are longitudinal and ring-shaped storage places which can be distinguished as active and passive heaps. Depending on the requirements (e.g. if different materials have to be stocked in one place), storage can be up against one or several walls. [Germany, 2001 #17]. E.g. fertiliser is stockpiled against three walls, also called an open bay, or in dedicated sheds. [IFA/EFMA, 1992, 24]. Table 3.28 shows the various constructions together with the name of the technique.

Table 3.26 gives the criteria for the selection of the storage shape. Figure 3.11 shows different geometries of heaps.

Longitudinal storage places	Ring-shaped storage places
are suitable for very high capacities (up to millions of tonnes)	are suitable for capacities up to 100000 tonnes
are suitable when the storage may be extended at a later date	are suitable if no extension is planned or necessary
are preferred on long sites	are preferred on squarer sites
are suitable when passive heaps are positioned next to active heaps	

Table 3.26: Criteria for the selection of longitudinal and ring-shaped storage places [Germany, 2001 #17]

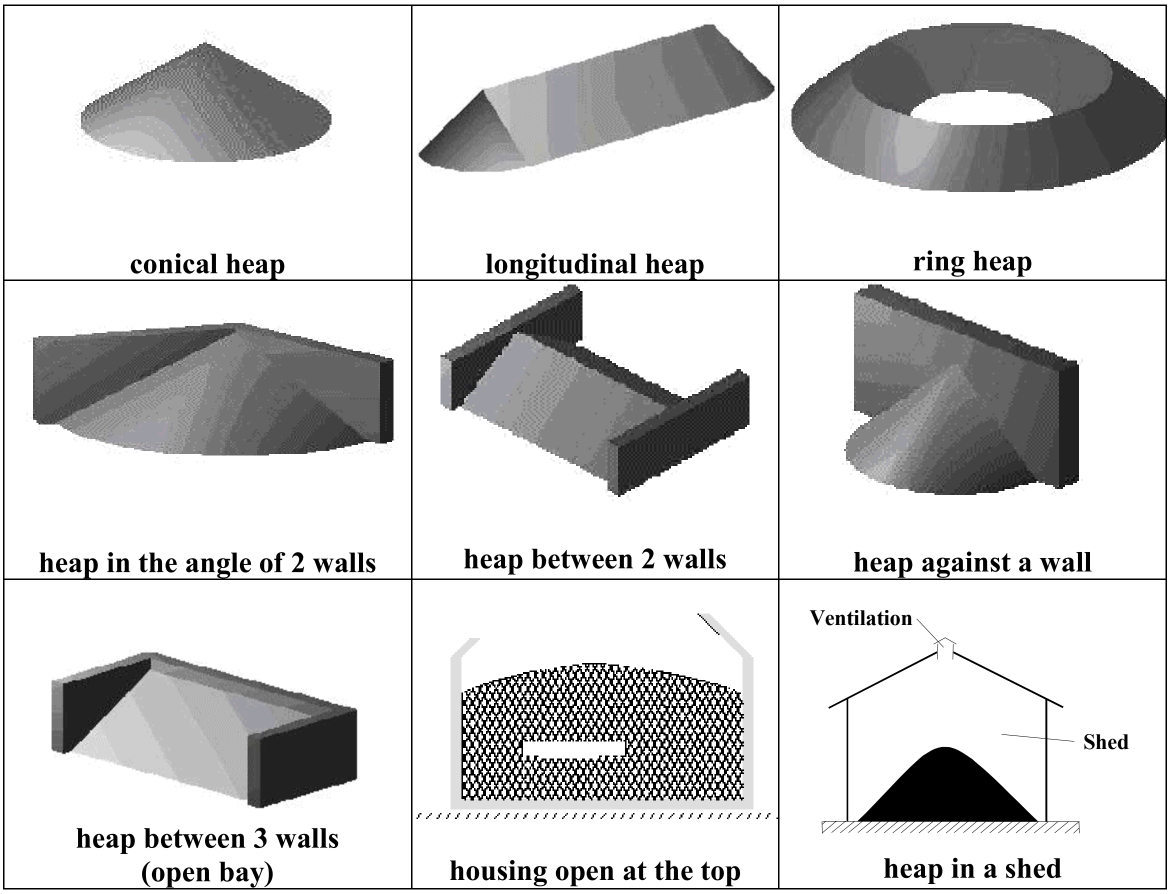


Figure 3.11: Shapes of heaps
[Germany, 2001 #17] with reference to Meyer/Eickelpasch, 1999

3.5.2 Sacks and bulk bags

Storage in sacks and bulk bags has no relevance to emissions. It is used especially for quality reasons and in cases in which very dusty goods are handled. In most cases the opening of sacks and bulk bags containing dusty materials is carried out in specialized installations with suitable suction installations within the production sheds. [UBA, 2001, 17]. The type of bags used, their size and construction, will depend on the frequency and method of handling climatic conditions and market requirements. For fertiliser often polythene bags are used because these are resistant to water and oil. [IFA/EFMA, 1992, 24].

3.5.3 Silos and bunkers

In some industrial branches silos are also called bunkers. Silos are normally used for the storage of dry and/or fine materials such as cement and grain. Bunkers are normally used for the storage of material composed of larger particles. The top of bunkers and silos can be open or closed. The open ones are relevant for emissions by wind erosion: emissions from closed ones only appear during loading and unloading. [UBA, 2001, 17].

Silos can be made of concrete, metal or plastic. The capacity of concrete silos can range up to tens of thousands of tonnes, the metal and plastic silos are of more moderate size. Depending on the product (e.g.clinker or cement), silos are equipped with a fabric filter, sometimes with fabric sleeves that can stand temperatures up to 150-160 °C. [Salzano, 2000, 89] [IFA/EFMA, 1992, 24]. E.g. fertiliser is stored in closed plastic silos or in open bunkers [IFA/EFMA, 1992, 24].

3.6 Handling of solids

The different techniques for handling solids are described in the sections as shown in Table 3.27.

Techniques for handling		Sections
The construction and reclaiming of heaps		Section 3.6.1
Grabs	batch process	Section 3.6.2.2
Optimised grabs	"	Section 3.6.2.3
Discharge hoppers in general	"	Section 3.6.2.4
Optimised discharge hoppers (in ports)	"	Section 3.6.2.4.1
Cascade hoppers	"	Section 3.6.2.4.2
Tubs	"	Section 3.6.2.5
Mobile loading devices	"	Section 3.6.2.6
Dump trucks	"	Section 3.6.2.7
Wagon emptying	"	Section 3.6.2.8
Dump pits	"	Section 3.6.2.9
Suction air conveyors	continuous process	Section 3.6.2.10.1
Pressure air conveyors	"	Section 3.6.2.10.2
Fill pipes	"	Section 3.6.2.11
Fill tubes	"	Section 3.6.2.12
Cascade tubes	"	Section 3.6.2.13
Chutes	"	Section 3.6.2.14
Thrower belts	"	Section 3.6.2.15
Belt conveyors	"	Section 3.6.2.16
Bucket elevators	"	Section 3.6.2.17
Trough chain conveyors	"	Section 3.6.2.18.1
Scraper conveyors	"	Section 3.6.2.18.2
Screw conveyors	"	Section 3.6.2.19
Feeders		Section 3.6.2.20

Table 3.27: Techniques for handling solids, with section references

3.6.1 The construction and reclaiming of heaps

There are several techniques to construct and reclaim a heap.

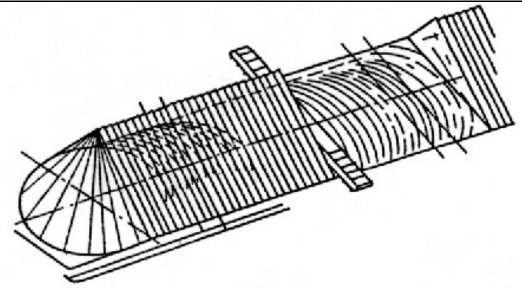
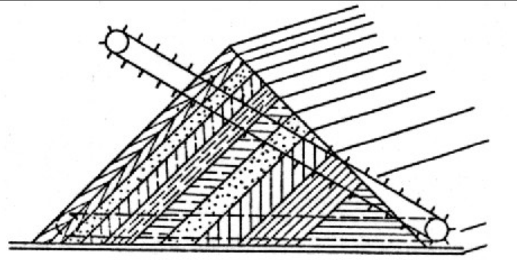
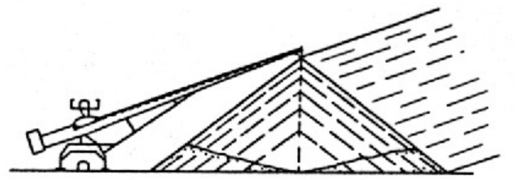
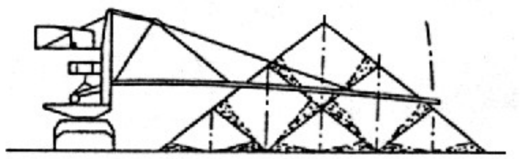
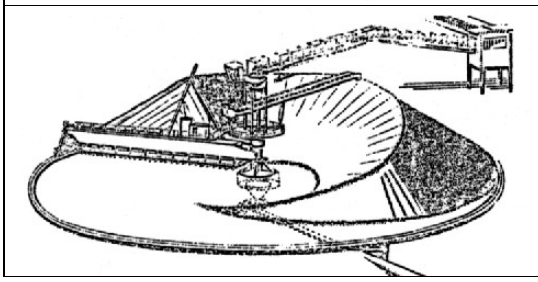
Structure of the heap	Technique	Explanation
	Cone-shell	Heaps with a conical profile that are constructed/reclaimed with a drivable conveyor (longitudinal heaps) or a rotating conveyor (ring-shaped heaps)
	Strata	Heaps built up in lateral sloping layers with a drivable conveyor that can be raised, lowered, slewed or telescoped
	Chevron	Heaps with sloping layers pitched like a roof and built up with a conveyor that can be raised and lowered
	Windrow	Heaps in rows which are built up in layers (like the chevron) with a drivable conveyor that can be raised, lowered, slewed or telescoped
	Chevcon	Mixture of cone-shell and chevron (roof-like sloping layers)

Table 3.28: Typical techniques to construct a heap
[UBA, 2001, 17]

Machines especially conceived for the construction of heaps are dumpers, such as tipper trucks or wagons and, for the reclaiming of heaps, back-loading devices such as bridge scrapers, lateral scrapers and portal scrapers. [UBA, 2001, 17].

Tripper cars throw the bulk material onto the heap from its side. Depending on the requirements, tripper cars can be equipped with a slewing belt or a transverse belt. On the same principle a heap can be filled directly from the wagon above the heap. [UBA, 2001, 17].

Belt dischargers are conveyor belts which throw the bulk material over the heap. Depending on the type of heap, these systems are fitted to rotating or running jibs/booms or supporting beams. Depending on the type of construction chosen, the band discharger can be slewed or adjusted in height and – should the situation require – be telescoped or traversed. [UBA, 2001, 17].

The system has to be flexible in cases where a mixing and homogenisation of the bulk material (so called mixing heaps) is required in addition to the storage function. [UBA, 2001, 17].

3.6.2 Loading and unloading devices

Section 3.6.2.1 describes the general emission aspects of loading and unloading. Sections 3.6.2.2 to Section 3.6.2.15 describe the techniques for the material pick-up and discharge. Sections 3.6.2.16 to 3.6.2.19. describe the techniques for conveyance. A clear distinction between the pick-up and discharge techniques and the conveyance techniques cannot be made and therefore all the techniques are described in this Section 3.6.2. Feeders are described in the final section, Section 3.6.2.20.

3.6.2.1 General emission sources from loading and unloading operations

In principle, loading/unloading operations can be described in three steps, the dust relevance of which is determined by the material itself and the techniques used. [UBA, 2001, 17].

1. **material pick-up, e.g.**
    - the unloading from ships or wagons by grabs
    - the mechanical unloading from ships or wagons by bucket elevators
    - the pneumatic unloading from ships by siphons
    - the grabbing of material by bucket loaders.

2. **material conveyance, e.g.**
    - the slewing of the filled grab with the crane beam
    - the conveying by bucket conveyors, elevators, belt conveyors
    - the conveying by pneumatic transport
    - the transport of material in a filled bucket of a bucket loader.

3. **material discharge, e.g.**
    - discharge of the material by the opening of the filled grab onto a loading area, into a hopper or onto a heap
    - discharge from a conveyor belt onto a loading area, a heap or another conveying system
    - the loading of a truck, wagon or ship by a downpipe
    - the discharge of the material from a bucket loader from a dumptruck.

The techniques of material pick-up and discharge can be classified as continuous and batch processes. Sections 3.6.2.2 to 3.6.2.9 describe the batch processes and Sections 3.6.2.10 to 3.6.2.19 describe the continuous processes. See also Table 3.27.

There is a world-wide trend towards using continuous systems for unloading specific bulk materials. This is especially valid for sea transport but also for the pneumatic unloading of silo trucks or wagons. The growing significance of continuous unloading systems in sea transport is caused by two factors. One is the relatively rapid and efficient unloading, which is important to save on high ship berthing costs. Secondly, continuous systems create less dust and noise and it is possible to reduce material losses in comparison to grab techniques. The use of continuous ship unloaders is limited by the size of the free ship load area. If the opening of the hold is too small (e.g. with converted tankers), mechanical systems such as bucket elevators or screw conveyors are often not practical. In these cases grabs are more favourable, with frontloading shovels for the trimming. [UBA, 2001, 17].

Dust is emitted while loading if: [UBA, 2001, 17]

- the motion of the mass flow is changed (change of direction or velocity)
- the size of surface particles is reduced by crushing or friction
- the moisture of the material is decreased by climatic conditions.

Closely related to the process of loading is the trimming of the material. This process is necessary when: [UBA, 2001, 17].

- any compacted material has to be loosened before the grab can pick it up
- the jib boom of the unloader is too short and the material must be brought to a central point
- the grabbing apparatus is too clumsy
- the remaining material around the edges has to be removed.

Other procedures to clean up the wagons and trucks from residues are: [UBA, 2001, 17].

- mechanical procedures: e.g. vibrators if dumpers are used, brushes
- hydraulic procedures: e.g. truck washing, direct water jet
- pneumatic procedures: e.g. industrial vacuum cleaners.

In many cases, frontloaders are used to trim the remaining material and to clean the ship's hold. Cleaning is normally only necessary where different bulk materials are being handled. [UBA, 2001, 17].

The use of continuous conveying systems is dependent on: [UBA, 2001, 17]

- the properties of the material, such as bulk density and angle of the heap, particle size, adhesion and cohesion properties and moisture sensitivity
- the sensitivity of the material to mechanical handling and its thermal and chemical properties
- the required throughput
- the economy

3.6.2.2 Grabs

Description: Grabs are technical installations with two or more controlled shells which penetrate the bulk material in open condition, pick up the material by closing and discharge it by opening. In general the capacity of grabs – dependent on the type of grab, its weight and size – is limited to 2000 to 2500 t/h. Grabs are normally only used to pick up the material; belt conveyors are used for further transport. Figure 3.12 shows a two-shell-grab. [UBA, 2001, 17].

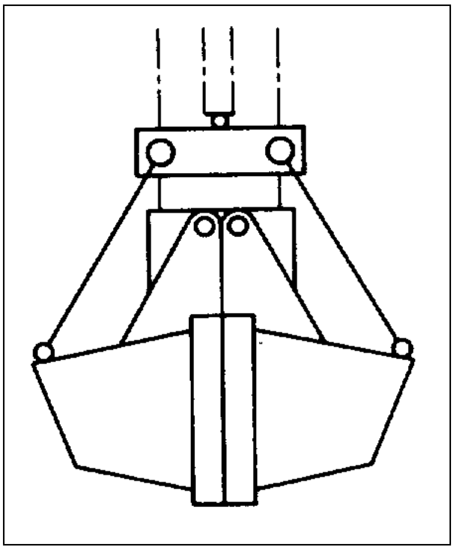


Figure 3.12: Two-shell-grab
[UBA, 2001, 17] with reference to Meyer, Eickelpasch, 1999

Grabs are the most commonly used tools in the loading and unloading processes because: [UBA, 2001, 17]

- they are versatile
- they can be easily swapped when another type of bulk material is to be handled
- their capital cost is relatively low
- they can load and unload at the same rate.

Potential disadvantages of the grab technique may be: [UBA, 2001, 17]

- the strong dependence on correct operating technique
- the low effective capacity in relation to the nominal capacity
- the weight of the grab shells themselves.

The controlling of the grabs is normally carried out mechanically with cables. The option of controlling the grabs hydraulically with motors is rarely used for bulk materials. A wire grab takes 10 seconds to close the shells, whereas a motor grab takes 20. [UBA, 2001, 17].

The shape of the edges of the grab is important to control dust emission.

Figure 3.13 shows different shapes of edges.

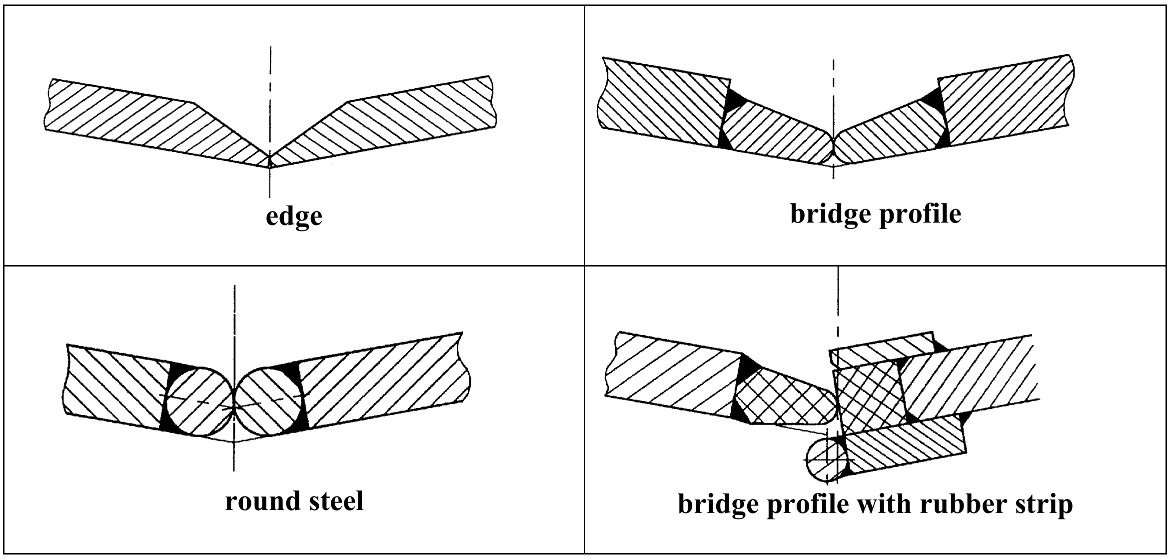


Figure 3.13: Different shapes of edges of grabs
[UBA, 2001, 17] with reference to MB Kröger Greifertechnik GmbH

The rubber joint is particularly suitable for very fine flowing bulk materials, e.g. fish meal. For lumpy bulk materials like iron and ores, rubber joints are not strong enough and are therefore not used. Rubber joints need to be cleaned and maintained regularly, if they are to be effective. [UBA, 2001, 17].

If different materials are handled, joints with two round steels edges are commonly used. Precise fitting of the grab edges is decisive for optimal closing and minimum dust emission. Problems with the precise fitting can arise from the constant abrasion of the edges. Edges which overlap prove in practice not to be suitable because they are especially sensitive to damage. [UBA, 2001, 17].

Emissions from grabs: Emission-relevant process steps are: [UBA, 2001, 17]

- dumping of the material (dust formation depends on the fall height)
- overloading or not totally closing the grab shells (the material spills)
- slewing of the grabs (dust emissions arise from drifting).

3.6.2.3 Optimised grab

Description: The essential properties of a dust-preventing grab are: [UBA, 2001, 17]

- its geometric shape and its optimal load capacity
- the grab volume should always be higher than the volume that is given by the grab curve (the grab curve is the curve that is described by the grab jaws while subsiding into the material)
- the inner surface should be smooth to avoid material adhering
- the closure capacity of the grab during permanent operation.

The closed jaw construction with a hopper-shaped opening has all the above-mentioned properties.

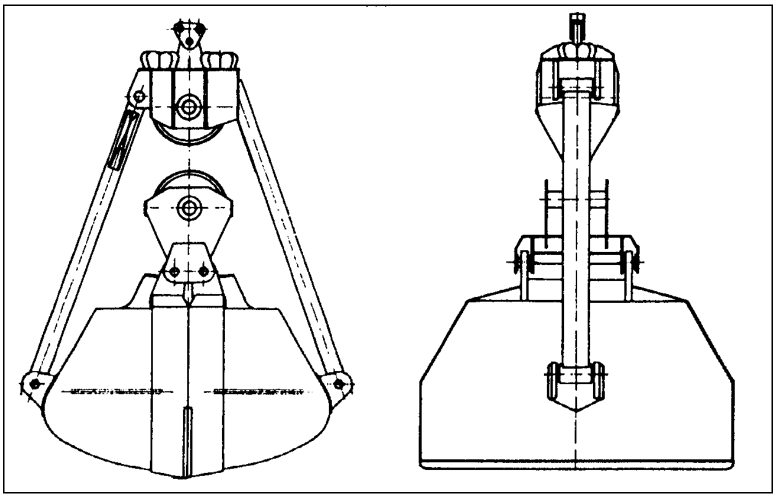


Figure 3.14: Closed grab jaw construction with a hopper-shaped opening (front and side view) [UBA, 2001, 17] with reference to MB Kröger Greifertechnik GmbH

Applicability: Grabs are used in sea and river ports and in storage places to load and unload fine flowing bulk materials; they are used for transport from ship to ship as well as from ship to storage and/or to wagon. Grabs are applicable for nearly all bulk materials, including those with a high moisture content (which is not the case with e.g. pneumatic systems). [UBA, 2001, 17].

Main achieved emission levels: A closed construction minimises the formation of dust emissions, but dust emissions and spillages may still cause considerable material losses of 2 to 5 %. [UBA, 2001, 17].

Cross-media effects:

References: These types of grabs are used in several sea and river ports, such as Neuss or Orsoy. [UBA, 2001, 17].

Operational data:

Economics: As a rough guide, a grab with a capacity of 13 m^3 costs DEM 83000 (about EUR 42000). Additional costs e.g. for the crane installation, have to be considered. [UBA, 2001, 17].

Driving force for implementation:

Reference literature:

3.6.2.4 Discharge hoppers in general

Description: Discharge hoppers are devices which take the discharged product (from grabs or from belts) and deliver it in a jet onto the load area of a vehicle (truck or wagon), onto another conveyor system or into the storage system. Discharge hoppers are often fitted with gratings or lamellas in order to ensure an even flow of material and to prevent bigger pieces of material blocking the flow; the lamellas require the bulk material to be fairly fluid. Feeders are used for even delivery to the next conveying device. Hoppers can be equipped with a height-adjustable loading tube and with a dust apron, when they are used e.g. for loading vehicles. [UBA, 2001, 17].

3.6.2.4.1 Optimised discharge hopper (in ports)

The following characteristics – which also can be combined – are relevant for dust prevention on hoppers: [UBA, 2001, 17]

- suction hoppers; dust/air mixtures are drawn through a dust filter
- closed hoppers; hoppers equipped with high side-walls with the following effects:
  - wind disturbance is prevented by the wall
  - dust distribution is locally limited by the hopper wall and the grab (when the grab stays long enough within the walled area)
  - any suction system installed is more effective (40 % less suction capacity is required in comparison to open hoppers)
- hoppers with installations such as baffles or a louvre-type grid closure with the effect that dust-air mixtures are held back; these installations require the bulk material to be fairly fluid.

Applicability: Loading and unloading of bulk materials in ports, e.g. ship unloading by grabs or discharge onto a belt after silo unloading to load a truck or a wagon. A hopper is suitable for nearly all bulk materials (up to a particular size); e.g. grain, fertilisers, coal, non-iron metal ores /-concentrates, raw materials of the cement industry. [UBA, 2001, 17].

Hoppers with high side-walls hinder the crane operator's view. Additionally, the dust-reducing effect of high side-walls is essentially dependent on the crane operator's technique. [UBA, 2001, 17].

Main achieved emission levels:

Cross-media effects:

References: Louvre-type grid closure with suction is applied in port Neuss, Norddeutsche Affinerie Hamburg and the port of Hamburg. Louvre-type grid without suction is applied in Raiffeisen Hauptgenossenschaft Nord, Uelzen (only for fertilisers). [UBA, 2001, 17].

Operational data:

Economics: An example is an investment of DEM 90000 (about EUR 46000) for a silo hopper with:

- 55° hopper slope angle
- a discharge gate of 400 mm
- a cylinder top of 3 m
- a diameter of 5 m
- dust valves (as dust barriers) with suction (7500 m^3/h)
- an antistatic filter
- control equipment.

Driving force for implementation:

Reference literature:

3.6.2.4.2 Cascade hopper

Description: The system consists of an off-set stack of buckets suspended on belts and enclosed in a tube Because the buckets are off-set, the conveyed material falls through the system at a low velocity. The particles therefore stay bound with each other and only a few fine particles are set free. Furthermore, air displacement is prevented. [UBA, 2001, 17].

The support installation at the lower end of the hopper is lifted and lowered by lift wires, which stack the hoppers automatically. Hoppers with throughputs of 30 to 5000 m^3/h are available. They are coated with extremely high-density polyethylene, sintered aluminium, ceramic brick and steel, which are all resistant to abrasion. [UBA, 2001, 17].

Another part of the hopper system is a transfer installation between the conveyor belt and the hopper, fixed to the conveyor belt. It has sheet metal baffles and guides to reduce dust formation and to direct the material at the correct angle and velocity in the hopper. Installing a level sensor enables the hopper automatically to maintain an appropriate distance from the surface of the material. [UBA, 2001, 17].

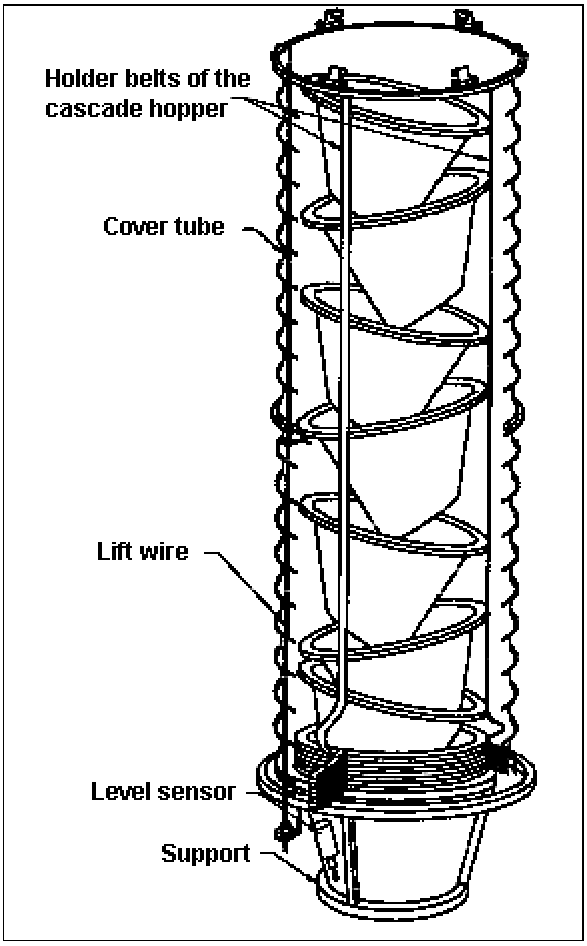


Figure 3.15: Typical cascade hopper
[UBA, 2001, 17] with reference to Cleveland Cascades U.K., 2000

Applicability: This technique can be used for the loading of ships, wagons, trucks and silos and for the transfer between conveyor belts. Suitable bulk materials are: powdery to coarse flowing bulk materials, practically used for potash, phosphate, grain, coal, coke, heavy sodium, aluminium oxide, cement and sodium phosphate. The technique has a relatively simple construction and needs only simple maintenance and cleaning. [UBA, 2001, 17].

Main achieved emission levels: A considerable reduction of dust formation is noted. [UBA, 2001, 17].

Cross-media effects:: A positive effect is the reduction of quality loss. [UBA, 2001, 17].

References: Kali Transport Hamburg, the ports of Wismar, Lübeck and Philippstal. [UBA, 2001, 17].

Operational data:

Economics: Costs are very case-specific. [UBA, 2001, 17].

Driving force for implementation:

Reference literature:

3.6.2.5 Tubs

Description: Tubs are used to load as well as to transport. Tubs are transportable vessels with at least one gate. They cannot pick up the material but are normally filled from the top. In order to empty the tubs a bottom plate is swung aside (bottom emptying tub), the tub is tilted (tilting tub) or gates open (a gate tub similar to the grab). Tubs are normally not suitable for dusty goods. [UBA, 2001, 17]. Figure 3.16 shows different tub types.

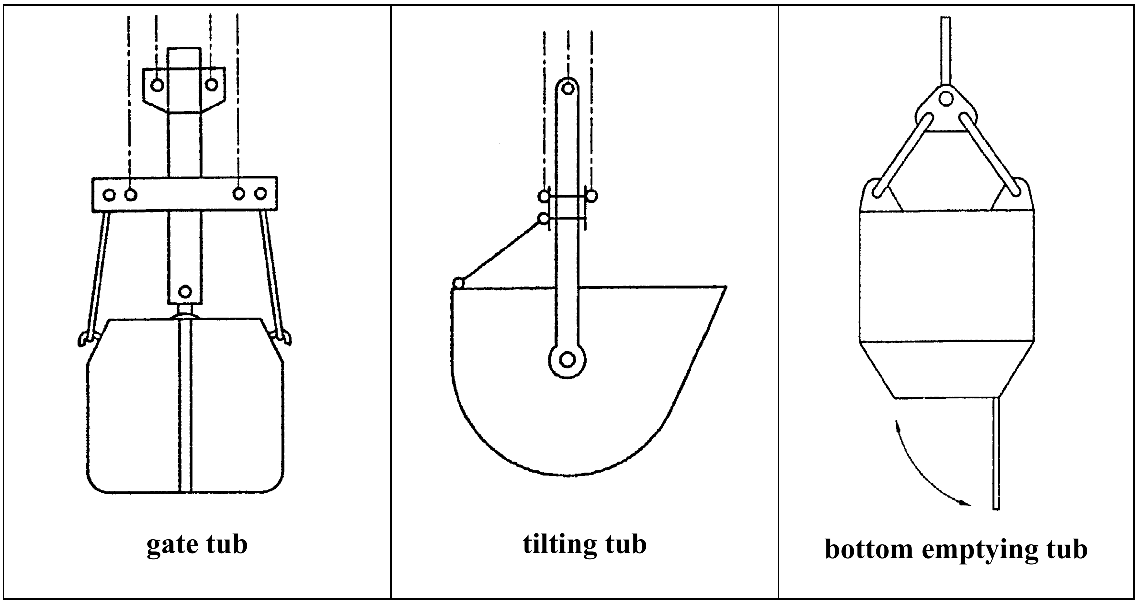


Figure 3.16: Different tub types
[UBA, 2001, 17] with reference to DIN 30800-3

3.6.2.6 Mobile loading devices

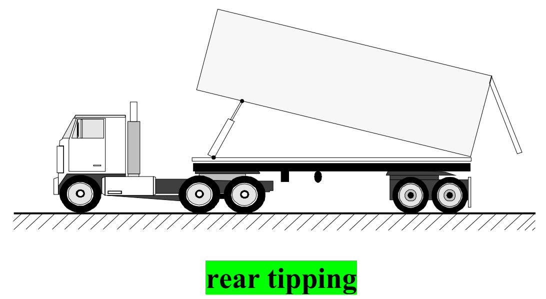
Description: Mobile loading devices are excavators and frontloaders. They are used: [UBA, 2001, 17]

- to work on small heaps
- to load vehicles
- to bring the material to bins or boxes
- to feed hoppers
- to trim the material in ships.

Emissions from mobile loading devices: Emissions arise from lifting up the bucket or from wind drifting or from dumping. The open handling favours dust formation. [UBA, 2001, 17].

3.6.2.7 Dump trucks

Description: The loading of a dump truck is achieved by mobile loading equipment. The unloading is achieved by tipping over the front or over the side. [UBA, 2001, 17].



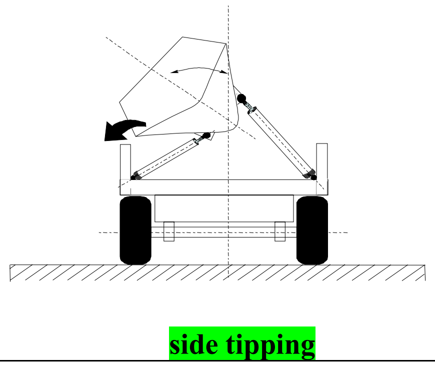


Figure 3.17: Dumptrucks
[UBA, 2001, 17] with reference to Meyer, Eickelpasch, 1999

The advantage of the tipping technology is the high capacity. Unloading is rapid and economical but can create quite a lot of dust emission. Additional equipment is needed to load the truck. [UBA, 2001, 17].

3.6.2.8 Wagon emptying

Description: Wagons are used to transport grain, fertiliser, coal, sand or ores. Table 3.29 shows typical bulk material wagons used in Germany.

Types	Principle	Bulk material
1. open wagons	• wagons open at the top • not self-unloading (partly by grabs or by special tilt equipment)	coal, briquettes, scrap, ores, stone and minerals
2. open wagon with gravity unloading – dosable –	• loading space with several juxtaposed hoppers • dosed lateral material unloading by gravity through dosable openings	gravel, sand, stone chippings
3. open wagon with gravity unloading – instantaneous	• wagon open at the top • saddle-shaped bottom • instantaneous material unloading through side-gates (also with bottom unloading)	gravel, sand, stone chippings
4. tipper wagon	• wagon with a pit, tiltable over the side and driven by a pneumatic ram • separated valves (the lower valve serves as a chute)	building waste, building material
5. wagon for pressure unloading	• closed wagons • emptying by pipes into silos	cement, lime flour, quartz sand, soda, aluminium oxide, sugar, flour, semolina, salt
6. covered wagon with gravity unloading – dosable –	• like 2, but with slewable roof	moisture-sensitive bulk materials, e.g. grain
7. covered wagon with gravity unloading – abruptly –	• like 3, but with slewable roof	moisture-sensitive bulk materials

Table 3.29: Survey of typical wagons for bulk materials
[UBA, 2001, 17]

The emptying of wagons is carried out via lateral discharge openings or at the bottom of the wagon. With lateral emptying, the material is led via special gutters to the next handling device or directly onto belts/bands. It is similar in principle to the bulk gutter unloading of road vehicles and is often used for fertiliser. Unloading stations are generally roofed or partly enclosed (particularly when handling moisture-sensitive bulk materials). Totally closed housing is not usual for railway unloading. [UBA, 2001, 17]

In seaports it is common practice to unload wagons over the side onto belts; the material is conveyed either to a subsequent means of transport (truck or ship) or to a storage system (heap, shed, silo). Figure III - 8 in the Annex shows some wagon types used by the German railway, with different unloading techniques. [UBA, 2001, 17].

Emissions from wagons: The loading (by grabs, loading pipes or discharge from conveyor belts) and unloading of the wagons are the two relevant process steps. Capsulation or suction systems can be installed. [UBA, 2001, 17].

Emission of dust from instantaneous discharge over the side is in general higher than from instantaneous discharge between the lines. Dosable unloading, however, produces less emissions than instantaneous discharge and can be compared with the emissions from a normal belt feeding station or point. [UBA, 2001, 17].

3.6.2.9 Dump pits

Description: Dump pits are ground excavations covered with a grid into which the material is tipped at high velocity. Dump pits are normally used to unload tipper wagons (e.g. with grain). [UBA, 2001, 17].

Dump pits can be equipped with so-called dust barriers. These are valves or lamellas which open when the material is fed in. The dust that comes up is held back either by the following material or, when the mass flow stops, by the closing dust barriers. Dump pits can also be equipped with a suction system. Apart from dust barriers or a suction system, the reception area can be housed. Another possibility is the housing of the vehicle and pit area by a movable curtain system. [UBA, 2001, 17].

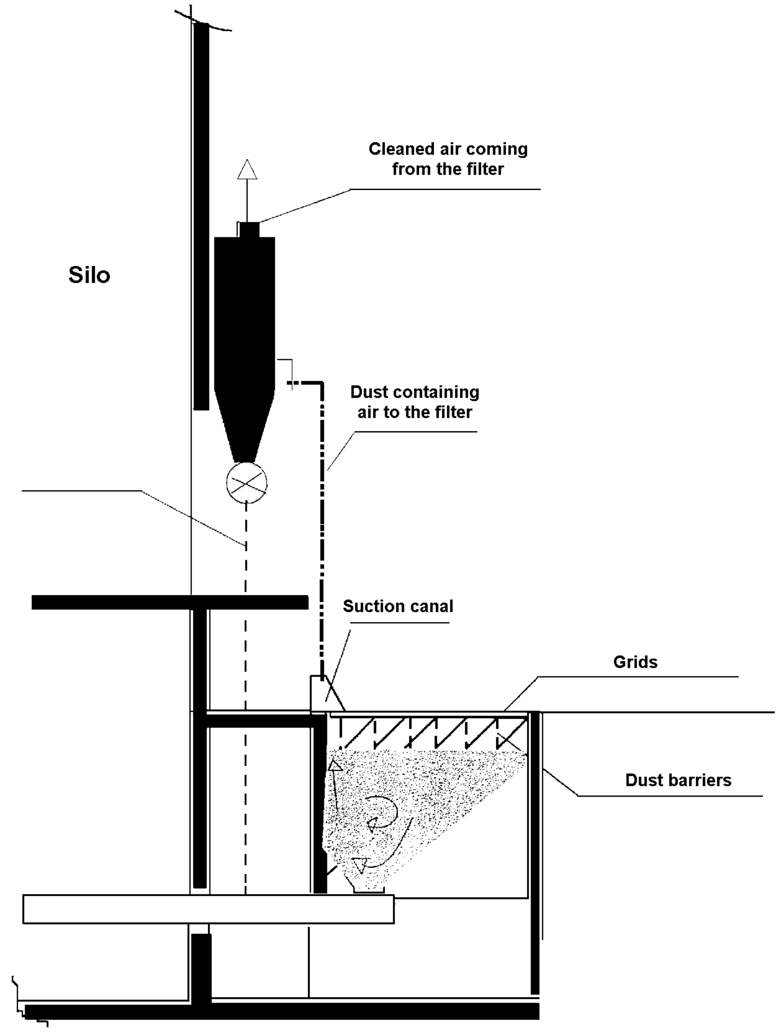


Figure 3.18: Dump pits with suction and dust barriers
[UBA, 2001, 17] with reference to Franz Rubert & Co. GmbH, 2000 (left picture) and Raiffeisen Hauptgenossenschaft Nord AG, 2000 (right picture)

Applicability: Dump pits were developed for the unloading of grain, but are in principle applicable for all free-flowing bulk materials. [UBA, 2001, 17].

Emissions from dump pits: Dump pits without dust barriers can cause high dust emissions; when grain is unloaded, dust can shoot up 3 metres high and be spread over the surrounding area. Sometimes dump pits are equipped with suction equipment. The disadvantage of this approach is high energy consumption and low effectiveness in dust reduction. In addition the suction capacity must be precisely adjusted to be effective without the risk of sucking the product itself as well. [UBA, 2001, 17].

Dust barriers reduce the flow capacity which can lead to dust emissions if the flow capacity is smaller than the unloading capacity of the truck or wagon. [UBA, 2001, 17].

Achieved emission reduction: The combination of a suction system and dust barriers has the advantage that the suction performance needed is considerably lower with dust barriers than without dust barriers; a reduction of 60 % is reported. [UBA, 2001, 17].

Combination 1: suction of the dump pit, installation of dust barriers and housing of the whole reception area results in an almost total prevention of diffuse dust emissions.

Combination 2: suction of the dump pit, installation of dust barriers and housing of the vehicle and pit area by a movable curtain system results in no visible dusts leaving the housing.

Cross-media effects: Suction systems generate noise and use energy. [UBA, 2001, 17].

In practice closed (or housed) dump pits are not very effective because the gates are not held closed. Another disadvantage of closed dump pits is that the vehicle - as an ignition source - stays within the housed area where the formation of explosible dust/air mixtures is possible. With combination 2 this is not the case. [UBA, 2001, 17].

Reference plants:
Combination 1: several in Germany
Combination 2: Raiffeisen Bezugsverein e. G., Süderbrarup; ATR Landhandel, Leezen (Germany). (This combination is not allowed in some German Länder). [UBA, 2001, 17].

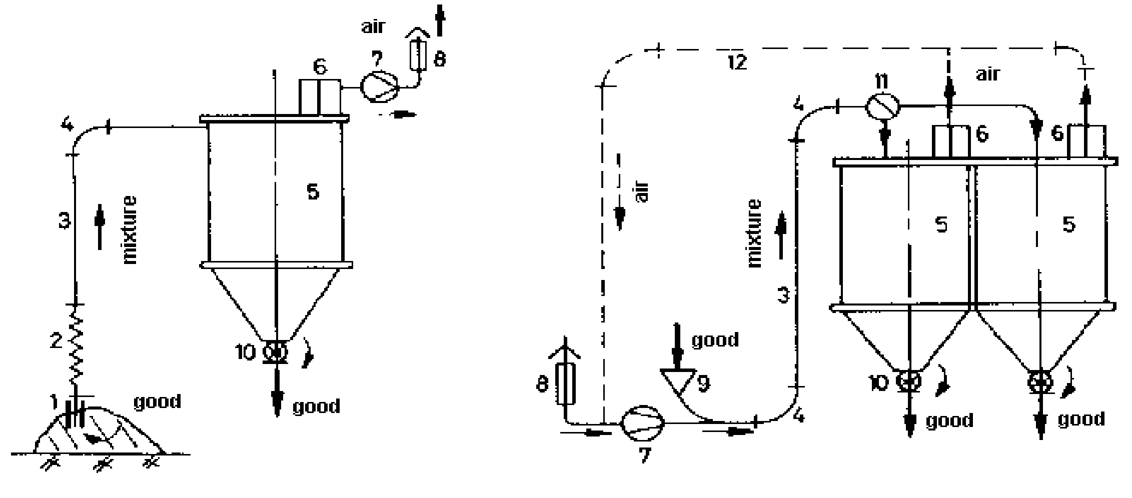
Economics:
Example 1: A new dump pit with a capacity of 7500 kg, with a fixed housing and suction, but without dust barriers, required an investment of DEM 450000 (about EUR 225000), reference year 2000.

Example 2: The retrofitting to an existing grain reception point, with a capacity comparable to example 1, of dust barriers, suction and a movable housing required an investment of DEM 200000 (about EUR 100000), reference year 2000. [UBA, 2001, 17].

The lower energy consumption for dump pits with dust barriers is an economic advantage. [UBA, 2001, 17].

3.6.2.10 Pneumatic conveyors

Pneumatic conveyors transport the material in closed pipes by streaming air. There are suction and pressure installations; Figure 3.19 shows the process principles of both systems.



explanation:

1. suction nozzle
2. moving part of the pipe
3. conveyor pipe
4. bend
5. separator and silo
6. filter
7. compressor
8. sound absorber
9. feed installation (e.g. hopper)
10. rotating feeder
11. diverter gate
12. air recirculation line

Figure 3.19: Function principle of a suction air (left) and a pressure air (right) conveyor [UBA, 2001, 17] with reference to Pfeifer, 1989

3.6.2.10.1 Suction air conveyors

Description: In order to unload ships, suction air conveyors are used, with the air compressor arranged at the end of the process chain. [UBA, 2001, 17].

Suction air conveyors may be installed as mobile or stationary installations. Mobile systems are suitable if different port activities take place at the same point or if the installation is only needed from time to time. Stationary installations are growing in number because the transport of goods is steadily increasing together with the number of suitable specialised terminals. [UBA, 2001, 17].

The material is sucked by a nozzle and is then transported under vacuum to the separator which separates air flow and material flow. The conveyed material is discharged in most cases over cell-wheel gates. At this point the vacuum is separated from the atmospheric pressure. The discharged material is then transferred to continuous conveying systems. [UBA, 2001, 17].

The installation is very flexible by: [UBA, 2001, 17]

- the rotating and the kick-in/kick-out movement of the suction head
- the bending and the telescopability of the vertical suction pipe
- the mostly drivable concept of the installation.

Nearly every point of the ship to unload can be reached. At the end of the unloading time the material layer gets too thin and it is more practical to use a frontloading shovel to trim the remaining material. [UBA, 2001, 17].

The throughput of pneumatic conveyors is influenced by the material type, the cross-section of the pipe, the air pressure and the route. E.g. grain can have a throughput of 500-600 tonnes per hour and aluminium oxide a throughput of 1000 tonnes per hour. [UBA, 2001, 17].

The essential advantages are the dust prevention because of the closed system and the dust control by filters, the simple construction, the long lifetime and the fact that no movable parts are used in the load room. The investment is relatively low. An essential disadvantage is the often high energy consumption.

Applicability: Suction air conveyors are suitable for bulk materials where the specific density is less than 1.2 g/cm^3. They are used in many industrial fields, typically in agriculture, mining, chemicals and foods industry for materials such as grain, aluminium oxide, petroleum coke, cement, limestone, lime and clay, potash, sodium sulphates and similar chemicals, fertilisers, salt and some plastics. They are used for the unloading of ships, wagons and trucks. [UBA, 2001, 17].

Emissions from suction air conveyors: Like all pneumatic systems, suction air conveyors have a very high energy consumption: for light materials such as agricultural products a value of 1 kWh per tonne and for heavy materials like clay or cement a value of 2 kWh per tonne. In comparison, values between 0.3 and 0.8 kWh per tonne can be assumed for mechanical conveyor systems. [UBA, 2001, 17].

Achieved emission reduction: Additional textile filters may be installed behind the separator to remove dust from the emitted air. Dust emission levels of 5 mg/Nm^3 can be achieved, but the filters are dimensioned for a dust emission of 20 to 25 mg/Nm^3 in order to reduce investment. [UBA, 2001, 17].

Trimming plays no important role in dust emission in comparison to the grab technique. [UBA, 2001, 17].

3.6.2.10.2 Pressure air conveyors

Description: Pressure air conveyors are mainly used for dust-free unloading in closed systems, e.g. with silo trucks. The principle of a pressure air conveyor is the same as the suction air conveyor except that the compressor is at the beginning of the unloading system (see Figure 3.19). The conveyed material is introduced into the conveyor pipe system via a feed mechanism (cell-wheel gate or screw or feed hopper) by injector effect. The conveyor pipe system is run at over-pressure. The next steps in the process are the same as those for suction air conveyors (see Section 3.6.2.10.1).

Applicability: Pressure air conveyors are suitable for fine particle crystalline bulk materials like cement, lime or gypsum. [UBA, 2001, 17].

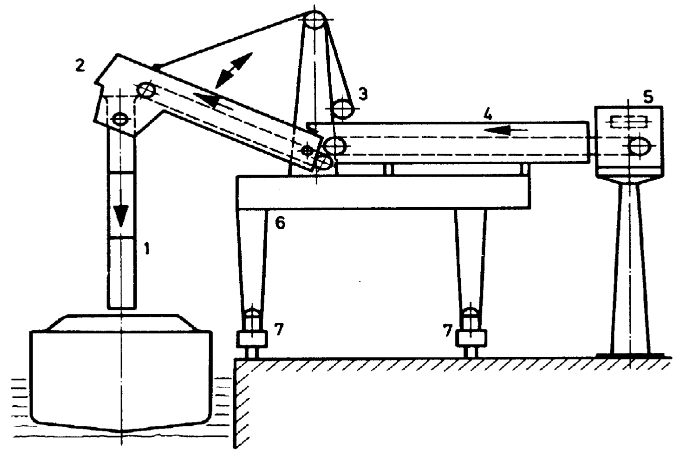
Emissions from pressure air conveyors: There is nearly no dust emission, because the conveying system is closed. The material pick-up can be the only dust relevant step in the process. [UBA, 2001, 17].

Suction air conveyor, as all pneumatic system, has a very high energy consumption. [UBA, 2001, 17].

The trimming plays no important role in dust emission in comparison to the grab technique. [UBA, 2001, 17].

3.6.2.11 Fill pipes

Description: With fill pipes, the material slides or falls down a pipe under gravity. There are several variations of fill pipes. Synonyms are 'loading pipe' and 'down pipe'. Figure 3.20 shows a ship loader for bulk materials with a fill pipe. [UBA, 2001, 17].



explanation:

1. telescopic fill pipe
2. rise and fall boom with belt conveyor
3. cable winch
4. belt conveyor with covering
5. conveyor bridge
6. portal crane
7. crane chassis

Figure 3.20: Ship loader with fill pipe
[UBA, 2001, 17] with reference to Pfeifer, 1989

Fill pipes are available as a rigid pipe or as a vertical and/or horizontal movable pipe. The movability is achieved by lifting devices with ropes, telescopic booms and kick-in / kick-out installations. With a movable fill pipe the fall height can be regulated and loading heads can be installed at the end of the pipe to regulate the output volume. A movable fill pipe can also be composed of an upper pipe and a lower pipe; they are joined with a seal and the lower one is telescoped by sliding pieces or pulleys. In very long pipes baffles are installed to reduce the fall velocity. [UBA, 2001, 17].

Applicability: Fill pipes are used to load containers, trucks, trains and ships. [UBA, 2001, 17].

Emissions: The fall velocity increases during unloading with the fill pipe so that particles separate and small dust particles are released. Furthermore, air is forced to the bottom with the falling material and carries out dust at the exit if loading heads or dust extraction units are not used. Furthermore the impact of the bulk material can cause additional dust emissions. The emission of dust depends on the length of the fall. [UBA, 2001, 17].

3.6.2.12 Fill tubes

Description: Fill tubes (also called loading tubes) can be used for closed and open loading. For an open loading of bulk materials onto open trucks, ships or heaps, covers or aprons are fixed at the end of the tube to minimize the spreading of dust. For closed loading in silo trucks or containers, a cone with a fill alarm is fixed at the end of the tube so that no dust can be emitted. The tube is composed of an inner and an outer tube and is made of plastic or of a tough woven plastic textile. [UBA, 2001, 17].

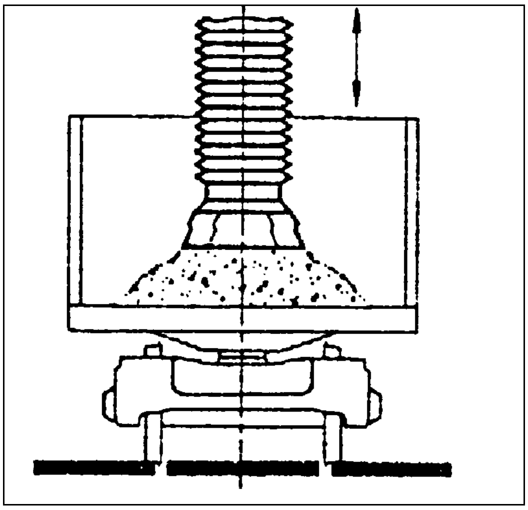


Figure 3.21: Fill tube
[UBA, 2001, 17] with reference to DIN 30800-3

Applicability: Fill tubes are used to load containers, trucks, wagons and ships. [UBA, 2001, 17].

Emissions: Similar to the fill pipe (Section 3.6.2.11), a fill tube minimizes the free surface in order to achieve a nearly dustless loading. [UBA, 2001, 17].

3.6.2.13 Cascade tubes

Description: A cascade tube is a loading tube where a cascade is put in; see Figure 3.22. The material slides and falls alternately. The low fall height and the changes of the direction mean that there is nearly no dust formation during the loading and the material is treated more carefully. [UBA, 2001, 17].

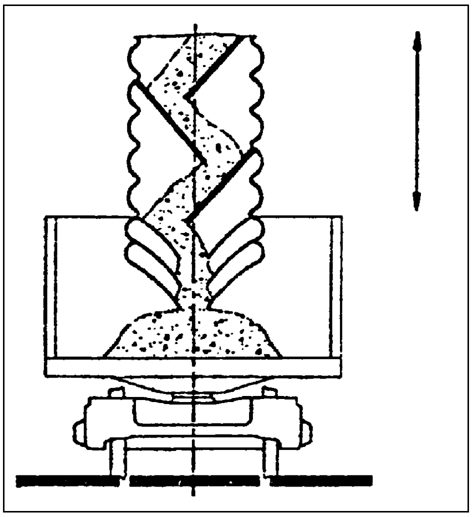


Figure 3.22: Cascade tube
[UBA, 2001, 17] with reference to DIN 30800-3

Applicability: Cascade tubes are used to load containers, trucks, wagons and ships. [UBA, 2001, 17].

Emissions: The cascade tube has far less dust emissions than the fill tube. [UBA, 2001, 17].

3.6.2.14 Chutes

Description: Chutes are bulk material conveyors where the material slides downwards in an open or closed sloping groove. Chutes are used as loading tools or as transfer devices between two conveyors. There are rigid and movable chutes. Movable chutes can be vertical and horizontal slewable or cross- and/or lengthwise drivable. [UBA, 2001, 17].

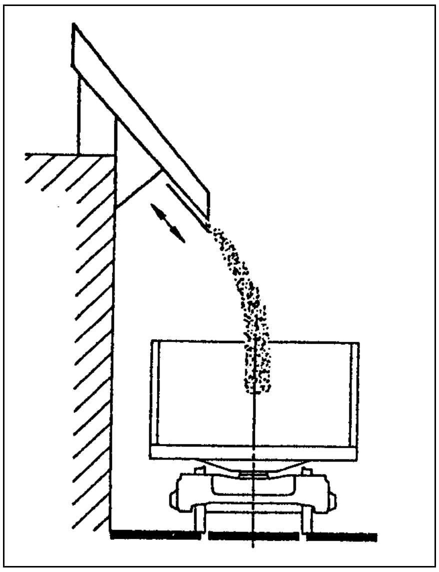


Figure 3.23: Loading of a wagon by a chute
[UBA, 2001, 17] with reference to DIN 30800-3

A minimum slope angle is required that varies with the specific flow properties of the conveyed material. Although a low-friction and/or high abrasion-resistance coating can be used to protect the chute, wear will still take place, at a rate dependent on:

- the chute length
- the angle of the slope
- the specific area load
- the slide velocity
- the frictional properties of the chute material. [UBA, 2001, 17].

Applicability: Generally, chutes are suitable for non-caking materials and for dry operations. [UBA, 2001, 17].

Because of the dust emissions, chutes are not applicable for fine powdery materials. [UBA, 2001, 17].

Emissions: The finer the material, the more dust will form. [UBA, 2001, 17].

3.6.2.15 Thrower belts

Description: Thrower belts are short rubber belt conveyors which reach very high conveyor velocities of 10 to 20 m/s. They are used as the last part of a loading chain if for local reasons the conveyor or loading system cannot be installed near enough to the discharge point. Examples are: [UBA, 2001, 17]

- ship loading in combination with vertical loaders if the loading bridge is not long enough

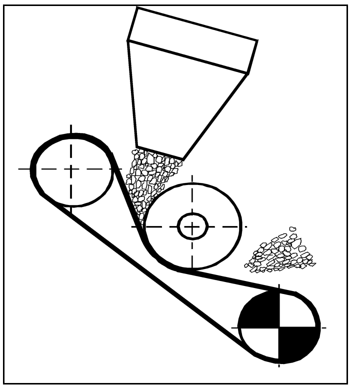


Figure 3.24: thrower belt
[UBA, 2001, 17] with reference to Meyer, Eickelpasch, 1999

- to feed smaller heaps if the material properties mean that only flat heap angles can otherwise be attained.

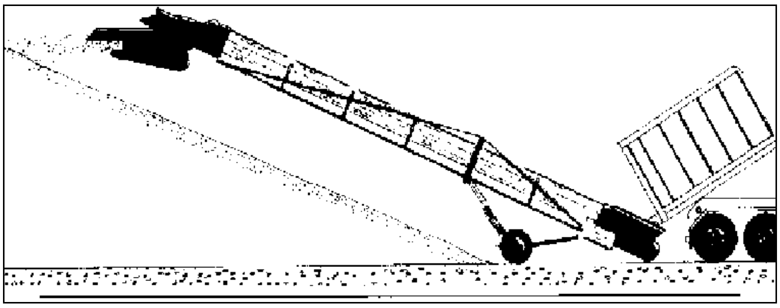


Figure 3.25: thrower belt used for constructing heaps
[UBA, 2001, 17] with reference to Meyer, Eickelpasch, 1999

Applicability: Thrower belts are used in situations where the conveyor or loading system cannot be installed near enough to the discharge point. [UBA, 2001, 17].

Emissions from thrower belts: Thrower belts cause a lot of dust emissions. [UBA, 2001, 17].

3.6.2.16 Belt conveyors

Description: Belt conveyors are the most used and the best-known continuous conveyor systems. On belt conveyors the conveyed material is transported on an endless belt on support pulleys, slide strips or on an air film, made of rubber or plastic. Types of belt conveyors are: [UBA, 2001, 17]

- **belt conveyors:** the material is transported on the top side of an endless rubber belt with wire reinforcement. They are used as mobile systems or as part of stationary installations. A characteristic of the conveyor belts is that they are concave

- **steep belt conveyors:** similar to the classic belt conveyor. In order to overcome slopes, the band is reinforced with profiles or small side-belts. A very concave profile is often used to form a pocket that grips the material sufficiently to transport it up steep slopes

- **tube belt conveyors:** a special type of the classic belt conveyor. After the feed-path the conveyor belt forms a nearly circular cross-section, the belt edges overlap and form a closed tube. The material is conveyed in the inner side of the band, which is rolled by (3 to 5) drive pulleys. The material is protected against the weather and dust emissions are minimised. At the - usually housed - discharge point the belt is opened to discharge the material

  applicability: belt conveyor of this type are suitable for fine and for lumpy materials up to a size of one third of the tube diameter. They are used to overcome long distances (and steep inclines of up to 60°), e.g. in mines and iron and steel works, because the system allows curves so that intermediate transfer points are not necessary. Other applications are in the cement, fertiliser, food and chemical industry, to transport materials such as, ores, coal, coke. limestone, broken stones, cement, gypsum, copper ore concentrate, ash and salt

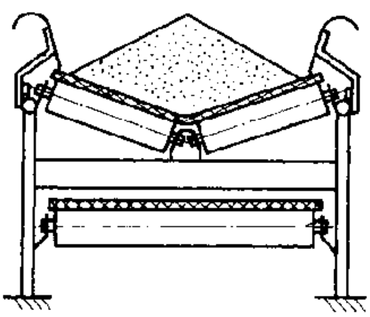
- **loop belt conveyors:** a relatively new kind of belt conveyor which is not often used, because of the high cost. The belt is formed as a loop by pressure and support pulleys. The belt is opened in order to discharge the material. With this type of conveyor extremely tight curves (up to 0.4 m) are possible.

Figure 3.26 shows the four belt conveyors described above.

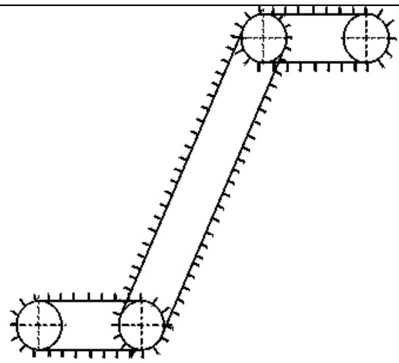
- **double belt conveyors** use two conveying belts, normally a support belt and a cover belt, which are brought together in the sloping or vertical part of the installation. The support band has raised edges and cross-profiles which support the material during vertical transport. At the bottom the belt system is led over a drum, from which it picks up the material while moving downwards. The wedge effect between the two belts carries the material upwards to the transfer point, which may be a hopper. [UBA, 2001, 17].

  applicability: this technique requires a relatively even particle size. Generally, materials between fine and coarse are suitable, but not powdery or lumpy materials or those that tend to cake on. [UBA, 2001, 17].

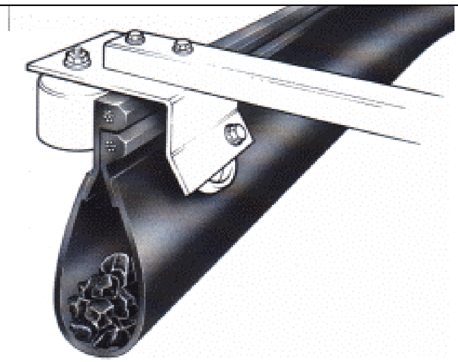
Emissions from band conveyors: With open outdoor conveying systems, dust emissions are caused by the wind, an effect exacerbated by the vibrations of unsupported conveyor belts. Dust emission also occurs when caked-on material falls off while the belt is running back after the discharge. Dust emission from the material that is fed onto the belt can occur if the feed velocity does not match the belt velocity. [UBA, 2001, 17].



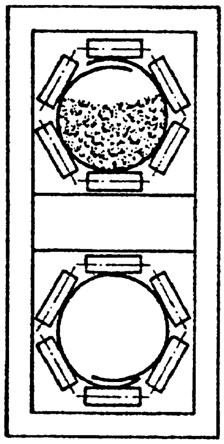
rubber belt conveyor (a)



steep belt conveyor (a)



loop belt conveyor (a)



tube belt conveyor (b)

Figure 3.26: Different band conveyors
[UBA, 2001, 17] with reference to Meyer, Eickelpasch, 1999 (a) and VDI 3971 (b)

3.6.2.17 Bucket elevator

Description: Bucket elevators are conveyors where the buckets that pick up the material are fixed to a drive mechanism such as a chain or a conveyor belt. The shape and material of the buckets depend on the material that is to be conveyed. Bucket elevators are used for vertical transport, as they can lift to great heights, but are also used as continuous ship unloaders to convey the material horizontally and vertically in one device. In those cases the conveyor foot is L-shaped. The advantage of the L-shaped foot is that the bulk material can be picked up fairly close to floor level and out of the corners of the ship's hold, which reduces the need for trimming. The flexible conveyor shoe can be adapted by hydraulic systems to the geometry of the hold, enabling optimum filling of the buckets. [UBA, 2001, 17].

The fill factor is the proportion between the design volume of the bucket and the actual fill and is dependent on: [UBA, 2001, 17]

- shape and velocity of the bucket elevator
- type of the bulk material being handled
- relative position of the buckets to the bulk material surface
- relative position of the buckets which are in contact with the bulk material.

The discharge of the material takes place at the head of the bucket elevator either by gravity unloading (with slowly running conveyor systems) or by centrifugal force (with fast running conveyor systems). The conveyor velocity is 0.3 to 1.6 m/s with steel chains and 1.5 to 4 m/s with conveyor belts. Conveyor heights of 110 m are achievable with a belt and 60 m with a chain. The maximum throughput may be up to 3000 t/h on average to 4000 t/h peak. [UBA, 2001, 17].

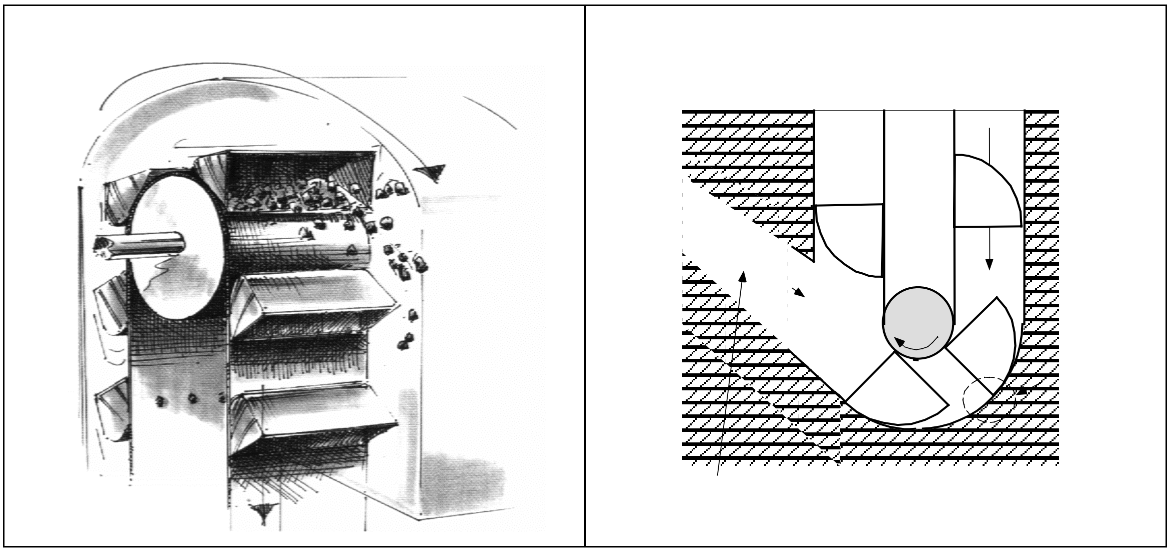


Figure 3.27: Construction and function principle of a bucket elevator
[UBA, 2001, 17] with reference to Meyer, Eickelpasch, 1999

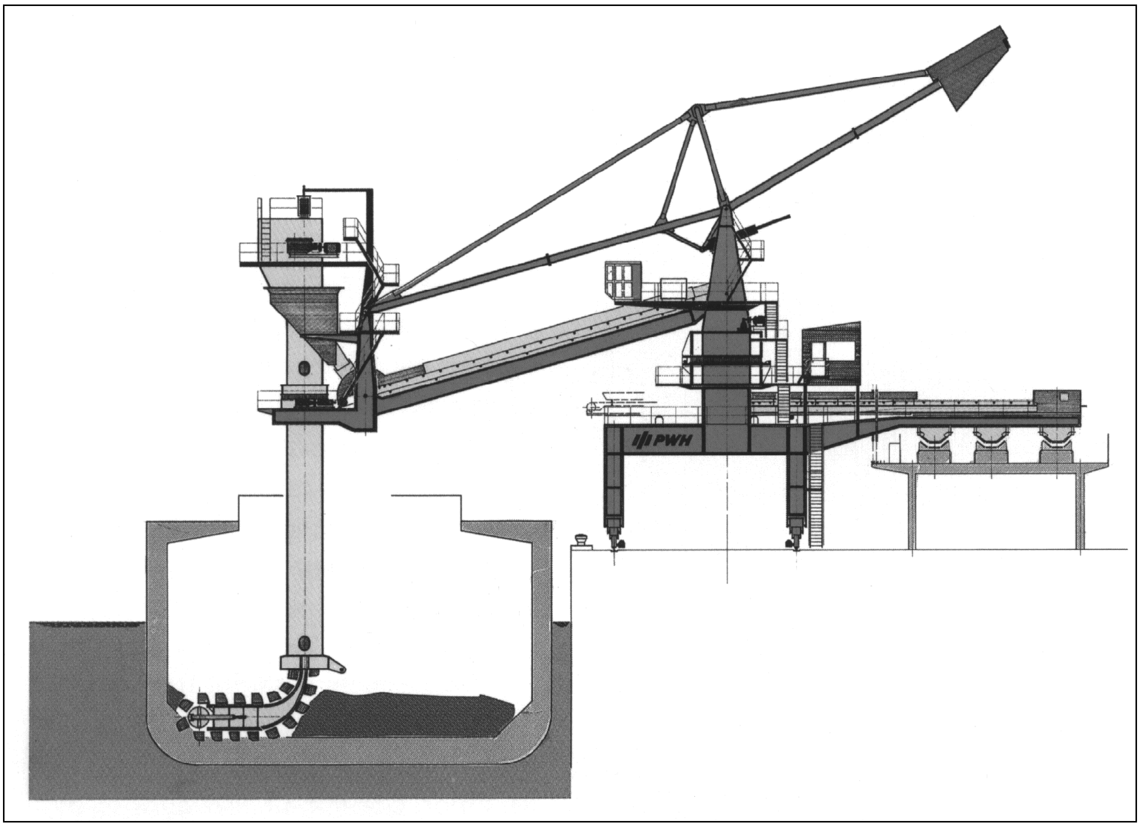


Figure 3.28: Continuous ship unloader with bucket elevator technique and L-shaped pick-up foot
[UBA, 2001, 17] with reference to Krupp Fördertechnik GmbH, 2000

Applicability: Bucket elevators are suitable for the conveying of bulk materials from powdery to moderately lumpy (up to 60 mm particle size) which have no caking-on and no strongly abrasive properties, e.g. flour, corn and pulses, sand, coal, limestone, cement or ash. [UBA, 2001, 17].

Emissions: The bucket elevator is encased and can be equipped with a suction system, so little or no dust emission will occur. The material pick-up and discharge are potential sources of dust emissions. [UBA, 2001, 17].

Reference plants: Bucket elevators with the L-shaped pick-up foot are applied in European steelworks such as Riva Acciai in Taranto, Italy, Sidmar Steelwork in Gent, Belgium, Ferrol, Spain and in Dillinger Hüttenwerke AG, Vereinigte Elektrizitätswerke Westfalen AG. [UBA, 2001, 17].

Economics: For the specific case of Dillinger Hüttenwerke the investment was around DEM 8 million (about EUR 4 million). The capacity of this ship unloader varies between 1200 and 1500 t/h, depending on the material that is conveyed. The alternative of two grab unloading stations would have required a (similar) investment of DEM 7 - 8 millions (reference year 2000), but has only one third of the capacity. [UBA, 2001, 17], with reference to Dillinger Hüttenwerke AG, 2000.

The energy and maintenance costs are one-third lower than for conventional grab unloading. Two persons are needed for the operation of the bucket elevator, but four persons are needed for the operation of two grabs. [UBA, 2001, 17], with reference to Dillinger Hüttenwerke AG, 2000.

3.6.2.18 Chain conveyors

Description: The chain conveyor is a closed and heavy-duty conveyor with one or more continuous drive chains. The chains are moved over sprockets; chain tensioners are used to stop the chains from sagging. Chain conveyors are characterized by a generally low energy consumption; some units show values of 0.006 kWh per tonne and meter conveyor height. The chain velocity is mostly under 1 m/s with a throughput of up to 1000 t/h. Damaged chain elements can be changed relatively simply. [UBA, 2001, 17].

Two types of chain conveyors are presented in the following sections: the trough chain conveyor (Section 3.6.2.18.1) and the scraper conveyor (Section 3.6.2.18.2).

3.6.2.18.1 Trough chain conveyors

Description: In a trough chain conveyor the chains run in a closed trough, as shown in Figure 3.29. The shape of the collector is chosen to suit the type of material being handled and the conveyor path:

- for horizontal and gently sloping conveyor paths, flat, rectangular or L-shaped collectors are used
- for steeply sloping and vertical paths, U-shaped, fork- or ring-formed collectors are suitable [UBA, 2001, 17].

The pick-up and discharge of the material are fairly easily accomplished and the material can be conveyed vertically. This technique has a relatively low space demand and has low or no dust emissions. Disadvantages are the high wear and the relatively high energy demand. The throughputs vary between 10 and 2000 m^3/h, with a maximum conveyor length of 50 to 150 m. [UBA, 2001, 17].

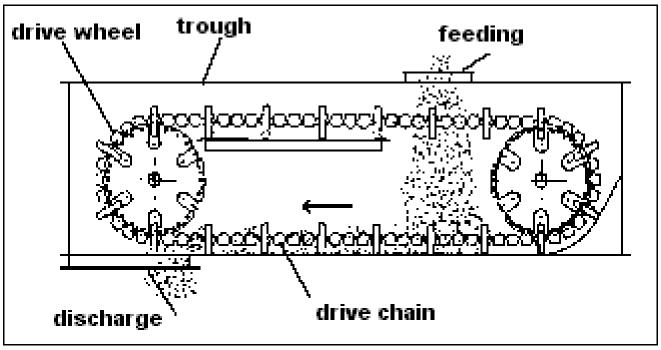


Figure 3.29: Principle of a trough chain conveyor
[UBA, 2001, 17] with reference to Meyer, Eickelpasch, 1999

Application: Trough chain conveyors are typically used in bunkers and silos for loading and unloading powdery and moderately lumpy materials that have no caking-on properties and a moisture content lower than 3.5 %. Because the trough chain conveyor is a closed system, it is used especially for grain, oil seeds, food and feed, coal, cement, chemical products and minerals. [UBA, 2001, 17].

Emissions: If the feed and discharge areas are enclosed or housed, no dust emissions arise. [UBA, 2001, 17].

3.6.2.18.2 Scraper conveyors

Description: A scraper conveyor is similar to a trough chain conveyor, but without a trough. The conveying is carried out by collectors attached to chains. The collectors push the material. The pick-up and discharge of the material can be made at any chosen point on the conveyor. [UBA, 2001, 17].

Application: Scraper conveyors are mostly used to feed and to reclaim heaps of ore, coal and salt. [UBA, 2001, 17].

Emissions: Dust is emitted during the pick-up and transport of the material. Friction effects between the material and the walls and bottom of the conveyor can cause crushing of the material. The dust formation from this effect can be minimized by dampening the material. [UBA, 2001, 17].

3.6.2.19 Screw conveyors

Description: Screw conveyors are bulk material conveyors in which the material is driven along a stationary trough or pipe by a rotary conveyor worm, whether horizontal or sloping up to 30˚. Vertical movement is also possible, but requires a totally different construction of the conveyor. With horizontal movement, the material is pushed forward along the bottom of the trough; with vertical movement, the material runs with the worm around the pipe. [UBA, 2001, 17].

With horizontal screws, the material can be picked-up and discharged at several points. The openings to discharge are directed with flights. Vertical screw conveyors have a lower material pick-up point and an upper material discharge point. The maximum fill degree in relation to the screw cross-section is 40 % for trough screw conveyors and up to 80 % for pipe screw conveyors. [UBA, 2001, 17].

The maximum throughput performance of a vertical screw conveyance is 1000 to 1200 t/h. A higher performance is technically possible, but is very expensive. [UBA, 2001, 17].

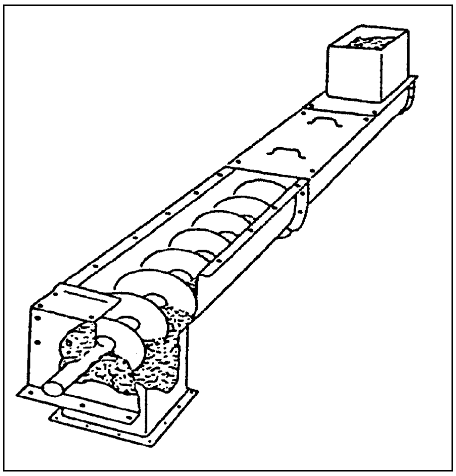


Figure 3.30: Scheme of a trough screw conveyor
[UBA, 2001, 17] with reference to VDI 3971

Application: Screw conveyors are especially suitable for conveying very dusty materials, e.g. iron ore, aluminium, cement, grain, fertilisers, coal, lime and phosphates. [UBA, 2001, 17].

Screw conveyors are used for the transport over relatively short distances (up to 40m) of materials ranging from those containing powdery, fine particles to lumpy bulk materials. They are unsuitable for abrasive materials or those that tend to cake on. [UBA, 2001, 17].

These devices are compact and – because of the kick-in/kick-out device – can reach areas that are otherwise difficult to access, although they are not suitable for ships with small hatches. Trimming is less than with a grab. Because of its versatility the screw conveyor is used in many fields. [UBA, 2001, 17].

Emissions: Vertical screw conveyors are always closed, whereas horizontal conveyors can be open or closed. In all cases dust is emitted at the points where the material is picked up and discharged, unless the transfer points are enclosed. [UBA, 2001, 17].

Cross-media effects: The energy consumption is relatively high due to the high driving power of the screw. [UBA, 2001, 17].

Reference plant: Stadtwerke Flensburg; Port of Borugas Ltd., Bulgaria; Kingsnorth Power Station, England; Calibra S.A. Lisbon, Portugal.

3.6.2.20 Feeders

Description: The feed and discharge points are the most significant for the formation of dust from continuous conveyor systems. Some typical feeders are: [UBA, 2001, 17]

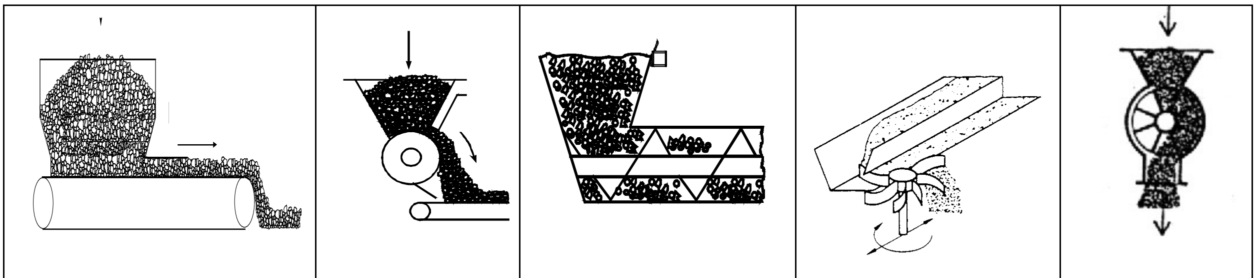
1. **belt feeders** are rectangular hoppers. The bulk material falls from the storage unit over the hopper onto the conveyor belt. Such hoppers are available as enclosed types, with optional suction or sprinkling systems

2. **roll feeders** are openings from bunkers or silos. The material is fed onto a rotating roller. The roll conveys the material to a conveyor system behind it. The feed velocity varies with the rotation speed of the roll

3. **screw feeders** correspond to the classic screw conveyors. By the rotation of the conveyor screw in a trough, material is transported in a controlled way from a longitudinal feed opening to the conveyor or storage unit behind it

4. **slit bunker feeders** are used to feed bunkers or silos. The material slides over a bevelled ground plate from the storage system in a discharge slot. A discharge carriage moves along the slot opening. At the discharge carriage a rotating bucket wheel is fixed which removes the material from the slit ground to the conveyor installation behind it.

5. **rotating feeders** are also used to feed the material to conveyor belts from bunkers or silos. The discharge is effected by cells. The cells with lamellas on a rotating axis are housed in a kind of cylinder with openings at the top and the bottom; those openings are sealed to the silo or bunker and to the conveyor band.



1. band feeder	**2. roll feeder**	**3. screw feeder**	**4. slit bunker feeder**	**5. rotating feeder**

Figure 3.31: Feeders
[UBA, 2001, 17] with reference to Meyer, Eickelpasch, 1999 and DIN 15201 part 2

Emissions from feeders: Dust emissions arise particularly from feeders which are not housed. Overfilling can occur if the feed system is not adapted to the storage or conveyor system, e.g. because the feed velocity is too high. [UBA, 2001 #17].

4 TECHNIQUES TO CONSIDER IN THE DETERMINATION OF BAT

4.1 Storage of liquid and liquified gas

4.1.1 General; Emission Control Measures (ECM)

This section contains a general overview of the various Emission Control Measures (ECM's) and each ECM will be assessed by:

A: emission level reductions achievable
B: applicability and operability
C: safety aspects and/or consequences
D: economics
E: references.

ECM Scorecards have been prepared for all types of storage tanks. Each scorecard provides information on typical control measures for gaseous and/or liquid emissions from:

1. operating procedures and training
2. inspection and maintenance practices
3. settings of PVRV's
4. internal floaters
5. containment measures
6. vapour balancing or vapour treatment
7. etc.

Annex IV. 1 ECM Scorecards shows thirteen ECM Scorecards for several storage modes for both, operational emissions and emissions from incidents/accidents.

4.1.2 General operational and organisational prevention techniques for tanks

Adequate organistional measures are important for safe and responsible operation of the installation. It is common practice that: [Germany, 1999 #18]

- emergency response plans and communication plans for internal purposes and to/for external locations are available and kept up to date. They allow swift intervention of internal and external rescue/support teams and therefore might reduce any negative consequences caused by an accident
- operating instructions are available and followed. They contain information pertaining to the operation of the installation, e. g. plans for monitoring and maintenance, for precautions against malfunctions and for dealing with any that occur
- training and instruction of employees are carried out on a regular basis. Employees are informed, among other things, about hazards to the workforce and potential consequences for the environment [Germany, 1999 #18]
- the company has in its possession relevant records and documentation on the storage mode (e.g. design data/drawings, inspection and maintenance records etc. [TETSP, 2001, 87].

4.1.3 Inspection and maintenance: prevention techniques for tanks

4.1.3.1 Inspection

It is common practice to use time-based inspection intervals, related to the stored product (aggressive or non-aggressive) and sometimes also to the geographic location and climate. An international trend is evident towards the replacement of time-based by condition-based inspection. For the latter to be successful it is necessary that comprehensive, accurate, up–to–date records be maintained, beginning with the original design and erection data. This is essential for establishing and verifying corrosion rates, for deciding when a tank should be taken out of service for inspection and/or repair and for specifying repair methods and extent. (EEMUA N° 183, 1999).

Inspection can be categorised as regular in-service inspection or as regular out-of-service inspection. An in-service inspection may be a simple, regular walk around the tank using a checklist (see Annex I. International Codes, e.g. API RP 575, Appendix C). Out-of-service inspection is a detailed inspection of the complete tank structure using a standard checklist (see Annex I. International Codes, e.g. API RP 575, Appendix C). (EEMUA N° 183, 1999).
To be completed.

The text below describes an example of a time-based inspection scheme.

Tank walls
Internal inspection of individual (stand-alone) tanks not used for the storage of toxic or odorous K3 (see Abbreviations, page 211) products needs to be carried out at least every 15 years. For groups of tanks[2], only every fourth tank needs to be inspected in accordance with the above-mentioned scheme for individual tanks. For the other tanks in the group, the period of 15 years can be extended to 20 years if no important failures are found. But if important failures are discovered, the other tanks in the group need to be inspected as soon as possible. [CPR9-3, 1984, 3].

Individual tanks used for the storage of K1 and K2 (see Abbreviations page 211) products or for toxic or odorous K3 (see Abbreviations page 211) products, need to be inspected internally at least every 10 years. For groups of tanks, again, only every fourth tank needs to be inspected every 10 years. For the other tanks in the group, the period of 10 years can be extended to 15 years if no important failures are found, otherwise they need to be inspected as soon as possible. [CPR9-3, 1984, 3].

External inspection is done by measuring the thickness of walls and fixed roofs of all the tanks, at least every 5 years. [CPR9-3, 1984, 3].

The minimum required thickness of the steel plates is 2 mm. [CPR9-3, 1984, 3].

Floating roof seals need to be inspected at least every six monts. [CPR9-3, 1984, 3]. Regular seal checks and early repairs are recommended. [Concawe, 1999, 41]

Vents need to be externally inspected at least every year for opening, closing and sealing performance. [CPR9-3, 1984, 3].

Valves, steps, platforms and instruments, need to be inspected regularly to ensure good performance. [CPR9-3, 1984, 3].

Earth-wires and the method for inspecting them always have to meet the standard NEN 1014. [CPR9-3, 1984, 3].

[2] In this case a group of tanks is considered to be tanks situated close to each other that are constructed in the same way, store the same product and are used under the same conditions.

Fire-systems need to be inspected at least every year. This includes testing whether the material is ready for immediate use. [CPR9-3, 1984, 3].

4.1.3.2 Corrosion protection

Coating: Corrosion is on of the main causes of equipment failure. It can occur both internally and externally on any exposed metal surface. Protection may be provided by paints or other coatings. Chemical-resistant coatings or paints are available. [HSE, 1998, 37]. Annex I. International Codes, shows an overview of various methods that may be used.

Internal corrosion may result from the accumulation of water in the tank. A means to remove such water may be necessary. Corrosion may occur unnoticed under thermal insulation or lagging. Corrosion under lagging has to be addressed as part of the planned preventive maintenance schedule for the tanks. [HSE, 1998, 37].

Cathodic protection is an option to prevent corrosion on the inside of above-ground tanks. [CPR9-3, 1984, 3]. Cathodic protection is achieved by placing sacrificial anodes in the tank that are connected to an impressed current system or by using galvanic anodes in the tank. Internal cathodic protection is no longer widely used in the petroleum industry, due to corrosion inhibitors that are now found in most refined petroleum products. [Concawe, 1999, 41].

4.1.4 Emissions to air: prevention techniques for tanks

The major operational sources of emissions to air from tank storage are: (see Figure 3.1)

- tank filling
- emptying / draining
- cleaning
- purging / blanketing
- manual gauging
- sampling (open, semi, closed)
- breathing / standing
- fugitive.

The major incidental sources of emissions to air from tank storage are: (see Figure 3.1)

- overfill
- leakage. [TETSP, 2001, 84]

The two significant types of emissions from fixed roof tanks are breathing and working losses. Breathing loss is the expulsion of vapour from a tank by vapour expansion and contraction, which are the results of changes in temperature and barometric pressure. This loss occurs without any liquid level change in the tank. The combined loss from filling and emptying is called working loss. [EPA, 1997, 66].

Emissions occur during filling operations as a result of an increase in the liquid level in the tank. As the liquid level increases, the pressure inside the tank exceeds the relief pressure and vapours are expelled from the tank. Emissions occur during emptying when air drawn into the tank during liquid removal becomes saturated with organic vapour and expands, thus exceeding the capacity of the vapour space. [EPA, 1997, 66].

Good engineering design is the first step to minimise the emissions from storage tanks. When designing to limit these emissions it is important to establish the paths via which emissions can occur. Various prevention techniques and their applicability are described in the following paragraphs.

4.1.4.1 External floating roof tank with aluminium dome

Description. Retrofitting an EFRT with a fixed or domed roof will reduce the emissions into the air. The typical aluminium (geodesic) dome roof structures, introduced in the mid 1970s as weather covers over water treatment facilities, are now also used for the storage tanks in the petrochemical industry. In addition to the prevention of snow accumulation on top of floating roofs, it was realised that dome roofs are also advantageous in the prevention of rainwater accumulation. The elimination of wind on top of the floating roof is another important feature.

The aluminium geodesic domes are generally available in a range from approximately 6 m up to 80 m diameter. The dome is in general composed of prefabricated aluminium I-shaped beams and panels. The beams are linked/bolted together, forming triangular spaces, which are closed by the pre-cut aluminium panels clamped on top of the beams. The domes can be prefabricated within the tank and lifted in position or assembled outside the tank and lifted in position by a crane. However, the diameter/size of the dome is then limited by the available crane capacity. The dome structure requires a tension ring to handle the outward radial thrust. This tension ring can be either integrated with the primary wind girder at the top of the tank shell or as integral section of the dome structure it self. The latter (self supporting dome) is the most cost effective solution and does not require a lot of hot work on the tank shell. Special care has to be taken when domes are installed without a tension ring to ensure that the tank shell top section has adequate horizontal support. [TETSP, 2001, 84]

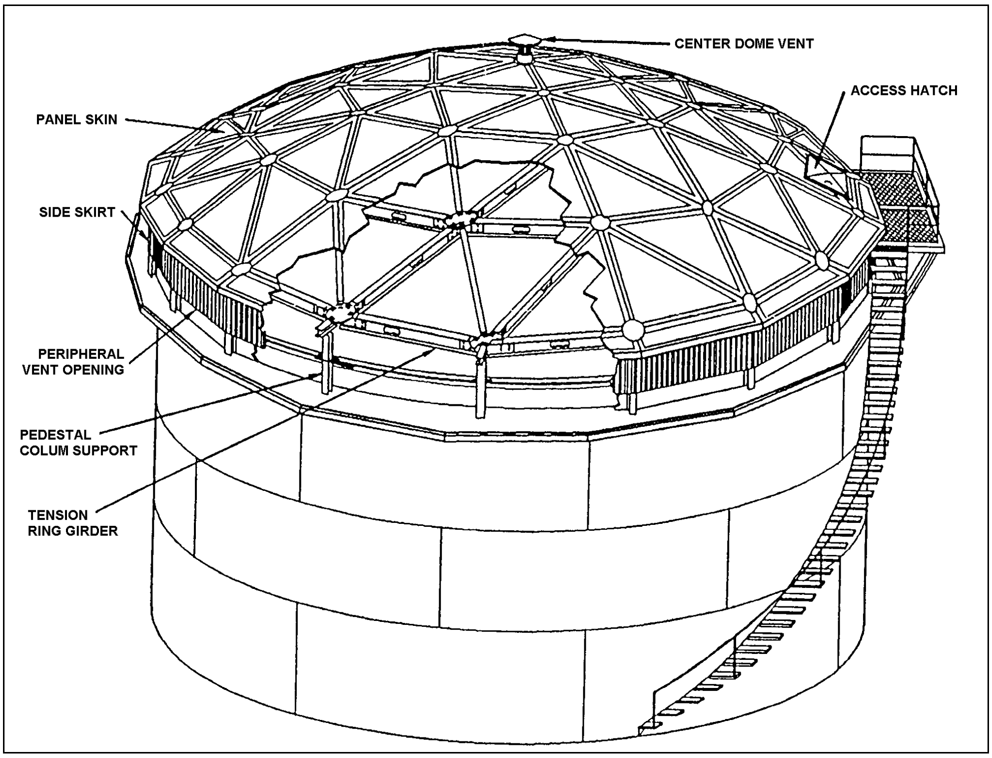


Figure 4.1: External floating roof tank equipped with a geodesic aluminium dome [draft EEMUA Pub 159]

4.1.4.2 Internal floating roof tank (IFRT)

Description. Installing an internal floating roof in a fixed roof tank will reduce the emissions into the air, as will retrofitting an EFRT with a fixed or domed roof.

An Internal Floating Roof Tank (IFRT) has both a permanent fixed roof and a floating roof (or deck) inside.

The deck in IFRTs rises and falls with the liquid level and either floats directly on the liquid surface (contact deck) or rests on pontoons several centimetres above the liquid surface (non-contact deck). Contact floating roofs can be:

(1) aluminum sandwich panels that are bolted together, with a honeycomb aluminum core
(2) pan steel decks with or without pontoons
(3) resin-coated, fiberglass reinforced polyester (FRP), buoyant panels.

The majority of direct contact floating roofs currently in service are aluminum sandwich panel-type or pan steel-type. The FRP decks are less common. The panels of pan steel decks are usually welded together.
Non-contact decks are the most common type currently in use. Typical non-contact decks are constructed of an aluminum deck and an aluminum grid framework supported above the liquid surface by tubular aluminum pontoons or some other buoyant structure covered with thin aluminium sheets or panels, usually sealed and bolted or riveted together.

Both contact and noncontact decks incorporate rim seals and deck fittings for the same purposes previously described for EFRTs. Emissions from floating roofs may come from deck fittings, nonwelded deck seams, and the annular space between the deck and tank wall.

Tanks fitted with an IFR may be freely vented by circulation vents at the edge and top of the fixed roof to minimize the possibility of vapour accumulation in the tank vapour space in concentrations approaching the flammable range. Working of PVRV, as ECM in this case, is considerably reduced.

Economics. Investment costs for installing an internal roof in a fixed roof tank costs, for tanks from 20 - 60 meters diameter, are 0.2 - 0.4 MEuros. [Concawe, 1999, 41] (reference made to UNECE/IFARE, Esso and BP Amoco Internal Data).

Reference: [Concawe, 1999, 41], [EPA, 1997, 66], [TETSP, 2001, 84]

4.1.4.3 Rim seals

Description
The rim seal system is designed to fill the gap between the outer pontoon of the floating roof and the tank shell (rim space) and therefore minimise emissions to air. The main construction is called the primary seal. To reduce emissions even further reduction, a secondary seal can be mounted above the primary seal.

Primary seals. The three basic types of primary seals used on external floating roofs are:

- vapour mounted, see Figure III - 2
- liquid mounted, see Figure III - 3
- mechanical (metallic) shoe, see Figure III - 4 and Figure III - 5.

Some primary seals on external floating roofs are protected by a weather shield. Weather shields may be of metallic, elastomeric, or composite construction and prolong the life of the primary seal by protecting the primary seal fabric from deterioration due to exposure to weather, debris and sunlight. Weather shields are less effective than rim mounted secondary seals in reducing emissions, primarily due to the unsealed radial joints.

Two types of materials are commonly used to make the wipers. One type consists of a cellular, elastomeric material tapered in cross section with the thicker portion at the mounting. Rubber is a commonly used material; urethane and cellular plastic are also available. All radial joints in the blade are joined. The second type of material that can be used is a foam core wrapped with a coated fabric. Polyurethane on nylon fabric and polyurethane foam are common materials. The core provides the flexibility and support, while the fabric provides the vapour barrier and wear surface.

Secondary seals. Secondary seals can be flexible wiper seals or resilient filled seals. For external floating roof tanks, two configurations of secondary seals are available: shoe mounted and rim mounted, as shown in Figure III - 5. Rim mounted secondary seals are more effective in reducing losses than shoe mounted secondary seals because they cover the entire rim vapour space. The mechanical shoe design is more durable.

For some external floating roof tanks, however, using a secondary seal further limits the tank's operating capacity because of the need to keep the secondary seal in contact with the tank shell when the tank is filled.

Main achieved emission levels. Assuming all seals are in good condition, mechanical shoe and liquid mounted resilient filled seals offer better control of emissions to air, as reflected by the API derived rim seal loss factors. Secondary seals reduce emissions by as much as 90 %. [Concawe, 1999, 41].

Cross-reference. Secondary seals reduce water ingress into the tank, thus decreasing tank draining and the associated emissions from sewer systems. [Concawe, 1999, 41]

Economics. The value of emissions savings alone sometimes offers little incentive to change to secondary seals but, when a seal requires replacement, the additional cost of fitting secondary seals is usually justified. [Concawe, 1999, 41]

Typical purchase cost (excluding installation) for a secondary seal constructed for a 30m EFRT is of the order of USD 7600. [Concawe, 1999, 41]

The investment costs for installing secondary/double seals on floating roof tanks are EUR 0.05 - 0.10 million for tanks with a diameter of 20 - 50 meters. [Concawe, 1999, 41] (with reference to UNECE/IFARE and BP Amoco Internal Data / UNECE EC AIRNVG6/1998/5).

Operational costs: replacement of secondary seals on floating roof tanks is necessary about every 10 years [Concawe, 1999, 41], although the period of replacement strongly depends on the condition of the tank shell, atmospheric conditions and quality of seal material [TETSP, 2001, 87]

Reference: [Concawe, 1999, 41], [EPA, 1997, 66], [TETSP, 2001, 87].

4.1.4.4 Roof fittings

Emission can occur through fittings on both floating and fixed roof tanks. Details of emission controls for fittings on EFRTs are given below.

Slotted still wells

Figure 4.2 shows the emission pathways of a still well. Emissions through the rim seal occur when wind flow over the tank roof sets up a pressure differential between the upstream and downstream section of the roof rim seal producing a flow regime around the rim seal gap.

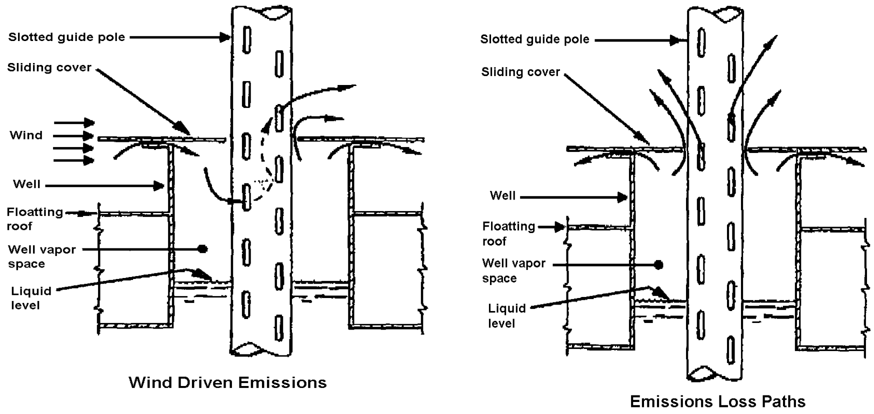


Figure 4.2: Emissions from still wells
[Concawe, 1999, 41]

For Example, Figure 4.3 shows a CBI design which incorporates the following features:

- ***well gasket:*** a gasket which seals the gap between the sliding cover and the fixed covers on the guide pole well. The sliding cover permits a degree of movement for the tank roof
- ***pole sleeve:*** the sleeve is attached to the sliding cover and surrounds the guide pole extending downward into the liquid product, thereby creating a barrier between the well vapour space and the guide pole
- ***pole wiper:*** this is a rubber seal attached to the top of the sliding cover and extending over the annular gap between the guide pole and the sleeve. The wiper not only eliminates losses through the gap, but also reduces the amount of stock clinging to the pole, during times when the tank level is lowered, by wiping the outside of the guide pole, reducing the tank working losses
- ***float & float wiper:*** this combination will reduce the emissions from inside the still well.

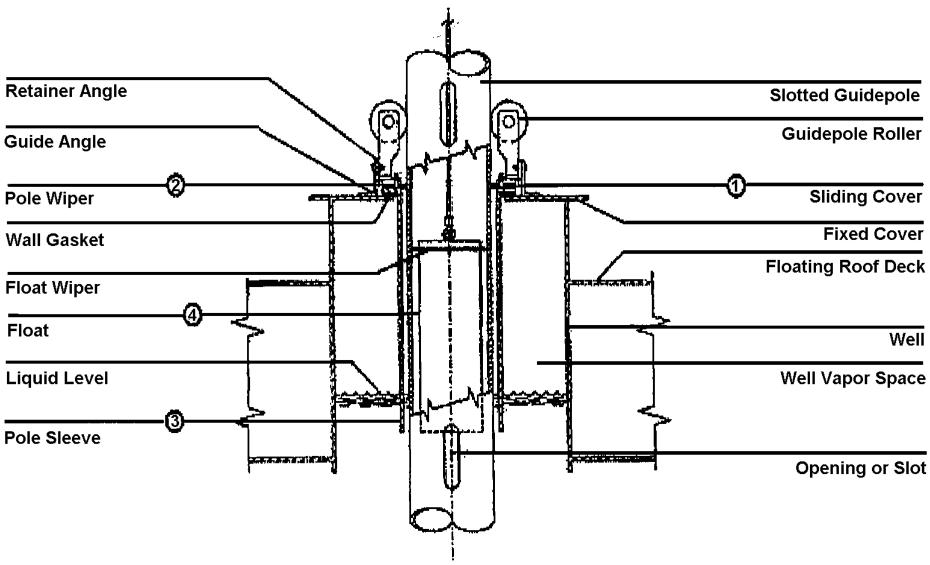


Figure 4.3: CBI design for emission reduction from still wells
[Concawe, 1999, 41]

Other still well controls have developed and these include e.g. UltraCheck Inc. based in Jacksonville, Florida, which is similar to the CBI design consisting of a fabric sleeve on the outside. The Ultra Check design has been installed on many tanks in the USA.

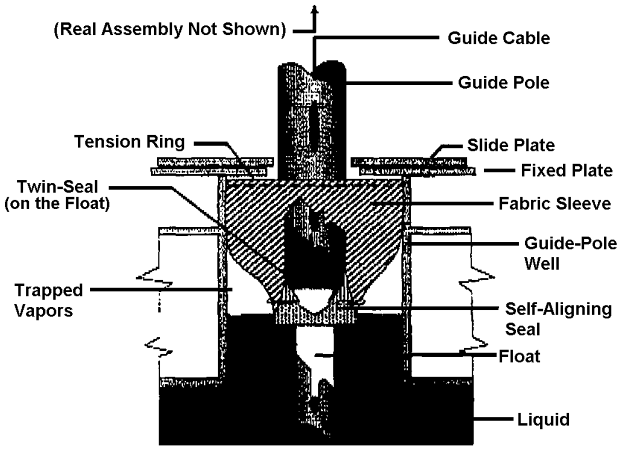


Figure 4.4: Ultra check design for emission reduction from still wells
[Concawe, 1999, 41]

Another example is the Motherwell Nayler Guide pole sleeve; the prototype is being tested in Australia. The design has also been trialled in the UK since January 1997. The cost is relatively low at EUR 2000 - 4000 with little installation cost.

Main achieved emission levels. Losses from uncontrolled still wells can represent as much as 97 % of floating roof tank fitting losses. [Concawe, 1999, 41].

Roof support legs
Although support leg emissions are individually relatively low compared to those from other tank roof fittings, on larger diameter tanks, where there can be more than 100 legs, losses can be more significant (especially where other control measures have been implemented). Bagging of legs can be achieved cheaply using rim seal material. A cheaper alternative, but perhaps only temporary, would be to tape up all the gaps on the legs. These techniques should virtually eliminate this source of emission. Like other control measures, their effectiveness relies on regular inspection, and in the case of support legs, this can usually be carried out visually.

Economics: Investment costs are EUR 6000 for roof legs- and still well- seals, for tanks with a diameter of 50 meters. Operating costs are minor. [Concawe, 1999, 41] (with reference to BP internal data).

The cost of installing a sliding cover with gasket, a float with wiper seal, a pole wiper and a pole sleeve, is site-specific and very much influenced by the actual installation costs. Typically the budgetary costs range between EUR 2000 - 5000 with the total costs likely to be EUR 15000 - 26000. The CBI design can be installed on tanks in service, but this strongly influences the installation costs. [Concawe, 1999, 41].

Where all the measures are installed on a floating roof tank and regular inspection ensures their effective operation, significant financial savings can be realised due to the reduction of emissions. The magnitude of these savings will be site-specific. [Concawe, 1999, 41]

Main achieved emission levels. Table 4.1 shows the effect of the different prevention techniques, which are described in Section 4.1.4.4, concerning the storage of crude oil in an EFRT.

Construction Options	Sliding Cover with Gasket	Pole Wiper	Pole Sleeve	Float with Wiper Seal	Roof Loss factor @ 5 mph	Roof Loss factor @ 15 mph	% Reduction from Industry std @15mph
Industry Std					1600	7300	0
1					20	1300	82
2					96	570	92.2
3					41	200	97
4					41	91	98.7

Table 4.1: Achievable emission reductions concerning the storage of crude in EFRT
[Concawe, 1999, 41]

4.1.4.5 Vapour balancing

Vapours displaced during filling of a storage tank are led back to the tank via a vapour-tight connecting pipe. The pipe for gas balancing is not shut during filling to prevent undue overpressure in the tank. It is designed in such a way so that they can remove displaced vapour/air-volumes without an increase in pressure. [Germany, 1999 #18].

4.1.4.6 Vapour treatment systems

Vapour treatment systems are described in detail in the BREF on common waste water and waste gas treatment and management in the chemical sector,.

4.1.4.7 Tank paint colour

The tank colour influences the amount of solar heat absorbed by all tanks and therefore the temperature of the liquid contents inside. This measure is applicable for all types of above-ground tanks. [Concawe, 1999, 41]. The impact of the tank colour is limited if the tank is already fitted with a floating roof. [TETSP, 2001, 87].

Table 4.2 shows the paint factors used in the above-ground atmospheric storage tank loss equation as given In AP-42.

Paint colour	Paint shade or type	Paint factor good condition	Paint factor poor condition
Aluminium	Specular	0.39	0.49
Aluminium	Diffuse	0.60	0.68
Grey	Light	0.54	0.63
Grey	Medium	0.68	0.74
Red	Primer	0.89	0.91
White	N/A	0.17	0.34

Table 4.2: Paint factors
[Concawe, 1999, 41]

From this table can be concluded that a white painted tank has the lowest emission compared with other paint colours. [Concawe, 1999, 41]

4.1.5 Emissions to soil and groundwater: prevention techniques for tanks

Secondary containment refers to additional protection against storage tank releases over and above the inherent protection provided by the tank container itself. There are three major types of secondary containment, including double tank bottoms, impervious membrane liners and tank farm bund containment. Each of these is described below, with indicative costs. [Concawe, 1999, 41]

4.1.5.1 Double tank bottoms

Installing a second impervious bottom to a tank provides a measure of protection against typically non-catastrophic releases due to corrosion, faulty weld joints, or flaws in the bottom material or the construction details. In addition to containment, the secondary bottom provides a means of allowing detection of a bottom leak. [Concawe, 1999, 41]

Double bottoms ran either be retrofitted on an existing tank or incorporated into the design of a new tank. If retrofitted, the existing tank bottom is normally used as the secondary flooring, and sand, gravel or concrete can be installed between the new primary and secondary floors. It is general practice to keep the interstitial space to a minimum and therefore the secondary bottom should slope the same way as the primary bottom. The slopes to the base of tanks can be either flat, cone-up (sloping from the centre down to the tank perimeter) or cone-down (sloping downward from the tank perimeter). [Concawe, 1999, 41]

Nearly all tank floors are made of carbon steel. If a double bottom is to be installed (either retrofit or new build), there are choices in material selection for the new floor. A second carbon steel floor can be utilised or a more corrosion-resistant stainless steel floor be installed. A third choice is to use a glass fibre-reinforced epoxy coating over the steel. [Concawe, 1999, 41].

Any product leak through a tank bottom can be identified by a leak detection system. Conventional leak detection systems include inspection ports, inventory control and inspection wells. More advanced systems include electronic sensing probes or energy pulse cables whereby product that comes into contact with the probe or cable will alter its impedance and trip an alarm. The use of double bottom tanks, however, allows a vacuum system to be installed. In this more recent and increasingly popular system, the space between the floors is kept under a vacuum that is continuously monitored. Any leak in the primary floor will dissipate the vacuum and trigger an alarm. [Concawe, 1999, 41]

Main achieved emission levels:

Economics:
Typical retrofit costs for these double bottoms, as quoted from German or Swiss suppliers (note that Germany and Switzerland are two of the few countries in Europe where double bottoms are mandatory), are as follows. Note that these costs include a vacuum leak detection system:

• Carbon steel: EUR 145 /sq. m
• Stainless steel: EUR 260 /sq. m
• Glass fibre-reinforced epoxy: EUR 235 /sq. m
[Concawe, 1999, 41]

Applicability:

Cross media effects:

Driving force for implementation:

Reference literature: [Concawe, 1999, 41]

4.1.5.2 Impervious membrane liners

The impervious membrane liner is a continuous leak barrier under the entire bottom circumference of the above-ground storage tank. It can be an alternative to a double bottom or it can be added as an extra measure of safety below the double bottom. Like the double bottom, it is primarily intended to arrest the small but persistent leak rather then address a catastrophic failure of the entire tank. [Concawe, 1999, 41]

The key to an effective liner is that the seams must be liquid-tight against either the steel shell of the tank or the concrete wall that supports and surrounds the tank. The minimum thickness of the flexible membrane is 30 mm (?), although 60 to 80 mm (?) thick sheets are commonly used. The membrane must be chemically resistant to the product stored in the tank. [Concawe, 1999, 41]

Impervious membrane liners are used in lieu of double bottoms in the United States and New Zealand. They can be installed either in a new-build design or as a retrofit and they generally include a leak detection system. [Concawe, 1999, 41]

Main achieved emission levels:

Economics: The cost of retrofitting a liner is slightly higher than installing a double bottom as it involves jacking-up the existing tank to install the membrane and leak detection system, An indicative cost is on the order of EUR 270/sq. m. As new-build construction, an impervious liner may be cheaper than a double bottom, but it may have a higher life cycle cost. This is because any future failures of the liner would require re-lifting the tank or reverting to a new double wall solution. [Concawe, 1999, 41].

Applicability:

Cross-media effects:

References:

Operational data:

Driving force for implementation:

Reference literature: [Concawe, 1999, 41]

4.1.5.3 Tank farm bund containment

Whereas double bottoms or impervious liners protect against the small but persistent leak, an impermeable tank farm bund is designed to contain large spills, such as caused by a shell rupture or a large overspill. [Concawe, 1999, 41]. The purpose of bunding is not only to prevent contamination of land and water courses, but also to:

- prevent the flammable liquid from reaching ignition sources
- prevent the liquid entering the drainage or water systems where it may spread to uncontrolled ignition sources
- allow the controlled recovery or treatment of the spilled material
- minimise the surface area of the liquid and so reduce the size of any fire that may occur
- prevent the spread of burning liquids which could present a hazard to other plant or personnel both on and off site. [HSE, 1998, 37]

The bund consists of a wall or dike around the outside of the tank (or tanks) to contain all or part of the tank contents in the event of a spill, and (ideally) an impermeable ground barrier between the tank and the dike to prevent infiltration of the product into the ground.

The dike is typically constructed of well-compacted earth or reinforced concrete. The height is normally sized to accommodate the maximum contents of the tank within the volume enclosed by the dike. However this philosophy of total capture is flawed if the ground between the tank and dike is permeable. Oil can quickly permeate downward and under the dike in these situations. [Concawe, 1999, 41]

There are a number of ways to seal the ground to prevent downward migration of spilled product. The cheapest is to utilise a low permeability clay that may be naturally present or be imported for the purpose, both natural clay and its synthetic counterpart, bentonite, however are susceptible to shrinking and cracking under dry conditions, and so measures must be taken to ensure the material stays moist, In a dry climate it may therefore be preferable to install an asphalt or concrete surface, although care must be taken to ensure that cracks do not develop over time. Another option is the use of a high density polyethylene liner (HDPE), although the concern here is to ensure the seams are properly bonded during installation. Also, if an HDPE liner is employed, it should be covered with 15 to 30 cm of well-graded sand, gravel or soil to protect against damage by vehicular traffic. [Concawe, 1999, 41]

Main achieved emission levels:

Economics: Representative costs for the various ground barriers are as follows:

- clay: EUR 18 /sq. m
- asphalt: EUR 28 /sq. m
- concrete: EUR 41 /sq. m
- bentonite: EUR 26 /sq. m
- HDPE: EUR 32 /sq. m

[Concawe, 1999, 41]

Applicability:

Cross-media effects: A final note on impervious barriers within tank bunds concerns rainwater runoff. As the ground is now sealed, a drainage system must be installed to handle the impounded rainwater which would otherwise percolate into the soil. Best practice at refineries is to segregate this clean tank farm stormwater from potentially contaminated storrnwater (such as might be generated at pipeline manifold or process areas) in order to minimise the amount of waste water processed through the facility's oily water treatment system.

References:

Operational data:

Driving force for implementation:

Reference literature: [Concawe, 1999, 41]

4.1.6 Emissions to water: prevention techniques for tanks

4.1.6.1 Tank water drainage

Tanks can be drained successfully manually with due care and attention. Care should be taken during draining of tanks, particularly where tanks have bottoms coned to the centre and a fixed draw-off pipe. In this case the draw-off pipe will be full of oil (or other product stored) as the last of the water is removed and subsequent water withdrawals must first displace the product. [Concawe, 1999, 41]

An alternative technology is automation of this process, as this will limit this stock carry-over and can be achieved by the installation of automatic or semi-automatic tank drain valves. [Concawe, 1999, 41]

Water drained from a tank is usually captured in a drainage or sewer system for further treatment of the water. Draining directly to the ground is not acceptable practice. [Concawe, 1999, 41]

The rate of water draw-off can influence emissions. Rapid valve opening and high flowrates may create a vortex which will pull both water and oil into the drain. At many sites tank drain valves are operated manually, with visual inspection of the drained liquid to determine when to stop draining. This should be at a stage where the water contains less than 10 % oil. However, this limit can be exceeded, allowing significant quantities of oil into the effluent system. [Concawe, 1999, 41].

Careful manual draining is still a viable option at many sites that store crude oil. However, it can be an extremely time consuming process. And it is practically impossible to eliminate all trace pollution of the water however well operated. Indirectly, emissions of hydrocarbon will result from the operation of draining water bottoms to air. Tests have shown that 30 % of hydrocarbons entering drainage systems will be lost through evaporation. As such, minimising product last in drained water will result in lower sewer emissions and lower costs to recovery. [Concawe, 1999, 41].

Main achieved emission levels:

Economics:

Applicability:

Cross-media effects:

References:

Operational data:

Driving force for implementation:

Reference literature: [Concawe, 1999, 41]

4.1.6.2 Semi-automatic tank drain valves

Semi-automatic tank draining systems are categorised as such because they need to be reset at the start of each draining operation. Commercial designs are available for products that have a (significantly) different density to water; this density difference is exploited to terminate draining operations. They are not powered and incur minimal installation cost. They present the least expensive alternative to manual draining. [Concawe, 1999, 41].

The designs generally consist of a small chamber with an inlet from the tank drain line and an outlet to the sewer system and a float. When the inlet valve is opened, the chamber fills with the water from the tank bottom causing the float (constructed or a hollow steel float ballasted with oil) to rise. The operator can then leave the operation unattended. Winterisation of these valves will be necessary in some climates. [Concawe, 1999, 41].

When the product starts to enter the chamber, the float will fall into a ring seal, shutting off the valve. [Concawe, 1999, 41].

An alternative methodology is to use a hydrocarbon sensor instead of a float. However, this element requires replacement after every draining and is therefore more suited to tanks that require infrequent draining. [Concawe, 1999, 41].

Main achieved emission levels:

Applicability. Potential problems are:

- cleanliness - the float can become jammed if debris enters the float chamber. This is a serious drawback if the valve sticks open releasing crude oil to the sewer
- premature closure – the valve can shut early if vortexing draws down the oil before draining is finished or if the flow drops. [Concawe, 1999, 41].

Cross-media effects:

References:

Operational data:

Economics: Costs are typically EUR 2000 - 3000.

Driving force for implementation:

Reference literature: [Concawe, 1999, 41]

4.1.6.3 Fully automatic tank drain valves

Fully automatic draining systems are designed to require minimal operator intervention and as such are significantly more expensive than semi-automatic systems. Power source at the tank is also needed. [Concawe, 1999, 41].

There are several different types with different characteristics. Correct selection is therefore crucial. [Concawe, 1999, 41].

Agar Dewatering System: this system uses an electromagnetic radiation probe to measure the hydrocarbon content of the water to be drained. The probe sends microwaves into the fluid and measures how much energy is absorbed by the fluid. Since water absorbs microwaves more strongly, it is possible to quantify the concentration of hydrocarbons. The technology can be used as a portable unit, a single source probe or a double probe, in which one probe is located at the drain outlet point and the other at about 600 mm above the tank floor (or at a prescribed level). Basically, when the upper probe detects water, the drain valve opens; when the lower detects oil the drain valve closes. [Concawe, 1999, 41].

Pautbac Tank Draining System: here the measurement is the dielectric constant - A capacitance probe is mounted in a circulating chamber in the tank drain. When the oil content reaches a pre-set value the valve automatically closes. There are potential problems with detection with rag layers. A well-defined interface is necessary for satisfactory operation. [Concawe, 1999, 41].

MFI Full Water Cut Meters: again uses dielectric properties for detection. Not widely used for draining systems but could be adapted. [Concawe, 1999, 41].

Tank Sentry System - measures refractive index using fibre optics. A new system with most experience in the USA. [Concawe, 1999, 41]

Main achieved emission levels:

Economics:
The costs for each unit of an Agar Dewatering System are about EUR 8000 plus installation costs. A Pautbac Tank Draining System unit costs about EUR 20000. For MFI Full Water Cut Meters (2" valve system), the costs are about EUR 25000. For a Tank Sentry System the costs are in the region of EUR 20000 - 30000. [Concawe, 1999, 41].

Applicability:

Cross-media effects:

References:

Operational data:

Driving force for implementation:

Reference literature: [Concawe, 1999, 41]

4.1.7 Waste: prevention techniques for tanks

4.1.7.1 Tank mixing

Sludge is a loose term for a semi-solid mixture of product, water and solids such as sand, scale and rust particles. Crude sludge can contain all of the above, including wax crystals, in varying quantities. [Concawe, 1999, 41].

Sludge deposition in storage tanks occurs by the mechanisms of molecular diffusion, gravity and chemical reactivity and depends on operating conditions. Sludge deposition is not usually even and does not necessarily build at the same rate. [Concawe, 1999, 41].

The amount of sludge depends on some or all of the following factors:

- temperature
- product type
- standing time
- mixer capacity
- type of tank bottom
- method of receipt (tanker, pipeline) [Concawe, 1999, 41].

Mixing offers the best technology for reducing sludge. Turbulent mixing occurs when fluid particles move past each other at different speeds setting up shear stresses forming eddies. The speed at which this occurs determines the mixing rate.

There are two types of mixers used:

- impeller mixers
- jet mixers.

Impeller mixers are more commonly used. To prevent sludge deposition the mixer position has to be such that a maximum economical flow is applied across the tank bottom. Best operation is to use mixers where the swivel angle can be changed. Multiple mixers are necessary in larger tanks. Where multiple mixers are in use, the recommended separation is between 22.5 and 45º, with all mixers located within a 90º quadrant in order to minimise sludge deposition.

Jet mixers tend to be more efficient and have lower running costs. [Concawe, 1999, 41].

Main achieved emission levels:

Applicability:

Cross-media effects:

References:

Operational data:

Economics. Impeller mixers tend to be cheaper to purchase (15 - 55 kW costs EUR 15000 - 25000) but dearer to operate (up to 4 times tank side entry mixers as these require a minimum power to develop a fluid motion necessary for the mixing process to commence)

For Jet mixers, 50000 Euro per unit are typical.

Where extra cost are incurred from the extra power required for mixing, these can be offset against improved measurement, reduced cleaning, reduced problems with crude feed upsets and less tank corrosion.

Driving force for implementation:

Reference literature: [Concawe, 1999, 41]

4.1.7.2 Tank cleaning

Where sludge depth in tanks becomes unacceptable high and cannot be reduced by mixing technology, tank cleaning will be necessary. A number of methods have been developed which eliminate the need to open the tank and will re-suspend deposits, and thus minimise losses. Chemical additive, centrifuging or oil circulation form the basis for these methods. [Concawe, 1999, 41].

Current practice for the removal of sludge build up in crude oil storage tanks involves the withdrawal from operational service and after the discharging of stored stock, purging the interior of any hazardous atmosphere. The sludge bottom is then removed manually and disposed of in a safe manner (e.g. land-farming, incineration). [Concawe, 1999, 41].

4.1.8 (Major) accidents: prevention techniques for tanks

The storage of (packaged) hazardous substances may create (serious) risks, not only to people working at the storage site, but also to the emergency services, the general public off-site and the environment. The incidents causing the greatest concern have generally resulted from the outbreak of fire. This is not only dangerous for the people working at the site, since a fire may cause the widespread distribution of substances harmful to the environment, either in the smoke plume or in the water used to fight the fire. [HSE, 1998, 35].

4.2 Handling of liquid and liquefied gas

4.3 Storage of gas

4.4 Handling of gas

4.5 Storage of solids

4.5.1 General; Emission Control Measures (ECM)

This section contains a general overview of the various Emission Control Measures concerning the storage of different bulk materials. Table III - 1, in the Annex shows the storage methods applied and the relevant bulk materials. Table IV - 1 shows the same bulk materials in combination with the selected techniques to consider in the determination of BAT (the candidate BAT). In that same table the selected technique is assessed against the following parameters: [UBA, 2001, 17].

- dust reduction potential through use of the candidate BAT
- energy consumption of the candidate BAT
- cross-media effects when employing the candidate BAT
- investment requirement of the candidate BAT
- operating costs of the candidate BAT

In the following sections the selected and assessed techniques are described in more detail, after a description of general approaches to dust minimisation.

4.5.2 General approaches to dust minimisation

There are several approaches to dust reduction: [UBA, 2001, 17]

1. **Pre-primary approaches** start with the production or extraction process and reduce the material's tendency to make dust before it leaves the production plant. Pre-primary approaches are outside the scope of this document and, apart from some examples in Section 4.6.2, are not further described.

2. **Primary approaches** are all the ways of reducing emissions during storage and can be divided into:
   - <u>organisational primary approaches:</u> behaviour of the operators
   - <u>technical primary approaches:</u> techniques which prevent dust formation
   - <u>constructional primary approaches:</u> constructions which prevent dust formation

3. **Secondary approaches** are abatement techniques to limit the distribution of dust.

Table 4.3 gives an overview of approaches and techniques that can reduce dust emissions from storage.

<table>
<tr><th colspan="3">Approaches and techniques to reduce dust emissions</th></tr>
<tr><td rowspan="3">primary</td><td>organisational</td><td>Lay-out and operation of storage places (by planner and operating personnel)
• reduction of transport distances
• maintenance (of prevention/reduction techniques)
• cleaning roads and devices
• reduction of wind attack areas</td></tr>
<tr><td>technical</td><td>• use of wind protection
• covering of heaps
• moistening of the heaps</td></tr>
<tr><td>constructional</td><td>• storage sheds
• storage in bunker and/or silo
• wind protection mound, fence and/or plantings</td></tr>
<tr><td>secondary</td><td colspan="2">• water curtain
• extraction of storage sheds</td></tr>
<tr><td colspan="3">Note: The boundary between primary and secondary approaches is not always clear; e.g. a water curtain limits the spread of dust emissions and is –at the same time – a means of dust binding.</td></tr>
</table>

Table 4.3: Approaches and techniques to reduce dust emission from storage
[UBA, 2001, 17]

4.5.3 Alternatives to heaps in the open air

4.5.3.1 Large-volume silo

Description: A large-volume silo has a flat bottom and a central discharge installation in which the silo content is stacked in horizontal layers. Within the silo there is a spreader, a telescopic pipe and a screw system. The screw system consists of a distribution screw and a dust barrier screw. The screw system is attached to the spreader by wires and guides in order to keep the screw system constantly on the surface of the stored material. [UBA, 2001, 17].

There are different construction types: [UBA, 2001, 17]

- **centre flow:** unloading is from the bottom; the material forms its own centre flow channel by gravity. The surface of the material forms a hopper. In order to bring the material into the centre of the silo, the screws rotate in opposition. The velocity of the screws determines the amount of material conveyed

- **centre flow with centre column:** a centre column supports the silo roof. The function principle is similar to the centre flow principle. It is used for big storage capacities

- **disc column** with which an artificial centre flow column is formed. The centre column consists of several discs. The system is suitable for bulk materials that are not free-flowing and for those with changeable flow characteristics.

By the use of filtering installations in the telescopic pipe and at the transfer points, an under-pressure is generated and dust is prevented from entering the silo.

Main achieved emission levels:

Applicability: Suitable bulk materials are: REA-gypsum, potato starch, limestone, fly ash, fertiliser and (partly) coal. [UBA, 2001, 17].

Cross-media effects:

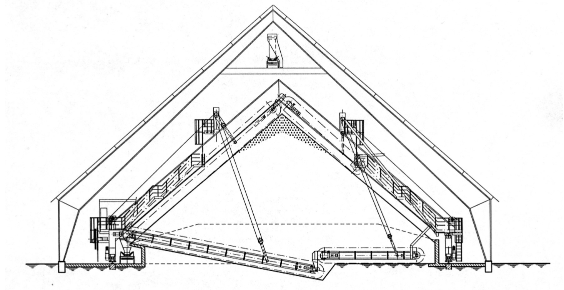
References: Power station Tiefstack (HEW) for hard coal and REA-gypsum, Deuben (MIBRAG), Chemnitz and Lippendorf (VEAG) for REA-gypsum.

Economics: The costs vary from installation to installation. Beside normal cost factors such as investment and maintenance, losses of quality and quantity of the stored materials must be considered.[UBA, 2001, 17].

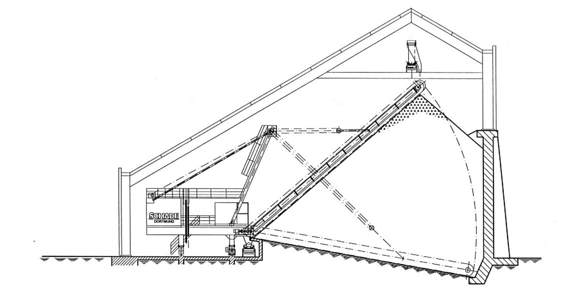
Driving force for implementation: The use of silo systems is suitable in those cases where only small storage areas are available, the quantities to store are limited and the environmental requirements are relatively high. [UBA, 2001, 17].

4.5.3.2 Shed or roof

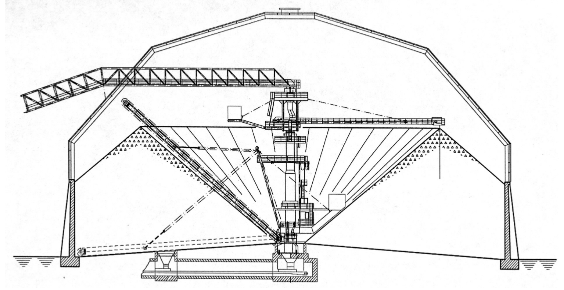
Description: A roof or a shed above a heap can reduce the emissions to air. In fact dust is formed by the same processes that operate on storage in the open air, but it can only exit via the shed openings. Shed openings are doors for mobile loading machines and openings for venting systems. Dust emissions coming from shed openings are relatively low if the ventilation is correctly dimensioned. The dusty air that is extracted by fans can be led through suitable filter systems. The sheds can reach sizes of 70 to 90 m diameter and capacities up to 100000 cubic metres. [UBA, 2001, 17]. The following figure shows some examples:



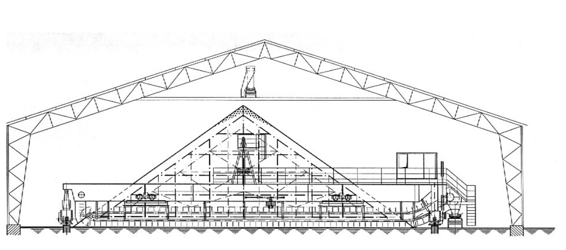
longitudinal store with discharge conveyor and portal scrapers



longitudinal store with discharge conveyor and side scraper



circular store with spreader and rotating scraper



longitudinal store with discharge conveyor and bridge scraper

Figure 4.5: Examples of sheds
[UBA, 2001, 17] with reference to Schade, Maschinenbau GmbH

Another example is the **hangar-type shed with bridge cranes** equipped with buckets. They are sturdy concrete structures, roofed and fitted with ventilation and lighting openings in their high walls. These openings are generally screened against the wind. This type of store is very compact and very versatile, since it can be subdivided into cells of different capacities. These cells can be put to different uses with relative ease. The bridge crane is generally run by an operator, but remote automated control of the crane has become popular very recently. [Salzano, 2000, 89].

The automated depot can reach capacities of up to tens of thousands of tonnes and is suited not only for storage, but also for mixing batches of one material or different materials. These depots are fitted with automatic machines for constructing and reclaiming heaps. The heaps are linear or circular, and are constructed by depositing several layers of material. Reclamation from the front of the heap is carried out by rotary bucket machines; for the side of the heap, scrapers are used. Automated depots typically use rubber conveyor belt for construction and reclamation. The various material transfer points are protected with conventional fabric filters. The roof generally complete and devoid of openings; the side-walls have doors for worker and machinery access. [Salzano, 2000, 89].

Applicability: Sheds are in current use e.g. for the homogenisation and storing of moisture sensitive or very dusty goods. [UBA, 2001, 17]. Depots with bridge cranes are suited to handling very small or large quantities of all types of materials, including clinker and solid fuels. [Salzano, 2000, 89].

Main achieved emission levels:

Cross-media effects: Because of the closed structure, any noise is confined to the interior where, in the case of automated depots, no staff are continuously present. [Salzano, 2000, 89].

References:

Operational data: In the production of hydraulic binders, automated depots and depots with bridge cranes are used for storing clinker and solid fuels. [Salzano, 2000, 89].

Economics:

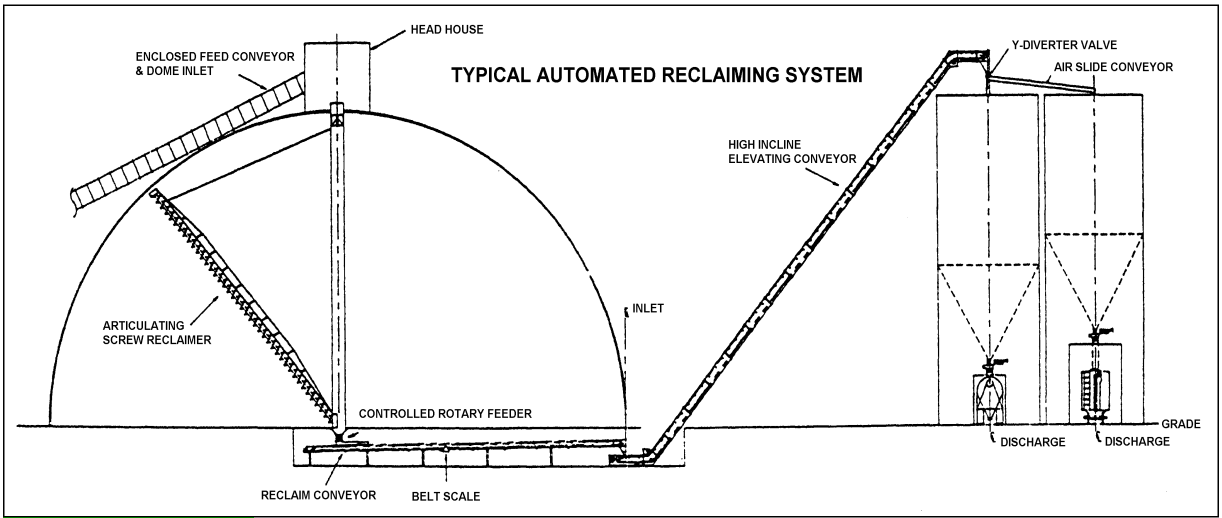
Driving force for implementation:

Reference literature:

4.5.3.3 Domes

Description: Figure 4.6 shows an example of a dome. Special techniques have been developed for dome construction; in most cases a mould (a special inflatable round shape) is used, onto which concrete is sprayed. They can be constructed in a short time and have a reasonable capacity (e.g. 4000 tonnes). [GEM Consultants, 1995, 78].

Advantage of this technique is the absence of pillars and the ability to control the climate. [GEM Consultants, 1995, 78].



what is "belt scale"?

Figure 4.6: Example of a dome
[GEM Consultants, 1995, 78]

Applicability: Domes are used fairly widely and for different types of products such as coal and fertiliser. [GEM Consultants, 1995, 78].

Main achieved emission levels:

Cross-media effects:

References:

Operational data:

Economics:

Driving force for implementation:

Reference literature:

4.5.3.4 Self-erecting covers

Description: The self-erecting cover is an alternative for storage of cereals in the open air and is applied in the US. With this technique the product is stacked from the top under a closed cover (tarpaulin); the heap grows under the cover. To prevent the tarpaulin from inflating, a continuous under-pressure under the tarpaulin is created by using fans (two fans of 40 kW each). The self-erecting cover was developed in order to: [GEM Consultants, 1995, 78].

- prevent product loss by wind action
- minimise the cost of cereal storage
- to achieve good aeration of the cereals.

The cover has to be removed when the reclaiming of the heap is started. It cannot be put back, which means that the whole heap has to be reclaimed in a short time to prevent weather damage to the product.

The lifetime of the cover/tarpaulin is rather short; the supplier gives a 5-year guarantee.

Applicability: This technique has been developed for storing cereals with a maximum capacity of 50000 m^3 and for a long period. To date it has only been used for the storage of cereals, but might be applicable for other products provided that the products have good flow properties and are permeable to air (comparable to cereals).

Main achieved emission levels: There is less product loss than with the storage of cereals in the open air, in which the top layer of the cereal heap has to be treated to prevent it from being blown around, thereby making it unsuitable for consumption.
.

Cross-media effects: Maintaining the underpressure demands the use of energy.

References: Storage of cereals in the US.

Operational data:

Economics:

Driving force for implementation:

Reference literature:

4.5.4 Dust prevention/reduction techniques and measures applied to heaps

Generally the most effective approach to prevent or reduce dust emissions from storage is closed storage in sheds, bunkers or silos, but this is not always possible for economic, technical and/or logistic reasons. This section discusses the many prevention and reduction techniques available for outdoor storage in heaps, starting with Table 4.4: Dust reduction approaches and their limitations. In the Sections 4.5.4.1, 4.5.4.2 and 4.5.4.3 the different techniques for water spraying are described.

Reduction approach	Comment	Relevant heap type
longitudinal axis of the heap parallel with the prevailing wind	possible limitations on implementation: • unfavourable geographic situation (in valleys / river courses) • unfavourable infrastructure (roads and rails cannot be diverted) • ownership (size and shape of the available site)	long-term and short-term storage
protective plantings, windbreak fences (4.5.4.4) or upwind mound to lower the wind velocity	• protective plantings are less effective in winter, because of the leaf fall, at the time when the wind velocities are particularly high	long-term and short-term storage
moistening of the heap surface by a sprinkler system (see Section 4.5.4.1)	possible restrictions: • moisture sensitivity of the material • no water resources • groundwater charges • not useful during stormy weather • not useful during frosty weather • danger of spoiling the goods (loss of quality)	long-term and short-term storage
only one heap instead of several heaps as far as possible	• not appropriate for storing different bulk materials together • shape and size of the site must be considered • suitable heap construction devices are necessary	long-term and short-term storage
if it is erected as a cone heap, the optimal slope angle $\alpha = 55°$	• slope angles are dependent on the properties of the bulk material and are difficult to influence. The optimal slope angle quoted is the ideal. Slope angles achieved in practice are between 20 and 45°.	long-term and short-term storage
if it is erected as a truncated cone, the optimal proportion of the radius of the upper flat part to the side length of the truncated cone is 0.55	• with this proportion an optimal minimisation of the free surface can be reached	long-term and short-term storage

Reduction approach	Comment	Relevant heap type
with regard to the free surface of heaps, a circular cross-sectional area is preferable to ring- or longitudinal heaps open ring-shaped heaps are more unfavourable than closed ring-shaped heaps	• circular heaps require special conveyor (e.g. long reach) • closed ring-shaped heaps can only be used for long-term storage; heaps which are constantly being constructed and reclaimed are always open	long-term storage
storage with retaining walls reduces the free surface, leading to a reduction of diffuse dust emissions. This reduction is maximised if the is placed upwind the heap	• this is useful for small and medium heaps, but not for big heaps • the walls can restrict access to the heap • retaining walls require extra investment	long-term and short-term storage
placing retaining walls close together	• increases the height of the heap	long-term and short-term storage
covering the surface with tarpaulins (4.5.3.4) or solidification of the surface or grassing-over	• only relevant for long-term storage	long-term storage
use of durable dust-binding substances (4.5.4.2)	• the binding substance may damage the goods • normally only relevant for long-term storage	long-term (to short-term) storage
not carrying out construction or reclamation during difficult weather (e.g. long dry periods, frosty periods, high wind velocities)	• considerable potential disruption to operations	short-term storage

Table 4.4: Dust reduction approaches and their limitations
[UBA, 2001, 17]

4.5.4.1 The techniques of water spraying

Description: The moistening of bulk materials by sprinkler irrigation is a practically proven technique to prevent dust formation. [UBA, 2001, 17]. The spraying can be done by using a permanent installation or mobile containers (e.g. tankers). [GEM Consultants, 1995, 78].

Efforts have been made to produce finer drops for binding the fine dust particles. These have involved the development of special nozzles for use with compressed air and the use of additives. [UBA, 2001, 17].

Applicability: Sprinkler irrigation is simple, but application is limited to bulk material that is not sensitive to moisture. Sprinkling is particularly suitable for existing plants where the space for filtering plants is not sufficient and water resources are available. [UBA, 2001, 17]

Main achieved emission levels: When spraying with water only, the estimated effectiveness is 80-98 % [GEM Consultants, 1995, 78].

Cross-media effects: The water consumption is relatively high and the sprinkling can make the material too wet to handle. Sometimes the material needs to be dried later, which can lead to increased energy-consumption. [UBA, 2001, 17].

References: Weser Engineering GmbH.

Operational data:

Economics: Water spraying plants require – depending on the number of transfer points – an investment of DM 10000 to 15000 (reference year 2000, about EUR 5000 to 7500). [UBA, 2001, 17].

Driving force for implementation:

Reference literature:

4.5.4.2 Water in combination with additives

Description: This is a spraying system that uses water in combination with additives. There are several additives on the market, including products that are readily biodegradable (that means that after 20 days, 80 % of the ecologically harmful substance is biodegraded). [UBA, 2001, 17].

The additives can have the following functions: [GEM Consultants, 1995, 78]

- **the moistening function,** which gives the solution or emulsion with which is sprayed the property to penetrate deep into the stored product. The additive can lower the surface tension of the emulsion or solution. An advantage of moistening with use of an additive is that dust emissions are also reduced in the subsequent handling of the product
- **the foaming function.** Dust is formed by the smaller particles in the bulk material. By adding a foaming additive that forms very small bubbles (0.1-50 µm), those small particles will be embedded in the bubbles. The quality of the foam and and the consequent dust emission reduction potential depend on the size of the bubbles and the stability of the foam
- **the binding function** which is a combination of the ability to bind the moisture and an adhesive function. For better moisture binding, he calcium oxide or magnesium oxide is mixed with the additive. Vegetable or mineral oils improve the adhesion between small particles.

Special adhesives are the so-called crust-forming substances. An example is the use of water-based latex polymers on coal heaps in the open air.

Applicability: This system is used on stones, fertilisers, ores, hard and brown coal, bauxite, slags and building wastes, in heap construction, the unloading of wagons and trucks and the loading of ships. It is sometimes integrated in a frontloader, in mobile loading devices or scaper conveyors. [UBA, 2001, 17].

Main achieved emission levels: A lower quantity of water is needed. The dust preventing effect is better compared to the use of only water. [UBA, 2001, 17].

The effectiveness of spraying with water mixed with additives is very dependent on how the technique is operated and the method, frequency and maintenance of the treatment. The effectiveness is estimated at 90-99 % (in comparison with an effectiveness of 80-98% when spraying with only water). [GEM Consultants, 1995, 78].

Disadvantages are that the additives may affect the material quality and additional devices for the mixing of water and the additives are necessary. [UBA, 2001, 17].

Cross-media effects:

References: Port Nordenham, Germany; Hoogovens, Netherlands.

Operational data: The additive used in Port Nordenham is ECS 89 and is used in the constant proportion of 1:3750 [UBA, 2001, 17]. At Hoogovens an emulsion with 3–5 % latex is used on heaps of coals [GEM Consultants, 1995, 78].

Economics: The running costs for Port Nordenham (energy, water and additive) are DEM 0.03 per tonne of sprayed substance (about EUR 0.02). [UBA, 2001, 17].

Driving force for implementation:

Reference literature:

4.5.4.3 Fine water fog

Description: Air with a constant pressure of 2 bar and water with a variable pressure between 0.5 and 1.5 bar are used to generate a fine water fog. The user can select a cone-shaped or a fan-shaped fog. The size of the water drops is between 1 and 50 µm (mostly between 1 and 10 µm), depending on the nozzle size and the water and air pressure. Machines are available with a variety of consumption rates, e.g.: 10 l/h, 25 l/h and 55 l/h. In practice 1 litre is needed per tonne of treated material. [UBA, 2001, 17].

The use of this technique requires a complete capsulation in order to guarantee an optimal dust reduction. If only a lateral capsulation is carried out, the effect is reduced to 50 %. The capsulation has normally sizes of 600 mm height and 2500 mm to 4000 mm length. Per nozzle 0.5 to 1 m^3 capsulated space is calculated. [UBA, 2001, 17].

The technique of spraying with fine water fog prevents the material from getting too wet. No additives and no antifreeze is needed. A disadvantages is that a complete capsulation is needed and a compressor. [UBA, 2001, 17].

Applicability: This technique can be used on heaps, for the loading/unloading of heaps and tip bunkers, the loading of ships with telescopic hoppers and the loading of trucks from silos.

Main achieved emission levels:

Cross-media effects: Water and energy are needed and the compressor generates noise. [UBA, 2001, 17].

References: Power station Mannheim, Braunschweigische coal-mining work AG – power station Offleben, VEAG Brown coal power station Jänschwalde, HKW Pforzheim, Energy supply Nordthüringen – HKW Erfurt, Energy supply Schwaben – Heilbronn.

Operational data:

Economics: In comparison to conventional dust reduction measures, the investment is lower, particularly if water, air and compressed air connections exist. The costs for a nozzle vary between DEM 1500 and 4000 (about EUR 760 – 2000) including controls and pipes, and DEM 800 – 900 (about EUR 400 - 460) not including controls and pipes. The investment cost for all the equipment needed is DEM 20000 (about EUR 10000). [UBA, 2001, 17].

Driving force for implementation:

Reference literature:

4.5.4.4 Wind protection methods

Description: A windshield can be a fence or a net at the boundary of the storage site. The purpose of a windshield is to lower the wind speed and thus lower the dust emissions. The layout of the windshields is very site-specific; research with the use of wind-tunnels can be useful. [GEM Consultants, 1995, 78].

The concept of storage with an embankment is in the Netherlands developed in the eighties in combination with the bridge-and landing type reclaimers. The reclaimer rides on top of the embankment, which makes it possible for the top of the storage heap to stay below the level of the bridge or landing. An important difference between an embankment protecting only the storage heap and one acting as a windshield around the borders of the whole storage site is that with the latter one the handling and transport on the site is also protected.

Applicability: Those techniques can be applied to any quantity of any type of product.

Main achieved emission levels: Research in Japan on the effect of nets as a windshield for the storage of coal has shown a 50 % reduction in wind velocity. The same reduction is achieved with an embankment of a rectangular heap in combination with a bridge reclaimer. [GEM Consultants, 1995, 78].

The embankment of storage heaps (without using a bridge reclaimer) has an estimated nett efficiency of 20-40 %. This is a nett figure because, although the erosion of the heaps is reduced by more than 50 %, the emissions from handling and transportation (with belt conveyors) increases in comparison with storage without a reduction technique. [GEM Consultants, 1995, 78].

Cross-media effects: There is a risk that birds get trapped in the nets. [GEM Consultants, 1995, 78].

Operational data: The embankment technique is used on a terminal for imported coals (17 different qualities) with a capacity of 8 million tonnes per year. They coals were imported by sea in ships with capacities of 40000 to 150000 tonnes. In the terminal the coals were readed into wagons and/or other ships. [GEM Consultants, 1995, 78].

Economics:

Driving force for implementation: This system was developed to achieve: [GEM Consultants, 1995, 78].

- a reduction of dust emission
- a reduction of operational cost by automating the process
- a reduction of losses due to heating
- optimised facility to mix the different qualities of coal.

Reference literature:

4.5.4.5 Tarpaulins or nets

Description: Tarpaulins or fine-mesh nets are used for: [GEM Consultants, 1995, 78]

- reducing dust emission
- reducing the nuisance caused by birds
- (for taurpaulins) protecting the material from getting wet.

The disadvantages of the use of nets or tarpaulins are:

- there is no reduction of dust emission during stacking or reclaiming
- the installation and removal are very labour-intensive
- their lifetime is very short.

Applicability: They are used for long-term storage of very easily dispersed substances, where e.g. moistening is not enough to prevent dust emissions. This technique is not often used.

Main achieved emission levels:

Cross-media effects:

References:

Operational data:

Economics:

Driving force for implementation:

Reference literature:

4.5.5 Vessels

Description

Applicability:

Main achieved emission levels:

Cross-media effects:

References:

Operational data:

Economics:

Driving force for implementation:

Reference literature:

4.5.6 Silos and bunkers

Description filtersystems

Applicability:

Main achieved emission levels:

Cross-media effects:

References:

Operational data:

Economics:

Driving force for implementation:

Reference literature:

4.6 Handling of solid

4.6.1 General; Emission Control Measures (ECM)

This section contains a general overview of the various Emission Control Measures for the handling of different bulk materials. Table III - 2, in the Annex shows the applied handling techniques and the relevant bulk materials. Table IV - 2 shows the same bulk materials in combination with the selected techniques to consider in the determination of BAT (the candidate BAT). In that same table the selected technique is assessed against the following parameters: [UBA, 2001, 17]

- dust reduction potential through use of the candidate BAT
- energy consumption of the candidate BAT
- cross-media effects when employing the candidate BAT
- investment requirement of the candidate BAT
- operating costs of the candidate BAT.

In the following sections the selected and assessed techniques are described in more detail, after a description of the general approaches to dust minimisation.

4.6.2 General approaches to dust minimisation

There are several approaches to dust minimisation: [UBA, 2001, 17]

1. **Pre-primary approaches** start with the production or extraction process and reduce the material's tendency to make dust before it leaves the production plant. Pre-primary approaches are outside the scope of this document and, apart from the following examples, are not further described:

   - Production of iron ore pellets
     Fine ores with particle sizes of 100 µm and smaller are formed (with additives) into small balls and are hardened by fire. Fine ore pellets have a high iron content and thus a high specific weight. They show an imperceptible tendency to make dust.

   - Production of fertilisers
     Some fertiliser products are called 'dust free'. These products consist of pellets which are produced with the explicit objective of minimising the tendency of the bulk material to make dust during loading and unloading processes.

   - Extraction of limestone
     By spraying the limestone with water and additives, a durable binding of dust particles with the limestone can be reached. The spraying is done in the limestone quarry itself in order to reduce dust formation during the local operations of crushing, classification, conveying and filling.

   - Extraction of mineral salts for industrial applications
     Mined mineral salts are processed by crushing and grinding directly in the quarry. 'Sticked powder' (= finest salt particles with sizes < 0.2 mm) is separated by passing through a sieve or by air classification. The result is a product that doesn't form dust during loading and processing.

   The application of pre-primary means has its limitations when it influences the properties of the products that are required by the buyer. E.g. there are processes to reduce the dust tendency of grains by a treatment with rape oil or chemical preservatives (e.g. with urea and propionic acid). But the treatment reduces considerably the marketing and application options, because flour from grains which is treated with rape oil can no longer be used for baking.

2. **Primary approaches** are all the ways of reducing emissions during storage and can be divided into:

    - organisational primary means: behaviour of the operators
    - technical primary means: techniques which prevent dust formation

3. **Secondary approaches** are abatement techniques to limit the distribution of dust

Table 4.5 gives an overview of approaches and techniques to reduce dust emissions from loading and unloading.

Approaches and techniques to reduce dust emission		
primary	**organisational**	Measures (for the crane operator) when using a grab: • reduction of the drop height when the material is discharged • total closing of the grab/jaws after material pick-up • leaving the grab in the hoppers for a sufficient time after the material discharge • stopping of grab operations when the wind is strong Measures (for the operator) when using a belt conveyor: • suitable conveyor speed • avoiding loading the belt up to its edges Lay-out and operation of storage sites (by the planner and the operating personnel) • reduction of transport distances • maintenance • cleaning of roads and equipment • reduction of wind attack areas
	technical	• use of wind protection (e.g. if the conveyor belts are open) • use of closed conveyors (e.g. tube belt conveyors, screw conveyors) • use of dump pits with loading heads • continuous and enclosed conveyor systems (bucket elevators, screw conveyors, pneumatic systems) • transfer points completely housed (e.g.on belt conveyors) • intensive belt cleaning by wiping or brushing to avoid trickling material • use of coated carrying straps for conveyor belts • use of hoppers • minimisation of free fall heights (e.g. cascade hoppers) • use of dust barriers on dump pits and hoppers
secondary	• belt conveyor transfer points with spraying devices • water curtain • suction and dedusting units at transfer points	
Note: The boundary between primary and secondary approaches is not always clear; e.g. a water curtain limits the spread of dust emission and is – at the same time – a method of dust binding		

Table 4.5: Approaches and techniques to reduce dust emissions from loading and unloading [UBA, 2001, 17]

4.6.3 Secondary approaches

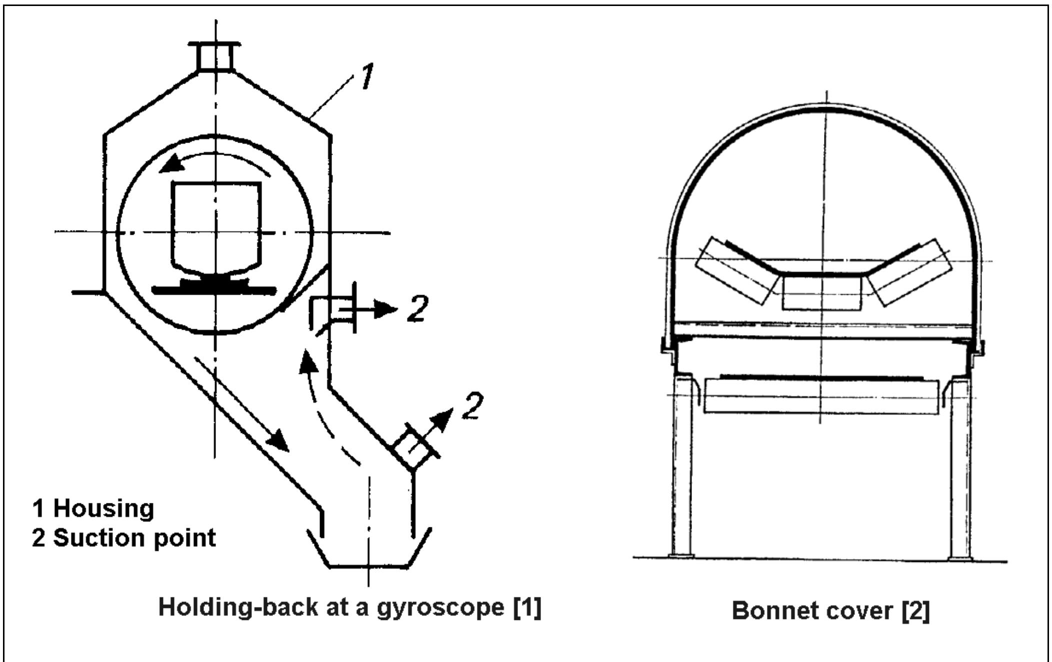
Besides handling techniques which generate less dust – the primary means – there are secondary approaches to reducing emissions, such as: [UBA, 2001, 17]

- housing of the dust source, possibly combined with a suction system
- use of dust separators
- use of sprinkling plants.

4.6.3.1 Housing of the emission source

Description: Transfer points, hoppers, bucket elevators and other potential dust sources are housed in order to prevent dust spreading and/or to protect the material against the weather. Housing is normally a pre-condition for air suction. There are two types of housings: a closed type and a half-open type, where the emission source is open at one side. The type of housing and its quality determine the success of the dust limitation and influence the effectiveness of the dedusting units used. [UBA, 2001, 17].

Besides the housing of specific points such as transfer points, it is also possible to cover – completely or partly – the whole conveyor path. The covers are made of sheet metal or plastic. [UBA, 2001, 17].



holding-back?

Figure 4.7: Construction types of housings
[UBA, 2001, 17] with reference to VDI 3929 and VDI 3606 (draft)

Applicability: Sometimes covers are not used because the mass flow cannot be observed. The design should take into consideration aspects such as fall height, belt width and belt velocity. [UBA, 2001, 17].

Main achieved emission levels:

Cross-media effects:

References:

Operational data:

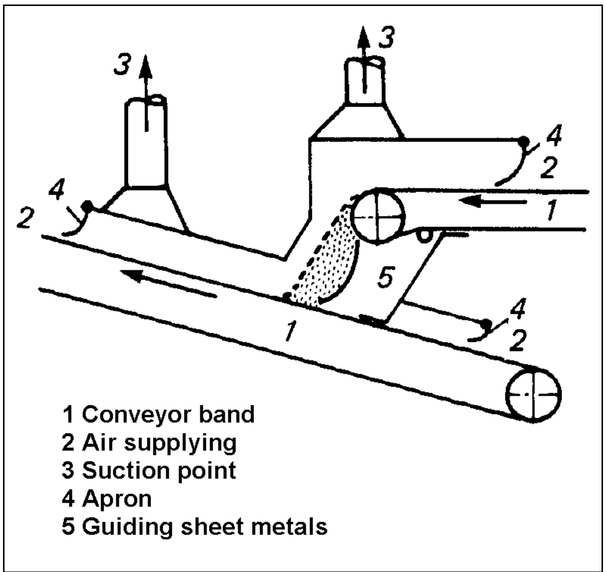
Economics:

Driving force for implementation:

Reference literature:

4.6.3.2 Extraction systems

Description: The use of extraction systems is common practice, whether as a central dedusting plant or several single dedusting units. In any case it is important to adjust the extraction system in such a way that no material is drawn into the air-stream; so, the extractors should be installed in the vicinity of the dust source, but not directly at it. Suction velocities of 1 to 2 m/s are normally adequate. If the dust/air stream contains too many particles, a centrifugal force separator can be installed. [UBA, 2001, 17]



2. Air supply?; 5. guiding sheet metals ??

Figure 4.8: Housing and extraction at a band transfer point [UBA, 2001, 17] with reference to VDI 3929

Normally filtering separators such as textile filters are used for the separation of the dust from the air-stream; they have the following advantages: [UBA, 2001, 17]

- broad application spectrum
- high separating performance
- high availability
- long filter element life
- simple construction
- not expensive with regard to investment and operating costs.

Different types of filter elements are offered, such as tube, pocket and cartridge filters. Different types of cleaning processes are: cleaning by mechanical shaking, blast cleaning and jet stream cleaning. [UBA, 2001, 17].

Applicability: Single units are often used when the distances between the dust sources are too great or when the dust consists of abrasive or explosive material. [UBA, 2001, 17].

Main achieved emission levels:

Cross-media effects:

References:

Operational data:

Economics: A central dedusting plant is in general less expensive than several single dedusting units with regard to the investment and the operating and maintenance costs. The investment costs for a central dedusting plant vary between DEM 60000 and 400000, reference year 2000 (about EUR 30000 - 200000). [UBA, 2001, 17].

Driving force for implementation:

Reference literature:

4.6.3.3 The technique of water spraying

See Sections 4.5.4.1, 4.5.4.2 and 4.5.4.3.

Description:

Applicability:

Main achieved emission levels:

Cross-media effects:

References:

Operational data:

Economics:

Driving force for implementation:

Reference literature:

5 BEST AVAILABLE TECHNIQUES

See Annex V. Gaseous & liquid emission control measure assessment matrix for an example of an emission control measure assessment matrix.

6 EMERGING TECHNIQUES

6.1 Storage of liquid and liquefied gas

6.2 Handling of liquid and liquefied gas

6.3 Storage of solids

6.4 Handling of solids

6.4.1 Screw conveyor

Description: The screw conveyor considered here is a continuous ship unloader with a screw pick-up device and a conveyor shaft. The unloading is done horizontally or by slewing the beam. The discharge is carried out layer by layer. The material is picked up by a digging screw, conveyed through a pipe screw and delivered at the top to the conveyor shaft. The screw has a length of 4 m, so the need for intermediate storage is negligible. The digging heads stick into the material, so dust emissions are prevented.

The conveyor shaft consists of four conveyor belts (gate belt, cover belt and two lateral top belts) which form a closed shaft. The gate belt and cover belt are separately driven at the same velocity (1 m/s). The gates are made of metal, but high-molecular plastics are also possible. The bulk material slides over the sloping gates on the boom belt. The transfer points are fitted with air extractors or have rubber lips in order to minimise dust emissions.

In order to trim the remaining material, additional equipment can be fixed to the screw pick-up or a grab can be used.

The maximum throughput capacity is 1000 - 1200 tonnes per hour, but capacities of 2000 tonnes per hour can probably be achieved in future. The minimum throughput capacity is 300 tonnes per hour.

Advantages:

- not noisy, not dusty, low weight
- relatively low specific energy consumption (use of gate belt conveyor as vertical conveyor)
- compact construction by combination of screw conveyor and gate belt
- simple gravity unloading
- no intermediate storage needed
- can also be used for the loading of ships.

Disadvantages:

- so far used only as a prototype in the port of Nürnberg
- additional equipment needed for trimming remaining material
- suitable only for ships with wide hatches

Applicability: This technique is especially suitable to unload river ships that transport coal to a power station with a port connection. The following options are available for existing plants:

- to replace a grab unloader by a screw conveyor so a higher unloading capacity can be achieved without increasing the load on the quay
- to expand an existing transhipment plant by a screw conveyor; the ship unloading goes faster and dust emissions are reduced.

Suitable bulk materials consist of dry and fine particles, especially coal, but also grain and fertilisers.

Reference plant: Until now this technique has been used (and with success) only in the port of Nürnberg to unload coal.

Economics: The investment depends on the ship size, the water height, the lifting height of the device and the dimensions of the quay.

The operating costs can be estimated at 2 to 3 %, but have to be specified for the individual case.

Cross-media effect: The energy consumption for the vertical conveyance only is 0.0088 kWh per tonne at a given lifting height of 1 metre. For all the driven equipment, the energy consumption for coal is estimated at 0.02 kWh per tonne over 1 metre, 0.037 kWh per tonne over 1 metre for zinc ore concentrate and 0.047 kWh per tonne over 1 metre for lead ore concentrate.

Reference literature: [UBA, 2001, 17].

6.4.2 Low-dust dock transhipment containers without negative pressure extraction

Description: The intake opening of the transhipment container is fitted with laminas. As the loaded grab enters the opening, the air thereby displaced is recirculated to the emptied grab. Hence negative pressure is automatically generated in the container by the bulk material as it is offloaded into a truck. The underpressure prevents dust escaping through any gaps in the seal between the grab and the intake opening. The material can thus be transferred from the grab to the container without the release of dust and without any additional energy input.

It is intended to fit the transhipment container with a height adjustable discharge pipe, so that the dump height is continually adjusted to the changing height of the material pile on the truck loading bed. The discharge pipe will be double walled, so that displaced air – particularly when filling tankers – can be returned to a recirculation pipe. The displaced air is hence channelled back to the transhipment container. Due to the properties of the material (in this case fertilisers), all parts in direct contact with the material are made of stainless steel.

The low-emission transhipment containers (e.g. hoppers) that are currently on the market are very expensive. They are equipped with air extraction and filter systems and have a high energy consumption. There is an unmet need for technologically appropriate transhipment containers within the price range of small and medium-sized enterprises that operate with low/no energy requirements and have a minimum dust emission. For this reason the dock transhipment container (bulk carrier) described above is being developed for fertilisers, designed to minimise diffuse emissions without any additional energy input. The development is sponsored by the Bundesstiftung Umwelt (National Environment Foundation).

Advantages: It is anticipated that diffuse emissions will be minimised by optimisation of the best currently available technologies (transhipment containers with high side panels, negative pressure extraction and dust traps). The key advantage would lie in a 100 % reduction in the energy requirement compared to currently available techniques.

Investment and operating costs are projected below those of available handling hoppers (with comparable dust reduction capability), as no dust precipitator is required and no additional energy costs have to be considered.

Applicability: This system is being developed initially for handling fertilisers in medium-sized enterprises. Applications are anticipated for this technology in handling other free-flowing bulk materials.

Reference literature: [UBA, 2001, 17].

6.4.3 Screw conveyor for non-ferrous ores and concentrates

Description: Copper ores and concentrates and other non-ferrous ores and concentrates, especially lead and zinc, are at present handled with grabs. Due to their properties (toxic constituents such as cadmium), the handling process needs to be further optimised by the development of improved pick-up devices.

Investigations have indicated that enclosed, continuous (on/off) loaders such as screw conveyors represent one possible solution. Trial runs with zinc and lead concentrates have already been carried out with a combined screw pick-up conveyor and vertical belt conveyor shaft.

The tendency of the concentrates to cake is problematic. This can result in deposition and ultimately blockages in the screw conveyor. More research is therefore required to identify a more suitable structural or coating material for the screw.

Reference literature: [UBA, 2001, 17].

ANNEXES

Annex I. International Codes

STORAGE of LIQUID PRODUCTS

OVERVIEW of INTERNATIONAL CODES, STANDARDS & GUIDELINES

By Main Storage Mode (updated January 2001)

No.	Item
	Introduction
	- Codes, Standards & Guidelines (and Countries) considered
	- Storage Modes considered
	- Applicability
	- Questions
1	Aboveground Storage
2	Underground Storage
3	Pressurized Storage
4	Refrigerated Storage
5	ISO Containers or IBC’s
6	Caverns for LPG Pressurized Storage or Mineral Oil
7	Example for Chemical Distribution – Storage of Packed product

INTRODUCTION

This overview has been updated (as an input document) for the BREF-IPPC support group / Technical European Tank Storage Platform (TETSP).

Codes, Standards & Guidelines (and Countries) considered

The overview is limited to codes/standards/guidelines published in the following countries:
- United States of America
- Germany
- United Kingdom
- France
- The Netherlands.

Please note that some of the codes and standards have been listed under a specific country since that country adopts them in this form; other countries may have used this code and used an unique number.

In alphabetical order, the following codes, standards and guidelines, amongst others, have been included: ABS, AFNOR, AMCA, AMD, ANSI, API, ARI, AS, ASME, ASTM, AWMA, AWS, BS, CAS, CEN, CGA, CODAP, CODRES, CPR, DIN, EEMUA, EIA, EMC, EN, ENV, FED, GPA, IEC, IEEE, IP, ISO, NACE, NFPA, PD, PEI, UL.

Please note that this is an overview that might not contain all available references yet. All readers are encouraged to list additional (Inter)National Codes/Standards/Guidelines, which can then be incorporated in this reference list.

Storage modes considered

Six storage modes for bulk liquids (and one example for storage of packed product) have been considered:
1. Aboveground storage tanks
2. Underground storage tanks
3. Pressurised storage
4. Refrigerated Storage
5. ISO Containers or IBC's
6. Caverns for LPG pressurised storage or mineral oil.
7. A typical example has been included for: Chemical distribution: Storage buildings for packaged storage (UK based).

Applicability

The attached preliminary overview comprises a listing of codes/standards/guidelines with respect to:
- Design,
- Construction,
- Inspection and Maintenance,
- And, where possible, Environmental prevention techniques of various storage modes for liquid products.

Several listed codes/standards/guidelines are applicable for the same storage mode and for other storage modes as well. No qualification is made on the suitability and/or applicability.

1. ABOVEGROUND STORAGE

1.0 General

CEN/TC 265, 2000 (draft version only available)
Specification for the design and manufacture of site built, vertical, cylindrical, flat bottomed, above ground, welded, metallic tanks for the storage of liquids at ambient temperature and above, Part 1: Steel Tanks

The following normative references were quoted in the latest CEN/TC 265 document:

EN 287-1
Approved testing of welders for fusion testing
Part 1: Steels

EN 288-1
Specification and approval of welding procedures for metallic materials
Part 1: General rules for fusion welding

EN 288-2
Specification and approval of welding procedures for metallic materials
Part 2: Welding procedure specification for arc welding

EN 288-3
Specification and approval of welding procedures for metallic materials
Part 3: Welding procedure tests for the arc welding of steels

EN 444
Non-destructive testing.
General principles for radiographic examination of metallic material by X-ray and Gamma-rays

EN 462-1
Image quality indicators (wire type)
Determination of image quality value

EN 462-2
Image quality indicators (step/hole type)
Determination of image quality value

EN 473
General priciples for the qualification and certification of NDT personnel

EN 571-1
Non-destructive testing, Penetrant testing
Part 1: General principles

EN 970
Non-destructive examination of fusion welds, visual inspection

EN 1092-1
Flanges and their joints
Circular flanges for pipes, valves, fittings and accessories, PN designed
Part 1: Steel flanges

EN 1290
Nondestructive examination of welds
Magnetic particle testing of welds

EN 1418
Welding personnel
Approval testing of welding operators for fusion welding and resistance weld setters for fully mechanized and automatic welding of metallic materials.

EN 1435
Non-destructive examination of welds
Radiographic examination of welded joints

EN 1714
Non-destructive examination of welds
Ultrasonic examination of welded joints

prEN 1759-1
Flanges
Part 1: Class designated circular steel flanges NPT ½” to 24”

EN 10025
Hot rolled products of non-alloy structural steels
Technical delivery conditions

EN 10028-2
Flat products made of steels for pressure purposes
Part 2: Non-alloy and alloy-steels with specified elevated temperature properties

EN 10028-3
Flat products made of steels for pressure purposes
Part 3: weldable grain steels, normalized

EN 10029
Hot rolled steel plates 3mm thick or above
Tolerances on dimensions, shape and mass

EN 10045-1
Metallic Materials, Charpy impact test
Part 1: Test method

EN 10088-1
Stainless steels
Part 1: List of stainless steels

EN 10088-2
Stainless steels
Part 2: Technical delivery conditions for steel sheet/plate and strip for general purposes

EN 10088-3
Stainless Steels
Part 3: Technical delivery conditions for semi-finished products, bars, rods and sections for general purposes

EN 10113-2
Hot rolled products in weldable fine grain structural steels
Part 2: Delivery conditions for normalized/normalized rolled steels

EN-10113-3
Hot rolled products in weldable fine grain structural steels
Part 3: Delivery conditions for thermomechanical rolled steels

EN 10204
Metallic products
Types of inspection documents

EN 10210-1
Hot finished structural hollow sections of non-alloy and fine grain structural steels
Part 1: Technical delivery conditions

prEN 10216-1
Seamless steel tubes for pressure purposes, Technical delivery conditions
Part 1: Non-alloy steel tubes with specified room temperature properties

prEN 10216-5
Seamless steel tubes for pressure purposes, Technical delivery conditions
Part 5: Stainless steel tubes

prEN 10217-1
Welded steel tubes for pressure purposes, Technical delivery conditions
Part 1: Non-alloy steel tubes with specified room temperature properties

prEN 10217-7
Seamless steel tubes for pressure purposes, Technical delivery conditions
Part 7: Stainless steel tubes

prEN 12874
Flame arrestors
Specification requirements and test procedures

EN 26520
Classifications of imperfections in metallic fusion welds, with explanations

ENV 1991-2-1
Eurocode 1: Basis of design and actions on structures
Part 2-1: Actions on structures- Densities, self-weight and imposed loads

ENV 1991-2-3
Eurocode 1: Basis of design and actions on structures
Part 2-3: Actions on structures- Snow loads

ENV 1993-1-1
Eurocode 3: Design of steel structures
Part 1-1: General rules and rules for buildings

prEN ISO 14122
Safety of machinery
Permanent means of access to machines and industrial plants

EN 485
Aluminium and aluminium alloys
Sheet, strip and plate

EN 754
Aluminium and aluminium alloys
Cold drawn rod/bar and tube

EN 755
Aluminium and aluminium alloys
Extruded rod/bar, tube and profiles

1.1 United States of America

API 048 (RS) l-DEC-1989
The Net Social Cost of Mandating Out-of-Service Inspections of
Aboveground Storage Tanks in the Petroleum industry

API 065 (RS) 1-SEP-1992
Estimated Costs and Benefits of Retrofitting Aboveground Petroleum
Industry Storage Tanks with Release Prevention Barriers

ANSI/API 12B l-FEB-1995
Specification for Bolted Tanks for Storage of Production Liquids

ANSI/API 12D 1-NOV-1994
Specification for Field Welded Tanks for Storage of Production Liquids

ANSI/API 12F 1-NOV-1994
Specification for Shop Welded Tanks for Storage of Production Liquids

ANSI/API 2610 1-JUL-1994
Design, Construction, Operation, Maintenance, and Installation of Terminal and Tank Facilities

API 1629 10-OCT-1993
Guide for Assessing and Remediating Petroleum Hydrocarbons in Soils

API 2000 l-APR-1998
Venting Atmospheric and Low-Pressure Storage Tanks: Nonrefrigerated
and Refrigerated

API 2015 l-MAY-1994
Safe Entry and Cleaning of Petroleum Storage Tanks, Planning and
Managing Tank Entry From Decommissioning Through Recommissioning

API 2021A 1-JUN-1998
Interim Study Prevention and Suppression of Fires in Large Aboveground
Atmospheric Storage Tanks

API 2202 1991
Dismantling and Disposing of Steel from Aboveground Leaded Gasoline
Storage Tanks

API 2350 1996
Overfill Protection for Petroleum Storage Tanks

API 2517 1989 (WITHDRAWN ITEM)
Evaporation Loss from External Floating-Roof Tanks – Includes 1994 Addenda

API 2517D 1-MAR-1993
Documentation File for API Publication 2517, Evaporation Loss from External Floating-Roof Tanks

API 2518 1-OCT-1991 (WITHDRAWN ITEM)
Evaporative Loss from Fixed Roof Tanks

API 2519 1-JUN-1983 (WITHDRAWN ITEM)
Evaporation Loss from Internal Floating-Roof Tanks

API 2519D 1-MAR-1993
Documentation File for API Publication 2597, Evaporation Loss from Internal Floating-Roof Tanks

API 301 1991
Aboveground Tank Survey: 1989, 1991

API 306 1991
An Engineering Assessment of Volumetric Methods of Leak Detection in Aboveground Storage Tanks

API 307 1991
An Engineering Assessment of Acoustic Methods of Leak Detection in Aboveground Storage Tanks

API 322 1994
An Engineering Evaluation of Acoustic Methods of Leak Detection in Aboveground Storage Tanks

API 323 1994
An Engineering Evaluation of Volumetric Methods of Leak Detection in Aboveground Storage Tanks

API 325 l-MAY-1994
An Evaluation of a Methodology for the Detection of Leaks in Aboveground Storage Tanks

API 327 1-SEP-1994
Aboveground Storage Tank Standards: A Tutorial

API 334 1-SEP-1995
A Guide to Leak Detection for Aboveground Storage Tanks

API 340 1-OCT-1 997
Liquid Release Prevention and Detection Measures for Aboveground Storage Facilities

API 341 l-FEB-1998
A Survey of Diked-Area Liner Use at Aboveground Storage Tank Facilities

API 351 l-APR-1999
Overview of Soil Permeability Test Methods

API 579 2000
Recommended Practice for Fitness-for-Service

API 620 l-FEB-1996
Design and Construction of Large, Welded, Low-Pressure Storage Tanks, Ninth Edition

API 650 1-NOV-1998
Welded Steel Tanks for Oil Storage

ANSI/API 651 1-DEC-1 997
Cathodic Protection of Aboveground Petroleum Storage Tanks

ANSI/API 652 l -DEC-1997
Lining of Aboveground Petroleum Storage Tank Bottoms

API 653 1-DEC-1995
Tank Inspection, Repair, Alteration, and Reconstruction

API 910 1-NOV-1997
Digest of State Boiler, Pressure Vessel, Piping, and Aboveground Petroleum Storage Tank Rules and Regulations

API MPMS Chapter 19.2 1-APR-1997
Evaporative Loss Measurement: Documentation File for API Manual of Petroleum Measurement Standards Chapter 19.2 – Evaporative Loss from Floating Roof Tanks

API MPMS Chapter 19.3C 1-JUL-1998
Evaporative Loss Measurement - Part C: Weight Loss Test Method for the Measurement of Rim-Seal Loss Factors for Internal Floating-Roof Tanks

API MPMS Chapter 7.4 1993
Static Temperature Determination Using Fixed Automatic Tank Thermometers

API RP 575 1-NOV-1995
Inspection of Low-Pressure Storage Tanks

API RP 2000-1952 31-DEC-1969 (WITHDRAWN ITEM)
Guide for Tank Venting and Recommended Procedure for Testing Venting Devices for Low-Pressure Aboveground Storage Tanks for Petroleum and Petroleum Products

AWMA 91.15.5 1-JUN-1991
Detection of Leaks in the Floor of Aboveground Storage Tanks by Means of a Passive Acoustic Sensing System

ANSI/AWWA Dl10-95 1995
Wire-wound Circular Prestressed Concrete Water Tanks (includes addendum Dl10a-96)

NACE 37928 1991 (WITHDRAWN ITEM)
Aboveground Storage Tanks: A State-of-the-Art Review, Volume l--

NACE (none) 1992 (WITHDRAWN ITEM)
Aboveground Storage Tanks: Current Issues-Design, Operations, Maintenance, Inspection and the Environment, Volume II

UL 142 1992
Steel Aboveground Storage Tanks for Flammable and Combustible Liquids

NFPA 30A
Code for Motor Fuel Dispensing Facilities and Repair Garages, 2000 Edition

NFPA 22
Standard for Water Tanks for Private Fire Protection, 1998 Edition

NFPA 395
Standard for the Storage of Flammable and Combustible Liquids at Farms and Isolated Sites, 1993 Edition

1.2 Germany

DIN 4119-1 1-JUN-1979
Above-Ground Cylindrical Flat-Bottomed Tank Installations of Metallic Material – Fundamentals, Design, Tests
Standard

DIN 4119-2 1-FEB-1980
Above-Ground Cylindrical Flat-Bottom Tank Installations of Metallic Material – Calculation

DIN 6600 1-SEP-1989
Steel Tanks for the Storage of Flammable and Non-Flammable Water Polluting Liquids; Concepts and Inspection

1.3 United Kingdom

BS 2654 1989
Specification for Manufacture of Vertical Steel Welded Non-Refrigerated Storage Tanks with Butt-Welded Shells for the Petroleum Industry

BS 2654 Amendment 1 1997
Amendment 1 - Specification for Manufacture of Vertical Steel Welded Non-Refrigerated Storage Tanks with Butt-Welded Shells for the Petroleum Industry

BS 8007 1987
Code of practice for design of concrete structures for retaining aqueous liquids

EEMUA 154
Guidance to Owners on Demolition of Vertical Cylindrical Steel Storage Tanks

EEMUA 159 1994
Users' Guide to the Maintenance and Inspection of Above-ground Vertical Cylindrical Steel Storage Tanks

EEMUA 180 1996
Guide for Designers and Users on Frangible Roof Joints for Fixed Roof Storage Tanks

EEMUA 183 1999
Guide for the Prevention of Bottom Leakage from Vertical, Cylindrical, Steel Storage Tanks

EMC 1980
European model code of safe practice in the storage and handling of petroleum products, part II, design, lay-out and construction

IP 33 /59 Flashpoints by the Abel Apparatus - Petroleum(Consolidation) Act 1928 Method Obsolete Last edition printed: 49th, 1990

IP 34 /99 Determination of Flash point - Pensky-Martens closed cup method IP-ASTM Joint Method ASTM D 93-97

IP 35 /63 (86) Determination of open flash and fire point - Pensky-Martens method Equivalent Standards: BS 2000: Part 35: 1993

IP 36 /84 (89) Determination of Open Flash and Fire Point - Cleveland Method IP-ASTM Joint Method ASTM D 92-97

IP 81 /59 Bitumen Emulsion - Coagulation, on Storage Obsolete Last edition printed: 22nd, 1963

IP 82 /53 Bitumen Emulsion - Long Period Storage Stability Obsolete Last edition printed: 30th, 1971

IP 113 /53 Flash Point (Closed) Cutback Bitumen Obsolete Last edition printed: 1992

IP 170 /99 Petroleum products and other liquids - Determination of flash point - Abel closed cup method Equivalent Standards: BS 2000: Part 170: 1998; \BS EN ISO 13736: 1998; ISO 13736: 1997

IP 230 /81 (87) Minimum handling and storage temperature of fuels Obsolete Last edition printed: 1997

IP 303 /83 (88) Determination of closed flash point - mini equilibrium method IP-ASTM Joint Method ASTM D 3828-97

IP 304 /80 Determination of Flash Point Closed Cup Equilibrium Method

IP 329 /84 Corrosive Properties of Water Based Hydraulic Fluid Obsolete Last edition printed: 1993

IP 378 /87 Storage Stability at 43{.}C of Distillate Fuel IP-ASTM Joint Method ASTM D 4625-92 (98)

IP 403 /94 Petroleum products - Determination of flash and fire points - Cleveland open cup method Equivalent Standards: BS 2000: Part 403: 1994; BS EN 22592: 1994; ISO 2592: 1973

IP 404 /94 Petroleum products and lubricants - Determination of flash point - Pensky-Martens closed cup method Equivalent Standards: BS 2000: Part 404: 1994; BS EN 22719: 1994; ISO 2719: 1988

IP PM CE /1996 Determination of flash point - transparent liquids - Pensky-Martens closed tester Obsolete; Proposed Method

IP PM CH /99 Determination of the hot storage stability of modified bituminous binders Proposed Method

IP Model Code of Safe Practice, part 19 Fire precautions at petroleum refineries and bulk storage installations

IP Code of Practice, 1994
Internal floating roofs for oil storage tanks

1.4 France

CODRES 1991
Code Français de construction des réservoirs cylindriques verticaux en acier avec tôles de robe soudées bout à bout, pour stockage de produits pétroliers liquides. – FRENCH

1.5 The Netherlands

Rules for Pressure Vessels
Dutch Code for Construction of Unfired Pressure Vessels. Section G.
Sections G801, G802 and G803

CPR 9-2 1985
Vloeibare aardolieprodukten. Bovengrondse opslag, kleine installaties - DUTCH

CPR 9-3 1984
Vloeibare aardolieprodukten. Bovengrondse opslag, grote installaties - DUTCH

CPR 9-6 25 mei 1998 Nr. 98/88
De opslag van vloeibare aardolieproducten

CPR 9-6 19 juli 1999 Nr. 99/135
Richtlijn voor opslag tot 150 m3 van brandbare vloeistoffen met een vlampunt van 55 tot 100 ^{o}C in bovengrondse tanks

CPR 12E Nr. 98/11 3 februari 1998
Berekeningsmethoden voor opstellen risicoanalyse gevaarlijke stoffen

CPR-12 Nr. 97/13128 juli 1997
Methoden voor het bepalen en verwerken van kansen

CPR 12^{E} 1 november 1999 Nr. 99/194
Methods for determining and processing probabilities

CPR 14E Nr. 97/13128 juli 1997
Methods for the calculation of physical effects

CPR 14^{E} 1 november 1999 Nr. 99/194
Methods for the calculation of physical effects

CPR 15-1 1994
Richtlijn 15-1 van de CPR, getiteld "Opslag gevaarlijke stoffen in emballage; Opslag van vloeistoffen en vaste stoffen (0 ton tot 10 ton)", tweede druk, uitgave 1994

CPR 15-2 1991
Richtlijn 15-2 van de CPR, getiteld "Opslag gevaarlijke stoffen, chemische afval stoffen en bestrijdingsmiddelen in emballage; opslag van grote hoeveelheden", eerste druk, 1991

CPR-16 Nr. 97/13128 juli 1997
Methoden voor het bepalen van mogelijke schade aan mensen en goederen

CPR 16^{E} 1 november 1999 Nr. 99/194
Methods for the determination of possible damage

CPR 18^{E} 1 november 1999 Nr. 99/194
Guidelines for quantitative risk assessment

CPR 20 31 januari 2000 Nr. 2000/013
RIB, Rapport Informatie-eisen BRZO'99

NEN-EN 14015, 2000 (draft version only available)
Specification for the design and manufacture of site built, vertical, cylindrical, flat bottomed, above ground, welded, metallic tanks for the storage of liquids at ambient temperature and above, Part 1: Steel Tanks (see also CEN/TC 265 under section General)

2. UNDERGROUND STORAGE

2.1 United States of America

API 1604 l-MAR-1996
Closure of Underground Petroleum Storage Tanks

API 1615 l-MAR-1996
Installation of Underground Petroleum Storage Systems

API 1621 l-MAY-1993
Bulk Liquid Stock Control at Retail Outlets

API 1629 10-OCT-1993
Guide for Assessing and Remediating Petroleum Hydrocarbons in Soils

API 1631 l-OCT-1997
Interior Lining of Underground Storage Tanks

API 1632 l-MAY-1996
Cathodic Protection of Underground Petroleum Storage Tanks and Piping Systems

API 1635-1987 1987 (WITHDRAWN ITEM)
Recommended Practice for Underground Petroleum Product Storage Systems at Marketing and Distribution Facilities, 3rd Edition

API 1650 1989
Set of Six API Recommended Practices on Underground Petroleum Storage Tank Management

API 1663A
Underground Storage Tank Installation Training Module - SET - Includes API 1663B, 1663C, 1663D, and 1663E

API 1663B
Underground Storage Tank Installation Training Module

API 1663C
Underground Storage Tank Installation Workbook/Exhibit Book Set
To accompany API 1663B

API 1663D
Underground Storage Tank Removal Training Module

API 1663E
Underground Storage Tank Removal Workbook/Exhibit Book Set
To accompany API 1663D

API 2000 l-APR-1998
Venting Atmospheric and Low-Pressure Storage Tanks: Nonrefrigerated and Refrigerated

ASTM D4021-92 15-JUN-1992
Standard Specification for Glass-Fiber-Reinforced Polyester Underground Petroleum Storage Tanks

ASTM E1430-91 6-SEP-1991
Standard Guide for Using Release Detection Devices with Underground Storage Tanks

ASTM E1526-93 15-MAR-1993
Standard Practice for Evaluating the Performance of Release Detection Systems for Underground Storage Tank Systems

ASTM El 990-98 10-OCT-1998
Standard Guide for Performing Evaluations of Underground Storage Tank Systems for Operational Conformance with 40 CFR, Part 280 Regulations

ASTM G158-98 10-SEP-1998
Standard Guide for Three Methods of Assessing Buried Steel Tanks

GPA 8175-77 1977 (WITHDRAWN ITEM)
GPA Method for the Underground Storage of Natural Gas Liquids

NACE RP0285-95 1995
Standard Recommended Practice - Corrosion Control of Underground Storage Tank Systems by Cathodic Protection

NFPA (fire) 326 1999
Safe Entry of Underground Storage Tanks

PEI RP100 1997
Recommended Practices for Installation of Underground Liquid Storage Systems

PEI RP 100-2000
Recommended Practices for Installation of Underground Liquid Storage Systems

UL 1316 1994
Glass Fiber Reinforced Plastic Underground Storage Tanks for Petroleum Products, Alcohols, and Alcohol -Gasoline Mixtures

UL 1746 1993
External Corrosion Protection Systems for Steel Underground Storage Tanks

UL 1746 Amendment 1 3-NOV-1997
External Corrosion Protection Systems for Steel Underground Storage Tanks

UL 1746 Amendment 2 24-SEP-2000
External Corrosion Protection Systems for Steel Underground Storage Tanks

UL 1746 Amendment 3 16-MAY-2000
External Corrosion Protection Systems for Steel Underground Storage Tanks

2.2 Germany

DIN 6600 1-SEP-1989
Steel Tanks for the Storage of Flammable and Non-Flammable Water Polluting Liquids; Concepts and Inspection

DIN EN 1918-5 JUL-1998
Gas supply systems - Underground gas storage – Part 5: Functional recommendations for surface facilities

DIN EN 976-1 1-SEP-1997
Underground Tanks of Glass-Reinforced Plastics (GRP)-Horizontal Cylindrical Tanks for the Non-Pressure Storage of Liquid Petroleum Based Fuels -Part 1: Requirements and Test Methods for Single Wall Tanks - GERMAN

DIN EN 976-2 1-SEP-1997
Underground Tanks of Glass-Reinforced Plastics (GRP) - Horizontal Cylindrical Tanks for the Non-Pressure Storage of Liquid Petroleum Based Fuels - Part 2: Transport, Handling, Storage and Installation of Single Wall Tanks - GERMAN

DIN EN 977 1-SEP-1997
Underground Tanks of Glass-Reinforced Plastics (GRP) - Method for One Side Exposure to Fluids - GERMAN

DIN EN 978 1-SEP-1997
Underground Tanks of Glass-Reinforced Plastics (GRP) - Determination of Creep Factor and Factor - GERMAN

2.3 United Kingdom

BS 2594 1975
Specification for Carbon Steel Welded Horizontal Cylindrical Storage Tanks

BS EN 1918-1 1998
Gas Supply Systems - Underground Gas Storage - Functional Recommendations for Storage in Aquifers

BS EN 1918-2 10-JAN-1998
Gas Supply Systems - Underground Gas Storage - Functional Recommendations for Storage in Oil & Gas Fields

BS EN 1918-5 1998
Gas Supply Systems - Underground Gas Storage - Functional Recommendations for Surface Facilities

BS EN 976-1 1997
Underground Tanks of Glass-Reinforced Plastics (GRP)-Horizontal Cylindrical Tanks for the Non-Pressure Storage of Liquid Petroleum Based Fuels -Part 1: Requirements and Test Methods for Single Wall Tanks - ENGLISH

BS EN 976-2 1997
Underground Tanks of Glass-Reinforced Plastics (GRP) - Horizontal Cylindrical Tanks for the Non-Pressure Storage of Liquid Petroleum Based Fuels - Part 2: Transport, Handling, Storage and Installation of Single Wall Tanks - ENGLISH

BS EN 977 1-SEP-1997
Underground Tanks of Glass-Reinforced Plastics (GRP) - Method for One Side Exposure to Fluids - ENGLISH

BS EN 978 1-SEP-1997
Underground Tanks of Glass-Reinforced Plastics (GRP) - Determination of Creep Factor and Factor – ENGLISH

IP 33 /59 Flashpoints by the Abel Apparatus - Petroleum(Consolidation) Act 1928 Method Obsolete Last edition printed: 49th, 1990

IP 34 /99 Determination of Flash point - Pensky-Martens closed cup method IP-ASTM Joint Method ASTM D 93-97

IP 35 /63(86) Determination of open flash and fire point - Pensky-Martens method Equivalent Standards: BS 2000: Part 35: 1993

IP 36 /84 (89) Determination of Open Flash and Fire Point - Cleveland Method IP-ASTM Joint Method ASTM D 92-97

IP 170 /99 Petroleum products and other liquids - Determination of flash point - Abel closed cup method Equivalent Standards: BS 2000: Part 170: 1998; \BS EN ISO 13736: 1998; ISO 13736: 1997

IP 230 /81 (87) Minimum handling and storage temperature of fuels Obsolete Last edition printed: 1997

IP 303 /83 (88) Determination of closed flash point - mini equilibrium method IP-ASTM Joint Method ASTM D 3828-97

IP 304 /80 Determination of Flash Point Closed Cup Equilibrium Method

IP 329 /84 Corrosive Properties of Water Based Hydraulic Fluid Obsolete Last edition printed: 1993

IP 403 /94 Petroleum products - Determination of flash and fire points - Cleveland open cup method Equivalent Standards: BS 2000: Part 403: 1994; BS EN 22592: 1994; ISO 2592: 1973

IP 404 /94 Petroleum products and lubricants - Determination of flash point - Pensky-Martens closed cup method Equivalent Standards: BS 2000: Part 404: 1994; BS EN 22719: 1994; ISO 2719: 1988

2.4 France

AFNOR NF EN 976-1 1-SEP-1997
Underground Tanks of Glass-Reinforced Plastics (GRP)-Horizontal Cylindrical Tanks for the Non-Pressure Storage of Liquid Petroleum Based Fuels -Part 1: Requirements and Test Methods for Single Wall Tanks - FRENCH

AFNOR NF EN 976-2 1-SEP-1997
Underground Tanks of Glass-Reinforced Plastics (GRP) - Horizontal Cylindrical Tanks for the Non-Pressure Storage of Liquid Petroleum Based Fuels - Part 2: Transport, Handling, Storage and Installation of Single Wall Tanks - FRENCH

AFNOR NF M 88-514 1-MAR-1980
Dual Material Tanks for Underground Storage of Liquid Petroleum Products.
Steel Exterior Tank. Plastic Interior Tank

AFNOR NF M 88-550 1979
Storage Tanks in Reinforced Plastic. Underground Tanks for Liquid
Petroleum Products.

2.5 The Netherlands

CPR 9-1 1983
Vloeibare aardolieprodukten. Ondergrondse opslag – DUTCH

CPR 12E Nr. 98/11 3 februari 1998
Berekeningsmethoden voor opstellen risicoanalyse gevaarlijke stoffen

CPR-12 Nr. 97/13128 juli 1997
Methoden voor het bepalen en verwerken van kansen

CPR 12^E 1 november 1999 Nr. 99/194
Methods for determining and processing probabilities

CPR 14E Nr. 97/13128 juli 1997
Methods for the calculation of physical effects

CPR 14^E 1 november 1999 Nr. 99/194
Methods for the calculation of physical effects

CPR 15-1 1994
Richtlijn 15-1 van de CPR, getiteld "Opslag gevaarlijke stoffen in emballage; Opslag van vloeistoffen en vaste stoffen (0 ton tot 10 ton)", tweede druk, uitgave 1994

CPR 15-2 1991
Richtlijn 15-2 van de CPR, getiteld "Opslag gevaarlijke stoffen, chemische afval stoffen en bestrijdingsmiddelen in emballage; opslag van grote hoeveelheden", eerste druk, 1991

CPR-16 Nr. 97/13128 juli 1997
Methoden voor het bepalen van mogelijke schade aan mensen en goederen

CPR 16^E 1 november 1999 Nr. 99/194
Methods for the determination of possible damage

CPR 18^E 1 november 1999 Nr. 99/194
Guidelines for quantitative risk assessment

CPR 20 31 januari 2000 Nr. 2000/013
RIB, Rapport Informatie-eisen BRZO'99

3. PRESSURISED STORAGE

3.1 United States of America

API 520-1 2000
Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries: Part 1 - Sizing and Selection

AS 1210 Amendment 1 1-FEB-1998
Unfired Pressure Vessels - Advanced Design and Construction

AS 1210 Supplement 1 1990
Unfired Pressure Vessels - Advanced Design and Construction - Remains current as supplement for 1997 edition

AS 1210 Supplement 1 - Amd 1 5-SEP-1995
Unfired Pressure Vessels - Advanced Design and Construction (Amendment 1 to Supplement 1)

AS 1210 Supplement 1 - Amd 2 1-JUL-1997
Unfired Pressure Vessels - Advanced Design and Construction (Amendment 2 to Supplement 1)

ASME Section IIA 1-JAN-98
1998 ASME Boiler and Pressure Vessel Code, Section 11: Materials - Part A: Ferrous Material Specifications

ASME Section IIB 1-JAN-98
1998 ASME Boiler and Pressure Vessel Code, Section 11: Materials - Part B: Nonferrous Material Specifications

ASME Section IIC 1-JAN-98
1998 ASME Boiler and Pressure Vessel Code, Section 11: Materials - Part C: Specifications for Welding Rods, Electrodes and Filler Metals

ASME Section IID 1-JAN-98
1998 ASME Boiler and Pressure Vessel Code, Section 11: Materials - Part D: Properties

ASME Section V 1-JAN-98
1998 ASME Boiler and Pressure Vessel Code, Section V: Nondestructive Examination

ASME Section VIII-DIV 1 1998
1998 ASME Boiler and Pressure Vessel Code, Section VIII, Division 1: Pressure Vessels

ASME Section VIII-DIV 2 1998
1998 ASME Boiler and Pressure Vessel Code, Section VIII, Division 3: Alternative Rules

ASME Section VIII-DIV 3 1998
1998 ASME Boiler and Pressure Vessel Code, Section VIII, Division 3: Alternative Rules for Construction of High Pressure Vessels

ASME Section X 1-JAN-98
1998 ASME Boiler and Pressure Vessel Code, Section X: Fiber-Reinforced Plastic Pressure Vessels

ASME CodeCases: BPV 01-JUL-98
1998 ASME Boiler & Pressure Vessel Code - Code Cases: Boilers and Pressure Vessels

GPA 8175-77 1977 (WITHDRAWN ITEM)
GPA Method for the Underground Storage of Natural Gas Liquids

NACE RP0285-95 1995
Standard Recommended Practice - Corrosion Control of Underground Storage Tank Systems by Cathodic Protection

NFPA (fire) 326 1999
Safe Entry of Underground Storage Tanks

PEI RP100 1997
Recommended Practices for Installation of Underground Liquid Storage Systems

UL 1746 1993
External Corrosion Protection Systems for Steel Underground Storage Tanks

UL 1746 Amendment 1 3-NOV-1997
External Corrosion Protection Systems for Steel Underground Storage Tanks

UL 1746 Amendment 2 24-SEP-2000
External Corrosion Protection Systems for Steel Underground Storage Tanks

UL 1746 Amendment 3 16-MAY-2000
External Corrosion Protection Systems for Steel Underground Storage Tanks

3.2 United Kingdom

BS 5276-1-1984
Pressure vessel details (dimensions). Specification for davits for branch covers of steel vessels

BS EN 286-1 1998
Simple Unfired Pressure Vessels Designed to Contain Air or Nitrogen - Pressure Vessels for General Purposes

BS PD 5500 15-NOV-1999
Specification for unfired fusion welded pressure vessels

BS 7005-1988
Specification for design and manufacture of carbon steel unfired pressure vessels for use in vapour compression refrigeration systems

AMD 10830
Amendment to PD 5500:2000. Specification for unfired fusion welded pressure vessels

Enquiry Case 5500/33:2000
Enquiry case to PD 5500:2000. Specification for unfired fusion welded pressure vessels

Enquiry Case 5500/119:2000
Enquiry case to PD 5500:2000. Specification for unfired fusion welded pressure vessels

Enquiry Case 5500/127:2000
Enquiry case to PD 5500:2000. Specification for unfired fusion welded pressure vessels

PD 6497-1982
Stresses in horizontal cylindrical pressure vessels supported on twin saddles: a derivation of the basic equations and constants used in G.3.3 of BS 5500:1982

PD 6550-1-1989
Explanatory supplement to BS 5500:1988 'Specification for unfired fusion welded pressure vessels', section three 'Design'. Domed ends (heads)

PD 6550-2-1989
Explanatory supplement to BS 5500:1988 Specification for unfired fusion welded pressure vessels', section three 'Design'. Openings and branch connections

PD 6550-3-1989
Explanatory supplement to BS 5500:1988 'Specification for unfired fusion welded pressure vessels', section three 'Design'. Vessels under external pressure

BS TH42069 1993
Pressure Vessels - Germany

BS TH42070 1993
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EEMUA 190 2000
Guide for the Design, Construction and Use of Mounded Horizontal
Cylindrical Vessels for Pressurises Storage of LPG at Ambient Temperature

IP 33 /59 Flashpoints by the Abel Apparatus - Petroleum(Consolidation) Act 1928 Method Obsolete Last edition printed: 49th, 1990

IP 34 /99 Determination of Flash point - Pensky-Martens closed cup method IP-ASTM Joint Method ASTM D 93-97

IP 35 /63(86) Determination of open flash and fire point - Pensky-Martens method Equivalent Standards: BS 2000: Part 35: 1993

IP 36 /84 (89) Determination of Open Flash and Fire Point - Cleveland Method IP-ASTM Joint Method ASTM D 92-97

IP 170 /99 Petroleum products and other liquids - Determination of flash point - Abel closed cup method Equivalent Standards: BS 2000: Part 170: 1998; \BS EN ISO 13736: 1998; ISO 13736: 1997

IP 303 /83 (88) Determination of closed flash point - mini equilibrium method IP-ASTM Joint Method ASTM D 3828-97

IP 304 /80 Determination of Flash Point Closed Cup Equilibrium Method

IP 329 /84 Corrosive Properties of Water Based Hydraulic Fluid Obsolete Last edition printed: 1993

IP 403 /94 Petroleum products - Determination of flash and fire points - Cleveland open cup method Equivalent Standards: BS 2000: Part 403: 1994; BS EN 22592: 1994; ISO 2592: 1973

IP 404 /94 Petroleum products and lubricants - Determination of flash point - Pensky-Martens closed cup method Equivalent Standards: BS 2000: Part 404: 1994; BS EN 22719: 1994; ISO 2719: 1988

IP 410 /99 Liquefied petroleum products - Determination of gauge vapour pressure - LPG method

IP 420 /95 LPG - Calculation of density and vapour pressure
Superseded by IP 432

3.3 France

CODAP 95
French Code for Construction of Unfired Pressure Vessels

3.4 The Netherlands

Rules for Pressure Vessels
Dutch Code for Construction of Unfired Pressure Vessels. Section D.

CPR 12E Nr. 98/11 3 februari 1998
Berekeningsmethoden voor opstellen risicoanalyse gevaarlijke stoffen

CPR-12 Nr. 97/13128 juli 1997
Methoden voor het bepalen en verwerken van kansen

CPR 12^E 1 november 1999 Nr. 99/194
Methods for determining and processing probabilities

CPR 13-1
Ammonia, Storage and Loading.

CPR 14E Nr. 97/13128 juli 1997
Methods for the calculation of physical effects

CPR 14^E 1 november 1999 Nr. 99/194
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CPR 15-1 1994
Richtlijn 15-1 van de CPR, getiteld "Opslag gevaarlijke stoffen in emballage; Opslag van vloeistoffen en vaste stoffen (0 ton tot 10 ton)", tweede druk, uitgave 1994

CPR 15-2 1991
Richtlijn 15-2 van de CPR, getiteld "Opslag gevaarlijke stoffen, chemische afval stoffen en bestrijdingsmiddelen in emballage; opslag van grote hoeveelheden", eerste druk, 1991

CPR-16 Nr. 97/13128 juli 1997
Methoden voor het bepalen van mogelijke schade aan mensen en goederen

CPR 16^E 1 november 1999 Nr. 99/194
Methods for the determination of possible damage

CPR 17-1 Nr. 98/88 25 mei 1998
De richtlijn aardgas-afleverstations voor motor-voertuigen

CPR 17-2 11 januari 1999 Nr. 99/001
Richtlijn voor het veilig stellen en repareren van motorvoertuigen

CPR 17-3 16 maart 1999 Nr. 99/038
Concept richtlijn voor installaties voor de inpandige aflevering van gecomprimeerd aardgas aan motorvoertuigen (Concept CPR 17-3)

CPR 18^E 1 november 1999 Nr. 99/194
Guidelines for quantitative risk assessment

CPR 20 31 januari 2000 Nr. 2000/013
RIB, Rapport Informatie-eisen BRZO'99

4. REFRIGERATED STORAGE

4.1 United States of America

API 620 l-FEB-1996
Design and Construction of Large, Welded, Low-Pressure Storage Tanks,
Ninth Edition -- Appendix Q Liquids down to -168 °C

API 620 l-FEB-1996
Design and Construction of Large, Welded, Low-Pressure Storage Tanks,
Ninth Edition -- Appendix R Liquids down to -51 °C

API 2000 l-APR-1998
Venting Atmospheric and Low-Pressure Storage Tanks: Nonrefrigerated
and Refrigerated

NFPA 50
Standard for Bulk Oxygen Systems at Consumer Sites, 1996 Edition

NFPA 50A
Standard for Gaseous Hydrogen Systems at Consumer Sites, 1999 Edition

NFPA 50B
Standard for Liquefied Hydrogen Systems at Consumer Sites, 1999 Edition

NFPA 57
Liquefied Natural Gas (LNG) Fuel Systems Code, 1999 Edition

NFPA 59
Standard for the Storage and Handling of Liquefied Petroleum Gases at Utility Gas Plants, 1998 Edition

NFPA 59A
Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG). 1996 Edition

UL 641 1994
Type L Low-Temperature Venting Systems

UL 873 1994
Temperature-Indicating and -Regulating Equipment

4.2 United Kingdom

BS 4741-1971 (WITHDRAWN ITEM)
Specification for vertical cylindrical welded steel storage tanks for low-temperature service: single-wall tanks for temperatures down to -50°C

BS 5387-1976 (WITHDRAWN ITEM)
Specification for vertical cylindrical welded storage tanks for low-temperature service: double-wall tanks for temperatures down to -196°C

BS 5429-1976
Code of practice for safe operation of small-scale storage facilities for cryogenic liquids

BS 6364-1984
Specification for valves for cryogenic service

BS EN 1160-1997
Installations and equipment for liquefied natural gas. General characteristics of liquefied natural gas

BS 7777-1 1993
Flat-Bottomed, Vertical, Cylindrical Storage Tanks for Low Temperature Service - Part 1: Guide to the General Provisions Applying for Design, Construction, Installation, and Operation

BS 7777-2 1993
Flat-Bottomed, Vertical, Cylindrical Storage Tanks for Low Temperature Service - Part 2: Specification for the Design and Construction of Single, Double and Full Containment Metal Tanks for the Storage of Liquefied Gas at Temperatures Down to 165 deg. C

BS 7777-3 1993
Flat-Bottomed, Vertical, Cylindrical Storage Tanks for Low Temperature Service - Part 3: Recommendations for the Design and Construction of Prestressed and Reinforced Concrete Tanks and Tank Foundations, and Design and Installation of Tank Insulation, Liners and Coatings

BS 7777-4 1993
Flat-Bottomed, Vertical, Cylindrical Storage Tanks for Low Temperature Service - Part 4: Specification for the Design and Construction of Single Containment Tanks for the Storage of Liquid Oxygen, Liquid Nitrogen and Liquid Argon

EEMUA 147
Recommendations for the Design and Construction of Refrigerated Liquefied Gas Storage Tanks

IP 33 /59 Flashpoints by the Abel Apparatus - Petroleum(Consolidation) Act 1928 Method Obsolete Last edition printed: 49th, 1990

IP 34 /99 Determination of Flash point - Pensky-Martens closed cup method IP-ASTM Joint Method ASTM D 93-97

IP 35 /63(86) Determination of open flash and fire point - Pensky-Martens method Equivalent Standards: BS 2000: Part 35: 1993

IP 36 /84 (89) Determination of Open Flash and Fire Point - Cleveland Method IP-ASTM Joint Method ASTM D 92-97

IP 170 /99 Petroleum products and other liquids - Determination of flash point - Abel closed cup method Equivalent Standards: BS 2000: Part 170: 1998; \BS EN ISO 13736: 1998; ISO 13736: 1997

IP 181 /76 Sampling Petroleum Gases including LPG Obsolete Last edition printed: Part IV

IP 194 /74 (81) Butadiene purity - GC method Obsolete Last edition printed: 1995

IP 230 /81 (87) Minimum handling and storage temperature of fuels Obsolete Last edition printed: 1997

IP 251 /76 Static Measurement of Refrigerated Hydrocarbon Liquids Published as Part XII Section 1 of the IP Petroleum Measurement Manual

IP 252 /76 Static Measurement of Refrigerated Hydrocarbon Liquids Published as Part XIII Section 1 of the IP Petroleum Measurement Manual

IP 264 /72 (85) Determination of Composition of LPG and Propylene Concentrates - Gas chromatography Method IP-ASTM Joint Method ASTM D 2163-91 (96)

IP 303 /83 (88) Determination of closed flash point - mini equilibrium method IP-ASTM Joint Method ASTM D 3828-97

IP 304 /80 Determination of Flash Point Closed Cup Equilibrium Method

IP 317 /95 Determination of residues in liquefied petroleum gases (LPG) - Low temperature evaporation method IP-ASTM Joint Method ASTM D 2158-92 Equivalent Standards: BS 2000: Part 317: 1995

IP 329 /84 Corrosive Properties of Water Based Hydraulic Fluid Obsolete Last edition printed: 1993

IP 337 /78 (95) Composition of Non-associated Natural Gas - Quantitative Gas Chromatography Method

IP 345 /80 Composition of Associated Natural Gas - Gas Chromatography Method

IP 395 /98 Liquefied petroleum gases - Assessment of the dryness of propane - Valve freeze method IP-ASTM Joint Method ASTM D 2713-91 (95) Equivalent Standards: BS 2000: Part 395: 1997; BS EN ISO 13758: 1997; ISO 13758: 1996

IP 403 /94 Petroleum products - Determination of flash and fire points - Cleveland open cup method Equivalent Standards: BS 2000: Part 403: 1994; BS EN 22592: 1994; ISO 2592: 1973

IP 404 /94 Petroleum products and lubricants - Determination of flash point - Pensky-Martens closed cup method Equivalent Standards: BS 2000: Part 404: 1994; BS EN 22719: 1994; ISO 2719: 1988

IP 405 /94 Commercial propane and butane - Analysis by gas chromatography Equivalent Standards: BS 2000: Part 405: 1994; BS EN 27941: 1994; ISO 7941; 1988

IP 410 /99 Liquefied petroleum products - Determination of gauge vapour pressure - LPG method Equivalent Standards: BS 2000: Part 410: 1998; BS EN ISO 4256: 1998; ISO 4256: 1996

IP 432 /2000 Liquefied petroleum gases - Calculation method for density and vapour pressure Equivalent Standards: BS 2000: Part 432: 1999; BS EN ISO 8973: 1999; ISO 8973: 1997

IP PM CD /96 Determination of the composition of liquefied petroleum gases - gas chromatography method. Proposed Method

IP Model Code of Safe Practice LPG, Volume 1, Part 9
Large bulk pressure Storage and refrigerated LPG

4.3 The Netherlands

Rules for Pressure Vessels
Dutch Code for Construction of Unfired Pressure Vessels. Section G.
Sections G804 and G805

CPR 8-3
Distributiedepots voor LPG - Dutch.

CPR 11-6 Nr. 98/88 25 mei 1998
Propaan. Vulstations voor spuitbussen met propaan, butaan en demethyl-ether als drijfgas

CPR 12E Nr. 98/11 3 februari 1998
Berekeningsmethoden voor opstellen risicoanalyse gevaarlijke stoffen

CPR-12 Nr. 97/13128 juli 1997
Methoden voor het bepalen en verwerken van kansen

CPR 12^{E} 1 november 1999 Nr. 99/194
Methods for determining and processing probabilities

CPR 13 Nr. 99/137 21 juli 1999
Richtlijnen voor opslag en verlading van ammoniak en voor de toepassing van ammoniak als koudemiddel in koelinstallaties en warmtepompen

CPR 13-1 Nr. 98/88 25 mei 1998
De opslag en verlading van ammoniak

CPR 13-1 Nr. 99/137 21 juli 1999
Ammoniak; opslag en verlading

CPR 13-2 Nr. 99/137 21 juli 1999
Ammoniak; toepassing als koudemiddel in koelinstallaties en warmtepompen

CPR 14E Nr. 97/13128 juli 1997
Methods for the calculation of physical effects

CPR 14^{E} 1 november 1999 Nr. 99/194
Methods for the calculation of physical effects

CPR 15-1 1994
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CPR 15-2 1991
Richtlijn 15-2 van de CPR, getiteld "Opslag gevaarlijke stoffen, chemische afval stoffen en bestrijdingsmiddelen in emballage; opslag van grote hoeveelheden", eerste druk, 1991

CPR-16 Nr. 97/13128 juli 1997
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CPR 16^{E} 1 november 1999 Nr. 99/194
Methods for the determination of possible damage

CPR 18^{E} 1 november 1999 Nr. 99/194
Guidelines for quantitative risk assessment

CPR 20 31 januari 2000 Nr. 2000/013
RIB, Rapport Informatie-eisen BRZO'99

5. ISO CONTAINERS OR IBC'S

5.1 United States of America

AS/NZS 3833-1998 5-SEP-1998. The Storage & Handling of Mixed Classes of Dangerous Goods in Packages & Intermediate Bulk Containers

ABS 13-1998 1998 Rules for Certification of Cargo Containers

AMCA 99 1986 Standards Handbook

ANSI MH26.1-1998 1998 Specifications for Industrial Metal Containers

ANSI MH5.1.3M-1992 1992 Requirements for Tank Containers for Liquids and Gases

ANSI MH5.1.5-1990 1990 Road/Rail Closed Dry Van Containers

ANSI MH5.1.9-1990 1990 Freight Containers - Automatic Identification

ANSI PRD1-1998 1998 Pressure Relief Devices for Natural Gas Vehicle (NGV) Fuel Containers

ANSI Z48.1 1971 (WITHDRAWN ITEM)Marking Portable Compressed Gas Containers - WITHDRAWN, No Replacement

ARI Guideline K (1997) 1997 Containers for Recovered Fluorocarbon Refrigerators

ARI Guideline N (1995) 1995 Assignment of Refrigerant Container Colors

AS 2278-1986 1986 Metal Aerosol Containers

AS 2278-1986 Amendement 1 1-JUN-1988 Metal Aerosol Containers

ASTM C148-00 2000 Standard Test Method for Polariscopic Examination of Glass Containers

ASTM C149-86(1995) 31-JAN-1986 Standard Test Method for Thermal Shock Resistance of Glass Containers

ASTM C224-78(R1999) 27-JAN-1978 Standard Practice for Sampling Glass Containers

ASTM C225-85(R1999) 26-JUL-1985 Standard Test Methods for Resistance of Glass Containers to Chemical Attack

ASTM D2463-95 10-NOV-1995 Standard Test Method for Drop Impact Resistance of Blow-Molded Thermoplastic Containers

ASTM D2561-95 10-NOV-1995 Standard Test Method for Environmental Stress-Crack Resistance of Blow-Molded Polyethylene Containers

ASTM D2659-95 10-NOV-1995 Standard Test Method for Column Crush Properties of Blown Thermoplastic Containers

ASTM D2684-95 10-NOV-1995 Standard Test Method for Permeability of Thermoplastic Containers to Packaged Reagents or Proprietary Products

ASTM D3068-80 (R1991) 30-MAY-1980 (WITHDRAWN ITEM)Standard Specification for Safe Fill of Aerosol Containers - WITHDRAWN - No Replacement

ASTM D3074-94 15-NOV-1994 Standard Test Method for Pressure in Metal Aerosol Containers

ASTM D3694-95 15-FEB-1995 Standard Practices for Preparation of Sample Containers and for Preservation of Organic Constituents

ASTM D3844-96 10-JUN-1996 Standard Guide for Labeling Halogenated Hydrocarbon Solvent Containers

ASTM D4306-97 10-DEC-1997 Standard Practice for Aviation Fuel Sample Containers for Tests Affected by Trace Contamination

ASTM D4728-95 10-NOV-1995 Standard Test Method for Random Vibration Testing of Shipping Containers

ASTM D4991-94(R1999) 15-JUN-1994 Standard Test Method for Leakage Testing of Empty Rigid Containers by Vacuum Method

ASTM D6063-96 10-DEC-1996 Standard Guide for Sampling Drums & Similar Containers by Field Personnel

ASTM D997-80(R1986) 3-MAR-1980 Standard Test Method for Drop Test for Loaded Cylindrical Containers

ASTM D998-94 15-MAY-1994 Standard Test Method for Penetration of Liquids into Submerged Loaded Shipping Containers

ASTM D999-96 10-FEB-1996 Standard Methods for Vibration Testing of Shipping Containers

ASTM ES26-93 28-JUL-1993 Emergency Standard Specification for Cautionary Labeling for Plastic Five-Gallon Open-Head Containers (Buckets)

ASTM F1115-95 10-SEP-1995 Standard Test Method for Determining the Carbon Dioxide Loss of Beverage Containers

ASTM F1615-95 10-SEP-1995 Standard Specification for Cautionary Labeling for Five-Gallon Open-Head Plastic Containers

ASTM F302-78(R1989) 25-AUG-1978 Standard Practice for Field Sampling of Aerospace Fluids in Containers

ASTM F926-85 23-AUG-1985 Standard Specification for Cautionary Labeling of Portable Kerosine Containers for Consumer Use

AWS F4.1-94 1994 (WITHDRAWN ITEM)Recommended Safe Practices for Preparation for Welding and Cutting of Containers and Piping

EIA 556A 11-NOV-1999 (WITHDRAWN ITEM)Outer Shipping Container Bar Code Label Standard

EIA 556B 1-NOV-1999 Outer Shipping Container Bar Code Label Standard

EIA JEP130 1-AUG-1997 Guidelines for Packing and Labeling of Integrated Circuits in Unit Container Packing

IEC 60096-1 Amendment 2 25-JUN-1993 Amendment No. 2

IEC 60204-3 (WITHDRAWN ITEM)Electrical Equipment of Industrial Machines - WITHDRAWN - Contained in IEC 60204-1

IEC 60249-1 Amendment 4 13-MAY-1993 Amendment No. 4

IEC 60249-2-1 Amendment 2 18-MAY-1993 (WITHDRAWN ITEM) Amendment No. 2

IEC 60249-2-10 Amendment 3 18-MAY-1993 Amendment No. 3

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IEC 60249-2-14 Amendment 3 18-MAY-1993 Amendment No. 3

IEC 60249-2-2 Amendment 3 13-MAY-1993 (WITHDRAWN ITEM) Amendment No. 3

IEC 60249-2-3 Amendment 2 13-MAY-1993 (WITHDRAWN ITEM) Amendment No. 2

IEC 60249-2-4 Amendment 3 18-MAY-1993 (WITHDRAWN ITEM) Amendment No. 3

IEC 60249-2-5 Amendment 3 13-MAY-1993 Amendment No. 3

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IEC 60249-2-7 Amendment 2 13-MAY-1993 Amendment No. 2

IEC 60249-2-9 Amendment 3 18-MAY-1993 Amendment No. 3

IEC 60264-1 31-DEC-1969 Packaging of winding wires. Part 1: Containers for round winding wires

IEC 60344 Amendment 1 1985 Amendment No. 1

IEC 60390A 1976 First supplement

IEC 60708-1 Amendment 3 1988 Amendment No. 3

IEC 60804 Amendment 1 15-SEP-1989 Amendment No. 1

IEC 60804 Amendment 2 21-SEP-1993 Amendment No. 2

IEEE C135.1-1999 30-DEC-1999 Galvanized Steel, Bolts and Nuts for Overhead Line Construction

UL 147B Amendment 1 1-MAR-1999 Nonrefillable (Disposable) Type Metal Container Assemblies for Butane

UL 2003 Outline 28-AUG-1992 Proposed Standard - Portable LP Gas Container Assemblies

CGA C-4 1990 (WITHDRAWN ITEM)American National Standard Method of Marking Portable Compressed Gas Containers to Identify the Materials Contained - WITHDRAWN

CGA G-6.7 1996 Safe Handling of Liquid Carbon Dioxide Containers That Have Lost Pressure

FED A-A-1235A 6-DEC-1984 Containers, Plastic, Molded (For Liquids, Pastes, and Powders)

FED A-A-2597A 25-JUL-1996 Dishpan (Food Container Pan)

FED A-A-30132A 18-MAY-1987 Disposable Container, Hypodermic Needle and Syringe

FED A-A-50019B 18-MAR-1988 Racks, Milk Container, Mobile and Racks, Egg Container, Mobile

FED A-A-50486A 23-NOV-1992 Container, Insulated, Shipping

FED A-A-51625B 24-NOV-1989 Disposal Container, Hypodermic Needle and Syringe (Non-Needle Removal)

FED A-A-51703(DM) 13-OCT-1986 Container and Pump, Dental (Mouthrinse)

FED A-A-52193A 18-JUL-1994 Food Container, Insulated, with Inserts

FED A-A-52486 13-DEC-1984 Mount, Shipping Container, Resilient: Shock and Vibration Damping

FED A-A-58041 15-MAR-1995 Trailer, LD-3 Container, Side Transfer, Turntable

FED A-A-59209 15-APR-1998 Paperboard, Ammunition Container

FED O-F-1044B 24-FEB-1975 Fuel, Engine Primer: Cold Starting, In Pressurized and Nonpressurized Containers

FED RR-C-550D 8-APR-1991 Containers, Fluid, for Paint Spray Equipment

FED RR-C-550D Amendment 19-FEB-1993 Amendment 1 - Containers, Fluid, for Paint Spray Equipment

NFPA (fire) 327 1993 (WITHDRAWN ITEM)Cleaning or Safeguarding Small Tanks and Containers Without Entry

NFPA 55 (WITHDRAWN ITEM)Standard for the Storage, Use and Handling of Compressed and Liquefied Gases in Portable Cylinders, 1998 Edition

5.2 Germany

DIN 30823 MAR 1999 (draft)
Intermediate bulk containers – Rigid IBC – Metal, rigid plastics and composite intermediate bulk containers; dimension, design, requirements, marking

DIN 55461-1 FEB 1990
Large size packages; flexible IBC; concepts, forms, dimensions, testing of dimensions

DIN 55461-2 JUL 1991
Large size packages; flexible IBC; dimensions

DIN 10955 1-APR-1983 Sensory Analysis - Testing of Container Materials and Containers for Food Products

DIN 168-1 1-DEC-1979 External Screw Threads - Part 1 - Especially for Glass Containers - Thread Sizes

DIN EN ISO 15867 NOV 1997 (draft)
Intermediate bulk containers (IBC) for non-dangerous goods - Terminology

ISO/DIS 11895 JAN 1996 (draft)
Specification for flexible intermediate bulk containers for non-dangerous goods

98/714098 DC APR 2000 (draft)
Pallet borne flexible intermediate bulk containers (PB FIBCs) for non-dangerous goods

ISO 10327 1-FEB-1995 Aircraft-Certified Aircraft Container for Air Cargo-Specification and Testing

ISO 10374 1-OCT-1991 Freight containers -- Automatic identification

ISO 11242 1-JUN-1996 Aircraft-Pressure Equalization Requirements for Cargo Containers

ISO 11418-1 1-OCT-1996 Containers and accessories for pharmaceutical preparations -- Part 1: Drop-dispensing bottles

ISO 11418-2 1-OCT-1996 Containers and accessories for pharmaceutical preparations -- Part 2: Screw-neck bottles for syrups

ISO 11418-4 1-OCT-1996 Containers and accessories for pharmaceutical preparations -- Part 4: Tablet bottles

ISO 11418-5 1-OCT-1997 Containers and accessories for pharmaceutical preparations -- Part 5: Dropper assemblies

ISO 1161 1984 Series 1 Freight Containers -- Corner Fittings -- Specification

ISO 1496-1 1990 Series 1 Freight Containers -- Specification and Testing -- Part 1: General Cargo Containers for General Purposes - Includes Amendments 1(1993) & 2 (1998)

ISO 1496-1/AMD1 1-OCT-1993 Amendment 1 to ISO 1496-1:1990 1AAA and 1BBB containers

ISO 1496-2 1996 Series 1 Freight Containers - Specification and Testing - Part 2: Thermal Containers - Includes Technical Corrigendum 1:1997

ISO 1496-3 1995 Series 1 Freight Containers - Specification and Testing - Part 3: Tank Containers for Liquids, Gases and Pressurized Dry Bulk

ISO 1496-4 1991 Series 1 Freight Containers -- Specification and Testing -- Part 4: Non-Pressurized Containers for Non-Bulk

ISO 1496-4/AMD1 1-OCT-1994 AMENDMENT 1 to ISO 1496-4:1991 1AAA and 1BBB containers

ISO 1496-5 1991Series 1 Freight Containers -- Specification and Testing -- Part 5: Platform and Platform-Based Containers

ISO 1496-5/AMD1 1-OCT-1993 Amendment 1 to ISO 1496-5:1991 1AAA and 1BBB containers

ISO 2308 1972 Hooks for Lifting Freight Containers of Up To 30 Tonnes Capacity - Basic Requirements

ISO 3871 1-FEB-1980 (HISTORICAL ITEM)Labelling of Containers for Petroleum or Non-Petroleum Base Brake Fluid

ISO 3874 1988 (HISTORICAL ITEM)Series 1 Freight Containers - Handling and Securing

ISO 3874 1-OCT-1997 Series 1 freight containers -- Handling and securing

ISO 4118 1-APR-1996 Non-Certified Lower Deck Containers for Air Transport-Specification and Testing

ISO 4128 1-SEP-1985 Air Mode Modular Containers

ISO 6346 1995 Freight Containers - Coding, Identification, and Marking

ISO 668 1995 Series 1 Freight Containers -- Classification, Dimensions and Ratings

ISO 6967 1-SEP-1994 Wide Body Aircraft Main Deck Container/Pallet Loader-Functional Requirements

ISO 6968 1-SEP-1994 Wide Body Aircraft Lower Deck Container/Pallet Loader-Functional Requirements

ISO 7458 1984 Glass Containers - Internal Pressure Resistance - Test Methods

ISO 7459 1984 Glass Containers - Thermal Shock Resistance and Thermal Shock Endurance - Test Methods

ISO 8106 1985 Glass Containers - Determination of Capacity by Gravimetric Method - Test Method

ISO 8162 1985 Glass Containers - Tall Crown Finishes - Dimensions

ISO 8163 1985 Glass Containers - Shallow Crown Finishes - Dimensions

ISO 8164 1990 Glass Containers - 520 ml Euro-form Bottles - Dimensions

ISO 8167 1-OCT-1989 Projections for resistance welding

ISO 830 1981 (HISTORICAL ITEM)Freight Containers - Terminology

ISO 830 1-OCT-1999 Freight containers -- Vocabulary

ISO 8323 1995 Freight Containers -- Air/Surface (Intermodal) General Purpose Containers -- Specification and Tests

ISO 90-2 1-OCT-1997 Light gauge metal containers -- Definitions and determination of dimensions and capacities -- Part 2: General use containers

ISO 9009 1991 Glass Containers - Height and Non-Parallelism of Finish with Reference to Container Base - Test Methods

ISO 9056 1990 Glass Containers - Series of Pilferproof Finish - Dimensions

ISO 9057 1991 Glass Containers - 28 mm Tamper-Evident Finish for Pressurized Liquids - Dimensions

ISO 9058 1992 Glass Containers - Tolerances

ISO 9100 1-OCT-1992 Wide-mouth glass containers -- Vacuum lug finishes -- Dimensions

ISO 9669 1990 Series 1 Freight Containers -- Interface Connections for Tank Containers

ISO 9711-1 1990 Freight Containers -- Information Related to Containers on Board Vessels -- Part 1: Bay Plan System

ISO 9711-2 1990 Freight Containers -- Information Related to Containers on Board Vessels -- Part 2: Telex Data Transmission

ISO 9897 1-OCT-1997 Freight containers -- Container equipment data exchange (CEDEX) -- General communication codes

ISO/IEC 2258 31-DEC-1976 Printing ribbons - Minimum markings to appear on containers

ISO/TR 15070 1996 Series 1 Freight Containers - Rationale for Structural Test Criteria

5.3 United Kingdom

BS 1136-1972 (WITHDRAWN ITEM)
Specification for mild steel refuse storage containers

BS 1133-7.7 1990 Packaging Code - Paper & Board Wrappers, Bags & Containers - Composite Containers

BS 3951-1 Section 1.3 1979 (WITHDRAWN ITEM)Freight Containers - Specification for Minimum Internal Dimensions for General Purpose Series 1 Freight Containers - WITHDRAWN, No replacement

BS 3951-2 Section 2.5 1992 Freight Containers. Specification and Testing of Series 1 Freight Containers. Platform and Platform-Based Containers

BS 5045-1 Amendment 1 1-AUG-1986 Amendment 1 - Transportable Gas Containers - Part 1: Specification for Seamless Steel Gas Containers above 0.5 Litre Water Capacity

BS 5045-1 Amendment 2 1991 Amendment 2 - Transportable Gas Containers - Part 1: Specification for Seamless Steel Gas Containers above 0.5 Litre Water Capacity

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BS 5045-1 Amendment 5 15-SEP-1997 Amendment 5 - Transportable Gas Containers - Part 1: Specification for Seamless Steel Gas Containers above 0.5 Litre Water Capacity

BS 5045-5 1986 Transportable Gas Containers - Specification for Aluminium Alloy Containers Above 0.5 Litre up to 130 Litres Water Capacity with Welded Seams

BS 5045-6 1987 Transportable Gas Containers - Specification for Seamless Containers of Less than 0.5 Litre Water Capacity

BS 5430-1 31-MAY-1990 Periodic Inspection, Testing and Maintenance of Transportable Gas Containers (Excluding Dissolved Acetylene Containers). Specification for Seamless Steel Containers of Capacity 0.5 Litres and Above

BS 5430-2 31-DEC-1990 Periodic Inspection, Testing and Maintenance of Transportable Gas Containers (Excluding Dissolved Acetylene Containers). Specification for Welded Steel Containers of Water Capacity 0.5 L up to 150 L

BS 5430-3 31-DEC-1990 Periodic Inspection, Testing and Maintenance of Transportable Gas Containers (Excluding Dissolved Acetylene Containers). Specification for Seamless Aluminium Alloy Containers of Water Capacity 0.5 Litres and Above

BS 5430-6 15-JUL-1994Periodic Inspection, Testing and Maintenance of Transportable Gas Containers (Excluding Dissolved Acetylene Containers). Specification for Seamless Steel and Aluminium Alloy Containers Having a Water Capacity of Less Than 0.5 Litre

BS 7320 Amendment 1 15-MAY-1994 Specification for Sharps Containers

BS 7864 1997 Specification for Plastics Containers for Surface Coatings

BS EN 20090-2 1993 Light Gauge Metal Containers - Definitions and Determination Methods for Dimensions and Capacities - Part 2: General Use Containers

BS EN 20090-2 Amendment 1 1-MAR-1993 Amendment 1 - Light Gauge Metal Containers - Definitions and Determination Methods for Dimensions and Capacities - Part 2: General Use Containers

BS EN 28362-1 1993 Injection Containers for Injectables and Accessories - Part 1: Injection Vials Made of Glass Tubing

BS EN 28362-2 1993 Injection Containers for Injectables and Accessories - Part 2: Closures for Injection Vials

BS EN 28362-3 1993 Injection Containers for Injectables and Accessories - Part 3: Aluminium Caps for Injection Vials

BS EN 28362-4 1993 Injection Containers for Injectables and Accessories - Part 4: Injection Vials Made of Moulded Glass

IP 230 /81 (87) Minimum handling and storage temperature of fuels.
Obsolete
Last edition printed: 1997

5.4 France

AFNOR NF M 88-610 1970 Petroleum Industry. Calibration Identification Plate for Containers

6. CAVERNS FOR LPG PRESSURISED STORAGE OR MINERAL OIL

6.1 United States of America

API 1114 1-JUN-1994
Design of Solution-Mined Underground Storage Facilities

API 1115 1-SEP-1994
Operation of Solution-Mined Underground Storage Facilities

6.2 United Kingdom

BS EN 1918-3 1998
Gas Supply Systems - Underground Gas Storage - Functional Recommendations for Storage in Solution-mined Salt Cavities

BS EN 1918-4 1998
Gas Supply Systems - Underground Gas Storage - Functional Recommendations for Storage in Rock Caverns

BS EN 1918-5 1998
Gas Supply Systems - Underground Gas Storage - Functional Recommendations for Surface Facilities

CAS Z341-98 1-DEC-1998
Storage of Hydrocarbons in Underground Formulations

7. Chemical Distribution – Standards, codes & regulations - A typical example in the UK

Series no	Title	Publ.	ISBN
	Chemical Industry:		
HSG71	Chemical warehousing – Storage of packaged dangerous substances (Revised)	1998	0 7176 1484 0
	Other Accident/Incident reports:		
	Fire & explosions at BandR Hauliers, Salford 25-9-82	1983	0 11 883702 8
	Fire at Allied Colloids, Bradford on 21 July 1992	1994	0 7176 0707 0
	Fire at Hickson and Welch	1994	0 7176 0702 X
	A report of the investigations into the fires and explosions at BP Oil, Grangemouth and Dalmeny, 13 and 22 March and 11 June 1987	1989	0 11 885493 3
	A report of the HSE investigation into the chemical release and fire at the Associated Octel Comp. Ltd.	1996	0 7176 0830 1
	The explosion and fires on the Pembroke Cracking Company plant at the Texaco refinery, Milford Haven on July 24 1994	1997	0 7176 1413 1
HSG51	The storage of flammable liquids in containers	1998	0 7176 1471 9
HSG135	Storage and handling of industrial nitrocellulose	1995	0 7176 0694 5
HSG71	Chemical warehousing – Storage of packaged dangerous substances (Revised)	1998	0 7176 1484 0
HSG158	Flame arresters – Preventing the spread of fires and explosions in equipment that contains flammable gases and vapours	1996	0 7176 1191 4
HSG176	The storage of flammable liquids in tanks	1998	0 7176 1470 0
HSG186	The bulk transfer of dangerous liquids and gases between ship and shore	1999	0 7176 1644 4
INDG230	Storage and handling ammonium nitrate	1996	Single copy available
CS3	Storage and use of sodium chlorate and other similar strong oxidants	1998	0 7176 1500 6
CS15	Cleaning and gas freeing of tanks containing flammable residues	1985	0 7176 1365 8
CS18	Storage and handling of ammonium nitrate	1986	0 11 883937 3
CS21	Storage and handling of organic peroxides	1991	0 7176 2403 X

Annex II.1 Dangerous substances and classification

[TETSP, 2001, 84]

Warning to the reader:
The contents of this annex reflects the status of the regulations at April 1st, 2001. This annex will need to be updated in the future according to the changes, which will occur to the regulation on classification of dangerous substances after this date.

SUBSTANCES AND CLASSIFICATION

1 Background

The classification of dangerous substances is the process of identifying their hazardous properties by using appropriate test methods, and allocating them to one or more hazard classes by comparing the results of the tests with the classification criteria. Preparations or mixtures may be classified either by testing or by applying calculation methods based upon the concentration of their hazardous components.

It should be noted that the classification systems described in this chapter do not necessarily cover all the criteria required for dangerous goods storage legislation in all Member States of the European Union. For example, in parts of Belgium, storage legislation covers flash points up to 250°C.

2 Regulatory Classification Systems

In Europe there are two main regulatory classification systems that provide information that may be relevant to the storage of dangerous goods and the nature of their hazards.

2.1 European Union Supply legislation

There are two primary Directives;

- 67/548/EEC – Dangerous Substances Directive as amended
- 1999/45/EC - Dangerous Preparations Directive as amended

A further relevant Directive is 91/155/EEC Safety Data Sheet Directive as amended.

2.2 Transport Legislation

The basis for transport legislation worldwide is the United Nations Recommendations on the Transport of Dangerous Goods (UN RTDG), commonly known as the “Orange Book”. These are recommendations, not regulations, and as such have no legal force. However they are implemented by international transport modal regulations as follows;

- Sea Global IMDG Code
- Air Global ICAO Technical Instructions
- Road Europe ADR Agreement
- Rail Europe RID Agreement

In Europe, ADR and RID are implemented at national level through the following Directives;

- Road: 94/55/EC on the approximation of the laws of the Member States with regard to the transport of dangerous goods by road. (ADR Framework Directive)
- Rail: 96/49/EC on the approximation of the laws of the Member States with regard to the transport of dangerous goods by rail. (RID Framework Directive)

As there are differences in the level of risk encountered in each transport mode, the international transport modal regulations do not fully replicate the UN RTDG. Therefore there are slight differences between them. For the purposes of this chapter, any references regarding transport are to the UN RTDG unless otherwise stated.

3 Scope of Regulatory Classification Systems

Classification systems classify dangerous goods into three distinct groups of hazards;

- Physico-Chemical Hazards
- Health Hazards
- Environmental Hazards

Within each of these groups of hazards, there are individual hazard classes and further differentiation into levels of hazard. The scope of the two regulatory systems differs.

3.1 European Supply system

The European Supply system classifies dangerous goods into the following hazard classes.

<u>Physico-Chemical Hazards</u>
- Explosive
- Oxidising
- Flammable

<u>Health Hazards</u>
- Acute toxicity - lethal and irreversible effects after a single exposure.
- Sub-acute, sub-chronic or chronic toxicity.
- Corrosive and irritant
- Sensitising
- Specific effects on health
  - Carcinogenicity
  - Mutagenicity
  - Reproductive toxicity

<u>Environmental Hazards</u>
- Aquatic environment
- Non-aquatic environment

Environmental Hazards for the non-aquatic environment includes substances listed in Annex I to Council Regulation (EC) No 2037/2000 on substances that deplete the ozone layer, and preparations containing them. Currently there are no classification criteria for Environmental Hazards for the non-aquatic environment in the primary Directives.

Annex V of the Dangerous Substances Directive 67/548/EEC contains the tests and procedures for classification.

There is differentiation into levels of hazard in a number of the hazard classes.

3.2 UN RTDG Transport system

The UN RTDG Transport system covers substances, mixtures (preparations) and also articles such as batteries (articles are not covered by the EU supply system). It deals with immediate hazards arising from a single exposure, and therefore health hazards in this system only include acute effects. All dangerous goods that are classified are assumed to be environmentally hazardous, but at present there are no separate criteria for this hazard. The ADR and RID modal regulations do contain criteria for aquatic toxicity that covers substances that are not otherwise classified. This is based on a subset of the EU supply criteria. The IMDG Code has its own system that can classify any substance as a severe marine pollutant or marine pollutant, but mixtures can only be classified as a marine pollutant. The UN RTDG Transport system also includes other hazards not covered by the EU supply system, i.e. gases that are compressed, liquefied, refrigerated or in solution, biological hazards and radioactive materials. The UN RTDG is also more comprehensive than the EU supply system in describing physico-chemical hazards.

The UN RTDG Transport system classifies into the following hazard classes and "Divisions" of hazard classes as follows;

Class 1 - Explosives

Division 1.1 Substances and articles, which have a mass explosion hazard
Division 1.2 Substances and articles, which have a projection hazard but not a mass explosion hazard;
Division 1.3 Substances and articles, which have a fire hazard and either a minor blast hazard or a minor projection hazard or both, but not a mass explosion hazard. This comprises substances and articles:
  (i) which give rise to considerable radiant heat; or
  (ii) which burn one after another, producing minor blast or projection effects or both;
Division 1.4 Substances and articles which present no significant hazard
Division 1.5 Very insensitive substances which have a mass explosion hazard
Division 1.6 Extremely insensitive articles which do not have a mass explosion hazard

Class 2 -Gases

Division 2.1 Flammable gases
Division 2.2 Non-flammable, non-toxic gases (includes oxidising gases)
Division 2.3 Toxic gases (includes corrosive gases)

Class 3 - Flammable liquids

Class 4 - Flammable solids; substances liable to spontaneous combustion; substances which, in contact with water, emit flammable gases

Division 4.1 Flammable solids, self-reactive and related substances and desensitised explosives
Division 4.2 Substances liable to spontaneous combustion
Division 4.3 Substances which in contact with water emit flammable gases

Class 5 - Oxidising substances and organic peroxides

Division 5.1 Oxidising substances
Division 5.2 Organic peroxides

Class 6 - Toxic and infectious substances

Division 6.1 Toxic substances
Division 6.2 Infectious substances

Class 7 - Radioactive material

Class 8 - Corrosive substances

Class 9 - Miscellaneous dangerous substances and articles (includes environmental hazards for dangerous goods not already classified in classes 1 to 8).

The UN RTDG Manual of Tests and Criteria contains the test methods, procedures and criteria for the classification of dangerous goods for transport.

In most hazard classes there is differentiation into hazard levels, called packing groups. Packing Groups are also used to determine the standard of packaging required, but because of the properties of explosives, self-reactive substances and organic peroxides, the packing group does not reflect the level of hazard of these.

4 Hazard Communication within Regulatory Classification Systems

Hazard Communication within the two main regulatory systems described in this chapter also differs.

In the EU supply system, the immediate hazard communication is by a label, and there are rules by which the requirements for most of the following label elements are determined;

- Chemical name of a substance or the trade name or designation of a preparation
- Chemical name of substances present in a preparation
- Danger symbol(s) (pictogram in a square box on an orange background)
- Indication(s) of danger
- Risk phrases (R phrases)
- Safety advice (S phrases)
- Nominal quantity (nominal mass or nominal volume) if for sale to the general public
- EC Number for substances
- Name, address and telephone number to contact for emergency information

In the EU supply system, more detailed information is contained in the safety data sheet. The Safety Data Sheet should always be considered as the primary source of hazard communication information for all purposes, and in particular storage.

In the UN RTDG, the label, UN number and proper shipping name on the packaging containing the dangerous goods provide the immediate information. The label is a diamond shape (a square on its point) containing a pictogram in the upper half. The colour of the label varies according to the hazard class. The IMDG Code has a marine pollutant label, a triangle (top half of the transport diamond) on a horizontal base. The UN RTDG lists UN Numbers and the rules for deriving the proper shipping name. The proper shipping name is usually the name of the chemical, or the main chemicals leading to the classification, but the European road and rail regulations, ADR and RID do not require this. In transport there are different means of providing the more detailed information, but ADR and RID usually provide it in the form of a TREMcard (TRansport EMergency card). Emergency services make use of the transport label and UN Number as a primary source of immediate information.

5 Physico-Chemical Hazards

5.1 Explosive Hazards

5.1.1 EU system

Explosives are assigned the danger symbol below and the indication of danger 'Explosive';

PICTURE

One of the following risk phrases is obligatory;

R2 Risk of explosion by shock, friction, fire or other sources of ignition
R3 Extreme risk of explosion by shock, friction, fire or other source of ignition

5.1.2 UN RTDG Transport System

Part I of the UN RTDG Manual of Tests and Criteria contains further tests, grouped into seven series, to determine the correct Division in Class 1 for explosives.

Explosives are defined as;

(a) Explosive substance is a solid or liquid substance (or a mixture of substances) which is in itself capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings. Pyrotechnic substances are included even when they do not evolve gases;
(b) Pyrotechnic substance is a substance or a mixture of substances designed to produce an effect by heat, light, sound, gas or smoke or a combination of these as the result of non-detonative self-sustaining exothermic chemical reactions;
(c) Explosive article is an article containing one or more explosive substances.

Substances classified as explosives of Divisions 1 to 3 are assigned a label containing a bomb symbol, and Substances of Divisions 4 to 6 are assigned a label without the "bomb" symbol, but containing the Division number as per the following label examples;

PICTURE

5.2 Oxidising and Organic Peroxide Hazards

5.2.1 EU system

This classification covers, organic peroxides, inorganic peroxides and other oxidising substances. For organic peroxides, the tests and criteria in Annex V of the Dangerous Substances Directive 67/548/EEC can be used to determine their explosive properties, but not their oxidising properties. Organic peroxide substances not classified as explosive are classified on the basis of their structure, and preparations are classified using a calculation method based on the percentage of active oxygen. Any organic peroxide or preparation is classified as oxidising, if the peroxide or its formulation contains:

- more than 5 % of organic peroxides, or
- more than 0.5 % available oxygen from the organic peroxides, and more than 5 % hydrogen peroxide.

They are assigned the danger symbol below and the indication of danger 'oxidising';

PICTURE\

One of the following risk phrases is obligatory;
R7 May cause fire
R8 Contact with combustible material may cause fire
R9 Explosive when mixed with combustible material

5.2.2 UN RTDG Transport System

The UN RTDG classifies Oxidising substances and Organic Peroxides separately.

(a) Division 5.1 *Oxidising substances*

These are defined as substances that, while in themselves are not necessarily combustible, may, generally by yielding oxygen, cause, or contribute to, the combustion of other material.

Classification distinguishes between Solids, Liquids and Gases. For Solids and Liquids only, three levels of hazard are differentiated. The Oxidising ability of gases is determined either by tests or by calculation methods adopted by ISO.

(b) Division 5.2 *Organic peroxides*

These are defined as Organic substances which contain the bivalent -0-0- structure and may be considered to be derivatives of hydrogen peroxide, where one or both of the hydrogen atoms have been replaced by organic radicals.

Organic peroxides are thermally unstable substances, which may undergo exothermic self-accelerating decomposition. In addition, they may have one or more of the following properties:

- (i) be liable to explosive decomposition;
- (ii) burn rapidly;
- (iii) be sensitive to impact or friction;
- (iv) react dangerously with other substances;
- (v) cause damage to the eyes.

Classification distinguishes between Solids and Liquids, and seven levels of hazard (Types A to G) are differentiated, but Type G is not regulated for transport.

Both Oxidising substances and Organic Peroxides of Types A to F are assigned the same label, which is a flame over an 'O';

PICTURE

Some Organic Peroxides may be subject to temperature control requirements or may have been desensitised by the use of compatible diluents, such as organic liquids or solids, inorganic solids or water so that in case of spillage or fire, the organic peroxide will not concentrate to a dangerous extent.

5.3 Flammability Hazards

5.3.1 EU system

Liquids

Classification differentiates into three hazard levels;

(a) Extremely flammable liquids having a flash point lower than 0°C and boiling point or initial boiling point lower than or equal to 35 °C.

They are assigned the symbol below and the indication of danger 'extremely flammable'

PICTURE

The following risk phrase is obligatory:- R12 Extremely flammable

(b) Highly flammable liquids having a flash point below 21°C and not classified as extremely flammable

They are assigned the symbol below and the indication of danger 'highly flammable';

PICTURE

The following risk phrase is obligatory:- R11 Highly flammable

(c) Flammable liquids having a flash point equal to or greater than 21 °C, and less than or equal to 55 °C. However, preparations do not have to be classified as flammable if the preparation does not support combustion and there is no reason to fear risks to those handling the preparations or to other persons.

There is no symbol or indication of danger.

The following risk phrases is obligatory:- R10 Flammable

Solids

There is a single hazard level for solids which may readily catch fire after brief contact with a source of ignition and which continue to burn or to be consumed after removal of the source of ignition.

They are assigned the symbol below and the indication of danger 'highly flammable';

PICTURE

The following risk phrase is obligatory:- R11 Highly flammable

Gases

There is a single hazard level for gases that are flammable in contact with air at ambient temperature and pressure.

They are assigned the symbol below and the indication of danger 'extremely flammable',

PICTURE

The following risk phrase is obligatory:- R12 Extremely flammable

Pyrophoric/Self Heating

There is a single hazard level for dangerous goods which may become hot and finally catch fire in contact with air at ambient temperature without any input of energy.

They are assigned the symbol below and the indication of danger 'highly flammable'

PICTURE

The following risk phrase is obligatory:- R17 Spontaneously flammable in air

Water Reactive evolving flammable gases

There is a single hazard level for water reactive dangerous goods that, in contact with water or damp air, evolve extremely flammable gases at a minimum rate of one litre per kilogram per hour.

They are assigned the symbol below and the indication of danger 'highly flammable';

PICTURE

The following risk phrase is obligatory:- R15 Contact with water liberates extremely flammable gases.

5.3.2 UN RTDG Transport System

Liquids

Flammable liquids are defined as liquids, or mixtures of liquids, or liquids containing solids in solution or suspension, e.g. paints, which give off a flammable vapour at temperatures of not more than 60.5 °C, closed-cup test, or not more than 65.6 °C, open-cup test, normally referred to as the flash point.

Classification differentiates into three hazard levels;

(a) High danger – Packing Group I

Flammable liquids having a boiling point or initial boiling point lower than or equal to 35°C.

(b) Medium danger – Packing Group II

Flammable liquids having a boiling point or initial boiling point greater than 35°C and a flash point below 23°C

(c) Low danger – Packing Group III

Flammable liquids having a boiling point or initial boiling point greater than 35°C, and a flash point equal to or greater than 23 °C, and less than or equal to 60.5°C. However, such liquids with a flash point of more than 35°C which do not sustain combustion may not have been classified as flammable liquids. Liquids are considered to be unable to sustain combustion (i.e. they do not sustain combustion under defined test conditions) if:

(i) They have passed a suitable combustibility test (see UN RTDG Manual of Tests and Criteria);
(ii) Their fire point according to ISO 2592:1973 is greater than 100 °C; or
(iii) They are water miscible solutions with a water content of more than 90 % by mass.

All hazard levels of flammable liquids are assigned the same label;

PICTURE

Note: In the UN RTDG due to various derogations, the packing group is not always a true guide as to the flammability or flash point range of preparations/mixtures for storage purposes.

A There are provisions in the UN RTDG allowing viscous liquid mixtures having a flash point of less than 23 °C to be placed in the low danger category, Packing Group III. This is usually on the basis of a combination of some of the following conditions;

- The viscosity expressed as the flow time in seconds;
- The closed-cup flash point;
- Less than 3 % of the clear solvent layer separates in a solvent separation test.
- No content of any substance classified for acute toxicity in Division 6.1 or corrosivity in Class 8

B In the UN RTDG, viscous preparations/mixtures in the low danger category, Packing Group III, may not have been regulated if;

- The flash point of 23 °C or above and less than or equal to 60.5 °C;
- They are not also classified for acute toxicity in Division 6.1 or corrosivity in Class 8;
- They contain not more than 20 % nitrocellulose provided the nitrocellulose contains not more than 12.6 % nitrogen by dry mass; and
- They are packed in receptacles of less than 450 l capacity;

And;

- Less than 3 % of the clear solvent layer separates in a solvent separation test.; and
- The flow time in the viscosity test with a jet diameter of 6 mm is equal to or greater than:
  (i) 60 seconds; or
  (ii) 40 seconds if the viscous preparations/mixture contains not more than flammable liquids

Note: These provisions are not applied consistently across all the modal regulations.

<u>**Solids**</u>

Flammable solids are defined as readily combustible solids which are powdered, granular, or pasty substances which are dangerous if they can be easily ignited by brief contact with an ignition source, such as a burning match, and if the flame spreads rapidly. The danger may come not only from the fire but also from toxic combustion products. Metal powders are especially dangerous because of the difficulty of extinguishing a fire since normal extinguishing agents such as carbon dioxide or water can increase the hazard.

Solids which may cause fire through friction are also defined as flammable solids and are classified by analogy with existing entries (e.g. matches).

Classification differentiates into two hazard levels;

(a) Medium danger – Packing Group II
(b) Low danger – Packing Group III

Both hazard levels of flammable solids are assigned the same label;

PICTURE

Gases

Flammable gases are defined as gases which at 20 °C and standard pressure of 101.3 kPa:
(i) are ignitable when in a mixture of 13 per cent or less by volume with air; or
(ii) have a flammable range with air of at least 12 percentage points regardless of the lower flammable limit.

Flammability is generally determined by tests or by calculation in accordance with methods adopted by ISO (see ISO 10156:1996). For transport this classification includes aerosols and small receptacles containing gas.

Hazard levels of gases are not differentiated. They are assigned the label below;

PICTURE

Self-Reactive and Related Substances

Self-reactive substances are defined as thermally unstable substances liable to undergo a strongly exothermic decomposition even without participation of oxygen. Substances are not considered to be self-reactive substances if:

- (i) they are explosives;
- (ii) they are oxidising;
- (iii) they are organic peroxides;
- (iv) their heat of decomposition is less than 300 J/g; or
- (v) the self-accelerating decomposition temperature is greater than 75°C for a 50kg package;

Substances related to self-reactive substances are defined as having a self-accelerating decomposition temperature greater than 75 °C. They can undergo a strongly exothermic decomposition and are liable, in certain packagings, to meet the criteria for explosives.

The decomposition of self-reactive substances can be initiated by heat, contact with catalytic impurities (e.g. acids, heavy-metal compounds, bases), friction or impact. The rate of decomposition increases with temperature and varies with the substance. Decomposition, particularly if no ignition occurs, may result in the evolution of toxic gases or vapours. For certain self-reactive substances, the temperature has to be controlled. Some self-reactive substances may decompose explosively, particularly if confined. This characteristic may be modified by the addition of diluents or by the use of appropriate packagings. Some self-reactive substances burn vigorously. Self-reactive substances are, for example, some compounds of the types listed below:

- Aliphatic azo compounds (-C-N=N-C-);
- Organic azides (-C-N3);
- Diazonium salts (-CN2+Z-);
- N-nitroso compounds (-N-N=O); and
- Aromatic sulphohydrazides (-SO2-NH-NH2).

Classification differentiates into seven levels of hazard (Types A to G), but Type G is not regulated for transport.

Types A to F are assigned the label below;

PICTURE

Some self-reactive substances may be desensitised through the use of a diluent. Diluents should not allow a self-reactive substance to concentrate to a dangerous extent in the event of leakage. The diluent has to be compatible with the self-reactive substance. Compatible diluents are those solids or liquids which have no detrimental influence on the thermal stability and hazard type of the self-reactive substance.

Some self-reactive substances may be subject to temperature control requirements. Liquid diluents in liquid formulations requiring temperature control have to have a boiling point of at least 60 °C and a flash point not less than 5 °C. The boiling point of the liquid has to be at least 50 °C higher than the control temperature of the self-reactive substance.

Desensitized explosives

Desensitized explosives are substances which are wetted with water or alcohols or are diluted with other substances to suppress their explosive properties.

They are assigned the label below;

PICTURE

Pyrophoric/Self Heating

Pyrophoric and self-heating substances are defined as;

(a) Pyrophoric substances are liquid or solid dangerous goods which even in small quantities ignite within five minutes of coming into contact with air. These are liable to spontaneous combustion;
(b) Self-heating substances are liquid or solid dangerous goods, other than pyrophoric substances, which in contact with air without energy supply are liable to self-heating. These substances will ignite only when in large amounts (kilograms) and after long periods of time (hours or days) and are called self-heating substances.

Self-heating of dangerous goods, leading to spontaneous combustion, is caused by reaction of the substance with oxygen and the heat developed not being conducted away rapidly enough to the surroundings. Spontaneous combustion occurs when the rate of heat production exceeds the rate of heat loss and the auto-ignition temperature is reached.

Classification differentiates into three hazard levels;

(a)	High danger	Packing Group I	Pyrophoric substances
(b)	Medium danger	Packing Group II	Self-heating substances
(c)	Low danger	Packing Group III	Self-heating substances

All hazard levels of Pyrophoric and Self-heating substances are assigned the same labels;

PICTURE

Water Reactive evolving flammable gases

These are defined as substances which in contact with water may emit flammable gases that can form explosive mixtures with air. Such mixtures are easily ignited by all ordinary sources of ignition, for example naked lights, sparking hand tools or unprotected light bulbs. The resulting blast wave and flames may endanger people and the environment.

Classification differentiates into three hazard levels based on the rate of evolution of the flammable gases;

(a) High danger Packing Group I

Evolution of flammable gases at a minimum rate of ten litres per kilogram per minute

(b) Medium danger Packing Group II

Evolution of flammable gases at a minimum rate of twenty litres per kilogram per hour
(c) Low danger Packing Group III

Evolution of flammable gases at a minimum rate of one litre per kilogram per hour

All hazard levels of these water reactive substances are assigned the same label;

PICTURE

5.4 Other Physico-Chemical properties

5.4.1 EU System

The EU system uses additional risk phrases that are applicable to dangerous goods, which are already classified. These risk phrases do not represent a classification. They are:

R1 Explosive when dry
For explosive dangerous goods put on the market in solution or in a wetted form, e.g. nitrocellulose with more than 12.6 % nitrogen.

R4 Forms very sensitive explosive metallic compounds
For dangerous goods which may form sensitive explosive metallic derivatives, e.g. picric acid, styphnic acid.

R5 Heating may cause an explosion
For thermally unstable dangerous goods not classified as explosive, e.g. perchloric acid > 50 %.

R6 Explosive with or without contact with air
For dangerous goods which are unstable at ambient temperatures, e.g. acetylene.

R7 May cause fire
For reactive dangerous goods, e.g. fluorine, sodium hydrosulphite.

R14 Reacts violently with water
For dangerous goods which react violently with water, e.g. acetyl chloride, alkali metals, titanium tetrachloride.

R16 Explosive when mixed with oxidising substances
For dangerous goods which react explosively with an oxidising agent, e.g. red phosphorus.

R18 In use, may form flammable/explosive vapour-air mixture
For preparations not classified as flammable, which contain volatile components which are flammable in air.

R19 May form explosive peroxides
For dangerous goods which may form explosive peroxides during storage, e.g. diethyl ether, 1,4-dioxan.

R30 Can become highly flammable in use
For preparations not classified as flammable, but which may become flammable due to the loss of non-flammable volatile components.

R44 Risk of explosion if heated under confinement
For dangerous goods not classified as explosive, but which may nevertheless display explosive properties in practice if heated under sufficient confinement. For example, certain substances which would decompose explosively if heated in a steel drum do not show this effect if heated in less-strong containers.

5.4.2 UN RTDG Transport System

Corrosivity to metal

Note: There is no equivalent criteria in the EU system.

This is defined as exhibiting a corrosion rate on steel or aluminium surfaces exceeding 6.25 mm a year at a test temperature of 55 °C.

For the purposes of testing steel, type P235 (ISO 9328 (II):1991) or a similar type, and for testing aluminium, non-clad types 7075-T6 or AZ5GU-T6 shall be used. An acceptable test is prescribed in ASTM G31-72 (Reapproved 1990).

Only one hazard level, Packing Group III is differentiated, which is assigned the same level as for Corrosive to living tissue;

PICTURE

Gases

The UN RTDG also classifies gases in other physical forms as listed below;

(a) Compressed gas - a gas (other than in solution) which when packaged under pressure for transport is entirely gaseous at 20 °C;
(b) Liquefied gas - a gas which when packaged for transport is partially liquid at 20 °C;
(c) Refrigerated liquefied gas - a gas which when packaged for transport is made partially liquid because of its low temperature; or
(d) Gas in solution - compressed gas which when packaged for transport is dissolved in a solvent.

The comprises of compressed gases; liquefied gases; gases in solution; refrigerated liquefied gases; mixtures of gases; mixtures of one or more gases with one or more vapours of substances of other classes; articles charged with a gas; tellurium hexafluoride; aerosols.

6 Health Hazards

6.1 Acute toxicity

6.1.1 EU System

Three routes of exposure are considered;

(i) Oral
(ii) Dermal
(iii) Inhalation

and these are differentiated into three levels of hazard;

(i) Very Toxic
(ii) Toxic
(iii) Harmful

Oral Toxicity

The criteria for the highest level of hazard, "Very Toxic", is;

- LD50 oral, rat < 25 mg/kg,
- less than 100 % survival at 5 mg/kg oral, rat by the fixed dose procedure, or high mortality at doses < 25 mg/kg oral, rat, by the acute toxic class method.

The following risk phrase is obligatory: R28 - Very toxic if swallowed

The criteria for the second level of hazard, "is;

- LD50 oral, rat: 25 < LD50 < 200 mg/kg,
- Discriminating dose, oral, rat, 5 mg/kg: 100 % survival but evident toxicity, or
- high mortality in the dose range > 25 to < 200 mg/kg oral, rat, by the acute toxic class method.

The following risk phrase is obligatory: R25 - Toxic if swallowed

There are two different criteria for the lowest level of hazard, which are;

(i) Acute Oral Toxicity

- LD50 per oral, rat: 200 < LD50 < 2000 mg/kg,
- discriminating dose, oral, rat, 50 mg/kg: 100 % survival but evident toxicity,
- less than 100 % survival at 500 mg/kg, rat oral by the fixed dose procedure., or
- high mortality in the dose range > 200 to < 2 000 mg/kg oral, rat, by the acute toxic class method.

The following risk phrase is obligatory: R22 - Harmful if swallowed

(ii) Aspiration Hazard
This is defined as liquid substances and preparations presenting an aspiration hazard in humans because of their low viscosity:

(a) For substances and preparations containing aliphatic, alicyclic and aromatic hydrocarbons in a total concentration equal to or greater than 10 % and having either

- a flow time of less than 30 sec. in a 3 mm ISO cup according to ISO 2431 (April 1996 / July 1999 edition) relating to 'Paints and varnishes - Determination of flow time by use of flow cups',

- a kinematic viscosity measured by a calibrated glass capillary viscometer in accordance with ISO 3104/3105 of less than 7 x 10-6 m^2/sec at 40° C (ISO 3104, 1994 edition, relating to 'Petroleum products - Transparent and opaque liquids - Determination of kinematic viscosity and calculation of dynamic viscosity'; ISO 3105, 1994 edition, relating to 'Glass capillary kinematic viscometers - Specifications and operating instructions'), or

- a kinematic viscosity derived from measurements of rotational viscometry in accordance with ISO 3219 of less than 7 x 10-6 m^2/sec at 40° C (ISO 3219, 1993 edition, relating to ‘Plastics – Polymers/resins in the liquid state or as emulsions or dispersions - Determination of viscosity using a rotational viscometer with defined shear rate’).

- Note that substances and preparations meeting these criteria need not be classified if they have a mean surface tension greater than 33mN/m at 25° C as measured by the du Nouy tensiometer or by the test methods shown in Annex V Part A.5.

(b) For substances and preparations, based on practical experience in humans.

The following risk phrase is obligatory: R65 - Harmful: may cause lung damage if swallowed

<u>Dermal Toxicity</u>

The criteria for the highest level of hazard, “Very Toxic”, is;

- LD50 dermal, rat or rabbit: < 50 mg/kg.

The following risk phrase is obligatory: R27 - Very toxic in contact with skin

The criteria for the second level of hazard, “Toxic”, is;

- LD50 dermal, rat or rabbit: 50 < LD50 < 400 mg/kg.

The following risk phrase is obligatory: R24 - Toxic in contact with skin

The criteria for the lowest level of hazard, “Harmful”, is;

- LD50 dermal, rat or rabbit: 400 < LD50 < 2 000 mg/kg.

The following risk phrase is obligatory: R21 - Harmful in contact with skin

<u>Inhalation Toxicity</u>

The criteria for the highest level of hazard, “Very Toxic”, is;

- LC50 inhalation, rat, for aerosols or particulates: < 0.25 mg/litre/4hr,
- LC50 inhalation, rat, for gases and vapours: < 0.5 mg/litre/4hr.

The following risk phrase is obligatory: R26 - Very toxic by inhalation

The criteria for the second level of hazard, “Toxic”, is;

- LC50 inhalation, rat, for aerosols or particulates: 0.25 < LC50 < 1 mg/litre/4hr,
- LC50 inhalation, rat, for gases and vapours: 0.5 < LC50 < 2 mg/litre/4hr.

The following risk phrase is obligatory: R23 - Toxic by inhalation

The criteria for the lowest level of hazard, “Harmful”, is;

- LC50 inhalation, rat, for aerosols or particulates: 1 < LC50 < 5 mg/litre/4hr,
- LC50 inhalation, rat, for gases or vapours: 2 < LC50 < 20 mg/litre/4hr.

The following risk phrase is obligatory: R20 - Harmful by inhalation

Acute Health Effects are assigned danger symbols and indications of danger as below;

Hazard Level 1 is assigned the indication of danger 'Very Toxic' and the danger symbol;

PICTURE

Hazard Level 2 is assigned the indication of danger 'Toxic' and the danger symbol;

PICTURE

Hazard Level 3 is assigned the indication of danger 'Harmful' and the danger symbol;

PICTURE

6.1.2 UN RTDG Transport System

The UN Transport system only classifies dangerous goods as posing health hazards when the effect is from a single exposure. Toxic dangerous goods are defined as substances liable either to cause death or serious injury or to harm human health if swallowed or inhaled or by skin contact. Except for Gases, these are differentiated into three levels of hazard.

Packing Group I	Substances and preparations presenting a very severe toxicity risk;
Packing Group II	Substances and preparations presenting a serious toxicity risk;
Packing Group III	Substances and preparations presenting a relatively low toxicity risk.

For inhalation toxicity, vapours, dusts and mists (Division 6.1) are treated differently to gases (Division 2.3).

<u>Oral Toxicity</u>

The criteria for classification are currently;

Packing Group I	LD50 < 5 mg/kg
Packing Group II	5 < LD50 < 50 mg/kg
Packing Group III, Solids	50 < LD50 < 200 mg/kg
Packing Group III, Liquids	50 < LD50 < 500 mg/kg

<u>Dermal Toxicity</u>

The criteria for classification are currently;

Packing Group I	LD50 < 40 mg/kg
Packing Group II	40 < LD50 < 200 mg/kg
Packing Group III, Solids	200 < LD50 < 1000 mg/kg

<u>Inhalation Toxicity – Dusts and Mists</u>

The criteria for classification are currently;

Packing Group I	LC50 < 0.5 mg/litre/1hr
Packing Group II	0.5 < LC50 < 2 mg/litre/1hr
Packing Group III, Solids	2 < LC50 < 10 mg/litre/1hr

Whereas the corresponding EU supply criteria is based on 4 hour exposure figures, the corresponding UN RTDG, criteria for inhalation toxicity of dusts and mists are based on LC50 data relating to 1 hour exposures. Where only LC50 data relating to 4 hours exposures are available, these figures are multiplied by four and the product substituted in the above criteria, i.e. LC50 (4 hours) × 4 is considered the equivalent of LC50 (1 hour).

Inhalation Toxicity –Vapours

In the UN RTDG system the volatility of liquids is taken into account in the classification criteria. Liquids having toxic vapours are assigned to the following packing groups, where "V" is the saturated vapour concentration in millilitres per cubic metre of air at 20 °C and at standard atmospheric pressure:

Packing Group I:	If V > 10 LC50 and LC50 < 1,000 ml/m^3;
Packing Group II:	If V > LC50 and LC50 < 3,000 ml/m^3, and not meeting the criteria for Packing Group I;
Packing Group III:	If V > 1/5 LC50 and LC50 < 5,000 ml/m^3, and not meeting the criteria for Packing Groups I or II.

Whereas the corresponding EU supply criteria is based on mg/litre 4 hour exposure figures, the corresponding UN RTDG, criteria for inhalation toxicity of vapours are based on LC50 data relating to 1 hour exposures expressed as millilitres per cubic metre. Where only LC50 data relating to 4 hours exposures are available, these figures are multiplied by two and the product substituted in the above criteria, i.e. LC50 (4 hours) × 2 is considered the equivalent of LC50 (1 hour).

Inhalation Toxicity –Gases

There is no differentiation into hazard levels and the criteria covers when the LC50 value is equal to or less than 5,000 ml/m^3 (ppm)

Hazard Communication for Toxic Substances in the UN RTDG

All physical states and hazard levels of toxic dangerous goods are assigned the same label;

PICTURE

6.2 Sub-Acute, Sub-Chronic or Chronic Toxicity

Note: These hazards are not covered in the UN RTDG Transport system

6.2.1 Very Serious Irreversible Effects by a Single Exposure

Three routes of exposure are considered;

(i) Oral
(ii) Dermal
(iii) Inhalation

and these are differentiated into three levels of hazard;

(i) Very Toxic
(ii) Toxic
(iii) Harmful

The criteria is that there is strong evidence that irreversible damage other than Carcinogenic, Mutagenic or Reproductive Toxic effects are likely to be caused by a single exposure by an appropriate route, generally in the same dose range as the equivalent for Acute Toxicity.

The following risk phrases are obligatory;

For Hazard Level one “Very Toxic” and Hazard Level two “Toxic”;

R39; Danger of very serious irreversible effects.

For Hazard Level three “Harmful”;

R40 (R68 from 30/07/2002); Possible risk of irreversible effects

In order to indicate the route of exposure, these risk phrases are used in combinations with the relevant Acute Toxicity risk phrase(s): R39/26, R39/27, R39/28, R39/26/27, R39/26/28, R39/27/28, R39/26/27/28, R39/23, R39/24, R39/25, R39/23/24, R39/23/25, R39/24/25, R39/23/24/25, R40/20, R40/21, R40/22, R40/20/21, R40/20/22, R40/21/22, R40/20/21/22.

Hazard Level 1 is assigned the indication of danger ‘Very Toxic’, and Hazard Level 2 is assigned the indication of danger ‘Toxic’ and both are assigned the danger symbol;

PICTURE

Hazard Level 3 is assigned the indication of danger ‘Harmful’, and the danger symbol;

PICTURE

6.2.1 Very Serious Irreversible Effects by Repeated or Prolonged Exposure

Three routes of exposure are considered;

(i) Oral
(ii) Dermal
(iii) Inhalation

and these are differentiated into two levels of hazard;

(i) Toxic
(ii) Harmful

The criteria is that there is serious damage (clear functional disturbance or morphological change which have toxicological significance) that is likely to be caused by repeated or prolonged exposure by an appropriate route.

Classification is as harmful when these effects are observed at levels of the order of:

Oral, rat < 50 mg/kg (bodyweight)/day,
Dermal,rat or rabbit < 100 mg/kg (bodyweight)/day,
Inhalation, rat < 0.25 mg/l, 6h/day.

These guide values are applied directly when severe lesions have been observed in a sub-chronic (90 days) toxicity test. When the results of a sub-acute (28 days) toxicity test have been used these figures are increased approximately three fold. If chronic (two years) toxicity test is available they are evaluated on a case-by-case basis. If results of studies of more than one

duration are available, then those from the study of the longest duration are normally used. Classification is as at least as toxic when these effects are observed at levels of one order of magnitude lower (i.e. 10-fold) than those for Harmful.
The following risk phrases are obligatory;

For both Hazard Levels, the following risk phrase is obligatory;
R48 Danger of serious damage to health by prolonged exposure

In order to indicate the route of exposure, these risk phrases are used in combinations with the relevant Acute Toxicity risk phrase(s): R48/23, R48/24, R48/25, R48/23/24, R48/23/25, R48/24/25, R48/23/24/25, R48/20, R48/21, R48/22, R48/20/21, R48/20/22, R48/21/22, R48/20/21/22..

The highest hazard level is assigned the indication of danger 'Toxic' and the danger symbol;

PICTURE

The lowest hazard level is assigned the indication of danger 'Harmful', and the danger symbol;

PICTURE

6.3 Corrosive and Irritant

Note: The UN RTDG Transport system only covers Corrosive effects

6.3.1 EU System - Corrosive

Corrosive is defined as being if during the test when applied to healthy intact animal skin, full thickness destruction of skin tissue on at least one animal is produced.

Two levels of hazard are differentiated.

The criteria for the most severe hazard level is if, when applied to healthy intact animal skin, full thickness destruction of skin tissue occurs as a result of up to three minutes exposure.

The following risk phrase is obligatory:- R35, Causes severe burns

The criteria for the less severe hazard level is if, when applied to healthy intact animal skin, full thickness destruction of skin tissue occurs as a result of up to four hours exposure.

The following risk phrase is obligatory:- R34 Causes burns

Both hazard levels are assigned the indication of danger 'Corrosive' and the danger symbol;

PICTURE

6.3.2 UN RTDG Transport System

Corrosive dangerous goods are defined as substances which, by chemical action, will cause severe damage when in contact with living tissue.

Note: Although the definition refers to destruction of living tissue, the criteria only refers to destruction of skin tissue. Refer to Physico-Chemical Hazards for Corrosivity to metal.

Three levels of hazard are differentiated.

Packing Group I	is assigned to substances that cause full thickness destruction of intact skin tissue within an observation period up to 60 minutes starting after the exposure time of three minutes or less;
Packing Group II	is assigned to substances that cause full thickness destruction of intact skin tissue within an observation period up to 14 days starting after the exposure time of more than three minutes but not more than 60 minutes;
Packing Group III	is assigned to substances that cause full thickness destruction of intact skin tissue within an observation period up to 14 days starting after the exposure time of more than 60 minutes but not more than 4 hours;

The following label is assigned

PICTURE

6.3.3 EU System - Irritant

Skin

Dangerous goods are considered to be Irritant if they cause significant inflammation of the skin which persists for at least 24 hours after an exposure period of up to four hours determined on the rabbit according to the cutaneous irritation test method, or if they cause significant inflammation of the skin, based on practical observations in humans on immediate, prolonged or repeated contact.

The following risk phrase is obligatory:- R38, Irritating to skin

Eyes

Two hazard levels are differentiated.

(i) Serious damage to eyes (higher hazard level)
(ii) Irritating to eyes (lower hazard level)

Dangerous goods are classified if, when applied to the eye of the animal, cause significant ocular lesions which occur within 72 hours after exposure and which persist for at least 24 hours, or if they cause significant ocular lesions, based on practical experience in humans.

Note: When a substance or preparation is classified as corrosive and assigned R34 or R35, the risk of severe damage to eyes is considered implicit and R41 is not included in the label.

The following risk phrases are obligatory:

(i) (higher hazard level) R41, Risk of serious damage to eyes

(ii) (higher hazard level) R36, Irritating to eyes

Respiratory System

A single hazard level is differentiated.

Dangerous goods are classified based on:

- practical observation in humans
- positive results from appropriate animal tests.

The following risk phrase is obligatory: R37, Irritating to respiratory system

All these Hazard levels and routes of exposure hazard levels are assigned the indication of danger 'Irritant' and the danger symbol;

PICTURE

6.4 Sensitisation

Note: These hazards are not covered in the UN RTDG Transport system

Sensitisation by inhalation

A single hazard level is differentiated.

Dangerous goods are classified as sensitising by inhalation;

- if there is evidence that they can induce specific respiratory hypersensitivity;
- where there are positive results from appropriate animal tests; or
- if it is an isocyanate, unless there is evidence that the specific isocyanate does not cause respiratory hypersensitivity

Evidence that the dangerous good can induce specific respiratory hypersensitivity will normally be based on human experience. In this context hypersensitivity is normally seen as asthma, but other hypersensitivity reactions such as rhinitis and alveolitis are also considered. The condition will have the clinical character of an allergic reaction. However, immunological mechanisms do not have to be demonstrated.

The following risk phrase is obligatory: R42, May cause sensitisation by inhalation

This is assigned the indication of danger 'Harmful', and the danger symbol;

PICTURE

Sensitisation by skin contact

A single hazard level is differentiated.

Dangerous goods are classified as sensitising by skin contact;

- if practical experience shows the dangerous goods to be capable of inducing a sensitisation by skin contact in a substantial number of persons, or
- where there are positive results from an appropriate animal test.

The following risk phrase is obligatory: R43, may cause sensitisation by skin contact

This is assigned the indication of danger 'Irritant', and the danger symbol;

PICTURE

6.5 Specific Effects on Health

Note: These hazards are not covered in the UN RTDG Transport system

These are commonly known as CMR (Carcinogenic, Mutagenic and Reproductive Toxic) effects. Each are differentiated into three levels of hazard. For the purpose of classification and labelling, and having regard to the current state of knowledge, they are divided into three categories. The placing into Category 1 is done on the basis of epidemiological data; placing into Categories 2 and 3 is based primarily on animal experiments.

Category 1 Known to be CMR to man. There is sufficient evidence to establish a causal association between human exposure to a substance and the development of CMR effects.

Category 2 Should be regarded as if they are CMR to man. There is sufficient evidence to provide a strong presumption that human exposure may result in the development of CMR effects, generally on the basis of:
- appropriate long-term animal studies,
- other relevant information.

Category 3 Cause concern for man owing to possible CMR effects but in respect of which the available information is not adequate for making a satisfactory assessment. There is some evidence from appropriate animal studies, but this is insufficient to place the substance in Category 2.

Carcinogenic

The following risk phrases are obligatory:

(i) (Category 1 & 2) R45, May cause cancer; or R49, May cause cancer by inhalation

(ii) (Category 3) R40, Possible risk of irreversible effects (from 30/07/2002 R40, Limited evidence of a carcinogenic effect)

Mutagenic

The following risk phrases are obligatory:

(i) (Category 1 & 2) R46, May cause heritable genetic damage

(ii) (Category 3) R40, Possible risk of irreversible effects (from 30/07/2002 R68).

Reproductive Toxic

Reproductive toxic effects are considered for two different types of effects;

- Fertility
- Development

The following risk phrases are obligatory:

Fertility

(i) (Category 1 & 2) R60. May impair fertility

(ii) (Category 3) R62, Possible risk of impaired fertility.

Development

(i) (Category 1 & 2) R61, May cause harm to the unborn child

(ii) (Category 3) R63, Possible risk of harm to the unborn child.

Dangerous goods which are classified as toxic to reproduction and which also cause concern due to their effects on lactation are in addition labelled with R64.
For each CMR effect of category 1 and 2 the following danger symbol is assigned;

PICTURE

For each CMR effect of category 3 the following danger symbol is assigned;

PICTURE

6.6 Other Health Effects

6.6.1 EU System

The EU system uses additional risk phrases that are applicable to dangerous goods, which are already classified. These risk phrases do not represent a classification. They are:

R29 Contact with water liberates toxic gas
For dangerous goods which in contact with water or damp air, evolve very toxic/toxic gases in potentially dangerous amounts.

R31 Contact with acids liberates toxic gas
For dangerous goods which react with acids to evolve toxic gases in dangerous amounts.

R32 Contact with acids liberates very toxic gas
For dangerous goods which react with acids to evolve very toxic gases in dangerous amounts.

R33 Danger of cumulative effects
For dangerous goods when accumulation in the human body is likely and may cause some concern.

R64 May cause harm to breastfed babies
For dangerous goods which are absorbed by women and may interfere with lactation or which may be present (including metabolites) in breast milk in amounts sufficient to cause concern for the health of a breastfed child.

R66 Repeated exposure may cause skin dryness or cracking
For dangerous goods which may cause concern as a result of skin dryness, flaking or cracking but which do not meet the criteria for R38 based on either:

- practical observation after normal handling and use, or
- relevant evidence concerning their predicted effects on the skin.

R67 Vapours may cause drowsiness and dizziness
For volatile dangerous goods containing substances which cause clear symptoms of central nervous system depression by inhalation and which are not already classified with respect to acute inhalation toxicity (R20, R23, R26, R68/20, R39/23 or R39/26).

6.6.2 UN RTDG Transport System

The UN RTDG system classifies hazards that are not covered under the two prime EU Directives.

Division 6.2 Infectious substances

Infectious substances are defined as those substances known or reasonably expected to contain pathogens. Pathogens are defined as micro-organisms (including bacteria, viruses, rickettsia,

parasites, fungi) or recombinant micro-organisms (hybrid or mutant), that are known or reasonably expected to cause infectious disease in animals or humans.
They are classified on the basis of their allocation to one of three risk groups based on criteria developed by the World Health Organisation (WHO) and published in the WHO "Laboratory Biosafety Manual, second edition (1993)".

Class 7 Radioactive Materials

Radioactive materials are defined as any material containing radionuclides where both the activity concentration and the total activity in the consignment exceed the values specified in paragraphs 401-406 of the Regulations for the Safe Transport of Radioactive Material, (1996 Edition) IAEA Safety Standards Series No.ST-1.

7 Environmental Hazards

7.1 EU System

Aquatic Toxicity

Substances classification is usually on the basis of experimental data for acute aquatic toxicity, degradation, and log Pow (or BCF if available). Classification of preparations is normally made by a calculation method based on the individual concentration limits of the components.

Classification differentiates into three hazard levels;

(a) Very Toxic

(i) acute aquatic toxicity criteria is

Acute Toxicity 96 hr LC50 (for fish) < 1 mg/l, or
Acute Toxicity 48 hr EC50(for Daphnia) < 1 mg/l, or
Acute Toxicity 72 hr IC50(for algae) < 1 mg/l

The following risk phrase is obligatory: - R50, Very toxic to aquatic organisms

(ii) acute/chronic aquatic toxicity

Acute Toxicity	96 hr LC50 (for fish)	< 1 mg/l, or
Acute Toxicity	48 hr EC50 (for Daphnia)	< 1 mg/l, or
Acute Toxicity	72 hr IC50 (for algae)	< 1 mg/l

and

- the substance is not readily degradable, or
- the log Pow (log octanol/water partition coefficient) > 3.0 (unless the experimentally determined BCF < 100).

The following risk phrases are obligatory:
- R50, Very toxic to aquatic organisms; and
- R53, May cause long-term adverse effects in the aquatic environment

They are assigned the symbol below and the indication of danger ‘Dangerous for the environment’.

PICTURE

(b) Toxic - acute/chronic aquatic toxicity

Acute Toxicity	96 hr LC50 (for fish)	1 mg/l < LC50 < 10 mg/l, or
Acute Toxicity	48 hr EC50 (for Daphnia)	1 mg/l < EC50 < 10 mg/l, or
Acute Toxicity	72 hr IC50 (for algae)	1 mg/l < IC50 < 10 mg/l

and

- the substance is not readily degradable, or
- the log Pow (log octanol/water partition coefficient) > 3.0 (unless the experimentally determined BCF < 100).

The following risk phrases are obligatory:
- R51, Toxic to aquatic organisms; and
- R53, May cause long-term adverse effects in the aquatic environment

They are assigned the symbol below and the indication of danger 'Dangerous for the environment'.

PICTURE

(c) Harmful

(i) acute aquatic toxicity criteria is

Substances not falling under the criteria listed above, but which on the basis of the available evidence concerning their toxicity may nevertheless present a danger to the structure and/or functioning of aquatic ecosystems.

The following risk phrase is obligatory: R52, Harmful to aquatic organisms

(ii) acute/chronic aquatic toxicity

Acute Toxicity	96 hr LC50 (for fish)	10 mg/l < LC50 < 100 mg/l, or
Acute Toxicity	48 hr EC50 (for Daphnia)	10 mg/l < EC50 < 100 mg/l, or
Acute Toxicity	72 hr IC50 (for algae)	10 mg/l < IC50 < 100 mg/l

and

the substance is not readily degradable

This criterion applies unless there exists additional scientific evidence concerning degradation and/or toxicity sufficient to provide an adequate assurance that neither the substance nor its degradation products will constitute a potential long-term and/or delayed danger to the aquatic environment.

The following risk phrases are obligatory:
- R52, Harmful to aquatic organisms; and
- R53, May cause long-term adverse effects in the aquatic environment

(iii) chronic aquatic toxicity

Substances not falling under the criteria listed above in this chapter, but which, on the basis of the available evidence concerning their persistence, potential to accumulate, and predicted or observed environmental fate and behaviour may nevertheless present a long-term and/or delayed danger to the structure and/or functioning of aquatic ecosystems.

The following risk phrase is obligatory: R53, May cause long-term adverse effects in the aquatic environment

Non-Aquatic Toxicity

Dangerous goods are classified on the basis of the available evidence concerning their toxicity, persistence, potential to accumulate and predicted or observed environmental fate and behaviour may present a danger, immediate or long-term and/or delayed, to the structure and/or functioning of natural ecosystems. Detailed criteria is to be elaborated later.

One or more of the following risk phrases is obligatory as appropriate;

R54 Toxic to flora
R55 Toxic to fauna
R56 Toxic to soil organisms
R57 Toxic to bees
R58 May cause long-term adverse effects in the environment

Similarly regarding danger for the atmosphere, dangerous goods are classified on the basis of the available evidence concerning their properties and their predicted or observed environmental fate and behaviour may present a danger to the structure and/or the functioning of the stratospheric ozone layer. This includes the substances which are listed in Annex I to Council Regulation (EC) No 2037/2000 on substances that deplete the ozone layer (OJ No L 244, 29.9.2000, p.1) and its subsequent amendments.

The following risk phrases is obligatory: - R59, Dangerous for the ozone layer.

All of these are assigned the symbol below and the indication of danger ‘Dangerous for the environment’.

PICTURE

7.2 UN RTDG Transport System

Currently the UN RTDG has no criteria for environmentally hazardous dangerous goods, although there is a placeholder for them in Class 9 of the UN RTDG. In Europe the road and rail transport regulations classify for environmental hazards utilising the very toxic and toxic hazard levels from the EU system. This applies to substances and mixtures that are not otherwise classified for transport. The UN RTDG Class 9 label is used to communicate this hazard.

For sea transport, the IMDG Code classifies substances as either severe marine pollutants or marine pollutants, but mixtures can only classified as marine pollutants based on a content of 1 % or more of severe marine pollutants or 10 % or more of marine pollutants. The IMDG Code system applies irrespective of whether the substances or mixtures are already classified for transport or not. This is essentially not a self-classification system for substances as IMO has a group of scientific experts, GESAMP, who have overall responsibility for the criteria and substance classifications. The label that is used is reproduced below (Note: in IMDG parlance this is called a mark rather than a label).

PICTURE

Annex II.2 Dispersiveness classes of solid bulk materials

Substances specifications	Dispersiveness class
Abbrände (pyrietas)	S1
Aluinaarde	S1
Bariet	S3
Bariet (gemalen)	S1
Bauxiet	
China gecalcineerd	S4
Gecalcineerd	S4
Gove	S4
Sherbo rivier	S4
Weipa	S4
Bimskies	S4
Borax	S3
Bruinsteen	S2
Calcium Carbid	S1
Carborundum	S5
Cement	S1
Klinker	S4
Cokes	
Steenkoolcokes	S4
Petroleumcokes, grof	S4
Petroleumcokes, fijn	S2
Petroleumcokes, gecalcineerd	S1
fluid cokes	S1
Derivates and related substances	
Aardappelmeel	S1
Aardappelschijfjes	S3
Alfalfapellets	S3
Amandelmeel	S3
Appelpulppellets	S3
Babassupellets	S3
Babassuschroot	S3
Beendermeel	S1
Beenderschroot	S3
Bierbostelpellets	S3
Bladmeelpellets	S3
Boekweitmeel	S1
Corndistillergrainpellets	S3
Corndistillergrainmeel	S3
Corncobpellets	S3
Cornplantpellets	S3
Citruspellets	S3
D.F.G. pellets (maiskiempellets)	S3
Gerstemeel	S1
Gerstpellets	S3
Derivates and related substances (continued)	
Grondnoten	S3
Grondnotenpellets	S3
Grondnotenschroot	S3
Quarbeanmealpellets	S3
Quarbeanmeal	S3

Havermeel	S1
Haverpellets	S3
Hominecychoppellets	S3
Hominecychopmeel	S3
Katoenzaadpellets	S3
Katoenzaadschroot	S3
Kapokzaadpellets	S3
Kapokzaadschroot	S3
Kardizaadschroot	S3
Koffiepulppellets	S3
Kopra	S3
Kopracakes	S3
Koprachips	S3
Koprapellets	S3
Kopraschroot	S3
Lijnzaadpellets	S3
Lijnzaadschroot	S3
Lucernepellets	S3
Macojapellets	S3
Macojaschroot	S3
Macunameel	S3
Maisglutenpellets	S3
Maisglutenmeel	S3
Maismeel	S1
Maltsproutpellets	S3
Mangopellets	S3
Mangoschroot	S1
Maniokpellets, hard	S3
Maniokwortel	S3
Mengvoederpellets	S3
Millrunpellets	S3
Miloglutenpellets	S3
Milomeel	S3
Moutkiempellets	S3
Negerzaadpellets	S3
Negerzaadschroot	S3
Olijfpulppellets	S3
Olijfschroot	S3
Palmpitten	S3
Palmpittenpellets	S3
Palmpittenschroot	S3
Palmpittencakes	S3
Peanuthullpellets	S3
Pine-applepellets	S3
Derivates and related substances (continued)	
Pollardpellets	S3
Raapzaadpellets	S3
Raapzaadschroot	S3
Ricehullpellets	S3
Ricehuspellets	S3
Ricebran	S1
Roggemeel	S1
Roggepellets	S3
Safflowerzaadpellets	S3
Safflowerzaadschroot	S3

Salseedextractionpellets	S3
Salseedschroot	S1
Sesamzaadpellets	S3
Sesamzaadschroot	S3
Soiulacpellets	S3
Sorghumzaadpellets	S3
Sojapellets	S3
Sojachips	S3
Sojameel	S3
Sojaschroot	S3
Splentgrainpellets	S3
Suikerbietenpulppellets	S3
Suikerrietpellets	S3
Sweetpotatopellets	S3
Tapiochips	S1
Tapiocabrokjes	S1
Tapiocapellets, hard	S3
Tapiocapellets, natives	S1
Tarwemeel	S1
Tarwepellets	S3
Theepellets	S3
Tucumschroot	S3
Veevoederpellets	S3
Zonnebloemzaadpellets	S3
Zonnebloemzaadschroot	S3
Dolomiet Brokken Gemalen	 S5 S1
Ore Amarilore, brokken Chroomore Ijzerore Koperore Loodore Mangaanore Tantalietore Titaanore Zinkblende	 S5 S4 see:ljzerore S4 S2 S5* S4 see: Titaan S4
Ferrochroom brokken	S5
Ferrofosfor, brokken	S5
Ferromangaan, brokken	S5
Ferrosilicium, brokken	S5
Fosfaat	S4
Fosfaat	S1
Gips	S3
Glasafval	S5

Graan	
Boekweit	S3
Gerst	S3
Gort	S3
Haver	S3
Haversereenings	S3
Kaficorn	S3
Lijnzaadscreenings	S3
Mais	S3
Milicorn	S3
Mout	S3
Raapzaadscreenings	S3
Ricehusk	S3
Rogge	S3
Rijst	S3
Sojagrits	S3
Sorghumzaad	S3
Tarwe	S3
Grind	S5
Hooovenslakken	S4
Huisvuil	…
IJzerore	
Beeshoek, fijn ore	S5*
Beeshoek, stuk ore	S5*
Bomi Hill, stuk ore	S4
Bong Range pellets	S5*
Bong Range concentraat	S4**
Braz. Nat. ore	S4
Carol Lake pellets	S5*
Carol Lake concentraat	S4**
Cassinga, fijn ore	S4
Cassinga, stuk ore	S5*
Cassinga pellets	S5
Cerro Bolivar ore	S4
Coto Wagner ore	S5**
Dannemora ore	S4
El Pao, fijn ore	S4
Fabrica pellets	S5*
Fabrica Sinter Feed	S5
Fabrica Special pellet ore	S5
F'Derik Ho	S4
Fire Lake pellets	S5*
Grängesberg ore	S4
Hamersley Pebble	S5*
Ilmeniet ore	S5
Itabira Special sinter feed	S5
Itabira Run of Mine	S5*
Kiruna B, fijn ore	S5
Kiruna pellets	S5*
Malmberg pellets	S5
Manoriver Ho	S4
Menera, fijn ore	S5
Mount Newman pellets	S4
Migrolite	S4
Mount Wright concentraat	S4**
Niniba, fijn ore	S5
Nimba ore	S4

Pyriet ore	S4
Robe River, fijn ore	S5*
Samarco pellets	S5*
Sishen, stuk ore	S5*
Sishen, fijn ore	S5*
Svappavaara ore	S4
Svappavaara pellets	S4
Sydvaranger pellets	S5*
Tazadit, fijn ore	S5*
Kalkzout	S5
Kalk	
Brokken	S5
Gemalen	S1
Klei	
Bentoniet, brokken	S3
Bentoniet, gemalen	S1
Chamotte klei, brokken	S4
Chamotte klei, gemalen	S1
Kaoline (China)klei, brokken	S3
Kaoline (China)klei, gemalen	S1
Kolen	
Bruinkool, briketten	S4
Poederkolen	S1
Kolen	S4
Kolen	S2
Antraciet	S2
Kunstmest	
Ammonsulfaatsalpeter	S3
Diamfosfaat	S1
Dubbelsuperfosfaat, Poeder	S1
Dubbelsuperfosfaat, korrels	S3
Kalkammon-salpeter	S3
Tripelsuperfosfaat, poeder	S1
Zwavelzure ammoniak	S3
Kyaniet	S4
Neveline	S1
Olivin steen	S4
Ongebluste kalk	S1
Peulvruchten	
Bonen	S3
Erwten	S3
Guarsplit	S3
Linzen	S3
Lupinezaad	S3
Paardebonen	S3
Sojabonen	S3
Sojabeanhusk	S3
Sojascreenings	S3
Wikken	S3
Piekijzer	S4
Pyrietas	S2
Polymeersubstancesen	
Kunststofpoeder	S1
Potas	S3
Puimsteen	S5
Roet	S1

Schroot, metaal	S4
Sillimaniet	S5
Sintels, slakken	S4
Sintermagnesiet	S3
Soda	S3
Stuiker	S3
Talk	
Gemalen	S1
Gebroken	S3
Tapioca	see: Derivaten
Titaan	
Ilmeniet	S5
Rutiel	S3
Rutielzand	S3
Rutielslakken	S5
Toonaarde	See: Aluinaarde
Ureum	S3
Vanadiumslakken	S2
Veltspaat	S5
Vermiculiet	
Brokken	S3
Gemalen	S1
Vliegas	S2
Vloeispaat	S5
Wolastonie	S5
Wegenzout	S5
Seeds and related substances	
Darizaad	S3
Kanariezaad	S3
Kardizaad	S3
Koolzaad	S3
Lijnzaad	S3
Maanzaad	S3
Millietzaad	S3
Mosterdzaad	S3
Negerzaad	S3
Paricumzaad	S3
Raapzaad	S3
Safflowerzaad	S3
Sesamzaad	S3
Tamarinzaad	S3
Zonnebloemzaad	S3
Zand	
Fijn zand	S3
Grof zand	S4
Olivin zand	S4
Rutielzand	see: Titaan
Zilverzand	S1
Zirconzand	S3
Zwaarspaat	S5
Zwavel	
Grof	S4
Fijn	S1

Notes to the table:
* *for storage; handling: S4*
** *for storage; handling: S5*

Annex II.3 Relevant solid bulk materials

No	Îndustrial activity according to annex I of the IPPC-Directive	wheat	barley	rye	aots	maize	rice	other grain	sugar beet pulp	flour, semolina	oil cake	other fodder	hard coal	brown coal	hard coal coke	brown coal coke	iron ores and conc.	non ferrous metal waste	copper ore and conc.	bauxite, alum. ores	manganes ores and conc.	other non-ferrous ores	iron and steel scrap	iron slag and ash	blast furnace	pyrite cinders	industrial sand	other natural sand	slag and ash not for smelting	gypsum and limestone	cement	lime	raw phosphates	potassium raw salts	phosphate slag	other phosphate fertilizer	potassium fertilizers	nitrogenious fertilizers	
1	**Energy**																																							
1.1	Combustion installation with a rated thermal output >50 MW												■	■	■	■													■											
1.3	Coke oven plant												■	■	■	■																								
1.4	Coal degasification												■	■																										
2	**Production and processing of metals**																																							
2.1	Roasting and cindering plants for metal ores														■		■							■	■	■			■	■										
2.2	Iron and steel production plants (> 2,5 t/ h)														■		■						■	■					■	■		■			■					
2.4	Iron metal foundaries (capacity > 20 t/d)														■	■							■	■			■		■	■		■								
2.5 a.	Production of non-ferrous crude metals from ore, concentrates and secondary raw materials														■	■		■	■	■	■	■		■	■				■	■										
2.5 b.	Melting of non-ferrous metals																	■			■	■		■			■		■	■		■								

No	Îndustrial activity according to annex I of the IPPC-Directive	wheat	barley	rye	aots	maize	rice	other grain	sugar beet pulp	flour, semolina	oil cake	other fodder	hard coal	brown coal	hard coal coke	brown coal coke	iron ores and conc.	non ferrous metal waste	copper ore and conc.	bauxite, alum. ores	manganes ores and conc.	other non-ferrous ores	iron and steel scrap	iron slag and ash	blast furnace	pyrite cinders	industrial sand	other natural sand	slag and ash not for smelting	gypsum and limestone	cement	lime	raw phosphates	potassium raw salts	phosphate slag	other phosphate fertilizer	potassium fertilizers	nitrogenious fertilizers	
3	**Mineral promissing industry**																																						
3.1	Production of cement bricks												■	■														■		■	■	■							
3.3	Manufacture of glass																										■		■	■									
3.4	Melting of mineral substances																												■										
3.5	Manufacture of ceramic products												■	■													■			■									
4	**Chemical industry**																																						
4.3	Production of fertilizers																																■	■		■	■	■	
5	**Waste treatment**																																						
5.1	Treatment plants for dangerous wastes																												■										
5.2	Incinerator for municipal wastes																												■										
6	**Other industrial branches**																																						
6.4 b.	Production of food products from vegetable raw materials	■	■	■	■	■	■	■	■	■	▒	▒																											

Table II.2. 1: Assignment of the industrial activities according to Annex I of the IPPC Directive to the relevant solid bulk materials [UBA, 2001, 17]

Annex III.1 Storage modes and equipment for liquids

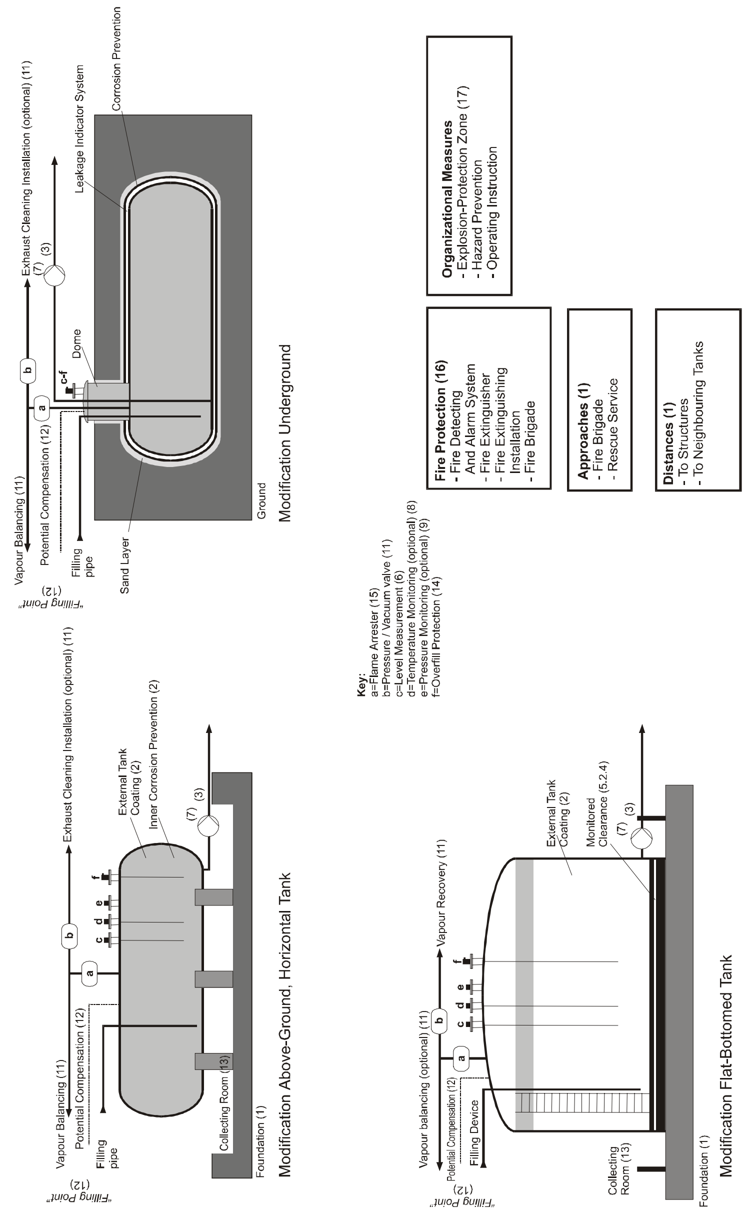


Figure III - 1: Above-ground horizontal tank an underground horizontal tank and a flat-bottomed vertical tank with equipment
Source: [Germany, 1999 #18]

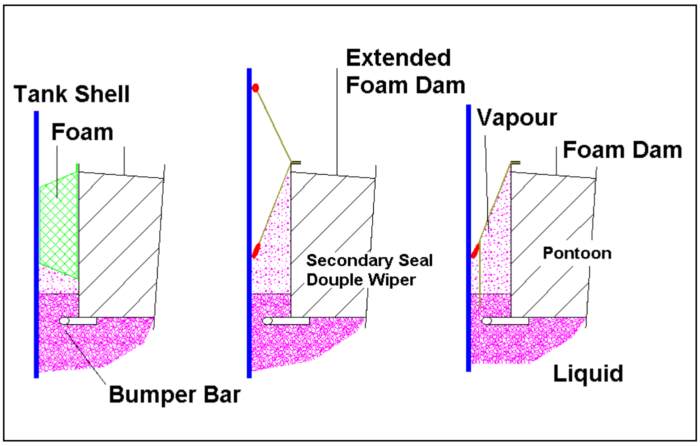


Figure III - 2: Vapour mounted seals (typical)
(source: [TETSP, 2001, 84], draft EEMUA Pub. 159)

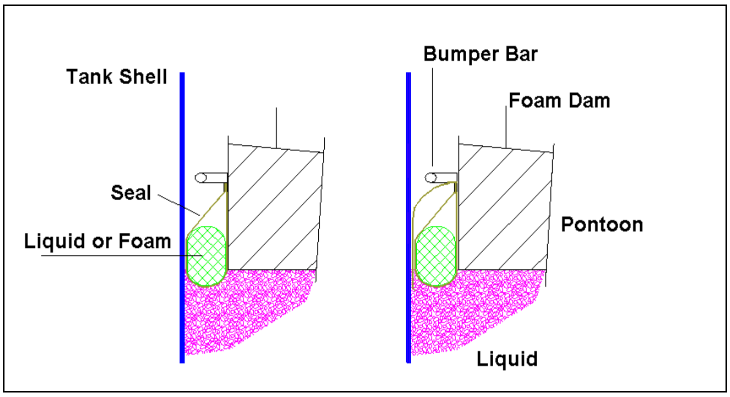


Figure III - 3: Liquid mounted seals (typical)
(source: [TETSP, 2001, 84], draft EEMUA Pub. 159)

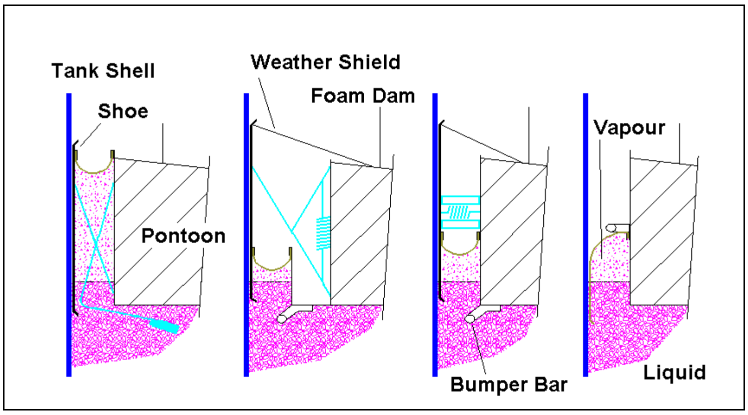


Figure III - 4: Liquid mounted mechanical shoe seals (typical)
(source: [TETSP, 2001, 84], draft EEMUA Pub. 159)

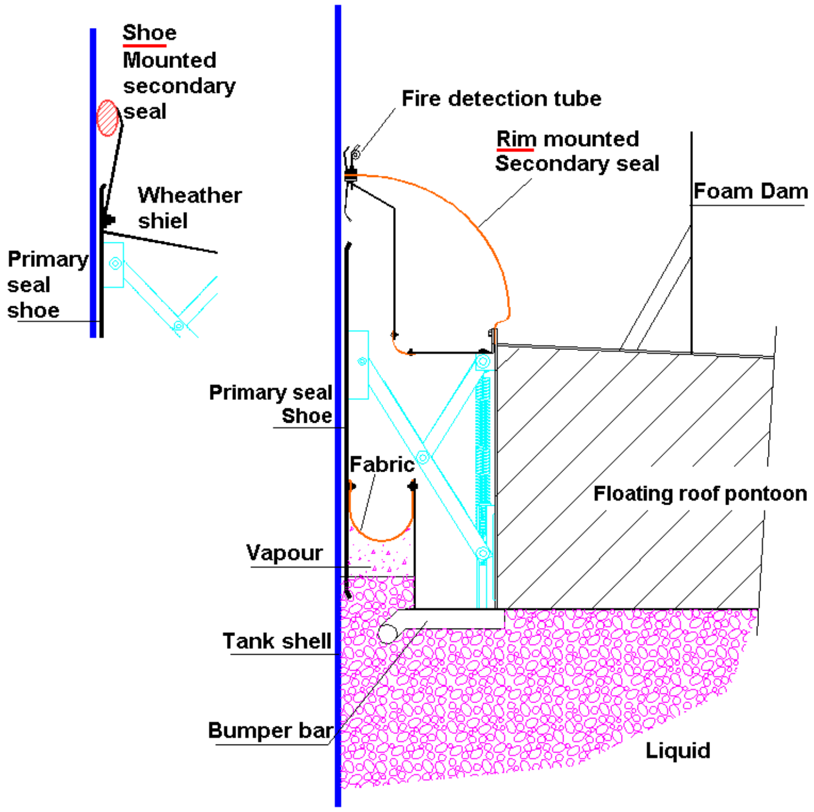


Figure III - 5: Liquid mounted mechanical shoe seal with a shoe mounted and a rim mounted secondary seals (typical)
[draft EEMUA Pub159]

Annex III.2 Storage modes and equipment for gasses

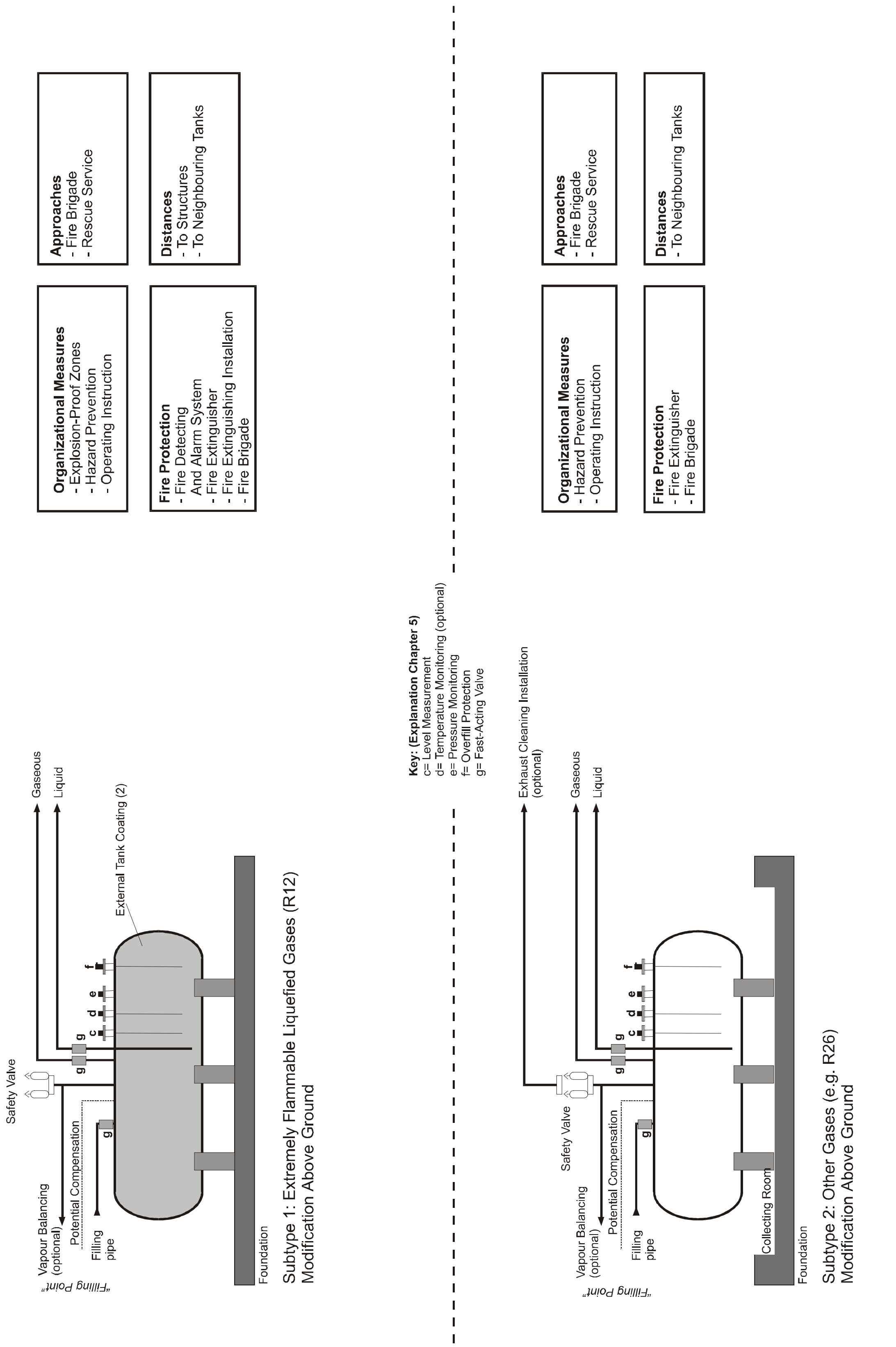


Figure III - 6: Horizontal storage tanks (pressurised)
[Germany, 1999 #18]

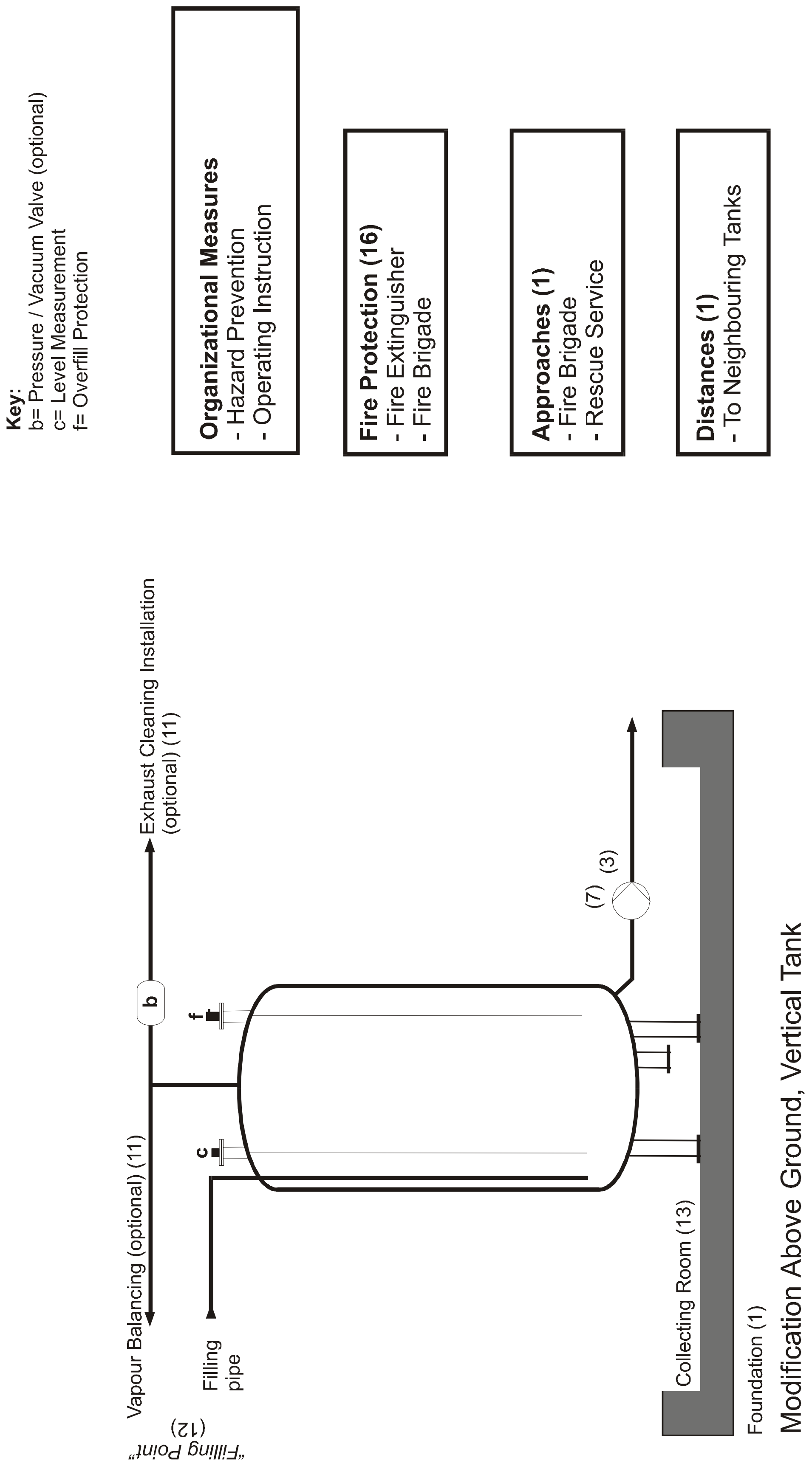


Figure III - 7: Vertical tank (pressurised)
Source: [Germany, 1999 #18]

Annex III.3 Storage modes and relevant solid bulk materials

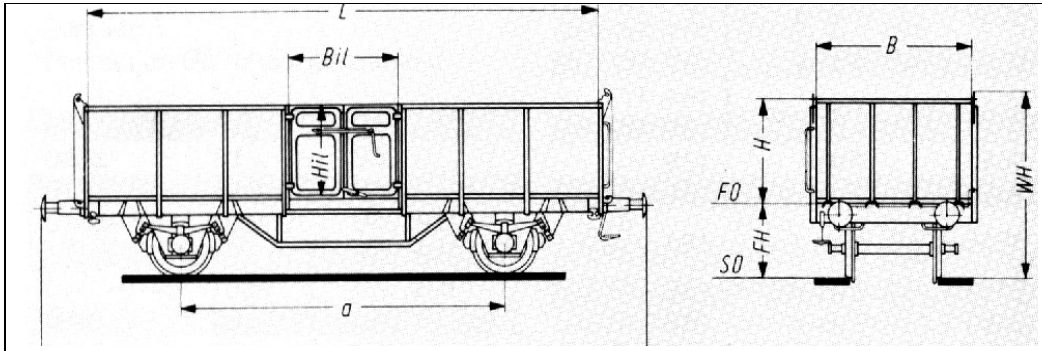
	grain	pit-coal	brown-coal	pit-coal coke	iron ores and concentrates	copper ores and concentrates	other non-iron metal ores and concentrates	gypsum	fertilisers
heap (outdoor storage)	X	X	X	X	X	X	X		X
bunker			X						X
silo	X	X	X					X	X
packed (sack, big-bags)								X	X

Table III - 1: Storage modes and relevant bulk materials
[UBA, 2001, 17]

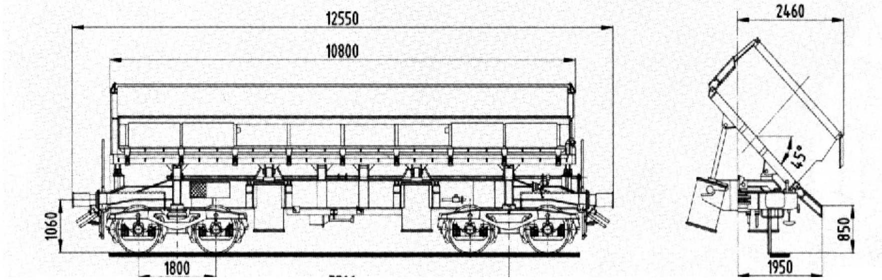
Annex III.4 Handling techniques and relevant solid bulk material

	grain	pit-coal	brown-coal	pit-coal coke	iron ores and concentrates	copper ores and concentrates	other non-iron metal ores and concentrates	gypsum	fertilisers
grab	X	X		X		X	X		X
hopper	X	X		X		X	X		X
tube							X	X	
mobile loading device	X	X	X	X	X	X	X		X
silo (truck or train)	X	X	X					X	X
tilting cart (truck or train)	X	X	X	X	X				X
dump pit	X	X		X	X				X
gravity conveyor	X	X	X	X	X	X	X	X	X
cascade chute	X	X					X		X
band conveyor	X	X	X	X	X	X	X	X	X
double belt conveyor	X								X
scraper conveyor	X	X	X		X				X
trough chain conveyor	X		X						X
chain conveyor (as unloader)	X								X
screw conveyor	X	X						X	X
bucket conveyor	X	X			X				
bucket elevator (ship unloader)		X			X				
pneumatic conveyor	X	X	X					X	X

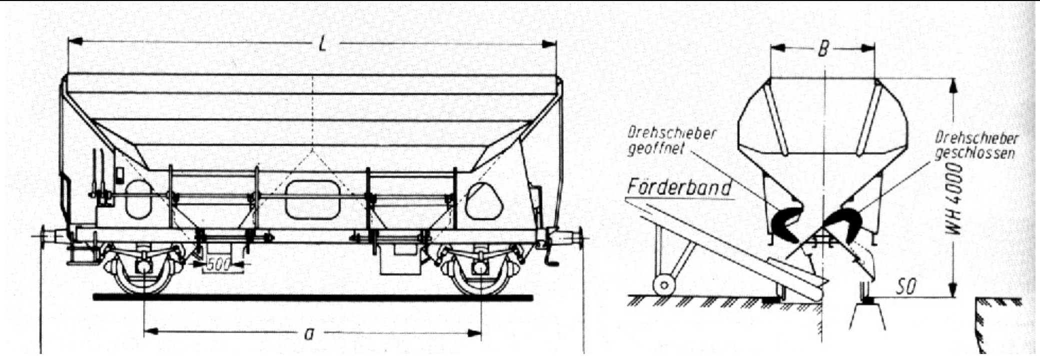
Table III - 2: Loading and unloading techniques and relevant bulk materials



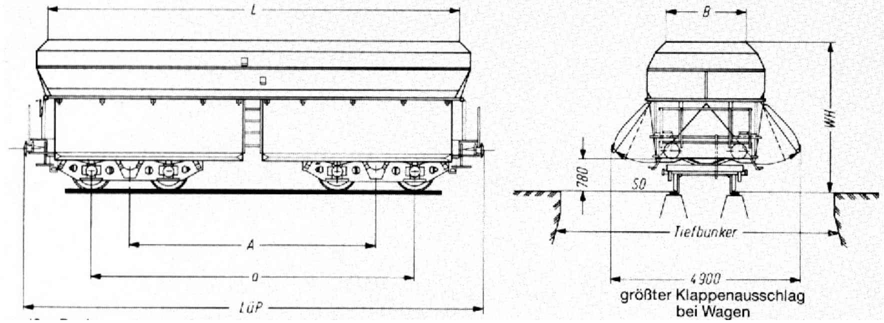
open wagon



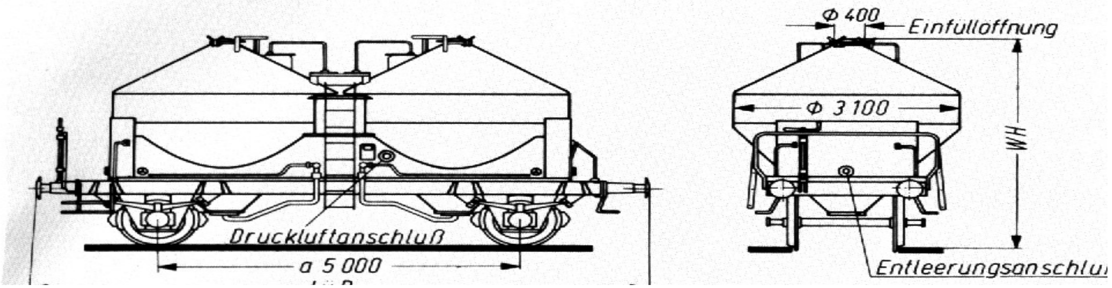
bulk material tilt wagon



bulk material wagon with dosable gravity unloading



bulk material wagon with sudden gravity unloading



wagon with pneumatic unloading

Figure III - 8: Wagons for transporting solid bulk materials, used in Germany
[UBA, 2001, 17] with reference to Railway Wagons, 1994

Annex IV. 1 ECM Scorecards for liquid and liquified gas

The next table consists of 13 different tables which refer to operational emissions from several storage modes:

Table IV- 1: ECM-cards operational emissions

Aboveground Atmospheric Storage: External Floating Roof				
Operational emissions				
Note 1:	Emission Frequency Score 1-3: 3 = frequent (daily), 1 = infrequent (once per few years)			
Note 2:	Emission Volume Score 0-3: 3 = largest, 0 = zero or negligible			
	These scores are relative values and are to be considered only for each storage mode			
Potential Emission Source	**Emission Frequency Note 1**	**Emission Volume note 2**	**Emission Score**	**POSSIBLE ECM's**
Gas Emissions				
filling	1	3	3	operating procedures/training
(until roof floats on liquid)				instrumentation
standing	3	1	3	shell/roof paint colour
				dome roof
				pontoon roof
				- with vapour mounted primary seal
				- with liquid mounted primary seal
				- with mechanical shoe seal
				- with secondary seal
				double deck roof
				- with vapour mounted primary seal
				- with liquid mounted primary seal
				- with mechanical shoe seal
				- with secondary seal
				sealing roof penetrations
				- guide pole
				- roof legs
				- still well cover
emptying	2	1	2	inner shell coating
(film of product left on shell)				shell scrapers (eg. for crudes)
emptying	1	1	1	operating procedures/training
(after roof lands on legs)				instrumentation
				secondary seal
cleaning	1	2	2	operating procedures/training
				closed cleaning system
blanketing				N/A
manual gauging	2	1	2	semi-closed gauging system (sealing still well openings)
				instrumentation
sampling	2	1	2	semi-closed sampling system
				shell-side sampling
fugitive	3	1	3	inspection/maintenance (including roof-shell seal tightness)
draining	2	1	2	semi-automatic water draw-off
Liquid Emissions				
draining	2	1	2	operating procedures/training
				automatic drain valve
				fixed, closed drain system
roof draining	2	0	0	operating procedures/training
				fixed, closed drain system
cleaning	1	3	3	operating procedures/training
sampling	2	0	0	operational procedures/training
				closed sampling system
				containment

Aboveground Atmospheric Storage: Fixed Roof Tank				
Operational emissions				
Note 1:	Emission Frequency Score 1-3: 3 = frequent (daily), 1 = infrequent (once per few years)			
Note 2:	Emission Volume Score 0-3: 3 = largest, 0 = zero or negligible			
	These scores are relative values and are to be considered only for each storage mode			
Potential Emission Source	**Emission Frequency Note 1**	**Emission Volume note 2**	**Emission Score**	**POSSIBLE ECM's**
Gas Emissions				
filling	2	3	6	Pressure Vacuum Relief Valve (PVRV)
				innerfloat/internal floating roof (IFR)
				- with primary seal
				- with secondary seal
				vapour collection
				- balancing
				- treatment
breathing	3	2	6	PVRV
				paint colour
				sun covers/heat shields
				innerfloat/IFR
				- with primary seal
				- with secondary seal
				vapour collection
				- vapour holding tank
				- treatment
emptying	2	1	2	PVRV
				innerfloat/IFR
				- with primary seal
				- with secondary seal
				vapour collection
				- balancing
				- treatment
cleaning	1	2	2	operating procedures/training
				closed cleaning system
blanketing	3	2	6	PVRV
				vapour collection
				- treatment
manual gauging	2	1	2	mechanical gauging system
				instrumentation
sampling	2	1	2	semi-closed sampling system
				(NB: only with PVRV with high pressure settings)
				shell-side sampling
fugitive	3	1	3	inspection/maintenance
draining	2	1	2	semi-automatic water draw-off
				fixed, closed drain system
Liquid Emissions				
draining	2	1	2	operating procedures/training
				fixed, closed drain system
cleaning	1	3	3	operating procedures/training
sampling	2	0	0	operating procedures/training
				liquid tight sampling system
				containment

Aboveground Atmospheric Storage: Horizontal Storage Tank				
Operational emissions				
Note 1:	Emission Frequency Score 1-3: 3 = frequent (daily), 1 = infrequent (once per few years)			
Note 2:	Emission Volume Score 0-3: 3 = largest, 0 = zero or negligible			
	These scores are relative values and are to be considered only for each storage mode			
Potential Emission Source	**Emission Frequency Note 1**	**Emission Volume note 2**	**Emission Score**	**POSSIBLE ECM's**
Gas Emissions				
filling	2	3	6	Pressure Vacuum Relief Valve (PVRV)
				vapour collection
				- balancing
				- treatment
breathing	3	2	6	PVRV
				paint colour
				sun covers/heat shields
				vapour collection
				- vapour holding tank
				- treatment
emptying	2	1	2	PVRV
				vapour collection
				- balancing
				- treatment
cleaning	1	2	2	operating procedures/training
				closed cleaning system
blanketing	3	2	6	PVRV
				vapour collection
				- treatment
manual gauging	2	1	2	mechanical gauging system
				instrumentation
sampling	2	1	2	semi-closed sampling system
				(NB: only with PVRV with high pressure settings)
				shell-side sampling
fugitive	3	1	3	inspection/maintenance
draining	2	1	2	operating procedures/training
				fixed, closed drain system
Liquid Emissions				
draining	2	1	2	operating procedures/training
				fixed, closed drain system
cleaning	1	2	2	operating procedures/training
sampling	2	0	0	operating procedures/training
				liquid tight sampling system
				containment

Aboveground Pressurized Storage: Spheres				
Operational emissions				
Note 1:	Emission Frequency Score 1-3: 3 = frequent (daily), 1 = infrequent (once per few years)			
Note 2:	Emission Volume Score 0-3: 3 = largest, 0 = zero or negligible			
	These scores are relative values and are to be considered only for each storage mode			
Potential Emission Source	**Emission Frequency Note 1**	**Emission Volume note 2**	**Emission Score**	**POSSIBLE ECM's**
Gas Emissions				
filling	2	1	2	control filling rate (non-condensables vented)
breathing				N/A
emptying				N/A
cleaning	1	2	2	operating procedures/training
				closed cleaning system
blanketing	2	1	2	vapour collection
				- treatment
gauging				N/A
sampling	2	1	2	vapour collection
				- treatment
fugitive	3	1	3	inspection/maintenance
draining	2	2	4	fixed, closed drain system (connected to vapour treatment)
Liquid Emissions				
draining	2	0	0	
cleaning	1	1	1	operating procedures/closed cleaning procedures
sampling	2	0	0	

Aboveground Pressurized Storage: Horizontal Storage Tank				
Operational emissions				
Note 1:	Emission Frequency Score 1-3: 3 = frequent (daily), 1 = infrequent (once per few years)			
Note 2:	Emission Volume Score 0-3: 3 = largest, 0 = zero or negligible			
	These scores are relative values and are to be considered only for each storage mode			
Potential Emission Source	**Emission Frequency Note 1**	**Emission Volume note 2**	**Emission Score**	**POSSIBLE ECM's**
Gas Emissions				
filling	2	1	2	control filling rate (non-condensables vented)
breathing				N/A
emptying				N/A
cleaning	1	2	2	operating procedures/training
				closed cleaning system
blanketing	2	1	2	vapour collection
				- treatment
gauging				N/A
sampling	2	1	2	vapour collection
				- treatment
fugitive	3	1	3	inspection/maintenance
draining	2	2	4	fixed, closed drain system (connected to vapour treatment)
Liquid Emissions				
draining	2	0	0	
cleaning	1	1	1	operating procedures/closed cleaning procedures
sampling	2	0	0	

Aboveground Refrigerated Storage				
Operational emissions				
Note 1:	Emission Frequency Score 1-3: 3 = frequent (daily), 1 = infrequent (once per few years)			
Note 2:	Emission Volume Score 0-3: 3 = largest, 0 = zero or negligible			
	These scores are relative values and are to be considered only for each storage mode			
Potential Emission Source	**Emission Frequency Note 1**	**Emission Volume note 2**	**Emission Score**	**POSSIBLE ECM's**
Gas Emissions				
filling	2	1	2	normally closed system (non-condensables vented)
breathing				N/A (failure of refrigeration not considered)
emptying				N/A
cleaning	1	2	2	operating procedures/training
				closed cleaning system
blanketing	2	1	2	vapour collection
				- treatment
gauging				N/A
sampling	2	1	2	vapour collection
				- treatment
fugitive	2	1	2	inspection/maintenance
draining				N/A
Liquid Emissions				
draining				N/A
cleaning				N/A
sampling				N/A

Underground Atmospheric Storage: Horizontal Storage Tank				
Operational emissions				
Note 1:	Emission Frequency Score 1-3: 3 = frequent (daily), 1 = infrequent (once per few years)			
Note 2:	Emission Volume Score 0-3: 3 = largest, 0 = zero or negligible			
	These scores are relative values and are to be considered only for each storage mode			
Potential Emission Source	**Emission Frequency Note 1**	**Emission Volume note 2**	**Emission Score**	**POSSIBLE ECM's**
Gas Emissions				
filling	2	3	6	Pressure Vacuum Relief Valve (PVRV)
				vapour collection
				- balancing
				- treatment
breathing	2	1	2	PVRV
emptying	2	1	2	PVRV
				vapour collection
				- balancing
				- treatment
cleaning	1	2	2	operating procedures/training
				closed cleaning system
blanketing	3	1	3	PVRV
				vapour collection
				- treatment
gauging	2	1	2	mechanical gauging system
				instrumentation
sampling	2	1	2	semi-closed sampling system
				(NB: only with PVRV with high pressure settings)
fugitive	3	1	3	inspection/maintenance
draining				N/A
Liquid Emissions				
draining	1	1	1	fixed, closed drain system
				operating procedures/training
cleaning	1	2	2	operating procedures/training
sampling				N/A

Underground Atmospheric Storage: Caverns				
Operational emissions				
Note 1:	Emission Frequency Score 1-3: 3 = frequent (daily), 1 = infrequent (once per few years)			
Note 2:	Emission Volume Score 0-3: 3 = largest, 0 = zero or negligible			
	These scores are relative values and are to be considered only for each storage mode			
Potential Emission Source	**Emission Frequency Note 1**	**Emission Volume note 2**	**Emission Score**	**POSSIBLE ECM's**
Gas Emissions				
filling	2	3	6	Pressure Vacuum Relief Valve (PVRV)
				vapour collection
				- balancing
				- treatment
breathing	2	1	2	PVRV
emptying	2	1	2	PVRV
				vapour collection
				- balancing
				- treatment
cleaning				N/A
blanketing				N/A
gauging	2	1	2	mechanical gauging system
				instrumentation
sampling	2	1	2	semi-closed sampling system
				(NB: only with PVRV with high pressure settings)
fugitive	3	1	3	inspection/maintenance
draining	2	1	2	fixed, closed drain system
Liquid Emissions				
draining	2	1	2	maintain sufficient water bottom by means of automation
cleaning				N/A
sampling	2	0	0	

Underground Atmospheric Storage: Salt Domes				
Operational emissions				
Note 1:	Emission Frequency Score 1-3: 3 = frequent (daily), 1 = infrequent (once per few years)			
Note 2:	Emission Volume Score 0-3: 3 = largest, 0 = zero or negligible			
	These scores are relative values and are to be considered only for each storage mode			
Potential Emission Source	**Emission Frequency Note 1**	**Emission Volume note 2**	**Emission Score**	**POSSIBLE ECM's**
Gas Emissions				
filling				? - to be investigated
breathing				N/A
emptying				? - to be investigated
cleaning				? - to be investigated
blanketing				N/A
gauging				? - to be investigated
sampling				? - to be investigated
fugitive				? - to be investigated
draining				? - to be investigated
Liquid Emissions				
draining	2	1	2	maintain sufficient water bottom by means of automation
cleaning				N/A
sampling	2	0	0	

Underground Pressurized Storage: Caverns				
Operational emissions				
Note 1:	Emission Frequency Score 1-3: 3 = frequent (daily), 1 = infrequent (once per few years)			
Note 2:	Emission Volume Score 0-3: 3 = largest, 0 = zero or negligible			
	These scores are relative values and are to be considered only for each storage mode			
Potential Emission Source	**Emission Frequency Note 1**	**Emission Volume note 2**	**Emission Score**	**POSSIBLE ECM's**
Gas Emissions				
filling	2	1	2	control filling rate (non-condensables vented)
breathing				N/A
emptying				N/A
cleaning				N/A
blanketing				N/A
gauging				N/A
sampling	2	1	2	vapour collection
				- treatment
fugitive	2	1	2	inspection/maintenance
draining	2	1	2	fixed, closed drain system
Liquid Emissions				
draining				maintain sufficient water bottom by means of automation
cleaning				N/A
sampling				N/A

Aboveground Atmospheric Storage: Lagoons & Basins				
Operational emissions				
Note 1:	Emission Frequency Score 1-3: 3 = frequent (daily), 1 = infrequent (once per few years)			
Note 2:	Emission Volume Score 0-3: 3 = largest, 0 = zero or negligible			
	These scores are relative values and are to be considered only for each storage mode			
Potential Emission Source	**Emission Frequency Note 1**	**Emission Volume note 2**	**Emission Score**	**POSSIBLE ECM's**
Gas Emissions				
filling (lagoon)	2	3	6	None
filling (basin)	2	3	6	floating cover
standing (lagoon)	3	3	9	None
standing (basin)	3	3	9	floating cover
				fixed cover
emptying	2	1	2	N/A
cleaning	1	2	2	operating procedures/training
				closed cleaning system (NB: only if cover installed)
blanketing				N/A
manual gauging				N/A
sampling				N/A
fugitive				N/A
draining				N/A
Liquid Emissions				
draining	2	1	2	fixed, closed drain system
				operating procedures/training
cleaning	1	3	3	operating procedures/training
sampling	2	0	0	

Floating Storage				
Operational emissions				
Note 1:	Emission Frequency Score 1-3: 3 = frequent (daily), 1 = infrequent (once per few years)			
Note 2:	Emission Volume Score 0-3: 3 = largest, 0 = zero or negligible			
	These scores are relative values and are to be considered only for each storage mode			
Potential Emission Source	**Emission Frequency Note 1**	**Emission Volume note 2**	**Emission Score**	**POSSIBLE ECM's**
Gas Emissions				
filling	2	3	6	Pressure Vacuum Relief Valve (PVRV)
				vapour collection
				- balancing
				- treatment
breathing	3	2	6	PVRV
				paint colour deck
				vapour collection
				- vapour holding tank
				- treatment
emptying	2	1	2	PVRV
				vapour collection
				- balancing
cleaning	1	2	2	operating procedures/training
				closed cleaning system
blanketing	3	2	6	PVRV
				vapour collection
				- treatment
gauging	2	1	2	mechanical gauging system
				instrumentation
sampling	2	1	2	semi-closed sampling system
				(NB: only with PVRV with high pressure settings)
fugitive	3	1	3	inspection/maintenance
draining	2	1	2	fixed, closed drain system
Liquid Emissions				
draining	2	0	0	
cleaning	1	3	3	operating procedures/training
sampling	2	0	0	

Aboveground Atmospheric Storage: Lifter Roof Tank				
Operational emissions				
Note 1:	Emission Frequency Score 1-3: 3 = frequent (daily), 1 = infrequent (once per few years)			
Note 2:	Emission Volume Score 0-3: 3 = largest, 0 = zero or negligible			
	These scores are relative values and are to be considered only for each storage mode			
Potential Emission Source	**Emission Frequency Note 1**	**Emission Volume note 2**	**Emission Score**	**POSSIBLE ECM's**
Gas Emissions				
breathing	3	0	0	N/A
filling	2	3	6	PVRV
				vapour collection
				- treatment
emptying	2	1	2	PVRV
				vapour collection
				- treatment
cleaning	1	2	2	operating procedures/training
				closed cleaning system
blanketing	3	2	6	PVRV
				vapour collection
				- treatment
manual gauging	2	1	2	mechanical gauging system
				instrumentation
sampling	2	1	2	semi-closed sampling system
				(NB: only with PVRV with high pressure settings)
				shell-side sampling
fugitive	3	1	3	inspection/maintenance
draining	2	1	2	semi-automatic water draw-off
				fixed, closed drain system
Liquid Emissions				
draining	2	1	2	operating procedures/training
				fixed, closed drain system
cleaning	1	3	3	operating procedures/training
sampling	2	0	0	operating procedures/training
				liquid tight sampling system
				containment

The next 13 tables refer to emissions due to incidents/accidents from several storage modes:

Aboveground Atmospheric Storage: External Floating Roof	
Emissions due to incidents/accidents	
Potential Emission Source	**POSSIBLE ECM's (Primary & Secondary only)**
Gas Emissions	
overfill	operating procedures/training
	instrumentation
	automation
leakages	inspection/maintenance
	fixed, closed drain systems
Liquid Emissions	
overfill	operational procedures/training
	instrument protection
	automation
	containment
leakage	monitoring
	inspection/maintenance
	containment
	automatic drain valve (roof drain leakage)

Aboveground Atmospheric Storage: Fixed Roof Tank	
Emissions due to incidents/accidents	
Potential Emission Source	**POSSIBLE ECM's (Primary & Secondary only)**
Gas Emissions	
overfill	operating procedures/training
	instrumentation
	automation
leakages	inspection/maintenance
Liquid Emissions	
overfill	operational procedures/training
	instrument protection
	automation
	containment
leakage	monitoring
	inspection/maintenance
	containment

Aboveground Atmospheric Storage: Horizontal Storage Tank	
Emissions due to incidents/accidents	
Potential Emission Source	**POSSIBLE ECM's (Primary & Secondary only)**
Gas Emissions	
overfill	operating procedures/training
	instrumentation
	automation
leakages	inspection/maintenance
Liquid Emissions	
overfill	operational procedures/training
	instrument protection
	automation
	containment
leakage	monitoring
	inspection/maintenance
	containment

Aboveground Pressurized Storage: Spheres	
Emissions due to incidents/accidents	
Potential Emission Source	**POSSIBLE ECM's (Primary & Secondary only)**
Gas Emissions	
overfill	operating procedures/training
	instrumentation
	automation
leakage	inspection/maintenance
	on-line monitoring
	gas detection
Liquid Emissions	
overfill	operational procedures/training
	instrument protection
	automation
	containment
leakage	monitoring
	inspection/maintenance
	containment

Aboveground Pressurized Storage: Horizontal Storage Tank	
Emissions due to incidents/accidents	
Potential Emission Source	**POSSIBLE ECM's (Primary & Secondary only)**
Gas Emissions	
overfill	operating procedures/training
	instrumentation
	automation
leakage	inspection/maintenance
	on-line monitoring
	gas detection
Liquid Emissions	
overfill	operational procedures/training
	instrument protection
	automation
	containment
leakage	monitoring
	inspection/maintenance
	gas detection

Aboveground Refrigerated Storage	
Emissions due to incidents/accidents	
Potential Emission Source	**POSSIBLE ECM's (Primary & Secondary only)**
Gas Emissions	
overfill	operating procedures/training
	instrumentation
	automation
	containment
leakage	inspection/maintenance
	on-line monitoring
	gas detection
	containment
Liquid Emissions	
overfill	operational procedures/training
	instrument protection
	automation
	containment
leakage	monitoring
	inspection/maintenance
	Containment

Underground Atmospheric Storage: Horizontal Storage Tank	
Emissions due to incidents/accidents	
Potential Emission Source	**POSSIBLE ECM's (Primary & Secondary only)**
Gas Emissions	
overfill	operating procedures/training
	instrumentation
	automation
leakages	inspection/maintenance
	monitoring
Liquid Emissions	
overfill	operational procedures/training
	instrument protection
	automation
	containment
leakage	monitoring
	inspection/maintenance
	containment

Underground Atmospheric Storage: Caverns	
Emissions due to incidents/accidents	
Potential Emission Source	**POSSIBLE ECM's (Primary & Secondary only)**
Gas Emissions	
overfill	operating procedures/training
	instrumentation
	automation
leakages	
Liquid Emissions	
overfill	operational procedures/training
	instrument protection
	automation
leakage	N/A

Underground Atmospheric Storage: Salt Domes	
Emissions due to incidents/accidents	
Potential Emission Source	**POSSIBLE ECM's (Primary & Secondary only)**
Gas Emissions	
overfill	Seek external advice
leakages	
Liquid Emissions	
overfill	operational procedures/training
	instrument protection
	automation
leakage	N/A

Underground Pressurized Storage: Caverns	
Emissions due to incidents/accidents	
Potential Emission Source	**POSSIBLE ECM's (Primary & Secondary only)**
Gas Emissions	
overfill	operating procedures/training
	instrumentation
	automation
leakage	inspection/repair
	on-line monitoring
	gas detection
Liquid Emissions	
overfill	operational procedures/training
	instrument protection
	automation
leakage	

Aboveground Atmospheric Storage: Lagoons & Basins	
Emissions due to incidents/accidents	
Potential Emission Source	**POSSIBLE ECM's (Primary & Secondary only)**
Gas Emissions	
leakages	N/A
overfill	instrument protection
	operating procedures/training
	automation
Liquid Emissions	
overfill	operational procedures/training
	instrument protection
	automation
	containment
leakage	monitoring
	inspection/maintenance
	containment

Other Storage: Floating Storage	
Emissions due to incidents/accidents	
Potential Emission Source	**POSSIBLE ECM's (Primary & Secondary only)**
Gas Emissions	
overfill	operating procedures/training
	instrumentation
	automation
leakages	inspection/maintenance
Liquid Emissions	
overfill	operational procedures/training
	instrument protection
	automation
leakage	monitoring
	inspection/maintenance

Lifter Roof Tank	
Emissions due to incidents/accidents	
Potential Emission Source	**POSSIBLE ECM's (Primary & Secondary only)**
Gas Emissions	
overfill	operating procedures/training
	instrumentation
	automation
leakages	inspection/maintenance
Liquid Emissions	
overfill	operational procedures/training
	instrument protection
	automation
	containment
leakage	monitoring
	inspection/maintenance
	containment

Table IV- 2: ECM-cards for emissions from incidentes/accidents

Annex IV. 2 ECM Scorecards for the storage of solids

- ***Dust reduction potential through use of BAT candidate***

++	very high or virtually complete prevention of diffuse emissions
+	clear reduction of diffuse emissions
0	no significant reduction of diffuse emissions or no clear conclusion possible

- ***Energy consumption of the BAT candidate***

+	low energy consumption
0	normal energy consumption or no reliable data is available
-	high energy consumption

- ***Cross-media effects when employing the BAT candidate***

(e.g. additional impact in the hydrological cycle or on ground and surface water, increase in waste production, increase of noise impact.)

+	reduction of dust emissions without cross-media effect
0	no significant impact or no reliable data available
-	cross-media effect

- ***Investment requirement of the BAT candidate***

+	low investment required
nd	no data available
-	high investment required

- ***Operating costs of the BAT candidate***

+	low
nd	no data available
-	high operating costs

Table IV - 1: ECM Scorecard for the storage of solids
[UBA, 2001, 17]

General comment: [InfoMil, 1992, 15]

S1 = highly drift sensitive, not wettable
S2 = highly drift sensitive, wettable
S3 = moderately drift sensitive, not wettable
S4 = moderately drift sensitive, wettable
S5 = not or very slightly drift sensitive

Relevant bulk material and inherent dustiness	Relevant IPPC activities (No. of appendix on IPPC Directive	BAT candidate	Dust redusing potential	Energy use	Cross-media effect	Investment costs	Operating costs	Cross-reference
Cereals • wheat: S3 • rye: S3 • maize: S3	6.4b	Silo	++	0	0	nd	nd	

Relevant bulk material and inherent dustiness	Relevant IPPC activities (No. of appendix on IPPC Directive	BAT candidate	Dust redusing potential	Energy use	Cross-media effect	Investment costs	Operating costs	Cross-reference
Brown coal: S4	1.1/1.3/1.4/3.1/3.5	Open storage with sprinklers, possibly with wind protection walls	+	0	0	+	nd	
Black coal: S4	1.1/1.3/1.4/3.1/3.5	Open storage with sprinklers, possibly with wind protection walls *)	+	0	0	+	nd	
		Enclosed storage	++	0	0	-	-	
		Large capacity silo	++	0	0	-	-	
*) Note: for long-term storage of coal compacted multi-layer accretion is recommended for safety (flammability) and quality reasons. With fine coal dumps (particle size < 10 mm), it is common practice to apply a covering layer of gravel, earth or other material or cover with a tarpaulin or to spray the material with a binding agent.								

Relevant bulk material and inherent dustiness	Relevant IPPC activities (No. of appendix on IPPC Directive	BAT candidate	Dust redusing potential	Energy use	Cross-media effect	Investment costs	Operating costs	Cross-reference
Coke: S1-S4	1.1/1.3/2.1/2.2/2.4/2.5a	Enclosed storage	+	0	0	nd	nd	

Relevant bulk material and inherent dustiness	Relevant IPPC activities (No. of appendix on IPPC Directive	BAT candidate	Dust redusing potential	Energy use	Cross-media effect	Investment costs	Operating costs	Cross-reference
Iron ores and concentrates • pellets: S5 • rock ore: S5 • ore dust: S4-S5	2.1/2.2	Open storage with sprinkler systems, possibly with wind protection walls	+	0	0	+	+	
Copper ores and concentrates: S4	2.5a	Enclosed storage	++	+	+	nd	nd	
Miscellaneous non-ferrous ores and concentrates: S2-S5	2.5a/2.5b	Open storage and sprinkling with a chalk suspension	0	+	0	nd	nd	
		Enclosed storage in halls	++	+	+	nd	nd	

Relevant bulk material and inherent dustiness	Relevant IPPC activities (No. of appendix on IPPC Directive	BAT candidate	Dust redusing potential	Energy use	Cross-media effect	Investment costs	Operating costs	Cross-reference
Gypsum: S3	1.1/2.1/2.2/2.4/2.5a/3.1/ 3.3/3.5	Large capacity silo *)	++	0	+	-	nd	
*) Note: use is restricted to gypsum used in flue gas desulphurisation								

Relevant bulk material and inherent dustiness	Relevant IPPC activities (No. of appendix on IPPC Directive	BAT candidate	Dust redusing potential	Energy use	Cross-media effect	Investment costs	Operating costs	Cross-reference
Fertiliser: S1-S3	4.3							

Relevant bulk material and inherent dustiness	Relevant IPPC activities (No. of appendix on IPPC Directive	BAT candidate	Dust redusing potential	Energy use	Cross-media effect	Investment costs	Operating costs	Cross-reference

Annex IV. 3 ECM Scorecards for the handling of solids

- ***Dust reduction potential through use of BAT candidate***

++	very high or virtually complete prevention of diffuse emissions
+	clear reduction of diffuse emissions
1	no significant reduction of diffuse emissions or no clear conclusion possible

- ***Energy consumption of the BAT candidate***

+	low energy consumption
1	normal energy consumption or no reliable data is available
-	high energy consumption

- ***Cross-media effects when employing the BAT candidate***

(e.g. additional impact in the hydrological cycle or on ground and surface water, increase in waste production, increase of noise impact.)

+	reduction of dust emissions without cross-media effect
1	no significant impact or no reliable data available
-	cross-media effect

- ***Investment requirement of the BAT candidate***

+	low investment required
nd	no data available
-	high investment required

- ***Operating costs of the BAT candidate***

+	low
nd	no data available
-	high operating costs

Table IV - 2: ECM Scorecard on the handling of solids
[UBA, 2001, 17]

General comment: [InfoMil, 1992, 15]

S1 = highly drift sensitive, not wettable
S2 = highly drift sensitive, wettable
S3 = moderately drift sensitive, not wettable
S4 = moderately drift sensitive, wettable
S5 = not or very slightly drift sensitive

Relevant bulk material and inherent dustiness	Relevant IPPC activities (No. of appendix on IPPC Directive	BAT candidate	Dust redusing potential	Energy use	Cross-media effect	Investment costs	Operating costs	Cross-reference
Cereals • wheat: S3 • rye: S3 • maize: S3	6.4b	Loading pipe with automatic height adjustment and loading head	++	+	0	nd	nd	
		Discharge tube with height adjustment and dust apron	+	+	0	nd	nd	
		Discharge tube with sealing cone and level sensor	++	+	0	nd	nd	
		Cascade chute	++	+	0	nd	nd	
		Reduced emission grabs	+	0	0	+	nd	
		Hopper at negative pressure	++	-	0	-	-	
		Chutes enclosed at negative pressure	++	-	+	-	-	
		Screw conveyor	++	-	0	-	+	
		Chain conveyor	+	0	0	nd	nd	
		Fully enclosed conveyor belt	++	0	0	nd	nd	

Relevant bulk material and inherent dustiness	Relevant IPPC activities (No. of appendix on IPPC Directive	BAT candidate	Dust redusing potential	Energy use	Cross-media effect	Investment costs	Operating costs	Cross-reference
Black coal: S4	1.1/1.3/1.4/3.1/3.5	Loading pipe with height adjustment without loading head	+	0	0	+	+	
		Cascade chute	++	+	0	-	nd	
		Reduced emission grabs	+	0	0	+	nd	
		Dedusted hopper *)	++	0	0	+	-	
		Bucket elevator	+	+	0	-	+	
		Screw conveyor	++	-	0	-	+	
		Open belt conveyors, entrenched with lateral wind protection	+	0	0	+	+	
		Enclosed belt conveyor	++	0	0	-	-	
		Tube belt conveyor	++	0	0	nd	nd	
		Sprinkler systems for conveyor transfer points	++	0	+	nd	+	
Brown coal: S4	1.1/1.3/1.4/3.1/3.5	Open belt conveyor with water sprayed conveyor transfer points	++	0	0	nd	nd	
		Open belt conveyor with neatively pressured conveyor transfer points	+	-	0	nd	nd	
		Pneumatic conveyor **)	++	-	0	-	+	
		Water jets/fine sprays at conveyor transfer points ***)	++	+	+	nd	+	
		Spraying with water and tensides at conveyor transfer points ***)	++	+	-	nd	-	

*) Note: dedusted means hoppers with high traverse walls and usually with dust filters
**) Note: use is restricted to brown coal dust and to compressed air conveyor systems
***) Note: used in power stations in coal bunkers, for example

Relevant bulk material and inherent dustiness	Relevant IPPC activities (No. of appendix on IPPC Directive	BAT candidate	Dust redusing potential	Energy use	Cross-media effect	Investment costs	Operating costs	Cross-reference
Coke: S1-S4	1.1/1.3/2.1/2.2/2.4/ 2.5a	Reduced emission grabs	+	0	0	+	nd	
		Dedusted hopper *)	++	0	0	+	nd	
		Open belt conveyor, entrenched and with lateral wind protection	+	0	0	nd	nd	
		Enclosed belt conveyor	++	0	0	-	nd	
*) Note: dedusted means hoppers with high traverse walls and usually with dust filters								

Relevant bulk material and inherent dustiness	Relevant IPPC activities (No. of appendix on IPPC Directive	BAT candidate	Dust redusing potential	Energy use	Cross-media effect	Investment costs	Operating costs	Cross-reference
Iron ores and concentrates • pellets: S4 • rock ore: S4 • ore dust: S4	2.1/2.2	Loading pipe with height adjustment without loading head	+	+	0	nd	+	
		Reduced emission grabs	+	0	0	+	nd	
		Dedusted hopper *)	++	0	0	+	nd	
		Bucket elevator	++	+	0	-	+	
		Open belt conveyors, embedded and with lateral wind protection	+	0	0	+	+	
		Water jets, possibly with additives at appropriate conveyor transfer points	++	+	0	nd	+	
Copper ores and concentrates: S4	2.5a	Emission optimised grabs	+	0	0	+	nd	
		Dedusted hopper *)	++	0	0	nd	nd	
		Enclosed belt conveyor	++	0	0	nd	nd	
Miscellaneous non-ferrous ores and concentrates: S2-S4	2.5a/2.5b	Reduced emission grabs	+	0	0	+	nd	
		Dedusted hopper *)	++	0	0	+	nd	
		Enclosed belt conveyor	++	0	0	nd	nd	
		Spraying with tensides	++	+	0	nd	nd	
*) Note: dedusted means hoppers with high traverse walls and usually with dust filters; they are not necessarily used for handling iron pellets, because of the barely perceptible dust generation								

Relevant bulk material and inherent dustiness	Relevant IPPC activities (No. of appendix on IPPC Directive	BAT candidate	Dust redusing potential	Energy use	Cross-media effect	Investment costs	Operating costs	Cross-reference
Gypsum: S3	1.1/2.1/2.2/2.4/2.5a/ 3.1/3.3/3.5	Cascade chute	++	+	+	-	nd	
		Loading pipes with sealing cone and level sensor	++	-	0	nd	-	
		Pneumatic conveyor systems	++	-	+	+	-	
		Tube belt conveyor						

Relevant bulk material and inherent dustiness	Relevant IPPC activities (No. of appendix on IPPC Directive	BAT candidate	Dust redusing potential	Energy use	Cross-media effect	Investment costs	Operating costs	Cross-reference
Fertiliser: S1-S3	4.3	Emission optimised grabs	+	0	0	+	nd	
		Reduced emission hopper not under negative pressure	++	+	0	+	+	
		Screw conveyor	++	-	0	+	nd	
		Pneumatic conveyor systems	++	-	0	+	-	
		Tube belt conveyor	++	0	+	nd	+	
		Cascade chute	++	+	0	-	nd	
		Loading pipe with height adjustment and dust apron	+	+	0	nd	nd	
		Loading pipe with sealing cone and level sensor	++	+	0	nd	nd	

Annex V. Gaseous & liquid emission control measure assessment matrix

Aboveground Atmospheric Storage: External Floating Roof														
Operational emissions														
Potential Emission Source Only scores >= 3 are considered	**POSSIBLE ECM's**	**Emission reduction potential**	**Opera-bility**	**Applica-bility**	**Safety aspects**	**Amount of waste & other emissions produced**	**Operatio-nal Score**	**CAPEX (new)**	**CAPEX (retrofit)**	**OPEX (Utilities)**	**OPEX (Ops & Main)**	**Cost score (new)**	**Cost score (retrofit)**	**Overall score**
Gas Emissions														
		A	B	C	D	E	=B+C+D+E	F	G	H	I	=F*(H+I)	=G*(H+I)	
filling	operating procedures/training													
(until roof floats on liquid)	instrumentation													
standing	shell/roof paint colour													
	dome roof													
	pontoon roof													
	- with vapour mounted primary seals													
	- with liquid mounted primary seals													
	- with mechanical shoe seal													
	- with secondary seals													
	double deck roof													
	- with vapour mounted primary seals													
	- with liquid mounted primary seals													
	- with mechanical shoe seal													
	- with secondary seals													
	sealing roof penetrations													
	- guide pole													
	- roof legs													
	- still well cover													
fugitive	inspection/maintenance													
	(incl. roof-shell seal tightening)													
Liquid Emissions														
cleaning	operational procedures/training													

Scoring definitions:
All scores range from 1 to 5
5-score on emission reduction potential indicates the highest reduction potential
5-score on operability means easiest to operate
5-score on applicability indicates that the ECM is suitable for the widest range of products
5-score on safe to use indicates safest to use for operators
5-score on Amount of Waste produced indicates the lowest amount of (additional) waste produced
5-score on all CAPEX/OPEX columns indicates lowest costs

GLOSSARY

Definition of materials

[CPR, 1991 first edition #8]

Combustible material:
A material that will continue to show a combustive reaction with air of normal composition and pressure even after the source of ignition is removed.

Carcinogenic material:
A material that is known to cause cancer in man.

Corrosive material:
A material that in contact with the skin can have a destructive effect on living tissue.

Explosive material:
A material that may explode when brought into contact with a flame or that is more sensitive to impact or friction than nitrobenzene.

Irritant material:
A material that through direct, prolonged or repeated contact with the skin or the mucous membranes can cause infection.

Highly flammable material:
A material that:

- when exposed to the atmosphere at normal temperature, can rise in temperature and finally ignite without the addition of energy;
- in solid form, when subjected to an ignition source for a short period of time, can be easily ignited and will continue to burn or smoulder after removal of the ignition source;
- in liquid form, has a flashpoint below 21° C;
- in gaseous form, at normal pressure, can be ignited with air, or
- in contact with water or humid air, will develop highly flammable gases in dangerous quantities (a material that develops highly flammable gases when brought into contact with water)

Environmentally harmful material:
A material that can cause acute or chronic effects in ecosystems; the classification of environmentally harmful materials takes place in accordance with the agreements included in the 67/548/EEC Directive.

Mutagenic material:
A material that is known to affect the structure of DNA.

Flammable material:
A material that in liquid form has a flashpoint of at least 21°C and not higher than 55°C.
Oxidant:
A material that can react highly exothermically when brought into contact with other materials, flammables in particular.

Harmful material:
A material that by inhalation or entry via the mouth or skin can cause disorder of a limited nature.

Teratogenic material:
A material that is known to be teratogenic to man.

Toxic material:
A material that by inhalation or entry via the mouth or skin, can cause serious acute or chronic dangerous disorders or even death.

Highly toxic material:
A material by inhalation or entry via the mouth or skin can cause very serious acute or chronic dangerous disorders or even death.

Definitions related to storage

Operational:	Emissions occurring due to normal operational activities. Frequency, volumes and loads are usually known up-front or can be estimated and some can be scheduled. The above can be used for determining best ratio of investment vs. efficiency when prioritising investments and determining best applicable emission reduction technique. Fugitive emissions and pressure relief are considered to be operational since they occur under normal operational circumstances.
Incidents:	Emissions due to incidents are those, which result from failure of protection systems and/or human error. Volumes and frequencies cannot be predicted and only mitigating measures can be provided.
Standing:	Product volume in tank not circulated and/or pumped in or out.
(Out)Breathing:	Gaseous emission due to ambient temperature change, usually daytime heating of contents of storage tanks (out breathing due to volume increase of gas and evaporation of liquid). Inbreathing due to cooling of contents (night-time volume decrease of gas and condensation of vapour) is not considered an emission source.
Filling:	Liquid stream replacing vapour contents of a system.
(Tank)Emptying:	Removing (part of) the liquid contents of a system (e.g. relevant for EFRT).
Purging:	Replacement of gaseous contents of system by air or inert gases.
Manual Gauging:	A method for measuring the liquid height of a tank, usually done by lowering a weighted tape through an opening in the tank roof.
Sampling:	Removing a small representative volume of liquid from the contents of system for test purposes. Usually done by opening valves directly connected to the main system and collecting liquid in a (semi)closed or open sample system.
Overfill:	Liquid spill due to filling of system beyond maximum contents caused by failure of overfill prevention systems.
Leakage:	Gaseous or Liquid spills out of system/equipment due to system/equipment failures.
Cleaning:	Removing of liquid and/or vapour contents of system by draining, flushing, scraping, purging etc. in order to prepare the system for maintenance/inspection activities or other products. Usually creates (small) waste liquid stream.

Pigging: Removing of contents of piping systems by means of a device pushed by an inert media or product which scrapes the contents of the system out of the system. Possible liquid and gaseous spillages at outlet of system.

(Dis)Connecting: Connecting transfer system to tanks, (un)loading system or other transfer system by means of removable connections (spool pieces etc.). Possible liquid and gaseous emissions when installing connection and removing connection.

(Un)Coupling: Connecting transfer system to tanks or other (un)loading system (liquid or gas containment systems, e.g. trucks, vessels, isocontainers etc.) by means of purpose-designed loading arms and/or hoses. Possible liquid and gaseous emissions when installing connection and removing connection.

Fugitive Emissions: Gaseous emission from system components (pump seals, mechanical seals, gaskets etc.) usually by permeation of gases through a bolted connection,

Draining: Emptying of liquid contents of system to collection system or other storage system creating a possible liquid waste stream.

Pressure relief: A system which prevents a liquid (or gas) system from overpressure due to ambient temperature changes, usually releasing some liquid contents of system to a collection system due to ambient temperature rise in daytime.

To be further expanded.

Abbreviations

BAT: Best Available Technology
ECM: Emission Control Measure

K_0 : this is the category of flammable liquids with a vapour pressure, at 37.8ººC, of 1 bar or more.

K_1 : this is the category of flammable liquids, not being K_0, with a flashpoint (determined with the Abel-Pensky instrument) at 1 bar, below 21ººC.

K_2 : this is the category of flammable liquids with a flashpoint (determined with the Abel-Pensky instrument) at 1 bar, below 55ººC but not below 21ººC.

K_3 : this is the category of flammable liquids with a flashpoint (determined with the Pensky-Martens instrument) at 1 bar, of 55ººC or higher, but not above 100ººC.

PVRV : pressure/vacuum relieve valves

To be further expanded.

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