Section 6

WASTE CLASSIFICATION

6.1 Introduction

The Minimum Requirements for classifying wastes are summarised in Table 6, at the end of this section.

Once the substances, compounds, properties and characteristics of a waste have been determined, usually by tests and analyses (see Section 5), it can be classified.

The objectives of the classification system are to:

• distinguish between Hazardous Waste and General Waste;
• determine the single most hazardous property of the waste and, hence;
• determine the degree of hazard posed by the Hazardous Waste;
• rate Hazardous Wastes, based on the properties and degree of hazard, and set requirements for pre-treatment and disposal;
• provide a hierarchical approach, which ensures that unnecessary restrictive measures and expenses are avoided.

An overview of the classification system was provided in Section 2 and the approach was described in Appendix 2.

6.2 SANS 10228

SANS 10228, Identification and Classification of Dangerous Goods for Transport, forms the basis of the Hazardous Waste classification system.

The SANS is derived from the International Maritime Dangerous Goods (IMDG) Code. This is a United Nations based system for the classification of dangerous goods to be transported by sea.

The IMDG Code was adopted by South Africa in 1986 (RSA-IMDG Code), to provide a uniform and internationally acceptable system for the identification and classification of hazardous substances. All existing and future legislation is therefore related to the Code.

The different aspects of Hazardous Waste management, such as packaging, temporary storage, transport, treatment and disposal are all based on the principles of SANS 10228 (see Appendix 2).

Extension of SANS 10228

In the SANS, hazardous substances are given an identification number and are classified into nine classes (see Table 6.1). Hazardous substances that fall into Class 6, Toxic and infectious substances are further divided into three danger groups.

However, these danger groups relate primarily to transportation, taking into account only the danger to humans. In this document, therefore, the SANS has been extended, to take into account potential hazardousness to the ecosystem, and especially groundwater.

This extension of the SANS can be seen in the Waste Classification Tables at the back of this document. In this, the Hazard Rating, the EEC, the Total Load, and the preferred treatment and disposal methods are provided for substances listed in the SANS.

Currently, some 750 of the more common Hazardous Waste substances generated in South Africa are listed in the Waste Classification Tables. With time, this information will be provided for all of the substances listed in the SANS. When complete, the extended SANS
should provide an easy and convenient means of identifying and classifying Hazardous Waste.

The Waste Classification Tables are mentioned at this early stage because of their importance. However, it is strongly recommended that the classification system outlined in the following sections be understood before any attempt is made to use them.

### 6.3 Confirming that a waste is Hazardous

Once the substances and properties of a waste have been determined (see Section 5), they are compared with the Waste Classification Tables, with the Basel Convention and with SANS 10228.

If any of the substances or characteristics of the waste are listed in the above sources, it is confirmed that the waste is a Hazardous Waste.

*Should a waste contain hazardous substances NOT listed in SANS 10228, the Competent Authority must be consulted before classification is attempted.*

References included at the end of this document, can also be used as a source of information regarding hazardous substances.

### 6.4 SANS 10228 Hazard Classes

When confirming that the waste is hazardous (see 6.3), the properties of the waste are tested against the nine SANS 10228 classes, i.e., is the waste flammable, explosive, corrosive, radioactive, toxic, etc. See Table 6.1 and Appendix 6.1 for class definitions.

From Diagram II, it can be seen that all classes of wastes, except gases or radioactive wastes, will ultimately have to be tested against Class 6, *Toxic and Infectious Substances*. This is because even though a waste may be treated or destroyed there will often be some form of residue which will require disposal. This residue will have to be analysed and its hazardousness (Hazard Rating)

will have to be determined before it can be disposed of.

### 6.5 Determining the Minimum Requirements

Once the SANS 10228 class has been determined, the relevant Minimum Requirements, i.e. treatment, incineration or destruction, can be determined from *Diagram III*. The user moves from Class 1 through to Class 9 in Diagram III by reacting to the Yes and No choices, and following the arrows as indicated. It is noted that the waste must be classified according to its most dangerous substance.

### 6.6 Minimum Requirements

**Class 1 (explosives)**

It is a Minimum Requirement that a waste or a substance in the waste that falls into Class 1 be pretreated. Direct landfilling is prohibited and the Explosives Act must be consulted.

Examples of wastes that would fall into Class 1 would include ammonium perchlorate, ammunition, explosive articles, cyclonite, dinitrophenol, hexanitrodiphenylamine and nitrocellulose.

**Class 2 (gases)**

It is a Minimum Requirement that flammable gases be subjected to thermal destruction.

Non-flammable gases may be released to the atmosphere, unless in contravention with the National Environment Management: Air Quality Act (Act 39 of 2004) and the Montreal Protocol. It is a Minimum Requirement, however, that poisonous gases be subjected to controlled destruction.

**Class 3 (flammable liquids)**

Direct landfilling of certain flammable liquids is PROHIBITED. It is a Minimum Requirement that flammable liquids with flashpoint <61°C be
treated to flashpoint >61°C. The residual product can then be regarded as non-flammable. However, the residue would then have to be evaluated for its toxicity potential (Class 6).

Examples of flammable liquid would include acetone, alcohol, ethyl ether, aviation gasoline, brake fluid or butaldehyde.

**Class 4 (flammable solids or substances)**

It is a Minimum Requirement that flammable solids be treated to non-flammability before disposal, see Diagram III. Thereafter, the waste must be tested against Class 6, and given a Hazard Rating.

**Class 5 (oxidising substances and peroxides)**

It is a Minimum Requirement that oxidising substances and organic peroxides be treated before disposal to neutralise their oxidation potential (see Diagram III). Thereafter, the waste must be tested against Class 6, and given a Hazard Rating.

**Class 6 (toxic and infectious substances)**

It is a Minimum Requirement that all wastes or residues of waste pass through Class 6. It is at this stage that the Hazard Rating are determined. This is shown in Diagram II. The methodology for determining the Hazard Rating is set out in Section 8.

It is a Minimum Requirement that infectious waste be destroyed. Thereafter, any residue must be given a Hazard Rating.

**Class 7 (radioactive material)**

Radioactive materials with a specific activity > 100 Bq/g and/or a total activity > 4 kBq are too dangerous to be directly disposed of at a landfill site. Special provision for the disposal of this class of materials has therefore been made in terms of the Nuclear Energy Act, 1999 (Act 46 of 1999).

**Class 8 (corrosive substances)**

Disposal of corrosive substances, pH <6 or pH >12, by landfill is prohibited. Corrosive substances must be pre-treated to pH 6 to 12 and thereafter given a Hazard Rating.

**Class 9 (miscellaneous dangerous substances)**

Class 9 provides for substances that may be difficult to classify according to the definitions in the SANS. Examples are regulated substances like liquids and solids with anaesthetic, noxious or similar properties, and miscellaneous articles and substances like asbestos, dry ice, environmentally hazardous substances, zinc dithionite, etc.

When wastes contain Class 9 substances or products, it is a Minimum Requirement that the Competent Authority be approached regarding the Hazard Rating. It is also a Minimum Requirement that written approval be obtained before disposal.
<table>
<thead>
<tr>
<th>Subject</th>
<th>Minimum Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classification</td>
<td>In accordance with its properties and characteristics, a Hazardous Waste must be placed in a SANS 10228 class.</td>
</tr>
<tr>
<td>Unlisted compounds</td>
<td>Should a Hazardous Waste contain compounds NOT listed in SANS 10228, the Competent Authority must be consulted before classification is attempted.</td>
</tr>
<tr>
<td>Class 1</td>
<td>Direct disposal of Class 1 wastes is PROHIBITED.</td>
</tr>
<tr>
<td>Class 1</td>
<td>Class 1 wastes to be pre-treated (destroyed).</td>
</tr>
<tr>
<td>Class 2</td>
<td>Flammable gases to be thermally destroyed. Non-flammable gases to be released to atmosphere, unless in contravention with the National Environment Management: Air Quality Act (Act 39 of 2004) and the Montreal Protocol. Controlled destruction of poisonous gases.</td>
</tr>
<tr>
<td>Class 3</td>
<td>Landfilling of flammable liquids, flashpoint &lt; 61°C is PROHIBITED.</td>
</tr>
<tr>
<td>Class 4</td>
<td>Flammable liquids to be treated to flashpoint &gt; 61°C.</td>
</tr>
<tr>
<td>Class 5</td>
<td>Landfilling of flammable solids is PROHIBITED.</td>
</tr>
<tr>
<td>Class 6</td>
<td>Class 6 wastes to be pre-treated (destroyed).</td>
</tr>
<tr>
<td>Class 7</td>
<td>Landfilling of Oxidising Substances and Organic Peroxides is PROHIBITED.</td>
</tr>
<tr>
<td>Class 8</td>
<td>Treatment to neutralize oxidation potential.</td>
</tr>
<tr>
<td>Class 9</td>
<td>Radioactive Substance with specific activity &lt; 100 Bq/g, total activity &lt; 4 kBq, to be incinerated or landfilled.</td>
</tr>
<tr>
<td>Class 10</td>
<td>Disposal of Radioactive Substance with specific activity &gt; 100 Bq/g, total activity &gt; 4 kBq, is PROHIBITED. Consult Department of Health.</td>
</tr>
<tr>
<td>Class 11</td>
<td>Disposal of Corrosive Substance, pH &lt; 6 and/or pH &gt; 12, by landfill is PROHIBITED.</td>
</tr>
<tr>
<td>Class 12</td>
<td>Corrosive Substance to be treated to pH 6 - 12.</td>
</tr>
<tr>
<td>Class 13</td>
<td>Competent Authority to be notified if a compound contains substances NOT listed in Class 9 and written approval must be obtained before disposal.</td>
</tr>
<tr>
<td>Class 14</td>
<td>Competent Authority to be notified if a compound contains substances listed in Class 9 and written approval must be obtained before disposal.</td>
</tr>
</tbody>
</table>
### TABLE 6.1
SANS 10228 Classes

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 1</td>
<td>Explosives</td>
</tr>
<tr>
<td>Class 2</td>
<td>Gases: compressed, liquefied or dissolved under pressure</td>
</tr>
<tr>
<td></td>
<td>Flammable gases</td>
</tr>
<tr>
<td></td>
<td>Non-flammable, non-toxic gases</td>
</tr>
<tr>
<td></td>
<td>Toxic gases</td>
</tr>
<tr>
<td>Class 3</td>
<td>Flammable liquids</td>
</tr>
<tr>
<td>3.1</td>
<td>Low flashpoint group of liquids; flashpoint below – 18°C c.c*.</td>
</tr>
<tr>
<td>3.2</td>
<td>Intermediate flashpoint group of liquids; flashpoint of –18°C up to, but not including 23°C c.c.</td>
</tr>
<tr>
<td>3.3</td>
<td>High flashpoint group of liquids flashpoint of 23°C up to, and including, 61°C c.c</td>
</tr>
<tr>
<td>Class 4</td>
<td>Flammable solids or substances</td>
</tr>
<tr>
<td>4.1</td>
<td>Flammable solids</td>
</tr>
<tr>
<td>4.2</td>
<td>Flammable solids liable to spontaneous combustion</td>
</tr>
<tr>
<td>4.3</td>
<td>Flammable solids which emit flammable gases when in contact with water</td>
</tr>
<tr>
<td>Class 5</td>
<td>Oxidising substances and organic peroxides</td>
</tr>
<tr>
<td>5.1</td>
<td>Oxidising substances</td>
</tr>
<tr>
<td>5.2</td>
<td>Organic peroxides</td>
</tr>
<tr>
<td>Class 6</td>
<td>Toxic and infectious substances</td>
</tr>
<tr>
<td>6.1</td>
<td>Toxic substances</td>
</tr>
<tr>
<td>6.2</td>
<td>Infectious material</td>
</tr>
<tr>
<td>Class 7</td>
<td>Radioactive substances</td>
</tr>
<tr>
<td>Class 8</td>
<td>Corrosive substances</td>
</tr>
<tr>
<td>Class 9</td>
<td>Other miscellaneous dangerous substances, that is any other substance which experience has shown, or may show, to be of such dangerous character that the provisions of this Section should apply to it.</td>
</tr>
</tbody>
</table>

* c.c. = closed cup

These classes are discussed further in Appendix 6.1.

In the SANS 10228, the nine classes are allocated a Danger Group (Groups I - III) for transport purposes. This should not be confused with the Hazard Rating for waste disposal described in Sections 2 and 8.
**DIAGRAM II  Classification Of Hazardous Waste**

<table>
<thead>
<tr>
<th>Class 1 Explosives</th>
<th>Class 2 Gases</th>
<th>Class 3 Flammable Liquids</th>
<th>Class 4 Flammable Solids</th>
<th>Class 5 Oxidising Substances &amp; Organic Peroxides</th>
<th>Class 6 Toxic &amp; Infectious Substances</th>
<th>Class 7 Radioactive Material</th>
<th>Class 8 Corrosives</th>
<th>Class 9 Miscellaneous Dangerous Substances</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

- Yes
- No

- Consult Explosives Act
- Destruction or Venting
- Treatment
- Treatment
- Treatment
- Consult Dept of Minerals & Energy (council for Nuclear Safety)
- Treat to pH 6-12
- Listed Compound

Use Class 6 Diagram IV to determine the hazard rating in terms of Mammalian & Ecotoxicity \((LD_{50}, LD_{50}, DOC, P_{ow}, K_{oc}, and EEC)\)

- Compounds not listed must be classified in accordance with the waste classification system and final verification must be obtained from the Competent Authority prior to disposal and for the purposes of updating the Waste Classification Tables.
- Only applicable where substance possesses toxicity as well as radioactivity (Uranium, lead and cadmium).
HAZARDOUS WASTE TREATMENT

7.1 Introduction

The Minimum Requirements for the treatment of Hazardous Waste are summarised in Table 7, at the end of this section.

After determining the relevant Minimum Requirements from Diagram III, Section 6, it may be necessary to treat the Hazardous Waste. The exact treatment method is usually not prescribed. The choice of technology applied to the approved treatment and disposal of a particular Hazardous Waste will depend upon the nature of the waste, the availability of treatment and disposal facilities, and the cost-effectiveness of treatment and disposal options.

The objectives of treating a Hazardous Waste or waste stream are to:

- reduce the toxicity of the harmful components so as to minimise the impact of the waste on the environment;
- comply with the relevant Acts and the Minimum Requirements for treatment and disposal.

This section provides a brief overview of possible Hazardous Waste treatment technologies. The methodologies outlined here can also often be used for the recovery of materials during waste minimisation and recycling programmes. Most treatment technologies can be readily adapted and modified to the requirements of a particular waste stream.

Once a waste has been treated, it will often have to be analysed once again for its hazardous properties and characteristics, see Section 5. The information obtained from this and previous analyses will then be used to determine the Hazard Rating of the waste, see Section 8.

7.2 Treatment technologies

The technology chosen for the treatment of a Hazardous Waste will be influenced by its physical and chemical characteristics, i.e.:

- gas, liquid, solid, sludge, in solution, a colloid etc.
- inorganic or organic
- concentration of both hazardous and non-hazardous components
- other characteristics that are used in Hazard Rating, such as mobility, toxicity, accumulation potential, etc.

The available technologies for the treatment of Hazardous Waste can be grouped generally as:

- physical treatment
- chemical treatment
- biological treatment
- immobilisation, solidification and encapsulation
- incineration

Site rehabilitation and clean-up technologies can also be regarded as forms of treatment.

7.3 Physical treatment

Physical treatment methods are used to re-move, separate and concentrate hazardous and toxic materials. For example, evaporation or filtration can be used to separate a liquid from dissolved or suspended solids.

There are many such conventional technologies that are commonly used in South Africa. The safety aspects of the processes and the environ-
mental problems that could arise during their use are well known and many processes have been identified as Best Developed Available Technologies (BDAT).

A list of physical treatment technologies together with a brief description of each process and its typical application is provided in Appendix 7, Table A.7.1.

### 7.4 Chemical treatment

Chemical treatment is used:

- to assist in the application of physical treatment technologies; and
- to lower the toxicity of a Hazardous Waste by changing its chemical nature. This often yields essentially non-hazardous substances, such as salts, carbon dioxide and water.

An example of chemical treatment would be the addition of acid to an alkaline waste stream to neutralise the pH.

Chemical treatment technologies are widely applicable, and many have been designated as BDAT. A list of technologies, together with a brief description of each process and its typical application is given in Appendix 7, Table A.7.2.

### 7.5 Biological treatment

In biological treatment, microbes are used to destroy or at least reduce the toxicity of a waste stream.

The use of selected or even engineered bacteria is making this technology one of increasing versatility and importance for the treatment of Hazardous Wastes.

The general types of transformations that can be accomplished biologically include:

- degradation of organics, e.g., phenols, to products such as carbon dioxide, methane, water and inorganic salts;
- reduction of inorganic substances, e.g., nitrate;
- complexation of heavy metals, e.g., nickel.

For convenience, contained biological waste treatment and exploitation may be divided into aerobic and anaerobic processes. The two are often used in series and in conjunction with physical and chemical treatment technologies.

#### 7.5.1 Aerobic treatment

In aerobic processes, organic matter is removed from solution by micro-organisms, by means of biological oxidation. Aerobic decomposition involves the breakdown of organic wastes to energy and cell mass in the presence of oxygen.

That is Organics + oxygen + Nitrogen + Phosphates = new cells, carbon dioxide, water and non-biodegradable residue.

Of particular importance are: the rate of the process, which can be slow for many industrial organic materials, e.g., polymers and oils; the phosphorus and nitrogen requirements; and the amount of sludge produced. Aerobic treatment is increasingly being used in the treatment of leachates from landfill sites.

#### 7.5.1 Anaerobic treatment

Anaerobic decomposition involves the breakdown of organic wastes to, mainly, gases and water in the absence of oxygen. Such gases would include methane and carbon dioxide.

In general, the process is slower than aerobic treatment, but a lower volume of sludge is produced and the potentially valuable resource methane gas is obtained.

Anaerobic technology is used in the treatment of food and brewery wastes and it has been shown that anaerobic methods can break down a variety of aromatic organic substances that have proven recalcitrant to aerobic treatment. Anaerobic decomposition occurs in landfills and is responsible for the generation of landfill gas.
7.6 Immobilisation, solidification and encapsulation

The prime objective of immobilisation, solidification and encapsulation techniques is to convert the Hazardous Waste into an inert, physically stable mass. This treated waste should have a very low leachability and sufficient strength to allow for landfilling or land reclamation.

Immobilisation (or chemical stabilisation) is a process in which the waste is converted to a more chemically stable or more insoluble or immobile form.

Solidification or cementation is a process in which the waste is converted to an insoluble rock-like material by being mixed with suitable materials.

Encapsulation is the coating or enclosure of waste with an inert durable material. Micro-encapsulation applies to the individual particles of a waste, while macro-encapsulation is the encapsulation of a mass of waste, which is normally in a container such as a drum.

The most common materials used are cementing agents, such as portland cements, lime, fly-ash and gypsum mixtures, although modified clay minerals that are now available on the market show considerable advantages over these more conventional materials.

Macro-encapsulation in specially designed cells of a variety of wastes contained in drums, is currently practised in South Africa. This includes both inorganic wastes, e.g., arsenic, and organic wastes, e.g., pesticides and PCBs.

7.7 Landfill-ash blend, neutralisation, precipitation

Landfill-ash blend involves the mixing or blending of a flammable waste with sufficient fly-ash, bottom ash or other material approved by the Competent Authority, so that the flash point is >61°C. Ash blending is considered a treatment process. The resulting product may be landfill co-disposed with General Waste in accordance with its Hazard Rating.

Neutralisation is the addition of acid or alkali to bring the pH in the region of 7. Lime is normally used to neutralise acid wastes prior to landfilling.

Precipitation is the addition of lime, sodium sulphide or other reagents that result in the formation of insoluble substances that come out of solution.

7.8 Incineration

Incineration can be regarded as both an option for treatment and for disposal, and is therefore discussed in Section 9.

7.9 Site rehabilitation and clean-up technologies

The choice of a strategy and a process for the clean-up and rehabilitation of an industrial site should be made on the basis of a detailed risk assessment that includes a hazard evaluation, exposure assessment and risk characterisation. However, the initial response should be to clean up the most obvious sources of pollution, such as old drums and stockpiles plus obviously contaminated soils and to contain potential run-off water on site in order to minimise further pollution.

Technologies that can be used to rehabilitate and clean up a site are:

- Engineering Containment
- Incineration or other thermal treatment
- Solidification/Stabilisation/Neutralisation
- Volatilisation or Soil Aeration
- Bio-treatment
- Vacuum Extraction

The main aim of engineering containment is to limit the movement of surface or groundwater into the contaminated area or to prevent contaminant migration from the site.
Options include the provision of covers, as for site closure, or vertical barriers by slurry trenching or cut-off or diaphragm wall technology.

7.10 Effluent and residue quality standards

Any effluent or residue that is to be released into the environment must conform to the standards of the relevant Acts or their regulations, such as:

- National Water Act, 1998
- Environmental Conservation Act, 1989; and the Environmental Conservation Amendment Act, 2003

They must also conform to any local by-laws or regulations.
Section 8

HAZARD RATING

8.1 Introduction

The Minimum Requirements for applying a hazard rating to a Hazardous Waste are summarised in Table 8, at the end of this section.

The Hazardous Waste has been treated to comply with the requirements for its SANS 10228 class (see Sections 6 and 7). Now, it or its residue must be tested against Class 6, Poisonous/Toxic Substances. It is at this stage that it is Hazard Rated and allocated a Hazard Rating.

In Class 6 of the SANS, provision is made for a hazardous substance to be classified as "toxic" and allocated a transport Danger Group (see Waste Classification Tables, Column 3). However, this Danger Group is allocated only in terms of acute mammalian toxicity ($LD_{50}$) or, in other words, the risk to humans during storage, handling and transport.

This is inadequate for waste disposal purposes. Assessment of the risk posed to health and the environment by the disposal of a chemical or a mixture must also take into account all the properties that are related to exposure within the environment, such as:

- biodegradability
- persistence
- bioaccumulation
- chronic toxicity
- concentration
- production volume
- high dispersion
- leakage to the environment.

Class 6 has therefore been extended to include ecotoxicity and environmental fate as well as chronic toxicity.

The objectives of Hazard Rating are to indicate:

- the risk posed by a Hazardous Waste and hence the degree of care required for its disposal;
- the class of Hazardous Waste landfill at which the waste may be disposed;
- the amount of a hazardous substance or compound that can be disposed of at a particular Hazardous Waste landfill site before it begins to pose a risk.

8.2 Hazard Ratings

As discussed in Section 2, the Hazard Rating is used to classify Hazardous Waste into four Hazard Ratings.

Hazard Rating 1: Extreme Hazard
Hazard Rating 2: High Hazard
Hazard Rating 3: Moderate Hazard
Hazard Rating 4: Low Hazard

The four Hazard Ratings are ranked according to a logarithmic progression, whereby Extreme Hazard is 10 times more toxic than High Hazard and 1000 times more toxic than Low Hazard.

Hazard Rating 1 (Extreme Hazard):

Is waste of first priority concern, containing significant concentrations of extremely toxic substances, including certain carcinogens, teratogens and infectious wastes.

Hazard Rating 2 (High Hazard):

Is waste of second priority concern with highly toxic characteristics or extremely toxic substances, which are not persistent, including certain carcinogens.

Hazard Rating 3 (Moderate Hazard):
Is waste of third priority concern, which is moderately toxic or which contains substances that are potentially highly harmful to human health or to the environment but are not persistent.

**Hazard Rating 4 (Low Hazard):**

Is waste that often occurs in large quantities and which contains potentially harmful substances in concentrations that in most instances would represent only a limited threat to human health or to the environment.

**Hazard Rating lower than Hazard Rating 4:**

where the classification falls below Hazard Ratings 1 to 4. The hazard posed by a waste can be considered to be low enough to allow the waste, with the consent of the Competent Authority, to be disposed of at a General Waste landfill with a leachate collection system.

The Hazard Rating determines the class of landfill at which a waste is disposed:

- Hazard Rating 1: Hazard Rating 2: 
  - H:H landfill
- Hazard Rating 3: 
  - H:H or H:h landfill
- Hazard Rating 4: 
  - landfill

The requirements for the siting, investigation, design, operation and monitoring of a Hazardous Waste landfill are more stringent than those for a General Waste landfill (see Minimum Requirements for Waste Disposal by Landfill). In turn, the requirements for an H:H landfill are more stringent than those for an H:h landfill.

### 8.3 Determining the Hazard Rating

Before attempting the Hazard Rating, the user should have obtained the necessary information from tests and analyses (see Section 5) and from the literature (see References).

To determine the Hazard Rating, the user will proceed from Phase A through to Phase H in Diagram IV.

Moving from Phase A to Phase D, does the waste contain:

- infectious material
- a teratogen
- a carcinogen
- a mutagen

Some compounds regarded as teratogens, carcinogens (A class or B class) or mutagens are listed in Appendices 5.2 & 5.3.

If it does contain any of the above, what is the concentration of the carcinogenic or mutagenic substance?

**It should be noted that the hazardous effects of some carcinogens are not related to their concentration in the waste, and cannot be reduced with dilution.**

Thereafter, what is the:

- biodegradation of the substance, measured as dissolved organic carbon (DOC) or chemical oxygen demand (COD), expressed as a percentage (%);
- accumulation potential of the substance, expressed as the octanol/water partition coefficient, $P_{ow}$;
- persistence potential of the substance, expressed as soil adsorption constant, $K_{oc}$.

From Phases E to H of Diagram IV, what is the:

- acute mammalian toxicity of the substance, expressed as LD$_{50}$ (mg/kg);
- acute ecotoxicity of the substance, expressed as LC$_{50}$ (mg/$\lambda$) of aquatic organisms;
- Estimated Environmental Concentration or EEC of the substance, expressed as parts per billion.
Having moved through Diagram IV, the Hazard Rating will have been determined.

Where Diagram IV indicates that the waste is "no risk" or "non-toxic", the waste can be disposed of at a General Waste landfill with a leachate collection system, a $G:B$+ landfill (see delisting, Section 8.4.1).

The above criteria are discussed in depth in Appendix 8.1. The EEC is discussed further, in Section 8.4, because it is a unique concept and because of the role that it plays in determining the Hazard Rating.
Hazard Classification for Waste Disposal

Class 6: Poisonous/Toxic Substances

**PHASE A**
(INFECTIOUS WASTE)
Infectious Waste
- Yes → PROCEED PHASE B
- No → Complete sterilization or incineration → EXTREME HAZARD GROUP I

**PHASE B**
(TERATOGENICITY) (Including Environmental Fate)
Teratogenic
- Yes → PROCEED PHASE C
- No → Carcinogenic and/or Mutagen
  - Yes → PROCEED PHASE D
  - No → EXTREME HAZARD GROUP I

**PHASE C**
(CHRONIC TOXICITY) (Including Environmental Fate)
Class A/B Carcinogen/Mutagen
- Yes → EXTREME HAZARD GROUP I
- No → Concentration >1%
  - Yes → MODERATE HAZARD GROUP III
  - No → PROCEED PHASE D

**PHASE D**
(CHRONIC TOXICITY) (Including Environmental Fate)
Class C/D Carcinogen
- Yes → MODERATE HAZARD GROUP IV
- No → PROCEED PHASE E

**PHASE E**
(ACUTE TOXICITY) (Including Environmental Fate)
Extremely Mammalian acute toxicity $L_D_{50} = < 5mg / kg$
- Yes → EXTREME HAZARD GROUP I
- No → Of extreme acute Ecotoxicity $L_C_{50} = < 1mg / l$
  - Yes → PROCEED PHASE F
  - No → Of moderate acute Ecotoxicity $L_C_{50} = 1-10mg / l$
  - Yes → No Risk Delist
  - No → EXTREME HAZARD GROUP I

**PHASE F**
(ACUTE TOXICITY) (Including Environmental Fate)
High Mammalian acute toxicity $L_D_{50} = 5-50mg / kg$
- Yes → PROCEED PHASE G
- No → Of high acute Ecotoxicity $E_C_{50} = 0.1 - 1mg / l$
  - Yes → No Risk Delist
  - No → EXTREME HAZARD GROUP I

**PHASE G**
(ACUTE TOXICITY) (Including Environmental Fate)
Moderate Mammalian acute toxicity $L_D_{50} = 50-500mg / kg$
- Yes → No Risk Delist
- No → Of low acute Ecotoxicity $E_C_{50} = 100-1000mg / l$
  - Yes → No Risk Delist
  - No → MODERATE HAZARD GROUP III

**PHASE H**
(ACUTE TOXICITY) (Including Environmental Fate)
Low Mammalian acute toxicity $L_D_{50} = 500-5000mg / kg$
- Yes → No Risk Delist
- No → Of medium acute Ecotoxicity $E_C_{50} = 5-10mg / l$
  - Yes → No Risk Delist
  - No → LOW HAZARD GROUP IV

Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste
8.4 The Estimated Environmental Concentration (EEC)

The Estimated Environmental Concentration (EEC) represents exposure by a hazardous substance in the waste, should it enter into the environment (air, water, and soil). It is used to assess the risk that a hazardous substance poses to the environment (please refer also to Appendix 8.1 and Appendix 8.2).

The pathway for the escape of a substance in waste is usually water. Therefore, in this document, EEC represents exposure in a body of water. It is used to:

- determine the amount of a substance in the waste, and hence the waste, that can be disposed of at a landfill per hectare per month;
- determine the total amount of a substance that can be disposed of at a landfill before the site must be closed for that substance (Total Load);
- assess whether, after treatment or tests, a waste can be reclassified to fall into a lower Hazard Rating or even be disposed of at a General Waste site approved by the Competent Authority.

If there is more than one hazardous substance in a waste stream, there will be more than one EEC.

The EEC of the most hazardous substance in the waste stream will determine the Hazard Rating.

The EEC can be determined using either a ‘fixed-scenario’ approach or a ‘site specific’ approach (or both).

8.4.1 Fixed-scenario approach to the EEC

The fixed-scenario approach to the EEC represents the worst-case scenario, that is, it assumes total concentration, as if all of the substance were to leach out of the waste and enter the environment.

The EEC is expressed in parts per billion (ppb) and is calculated using the simplified formula*

$$\text{EEC (ppb)} = \text{dose (g/ha/month)} \times 0.66$$

Where dose represents the total amount in grams of the substance in the waste to be disposed of on one hectare of the disposal site per month.

For examples of the calculation of the EEC using the fixed-scenario approach, please refer to Appendix 8.3.

8.4.2 Risk assessment approach to the EEC

The ‘fixed-scenario’ approach to the determining the EEC applies as a general rule. However, the Minimum Requirements take into consideration cases where site-specific factors are such that the rule cannot or need not be applied. A site-specific

---

*When wishing to optimise the concept of the EEC, in terms of site-specific parameters and conditions, the procedures become compounded and complex. Therefore, within the agreed scope and context of this document, only a brief introduction to the EEC has been regarded appropriate. For more information, the Department should be consulted.

† 0.66 is derived from the ratio of the substance in a weight of underground body of water.

$$\text{EEC(ppb)} = \frac{A \ (\text{waste load/ha of land/month})}{B \ (\text{weight of underground body of water})}$$

Where A: Waste in g/ha x size of drainage basin x percentage which may leach into the groundwater.

Where B: Surface area of body of water x average depth x weight of water.
risk assessment can therefore be used as an alternate or additional means of determining the risk of exposure (EEC). This approach is discussed in detail in Appendix 8.4.

The ‘fixed-scenario’ approach to the EEC assumes that all of the substance leaches out of the waste and enters the environment. The site-specific risk assessment approach, on the other hand, takes into account attenuation factors. For example, where a waste is to be disposed of by landfill, such factors as capping, waste properties, waste pretreatment, site operation and liner systems would be used when determining the EEC.

8.4.3 Exposure and delisting

The first Yes/No replies determining the Hazard Rating in Diagram IV, Phases E to H, are according to acute mammalian toxicity (LD$_{50}$) and acute ecotoxicity (LC$_{50}$). See Table 8.1.

<table>
<thead>
<tr>
<th>LD$_{50}$ (mg/kg)</th>
<th>LC$_{50}$ (mg/λ)</th>
<th>Hazard Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;5</td>
<td>&lt;1</td>
<td>HR1</td>
</tr>
<tr>
<td>5 to 50</td>
<td>1 to 10</td>
<td>HR2</td>
</tr>
<tr>
<td>50 to 500</td>
<td>10 to 100</td>
<td>HR3</td>
</tr>
<tr>
<td>500 to 5000</td>
<td>100 to 1 000</td>
<td>HR4</td>
</tr>
</tbody>
</table>

The LC$_{50}$ and LD$_{50}$ acute toxicity values are the concentration at which a substance poses an acceptable exposure to the environment.$^*$

0.1 x LC$_{50}$ is therefore termed Acceptable Exposure to the aquatic environment.

With regard to acute toxicity values, in terms of LD$_{50}$, a Reference Dose (RfD) or Tolerance Daily Intake (TDI) of a non-carcinogenic substance is a daily exposure normally derived from tests involving surrogates such as rodents, and extrapolated to the human species, and which is considered not likely to be of appreciable adverse consequence during a lifetime exposure. It is therefore termed the Acceptable Exposure to human health, and is expressed in mg/kg body weight/day.

The Acceptable Exposure for human health of a substance which displays carcinogenic properties, is the exposure derived from the Slope Factor (SF) of a dose-response curve in which excess risk is linearly related to dose, and which could result in an additional cancer incidence in a population of 10 000.

The EEC is always compared to Acceptable Exposure, to indicate whether either the aquatic environment or human health will be at risk.

When exposure, EEC, falls within the Acceptable Exposure, the compound can be regarded as a lesser or no appreciable threat to the environment or human health. The compound can then be delisted. Please refer to Appendix 8.5 for more detail.

$^*$ The factor of 10 is calculated from a cross section of typical dose-response data, with a typical slope of dose-response curves. From an exposure 10 times lower than the LC$_{50}$, approximately 0.00034% or one in 300 000 of a population exposed to the contaminant, are likely to die.
Delisting is when a hazardous compound in a waste moves from a specific risk group to a lower risk or 'non-risk' group. It does not become a non-hazardous compound, but the associated risk declines to a risk, which is smaller or even acceptable.

Delisting from a specific hazardous rating to a lower hazardous rating or “non-risk” group is when the Estimated Environmental Concentration (exposure) of a contaminant is less or below the acceptable exposure of the same contaminant:

<table>
<thead>
<tr>
<th>Classification:</th>
<th>Low /10</th>
<th>Moderate /10</th>
<th>High /10</th>
<th>Extreme</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard Rating:</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>LC₅₀ (mg/λ):</td>
<td>100 – 1 000</td>
<td>10 – 100</td>
<td>1 – 10</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Acceptable Exposure to Environment (mg/λ):</td>
<td>10 – 100</td>
<td>1 - 10</td>
<td>0.1 – 10</td>
<td>&lt;0.1</td>
</tr>
<tr>
<td>LD₅₀ (mg/kg):</td>
<td>500 – 5 000</td>
<td>50 – 500</td>
<td>5 – 50</td>
<td>&lt;5</td>
</tr>
<tr>
<td>Acceptable Exposure (mg/λ) to Human Health (systemic):</td>
<td>TDI or RfD \times \frac{70kg}{2λ}</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acceptable Exposure (mg/λ) to Human Health (carcinogenic):</td>
<td>\left( \frac{10^{-4} \times 70kg}{SF(mg/kg/day)} \right) \div 2λ</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**EEC (Exposure)**

\[
\begin{align*}
\text{if } & >0.1 \times \text{LC}_{50} \\
\text{or} & >\text{AE (systemic)} \\
\text{or} & >\text{AE (carcinogenic)} \\
\Rightarrow & \text{ = RISK} : \text{REMAIN in Hazard Rating} \\
\end{align*}
\]

\[
\begin{align*}
\text{if } & <0.1 \times \text{LC}_{50} \\
\text{and} & <\text{AE (systemic)} \\
\text{and} & <\text{AE (carcinogenic)} \\
\Rightarrow & \text{ = NO RISK} : \text{Hazard Rating can DELIST to GB\textsuperscript{+} landfill site} \\
\end{align*}
\]
EXAMPLE 1: EEC higher than Acceptable Exposure (AE)

The total constituent analysis of a waste stream indicates that zinc ($\text{Zn}^{2+}$) is present at a concentration of 120 mg/kg. If 300 000 kg of this waste is produced per month, then the site would receive 36 000 g of zinc per month.

Teratogen : Negative
Mutagen : Negative
Carcinogen : Negative
$\text{LD}_{50}$ : 350 mg/kg (HR3)
$\text{LC}_{50}$ : 7.0 mg/λ (HR2)
TDI/RfD : 0.3 mg/kg/day

The EEC is calculated:

$$\text{EEC (ppb)} = \text{dose (g/ha/month)} \times 0.66$$
$$= 36 000 \times 0.66$$
$$= 23 760 \text{ ppb}$$

The AE’s must now be calculated for both the environment and human health.

From the literature, it is determined that the LC$_{50}$ (96 hours for Bluegill) is 7.0 mg/λ. This is in the high hazard category (see Table 8.1).

The literature also indicates an LD$_{50}$ of 350 mg/kg for oral exposure to the rat. This is in the moderate hazard category (HR3). The entire waste stream must therefore be classified as Hazard Rating 2, because zinc indicates to be of a higher hazardous nature (HR2) to the environment, than for human health (HR3).

Acceptable Exposure (environment)

$$= 0.1 \times \text{LC}_{50}$$
$$= 0.1 \times 7.0 \text{ mg/λ}$$
$$= 0.70 \text{ mg/λ}$$
$$= 700 \text{ ppb}$$

Acceptable Exposure (human health)

$$= \frac{\text{RfD x 70kg}}{2\lambda}$$
$$= \frac{0.3 \text{ mg/kg/day} \times 70 \text{ kg}}{2\lambda}$$
$$= 0.1 \text{ mg/λ}$$
$$= 10 500 \text{ ppb}$$

The EEC is compared to the Acceptable Exposure:

$$23 760 \text{ ppb} > 700 \text{ ppb (environment)}$$
$$23 760 \text{ ppb} > 10 500 \text{ ppb (human health)}$$

The EEC is greater than the Acceptable Exposure of either or both the environment or human health, and is therefore still classified as Hazard Rating 2. It must be disposed of at an H:H waste disposal site.

Example 2: EEC less than Acceptable Exposure

A fine ash waste stream contains Iron (Fe) at a concentration of 1.5 mg/kg. The waste volume is 116 289 t/annum, to be disposed of at a landfill with an area of 32.5 ha.

Teratogen : Negative
Carcinogen : Negative
$\text{LD}_{50}$ : 1 280 mg/kg (HR4)
$\text{LC}_{50}$ : 90 mg/λ (HR3)
TDI/RfD : Not available. Consult the relevant provincial environmental authority

The EEC is calculated:

$$\text{Waste} = \frac{116 289 \text{ t/annum}}{32.5 \text{ ha}}$$
$$= 9 690 750 \text{ kg/month/32.5 ha}$$
$$= 298 177 \text{ kg/month/ha}$$

Fe in waste = $298 177 \times 1.5 \text{ mg/kg}$
$$= 447 \text{ g/ha/month}$$

$$\text{EEC} = 447 \text{ g} \times 0.66$$
$$= 295 \text{ ppb}$$

The Acceptable Exposure (AE) for the environment is calculated:

$$\text{Environment: } 0.1 \times 90 \text{ mg/λ}$$
$$= 9 \text{ mg/λ}$$
$$= 9 000 \text{ ppb}$$

Human health: Not available, probably due to limited risk to human health. Consult the relevant provincial environmental authority.

The EEC is compared to the AE

As the EEC for iron in the fine ash (295 ppb) is less than the Acceptable Exposure (0.1 x LC$_{50}$), (9 000 ppb), the waste is 'no risk', see Table 8.2. It can therefore be delisted and disposed of at an authorised General Waste site with a liner and leachate management system approved by the Competent Authority.
Note: This will only be the case if there is no other hazardous substance in the waste, with an EEC > than the Acceptable Exposure, that requires that the waste be disposed as a higher Hazard Rating.

Further examples of the use of the EEC to determine the Hazard Rating are provided in Appendix 8.3.

8.5 Using the EEC to determine the amount of a hazardous substance that can be disposed of in g/ha/month

Please refer to Appendix 8.4 and Appendix 8.6.

The EEC is used to determine the dose, or amount of a substance that can be disposed of in g/ha/month. Once again, as a precautionary measure, and to avert a risk situation, the EEC must not exceed the Acceptable Exposure.

For the fixed-scenario approach, the dose would be determined as follows:

EEC = Acceptable Exposure
dose (g/ha/month) x 0.66 = 0.1 x LC50

Therefore dose (g/ha/month) = \( \frac{0.1 \times \text{LC}_{50}}{0.66} \)

Example: A waste contains a compound C at a concentration of 5 mg/kg (ppm) with the following characteristics:

**Carcinogen, Positive, B2**
- \( \text{LD}_{50} = 3500 \text{ mg/kg (HR4)} \)
- \( \text{LC}_{50} = 0.32 \text{ mg/}\lambda \text{ (HR1)} \)
- \( K_{oc} = 10000 \)
- \( P_{ow} = 1531561 \)
- \( \text{TDI/RfD} = 0.0008 \text{ mg/kg/day} \)
- Carcinogenic Slope factor \( r = 1.60 \text{ mg/kg/day} \)

Using these characteristics, compound C is classified, using Diagram IV, as an extreme hazard, i.e., Hazard Rating 1.

To determine the amount of compound C that can be disposed in g/ha/month, the AE is to be calculated for the environment and human health:

**AE environment:**
\[
\text{AE environment} = 0.32 \text{ mg/}\lambda \times 0.1 = 0.032 \text{ mg/}\lambda = 32 \text{ ppb}
\]

**AE human health (systemic):**
\[
\text{AE human health (systemic)} = \frac{0.0008 \text{ mg/kg/day} \times 70\text{kg}}{2\lambda} = 0.028 \text{ mg/}\lambda = 28 \text{ ppb}
\]

**AE human health (carcinogenic):**
\[
\left( \frac{10^{-4} \times 70\text{kg}}{1.60 \text{ mg/kg/day}} \right) \div 2\lambda = 0.0022 \text{ mg/}\lambda = 2.2 \text{ ppb}
\]

The EEC must not exceed the lowest AE, i.e., 2.2 ppb, to avert a risk situation.

EEC = AE
dose (g/ha/m) x 0.66 = 2.2 ppb
dose = \( \frac{2.2 \text{ ppb}}{0.66} \) = 3.3 g/ha/month

The amount of compound C that can be disposed of at a landfill site is therefore 3.3 g/ha/month.

From this, it is possible to calculate the amount of the waste containing C at a concentration of 5 ppm that can be disposed of at a landfill site per month:

Total amount of waste = \( \frac{3.3 \text{ g/ha/month}}{5 \text{ ppm}} \) = 660 kg/ha/month

8.5.1 Using the EEC to determine the loading rate at which sewage sludge may be co-disposed at a General waste site

As a consequence of industrial activities within their catchments, many sewage treatment plants produce sludge that has elevated concentrations of
certain potentially toxic metals and elements (PTMEs), [Ref: Snyman HG, Herselman JE and Kasselman G, A metal content survey of South African sewage sludge and an evaluation of analytical methods for their determination, Water Research Commission Report, Pretoria, 2004]. It is the potential leaching of these PTM’s into the subsurface below a landfill that is of concern and the reason that the loading rate (or co-disposal ratio discussed in Section 10.3.2 of the Minimum Requirements for Waste Disposal by Landfill) may have to be restricted.

To calculate the allowable loading rate it is necessary to determine the leachable fraction of the following heavy metals: cadmium, copper, lead and zinc. However, since an ICP scan provides for 33 elements at no extra cost, it is suggested that a full ICP scan is done on the leachate fraction to cover all 33 elements.

The Acceptable Exposure, AE must be compared with the Estimated Environmental Concentration (EEC). The EEC is discussed in 8.4, but for the purposes of calculating allowable loading rates (or co-disposal ratios) it should be based on leaching tests carried out using the TCLP method (see Appendix 8.7), with the results expressed as mg/kg dry sludge. If the EEC calculated in this manner exceeds the AE, the loading rate must be reduced until the EEC = AE. An example of using this approach is given in 8.4.3.

8.5.2 Using the EEC to determine the acceptable ratio for co-disposal of sewage sludge with refuse at a General waste site

In Section 10.3.2 of the Minimum Requirements for Waste Disposal by Landfill, the maximum allowable ratio of sewage sludge to refuse (on a wet mass basis) for co-disposal at a general waste landfill is 1:10. Depending on the concentrations of the metals in the sewage sludge, it may be necessary to reduce this ratio, as follows.

Consider dewatered sewage sludge at 20% solids that had a zinc (Zn^{2+}) concentration determined from a TCLP test of 118.85mg/kg dry sludge [Ref: Kasselman G, An evaluation of predictive environmental test procedures for sewage, Pretoria University, Pretoria, 2004]. If it were to be co-disposed with refuse at a 1 hectare general waste site at a ratio of 1:10 and the refuse deposition rate was 600 tonne per day, the Loading Rate (LR) of the sludge would be:

\[ LR = \text{General waste deposition rate} \times \text{co-disposal ratio} \times \text{percent solids} \]

\[ LR = (600 \text{ tonnes/day} \times 30 \text{ days/month}) \times (1 \text{ part sludge} / 10 \text{ parts waste}) \times 0.2 \]

\[ LR = 360 \text{ tonnes/month} = 360000 \text{ kg/month of dry sewage sludge} \]

Calculate the AE:

\[ AE = 0.1 \times LC_{50} \]

\[ AE = 0.1 \times 7.0 \text{ mg/l} \]

\[ AE = 0.7 \text{ mg/l} = 700 \text{ ppb} \]

Calculate the EEC:

\[ EEC = \text{loading rate} \times \text{leachable concentration} \times 0.66 \]

\[ EEC = 360000 \text{ kg/month} \times (118.85 \text{ mg/kg}) \times 0.66 \]

\[ EEC = 28238.6 \]

Compare the AE and the EEC

EEC>AE, therefore the co-disposal ratio needs to decrease until the EEC equals the AE

Calculate the allowable co-disposal ratio

\[ \text{Allowable ratio} = \frac{\text{EEC}}{\text{AE}} = \frac{28238.6}{700} = 40.3 \]

Therefore the allowable co-disposal ratio is 1:40.3.

Calculate the mass of sludge that can be co-disposed.

\[ \text{Mass of sludge that can be co-disposed} = \frac{\text{General deposition rate}}{\text{co-disposal ratio}} \]

\[ \text{Mass of sludge that can be co-disposed} = (600 \text{ tonnes/day} / 40.3) = 14.9 \text{ tonnes/day.} \]
8: HAZARD RATING

8.6 Using the EEC to determine the Total Load

The capacity of a hazardous waste landfill to safely accept a certain substance must be determined. This is termed the Total Load. (Please refer to Appendix 8.6).

The Total Load capacity of a landfill site will be influenced by the inherent hazardousness of the waste, by the mobility (leachability) of the waste, and by the landfill design (leachate collection system, liners, etc).

The flow of leachate through the liner of a Hazardous Waste Landfill is estimated to be 5%, with 95% of the leachate being adsorbed permanently in the waste or captured by the leachate collection system.

The Total Load capacity is calculated by multiplying the allowed monthly volume per hectare, by a factor of 100.

Example of calculation of the Total Load:

In the example of compound C:

Carcinogen, Positive, B2
LD₅₀ = 3 500 mg/kg (HR4)
LC₅₀ = 0.32 mg/λ (HR1)
Kₒc = 10 000
Pₒw = 1 513 561
TDI/RfD = 0.0008 mg/kg/day
Carcinogenic
Slope factor = 1.60 mg/kg/day
AE = 2.2 ppb

Compound C will be classified, using Diagram IV as Extreme Hazard, i.e., Hazard Rating 1.

If it is to be disposed of in a Hazardous Waste landfill, then EEC must not exceed the Acceptable Exposure:

EEC = Acceptable Exposure
g/ha/month x 0.66 = 2.2 ppb
g/ha/month = 3.3 ppb/0.66
= 3.3 g/ha/month
Total Load Capacity = 3.3 x 100
= 330 g/ha

If compound C is present in a waste stream at a concentration of 5 mg/kg (ppm) and the amount of C that can be disposed of is 330 g/ha, then the total amount of waste that can be disposed of is:

Total Load
= \frac{330 \text{ g/ha}}{5 \text{ mg/kg}}
= 66 000 \text{ kg/ha}
= 66 \text{ tonnes/ha}

Thereafter, the site will have to close down with regard to compound C.

Other hazardous wastes that do not contain compound C can, of course, still be disposed of at the site.

8.7 Delisting a Hazardous Waste stream by means of treatment or tests

A Hazardous Waste or waste stream may consist of any number of different substances and compounds. In accordance with the Precautionary Principle, it is the most hazardous substance and its concentration that determines the class, the Hazard Rating, and hence the ultimate method of disposal of a waste or waste stream. In most cases, therefore, a single characteristic, often resulting from a single substance, will determine the classification.

Treatment

Since a single substance can determine the Hazard Rating, treatment can be used to reduce the hazardousness of the substance. Thereafter, the next most hazardous substance will determine the Hazard Rating.

Treatment can thus be used to delist a waste to a lower Hazard Rating or to allow a waste to be disposed of as a General Waste. Note, however, that the treated waste will have to be tested and analysed once more to confirm the efficacy of the treatment.

Leachability tests

The EEC is based on the total concentration of a hazardous substance in an aquatic environment, see Appendix 8.1. However, not all of a hazardous...
substance in the waste stream will necessarily leach out into the environment. There could therefore be cases where it may be considered that the Hazard Rating based on the EEC is too conservative.

In such cases, tests such as the Toxicity Characteristic Leaching Procedure (TCLP) or the Acid Rain test can be used to determine the amount of a hazardous substance that will leach out of the waste stream, (see Appendix 8.8).

The TCLP test is used where wastes are co-disposed with domestic waste or other Hazardous Wastes containing organic matter that could generate organic acids. The Acid Rain test is used when inorganic wastes are disposed of in a dedicated site (mono-disposed). No organic acids would be generated in such a site.

From the test results, the EEC can be recalculated, and the results submitted to the Competent Authority to motivate that a specific Hazardous Waste stream be 'delisted' to a lower Hazard Rating.

**Example of delisting:**

The TCLP test was performed on the zinc containing waste stream described in Section 8.4.1. It was found that only 0.6 mg/kg of the total amount of zinc contained in the waste stream leached out under the fairly rigorous test conditions.

The EEC for zinc can now be recalculated as:

\[
\text{EEC} = 300 \ 000 \text{kg} @ 0.6 \text{ mg/kg} \\
= 180g \times 0.66 \\
= 119 \text{ ppb}
\]

The EEC is compared to the Acceptable Exposure

\[119 \text{ ppb} < 700 \text{ ppb}\]

As the EEC for zinc is now lower than the Acceptable Exposure, the waste stream can be delisted, with regard to zinc, from Hazard Rating 2 to General Waste Quality, see Table 8.2. If there is no other hazardous substance in the waste with a higher Hazard Rating, the waste can now be disposed of at a **G:B** landfill site.

### 8.8 Application of Hazardous Waste in downstream uses

A Hazardous Waste may be used in downstream applications such as brick manufacturing and road aggregate. It is a Minimum Requirement that any downstream application must conform to the principle of acceptable risk to human health and the environment (see Appendix 8.9). It is also a Minimum Requirement that the Generator of the waste obtain special permission in writing from the relevant provincial environmental authority before downstream use of Hazardous Waste is attempted.
# TABLE 8
Minimum Requirements for Hazard Rating

<table>
<thead>
<tr>
<th>Subject</th>
<th>Minimum Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class 6, Toxic and Infectious materials</td>
<td>All Hazardous Wastes or residues must be tested against Class 6, Toxic and Infectious substances.</td>
</tr>
<tr>
<td>Hazard Rating</td>
<td>The waste must be Hazard Rated to determine the Hazard Rating into which it falls.</td>
</tr>
<tr>
<td>Dose (g/ha/month)</td>
<td>The amount of a hazardous substance in a waste that can be disposed of at a landfill per month must be determined, using the EEC.</td>
</tr>
<tr>
<td>Total Load</td>
<td>The capacity of a Hazardous Waste landfill to safely accept a certain substance must be determined.</td>
</tr>
</tbody>
</table>
Section 9

DISPOSAL OF A HAZARDOUS WASTE
9.1 Introduction

The Minimum Requirements for the disposal of a Hazardous Waste are summarised in Table 9, at the end of this section.

After being placed in a SANS 10228 class (see Section 6), a Hazardous Waste would have been treated in accordance with the requirements for that class (see Section 7). Subsequently it or its residue would have been given a Hazard Rating (see Section 8). The waste would possibly have been treated once more, to reduce the Hazard Rating. Now the waste must be safely disposed of.

The objectives of the Minimum Requirements for the disposal of a Hazardous Waste are to:

- ensure that any adverse impact on the environment is minimised
- prevent hazardous substances leaching or moving into the environment, in particular the ground and surface waters
- ensure that Hazardous Waste is disposed of in accordance with the class and the Hazard Rating
- to act as a mechanism ensuring the disposal of Hazardous Waste in an orderly manner, thus avoiding detrimental effects both in the short- and long-term to humans and to the environment.

In general, the higher the Hazard Rating of a waste, the greater the control that should be exercised over the disposal route. For an extremely Hazardous Waste, e.g. Hazard Rating 1, the Competent Authority will prescribe, and will require to approve, the technology to be applied to its treatment and disposal.

The options available for the disposal of Hazardous Waste can be classed generally as:

- landfill
- incineration

The preferred technology for most organic wastes is incineration, since the advantage of incineration is that, apart from the residual ash which must be landfilled, the waste is destroyed and the risk posed by the waste is minimised. Because of a lack of facilities and the high cost of incineration, however, the most common method of disposal of organic and inorganic Hazardous Waste in South Africa at present is landfill.

9.2 Landfill

Hazardous Waste may only be disposed of at a landfill designed specifically for the disposal of Hazardous Waste and legally authorised by the Competent Authority, in terms of the Environmental Conservation Act.

As discussed in Section 2, landfills that can accept Hazardous Waste are classified as H:H landfills and H:h landfills.

H:H landfills can accept all wastes that are allowed to be landfilled. H:h landfills, which are not as stringently designed, may only accept Hazard Rating 3 and 4 waste, and General Waste. Hazardous Wastes that are classified as extremely or highly toxic, i.e., Hazard Rating 1 or 2, may only be disposed of in a permitted H:H site, if landfill is the management option of choice.

9.2.1 Total Load

Disposal volumes must be in accordance with the calculated EEC, multiplied by a factor of 100, see Total Load, Section 8.4.3 and Appendix 8.4.

Hazardous Waste sites, H:H.

Hazardous Waste, Hazard Ratings 1, 2, 3 and 4, may be disposed in sites permitted for Hazardous Waste but may not exceed the total load per hectare as explained in the text of Appendix 8.1 (7). Also refer to section 8.4.3 for examples.

Hazardous Waste sites, H:h:

Hazardous Waste, Hazard Ratings 3 and 4, may be disposed of at landfill sites permitted as H:h sites but may not exceed the total load per hectare as explained in the text of Appendix 8.1 (7). Also refer to section 8.4.2 for examples.
Wastes which exceed the set criteria must either be treated until they meet the criteria or they must be destroyed (for example, by incineration) or isolated from the environment (for example, by encapsulation).

*Solvents of concern*

The landfilling of certain solvents is restricted because of their effects on liners, mobilisation of other wastes and the ability of treatment procedures to remove, destroy or immobilise the hazardous substances of the waste. There is also strong evidence that certain volatile chemicals can diffuse through clay and flexible membrane liners when present even in low amounts. For the solvents listed in Appendix 9.2, therefore, the total load to be disposed of per hectare of any site must not exceed the amount listed in gram/ hectare/ month.

### 9.2.2 Co-disposal at landfills

The objective of the co-disposal of General Waste and Hazardous Waste is to absorb, dilute and neutralise any liquids and to provide a source of biodegradable materials in order to encourage microbial activity that will assist in the degradation of hazardous substances. Co-disposal also improves trafficability within the landfill.

The ratio of Hazardous Waste to General Waste required to absorb liquids and obtain an appropriate dilution of the Hazardous Waste is discussed in Section 10.3.4. and Appendix 10.1, *Minimum Requirements for Waste Disposal by Landfill*.

The Total Load of a waste, as determined from the EEC, is not affected by co-disposal.

### 9.2.3 Encapsulation

Encapsulation (or macro-encapsulation) is the containment of waste in drums or other approved containers within a reinforced concrete cell that is stored in a specifically prepared and engineered area within a permitted Hazardous Waste landfill.

The Competent Authority must approve an encapsulation procedure and the Generator must ensure that a waste disposal company utilises an approved procedure.

Encapsulation procedures must conform to the SANS 1200 series and Standard Specifications for Civil Engineering Construction. The cell must remain integral if subsidence occurs or if there is an earthquake.

The Competent Authority requires that the operator keep full records of each encapsulation cell, its location within the landfill, its number and the date of completion, and the contents of each drum or container. The name of the Generator or Generators of the waste in each drum or container stored within each encapsulation cell must be recorded.

### 9.2.4 Landfill disposal restrictions

The disposal of Hazardous Wastes that exhibit the characteristics of flammability, corrosivity, or reactivity to a permitted landfill is strictly controlled (see Diagram III).

#### Flammable Wastes:

Landfilling of Hazardous Wastes with a flash point below 61°C, Danger Group 3, is PROHIBITED (for Class 4, Flammable solids see Reactive Wastes below).

#### Corrosive Wastes:

Class 8, Corrosive Substances, must be neutralised prior to disposal at a permitted landfill. Hazardous Wastes with a pH less than 6 or greater than 12 CANNOT be directly landfilled.

#### Reactive Wastes:

Classes 4 and 5, Reactive Substances, must be treated to reduce their reactivity prior to disposal at a permitted landfill. Direct disposal of wastes that react with water, air or components of the waste, or that could generate unacceptable amounts of
toxic gases within the landfill is totally PROHIBITED.

9.2.5 Prohibition of waste disposal by landfill

It is anticipated that a few substances could pose such a high risk that the disposal of the waste by landfill should be totally disallowed. In such cases, the total destruction of the waste will be required.

Explosive wastes:

The direct landfilling of Class 1, Explosive wastes, is totally PROHIBITED. Explosive wastes must be incinerated, exploded or chemically treated before the residues are landfilled.

Waste compressed gases:

The direct landfilling of Class 2 waste compressed gases, is totally PROHIBITED. Flammable gases must be safely burned or incinerated, non-flammable gases can be vented safely to the atmosphere provided this procedure does not violate the National Environment Management: Air Quality Act (Act 39 of 2004) and poisonous gases must be incinerated or chemically treated. Empty cylinders containing gaseous residues at atmospheric pressure may be landfilled provided this does not violate the permit conditions.

Radioactive waste:

Class 7, Radioactive wastes, are covered by the Atomic Energy Act, 1967, (Act 90 of 1967) and the Hazardous Substances Act, 1973 (Act 15 of 1973); their disposal in a landfill is PROHIBITED. Only those wastes defined as "inactive wastes", i.e., with a specific activity less than 100 becquerels per g (Bq/g) and total activity less than 4 kBq, may be disposed as normal waste.

9.2.6 Conditional disposal of organic waste

The disposal of halogenated organic wastes by the approved process, e.g., encapsulation or landfill, is only permitted in the absence of a proper incineration facility.

9.3 Historic pollution and accidental spills

'Land treatment' is a form of disposal. It relies upon the natural capacity of soil and the addition of micro-organisms to attenuate, disperse and biologically degrade hazardous substances. Wastes that have been successfully treated in this way include those from petroleum refineries and the textile industry. In theory, almost any organic waste can be treated by land treatment. However, our knowledge of the mechanisms of attenuation, dispersal and biological degradation is extremely limited. Land treatment may therefore NOT be used as a means of Hazardous Waste disposal except in cases of historic pollution or accidental spills.

Where waste has been disposed of directly onto land:

- exposure of any hazardous substance in the waste must be less than or equal to the Acceptable Exposure (0.1 x LC50)
- if greater than the Acceptable Exposure, it must be treated or remediated until it is less than the Acceptable Exposure.

9.4 Incineration

Incineration is the preferred means of disposal for most organic and selected inorganic Hazardous Wastes. It is simply the controlled combustion of waste materials to reduce these to a non-combustible residue or ash and exhaust gases, i.e., carbon dioxide and water. The combustion of sulphur and chlorine containing wastes can lead to considerable quantities of acid gases, such as sulphur dioxide and hydrochloric acid, but these can be scrubbed from the gas stream prior to discharge to the atmosphere. In South Africa, as in the USA and in Europe, incineration is the preferred technology for many organic Hazardous Waste streams (see Hazardous Waste Classification Tables).
There are many different types of incineration technology, but the Rotary Kiln, Multiple Hearth and Fluidised Bed Furnaces have been shown to be the most versatile for Hazardous Waste streams. Hazardous Waste normally requires very high temperatures (up to 1,250°C) and long residence times (1 to 2 seconds) for essentially complete combustion of thermally stable materials such as PCB’s and dioxins. The need for considerable atmospheric pollution control equipment, which often costs more than the combustor itself, the sophistication of the equipment required for the safe handling and analysis of highly toxic materials, and the need for highly trained staff all contribute to the high cost of incineration.

Selected Hazardous Wastes are being burned extremely successfully as fuels in more than 25 cement kilns in the USA. There are a number of advantages to cement kilns, including the high temperatures (up to 1,500°C) that are reached in order to manufacture the cement clinker. The long gas residence times (up to 6 seconds), the automatic scrubbing of noxious gases such as hydrogen chloride from the gas stream by the alkaline conditions in the kiln, and the savings in conventional fuel such as coal. Also, because they are existing facilities, there is usually less public opposition to their siting. The capital expenditure required is only about 10% of that needed to build a dedicated chemical incinerator.

There are disadvantages, however, since only limited amounts of certain hazardous substances, such as heavy metals, sulphur, and chlorine, can be added. Due to their effect on the operation of the kiln or on the quality of the clinker, and because of the increase in the cost of monitoring the stack gases, and because the waste should preferably have a reasonable calorific value and therefore pre-treatment is often necessary.

### 9.4.1 Disposal of infectious or medical waste

Infectious waste includes not only that from hospitals - generally termed Medical or Clinical Waste - but also waste from biological research facilities and water analysis laboratories. Medical waste includes human tissue.

Infectious waste is classified as Hazard Rating 1 or Extreme Hazard waste. Methods for its disposal are incineration or, if no incineration facility is available, pre-treatment by sterilisation, direct irradiation or micro-waving before landfilling at an HH or H:h site.

Medical waste must be incinerated, since the National Health Act, 2003 (Act 61 of 2003), requires that all human parts be incinerated.

All infectious waste must be sterilised prior to landfilling at Hazardous Waste sites or alternatively incinerated at approved incineration facilities.

For more information on the disposal of medical and infectious waste, please refer to Appendix 9.1.
TABLE 9
Minimum Requirements for Disposal

<table>
<thead>
<tr>
<th>Subject</th>
<th>Minimum Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Landfill class</strong></td>
<td>Hazard Rating 1 and 2 wastes must be disposed of at an <strong>H:H</strong> landfill. Hazard Rating 3 and 4 wastes must be disposed of at either an <strong>H:H</strong> or an <strong>H:h</strong> landfill.</td>
</tr>
<tr>
<td><strong>Dose</strong></td>
<td>The amount of a hazardous substance that may be disposed of per hectare per month must not be exceeded.</td>
</tr>
<tr>
<td><strong>Total Load</strong></td>
<td>The Total Load capacity of a landfill must not be exceeded.</td>
</tr>
<tr>
<td><strong>Solvents</strong></td>
<td>The landfilling of solvents listed in Appendix 9.2 is restricted and the given Total Load may not be exceeded.</td>
</tr>
<tr>
<td><strong>Encapsulation</strong></td>
<td>An encapsulation procedure must conform to SANS 1200 series and the requirements set out in Table A.7.4 and must be approved by the Competent Authority. The encapsulation of Class 1.1 to 1.4 explosive wastes, gases, organic peroxides, flammable solids, corrosive substances with a pH &lt;6 or &gt;12, is prohibited.</td>
</tr>
<tr>
<td><strong>Record Keeping</strong></td>
<td>The Operator must keep full records for each engineered cell, its location within the landfill, its number and the date of completion. The contents of each drum or container and the name of the Generator or Generators of the waste in each drum or container that is stored within the cell.</td>
</tr>
<tr>
<td><strong>Flammable Wastes</strong></td>
<td>Landfilling of waste with a flash point below 61°C is PROHIBITED.</td>
</tr>
<tr>
<td><strong>Corrosive Wastes</strong></td>
<td>Landfilling of waste with a pH &lt;6 or &gt;12 is PROHIBITED.</td>
</tr>
<tr>
<td><strong>Reactive Wastes</strong></td>
<td>The direct disposal of wastes that react with water, air or components of the waste, or that could generate unacceptable amounts of toxic gases within the landfill is totally PROHIBITED. Please refer to Table A.7.3.</td>
</tr>
<tr>
<td><strong>Explosive Wastes</strong></td>
<td>Landfilling of explosive wastes is PROHIBITED.</td>
</tr>
<tr>
<td><strong>Gases</strong></td>
<td>Landfilling of gases is PROHIBITED.</td>
</tr>
<tr>
<td><strong>Radioactive Wastes</strong></td>
<td>Class 7, Radioactive waste, is covered by the Atomic Energy Act, 1967, and disposal in a landfill is PROHIBITED.</td>
</tr>
<tr>
<td><strong>Radioactive Wastes</strong></td>
<td>Only those radioactive wastes defined as &quot;inactive&quot;, i.e., with a specific activity less than 100 becquerels per g (Bq/g) and total activity less than 4 kBq (0.1uCi), may be disposed as waste.</td>
</tr>
<tr>
<td><strong>Organic Waste</strong></td>
<td>Halogenated organic waste may only be disposed of by landfill in the absence of an incineration facility.</td>
</tr>
<tr>
<td><strong>Infectious Waste</strong></td>
<td>Landfilling of infectious waste is PROHIBITED unless special permission is granted by the Competent Authority (see Minimum Requirements for Waste Disposal by Landfill). Infectious Waste must be incinerated or sterilised.</td>
</tr>
<tr>
<td><strong>Downstream application of Hazardous Waste</strong></td>
<td>Downstream uses of Hazardous Waste is PROHIBITED unless the application conforms to acceptable exposure, and special permission is granted by the Competent Authority.</td>
</tr>
</tbody>
</table>
## TABLE 9.1
Advantages and Disadvantages of Infectious Waste Handling/Disposal Techniques

<table>
<thead>
<tr>
<th>SYSTEM</th>
<th>9.4.1.1</th>
<th>ADVANTAGES</th>
<th>DISADVANTAGES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incineration</td>
<td>maximum volume weight reduction</td>
<td>• non-combustibles not reduced in volume (ash, metal, etc)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>sterile residue when operated properly</td>
<td>• complex operation considering environmental factors</td>
<td></td>
</tr>
<tr>
<td></td>
<td>moderate amount of space required</td>
<td>• requires trained operator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>air emissions can be controlled</td>
<td>• non-combustibles and ash may pose a disposal problem and auxiliary fuel may be required</td>
<td></td>
</tr>
<tr>
<td>Hydropulping</td>
<td>reduction in volume</td>
<td>• adds substantial weight to product for disposal</td>
<td></td>
</tr>
<tr>
<td></td>
<td>should provide good disinfection</td>
<td>• difficult for biomonitoring</td>
<td></td>
</tr>
<tr>
<td></td>
<td>substantially changes appearance of waste</td>
<td>• chlorine solution discharged to POTW* may not be acceptable</td>
<td></td>
</tr>
<tr>
<td>Sterilisation (Autoclaving)</td>
<td>low cost (capital &amp; operating)</td>
<td>• may have increased waste handling</td>
<td></td>
</tr>
<tr>
<td></td>
<td>low maintenance</td>
<td>• need thorough testing program (spore strip testing)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• no volume reduction</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• no change in appearance of waste</td>
<td></td>
</tr>
<tr>
<td>Direct Irradiation</td>
<td>positive disinfection, very reliable for providing good disinfection</td>
<td>• not demonstrated for infectious waste treatment</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• permitting expensive and special licences required</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• high capital cost</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• extensive monitoring required</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• no volume reduction</td>
<td></td>
</tr>
<tr>
<td>Compaction</td>
<td>reduces volume of waste</td>
<td>• does not reduce weight</td>
<td></td>
</tr>
<tr>
<td></td>
<td>relatively inexpensive</td>
<td>• no disinfection</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• may not render sharps unusable</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• may cause leakage problem</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• may cause difficulty in incineration or other treatment</td>
<td></td>
</tr>
<tr>
<td>Microwaving</td>
<td>reduces volume of waste (because of grinding)</td>
<td>• may result in fugitive emissions of volatile organic substances (VOC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>moderate cost</td>
<td>• requires strict monitoring program</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• biomonitoring difficult</td>
<td></td>
</tr>
<tr>
<td>Sterilisation/Compaction</td>
<td>positive disinfection</td>
<td>• difficult to perform biomonitoring</td>
<td></td>
</tr>
<tr>
<td></td>
<td>good volume reduction</td>
<td>• no weight reduction</td>
<td></td>
</tr>
<tr>
<td></td>
<td>low cost</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>results in change in appearance of waste</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sterilisation/Grinding</td>
<td>low cost</td>
<td>• moderate maintenance required</td>
<td></td>
</tr>
<tr>
<td></td>
<td>good volume reduction</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>substantially changes appearance of waste</td>
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</tr>
<tr>
<td></td>
<td>positive disinfection</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>not difficult to perform biomonitoring</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Publicly owned treatment works (municipal wastewater treatment plant)