GUIDANCE FOR THE CLASSIFICATION, RATING AND DISPOSAL OF COMMON HAZARDOUS WASTE STREAMS

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Water Research Commission

GUIDANCE FOR THE CLASSIFICATION, RATING AND DISPOSAL OF COMMON HAZARDOUS WASTE STREAMS

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Environmental Business Strategies (Pty) Ltd

Report to the Water Research Commission

on a project entitled

Development of Guidelines and Recommendations towards the Classification, Rating and Disposal of Common Industrial Hazardous Waste Streams for the purposes of General Authorisation for Waste Disposal

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EXECUTIVE SUMMARY

The management and disposal of waste, and, in particular hazardous waste, is a critical element in protecting South Africa's environment. Inappropriate and irresponsible handling and disposal of hazardous waste leads to the pollution of ground, groundwater, stormwater, as well as other watercourses.

In order to ensure that waste is handled and disposed of in a responsible and legally compliant manner, waste must be classified so as to establish the nature and hazard thereof. The acceptable disposal location can then be determined.

Environmental Business Strategies (Pty) Ltd (EBS) has worked with many industries that have generated hazardous wastes in South Africa, with approximately 90% of these waste streams (by number) being common to most industries. EBS's experience is that the classification, rating, and disposal requirements of these streams proved problematic, for a variety of reasons. These requirements were not being performed by the generators, thereby resulting in legal non-compliance, incorrect treatment, as well as disposal, and, in many cases, contamination of groundwater and stormwater. The reasons for non-compliance include:

- The lack of available information regarding the waste streams;
- Expensive laboratory analyses;
- A lack of understanding regarding the legal application of the Minimum Requirements for the Handling Classification and Disposal of Hazardous Waste (DWAF, 1998, 2nd Edition)[1], as well as the requirements for hazardous waste disposal, and
- The lack of enforcement regarding legislative requirements.

Instead of every waste generator performing a separate waste classification for these common hazardous waste streams, it was proposed that a generic classification for these streams be developed. Having obtained more detailed information on the common waste streams, the generator would be able to concentrate resources on their specific waste streams, which typically constitute more than 80% of the total waste (by mass) produced by the generator. It is, therefore, hoped that the generator would be able to use its resources more appropriately to implement waste minimisation and recycling projects on its unique waste streams.

Therefore, EBS initiated this study with the Water Research Commission in order to develop user-friendly guidance documents and recommendations for the classification and disposal of common industrial hazardous wastes. These guidance documents should consequently add value to the Minimum Requirements and the waste management industry, thereby improving both the time and costs required by industry, consultants, waste contractors, disposal companies, auditors and the authorities. The study is therefore expected to assist these parties.

A workshop was held with a number of interested and affected parties in order to discuss the project, as well as to determine which waste streams should be included in this document. Based on the outcome of the workshop, 20 waste streams, for which the guidance documents have been developed, were selected. Waste streams selected for inclusion in this document were decided upon based on hazardous wastes that would be generated by a wide array of industries.

[1] Hereafter referred to as the "Minimum Requirements"

Researched information for each guidance document for the 20 respective waste streams contains information on the following topics:

1. Waste Generation Processes / Industrial Application;
2. Background Information;
3. Classification and Rating;
4. Environmental and Health Concerns;
5. Unacceptable Disposal Options;
6. Acceptable Disposal Options;
7. Industry Trends and other Information, and
8. Illustrative Pictures.

In addition to the guidance documents of each waste stream, further information is provided on the legal requirements, waste management principles and best practises in South Africa for the handling, storage, transportation and disposal of wastes.

ACKNOWLEDGEMENTS

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The Reference Group responsible for this project consisted of the following persons:

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Furthermore, the authors would like to express their gratitude to the following for their valuable assistance with this project:

- Institute of Waste Management of South Africa (IWMSA)
- Industry and interested members

The project team consisted of the following persons:

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The management and disposal of waste, and, in particular hazardous waste, is a critical element in protecting South Africa's environment. Inappropriate and irresponsible handling and disposal of hazardous waste leads to the pollution of ground, groundwater, stormwater, as well as other watercourses.

In order to ensure that waste is handled and disposed of in a responsible and legally compliant manner, the waste must be classified to establish the nature and hazard of the waste in order to determine the acceptable disposal location and prevent negative impacts hazardous waste may have on surface water and groundwater systems.

Environmental Business Strategies (Pty) Ltd (EBS) has worked with many industries that have generated hazardous wastes in South Africa, with approximately 90% of these waste streams (by number) being common to most industries. EBS's experience is that the classification, rating, and disposal requirements of these streams proved problematic, for a variety of reasons. These requirements were not being performed by the generators, thereby resulting in legal non-compliance, incorrect treatment, as well as disposal, and, in many cases, contamination of groundwater and stormwater.

These reasons included the following:

- Information on the constituents of the waste is not sufficient
  - The Material Safety Data Sheets (MSDS) of the constituent substances do not contain sufficient information
  - Information from suppliers is often not much more than that included in the Material Safety Data Sheets (MSDSs)
- The nature of the waste is not necessarily a summation of the various substances used in the plant's processes.
- Chemical reactions can take place between the substances to generate a waste stream different to the original contents.
- South African legislation and codes regarding dangerous goods (listed in SANS 10228) was developed with a focus on health and safety and not on the environment. Thus many environmentally dangerous goods are not specifically listed in SANS 10228.
- The laboratory testing of the wastes is expensive especially to the industry as a whole when similar waste streams produced by the same activities are tested across the industry.
- There is a need for understanding in industry regarding the legal requirements for hazardous waste disposal and application of the Minimum Requirements for the Handling Classification and Disposal of Hazardous Waste.
- There is a lack of enforcement of the legal requirements with regards to waste management.
- The costs associated with waste management and the classification thereof proved to be considerable to companies with many waste streams (requiring specialists and laboratory fees).

It became evident that there was a strong need to research the nature and toxicity of those hazardous waste streams common to industry to classify and rate the waste and establish the most effective and practicable waste disposal method. Discussions with DWAF (Department of Water Affairs and Forestry) and DEAT (Department of Environmental Affairs and Tourism) confirmed that the proposed research was in alignment with the principles of waste management, and that the research to be conducted is necessary. The research conforms to the waste management hierarchy described and embodied by the Minimum Requirements, and to the National Waste Management Strategy.

Instead of every waste generator performing a separate waste classification for these common hazardous waste streams, it was proposed that a generic classification for these streams be developed within certain constraints. This would allow the industry and/or generator of the waste to concentrate resources on their industry specific waste streams.

EBS therefore initiated a study under the Water Research Commission in order to develop user-friendly guidance documents and recommendations for the *classification and disposal of common industrial hazardous wastes*.

The guidance documents should consequently add value to the Minimum Requirements and the waste management industry thereby improving both the time and costs required by industry, consultants, auditors, and the authorities. It is expected to assist:

- **Industry** who often have limited time and budgets especially with respect to environmental issues (SME's are particularly sensitive);
- **Waste Contractors and Disposal Companies** who require information on the waste streams before disposal;
- **Environmental Consultants** who often require clarity regarding the interpretation of documents such as the minimum requirements and other legislation;
- **Auditors** to base their audit on clear and measurable parameters; and
- **Authorities** (DEAT, DWAF) who would like to increase their efficiency in handling similar queries for issues regarding the Minimum Requirements.

Sections 2 to 5 provide background information on waste management, including the legislative setting for waste management, waste classification, hazard rating and landfill design. Section 2.4 describes good practices and Minimum Requirements for the temporary storage and handling of hazardous waste on site. Section 5 contains the guidance documents for the respective waste streams.

Aims of the research project

The guidance document emanated from a project funded by the Water Research Commission entitled:
'Development of Guideline Documents and Recommendations towards the Classification, Rating and Disposal of Common Industrial Hazardous Waste Streams for the Purposes of General Authorisation for Waste Disposal'

The initial aims at the outset of this research project were to:

1. Assist industry, waste management companies, government, consultancies, industrial and environmental organisations and associations in understanding how to handle common hazardous waste streams. These guidance documents will complement the *Minimum Requirements for Handling, Classification and Disposal of Hazardous Wastes,* stream line the waste management industry and assist DWAF and DEAT towards developing General Authorisation for Hazardous Waste Disposal.
2. Produce a document of recommendations and proposed guidance documents concerning the classification and disposal of these common wastes streams.
3. Develop a simple and easy-to-use guide for determining whether a waste may be considered a 'common' waste stream that does not require laboratory analysis.
4. Develop a methodology to rate a number of common hazardous waste streams (to determine their hazardous properties).
5. Assess the risk of a number of common hazardous waste streams to establish standard acceptable disposal methods (where laboratory analysis is not required).
6. Recommend the delisting of certain waste streams where appropriate for less stringent disposal requirements.
7. Provide a training course for industry, auditors, consultants and/or authorities on the classification and disposal of hazardous waste with specific regard to common hazardous wastes (in Johannesburg, Cape Town and Durban). This will be augmented by a training course offered to university students in Cape Town, Durban, Johannesburg, and Pretoria to develop competency in waste management amongst PDI's.
8. Provide recommendations to the Department of Labour and South African National Standards (SANS) for changes to SANS 10228 (Identification and Classification of Dangerous Substances and Goods) to include substances that are dangerous to the environment and not only health and safety.

The approach to meeting these aims is discussed in the next section. It must be noted however, that during the course of the project, these aims, in particular aims 1, 6 and 8, were revised based on meetings with the reference group, the authorities (DWAF), and other stakeholders.

The overall project's focus was aimed at providing information to the generators, and thus aim 1, the development of general authorisation, and aim 8, the recommendations for changes to SANS 10228, would have required extensive consultation and discussions with additional stakeholders as well as further research not considered within the scope of this project. Furthermore, there are already panels for reviewing and amending the SANS codes or changes to alternative classification systems (such as the draft SANS 10234 – Globally Harmonised System for the Classification and Labelling of Chemicals).

Recommendations for the generic delisting of a waste stream (aim 6) is not encouraged by the authorities, and thus delisting is not discussed for each waste stream, but included in the introductory sections as an approach to waste management.

Approach of the research project

The first step of the project was the identification of key stakeholders and public participation. A workshop was held with all interested and identified stakeholders. Based on the recommendation of the stakeholders, a list of common industrial waste streams were identified.

A literature review was conducted on available information and methodologies for determining the hazardous properties of the waste streams (nationally and internationally). The information was collected through the following means:

- Material safety data sheets (MSDS's) form suppliers
- Researching documents on the internet
- Consulting waste disposal specialist and academics (waste companies and universities)
- Consulting laboratory specialists
- Communication with authorities (DWAF and DEAT)
- Reviewing books, journals and articles

Note: As DWAF and DEAT were in the process of reviewing and updating the 2nd Edition of the Minimum Requirements when this project was initiated, a decision was made to extend the project to include the revision of the 3rd Edition. However, the project was only able to accommodate the *draft* 3rd Edition, which became available in September 2005. The waste streams were classified using the data specified in the draft 3rd Ed. of the MR. This draft 3rd edition is currently subject to review by the technical committee and therefore changes to the classification procedures and values stated may have an implication for this guidance document.

The last step was the development and presentation of training courses for industry, government, consultants and waste disposal companies in the cities of Johannesburg, Cape Town and Durban. Attendance was excellent and valuable feedback was received during these training courses.

A short introduction course raising awareness of the importance of waste management was also presented to all interested students at the following institutions:

- University of Witwatersrand
- University of Natal and
- University of Cape Town

What information is contained in each Guidance Document?

Each guidance document provides valuable information on the respective waste streams. The information will thus improve understanding of the risks associated with the waste stream, such that the waste may be disposed of in an environmentally responsible manner. Each guidance document for the respective waste streams contains information on the following topics:

Information for each waste stream includes:
1. **Waste Generation Processes / Industrial Application**
2. **Background Information**
3. **Classification and Rating**
4. **Environmental and Health Concerns**
5. **Unacceptable Disposal Options**
6. **Acceptable Disposal Options**
7. **Industry Trends and other Information**
8. **Illustrative Pictures**

What do I do with the Guidance Documents?

- Peruse through the guidance documents to obtain information on the various waste streams that may be generated on an industrial site, and for other information relating to waste management.

- Use and apply this information and the sections on Classification and Rating and Disposal Options in particular to ensure that waste is disposed of in an environmentally responsible and legally compliant manner.

- Use the information to procure documentation when compiling (for example) Terms of Reference for waste tenders and proposals, contracts with waste contractors, waste transporters and disposal companies.

- Use the summary table (at the back of this document) as a quick guide for information pertaining to the classification and disposal of the respective waste streams.

What do I do if I generate the wastes included in these Guidance Documents?

- Peruse the guidance document for that waste stream and become familiar with the relevant information. Use the information to correctly classify the waste so that it can be disposed of in a legal and responsible manner.

- Ensure the receiving disposal site has a waste permit (or exemption) issued by DWAF (or DEAT if the site has been authorised from January 2006) to receive the waste stream in question, and that the site is aware of the nature of the waste stream. Ensure appropriate documentation, such as Waste Manifest Documentation and Certificate of Safe Disposal, has been compiled completed accurately and comprehensively for each load of waste disposed. This is vital to ensure that all waste generated, transported and disposed of may be accounted for and that quantities recorded for waste leaving the *generators* site may be reconciled with the quantities recorded at the *disposal* site (be it landfill, incinerator, recycler etc.).

- Apply all principles of good environmental and waste management practise, taking into account the Waste Hierarchy, principles and regulatory requirements (see section 3).

2 WASTE MANAGEMENT PRINCIPLES, POLICY AND LEGISLATION IN SOUTH AFRICA

There are many legislative requirements that regulate the management of waste in South Africa. This includes international conventions, national acts and regulations, provincial regulations, and local municipal by-laws. In addition, DWAF have developed a number of policies that relate to specific waste streams and to disposal site authorisations. A series of three documents, The Minimum Requirements, of which Document 1, the *Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste* is the most applicable document for industry and these guidance documents, aims to ensure the sustained fitness for use of South Africa's water sources and to protect both the public and the environment from harmful effects of incorrect waste management, without impairing the essential economic development in South Africa[1]. The 3rd edition of the Minimum Requirements is expected to be published mid 2006. The methodology for the classification is outlined in Section 3.

To assist users of these guidance documents in understanding the legal requirements of industry (the waste generator) with regards to waste management, this section provides a summary of the applicable legislation and policies.

Relevant waste management legislation include:

- National Environmental Management Act, 1998 (Act 107 of 1998)
- Environment Conservation Act (Act 73 of 1989) Section 20
- National Water Act (Act 36 of 1998)
- Health Act (Act 63 of 1977)
- Air Quality Act (Act 39 of 2004)
- Hazardous Substances Act (Act 15 of 1973)
- Nuclear Energy Act (Act 131 of 1993) Section 45 & 46 Authority over management of radioactive waste, storage of irradiated nuclear fuel, discarding of radioactive waste and storage of irradiated nuclear fuel
- General Regulations made in terms of the Medicines and Related Substances Act, 1965 (Act No. 101 of 1965): Section 27
- Occupational Health and Safety Act (Act 85 of 1993)

2.1 The Waste Hierarchy

It is important to note the Integrated Waste Management approach is encouraged by DWAF in the Minimum Requirements. This approach is a widely accepted environmental concept in which waste management follows the step-wise procedure, also known as the "Waste Hierarchy" as illustrated in Figure 2.1.

- Waste Prevention – the prevention and avoidance of the production of waste
- Waste Minimisation – the economic reduction of the volume of waste during production (by means of different processes or clean technology)
- Re-use, recycling and energy recovery – in-house or external re-use or recycling of the wastes or use of the calorific value of the waste for energy use
- Waste Treatment – the treatment of waste to reduce waste volumes or hazardousness
- Waste Disposal – the environmentally safe disposal of waste

[1] Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste, Draft 3rd Edition (DWAF, 2005)

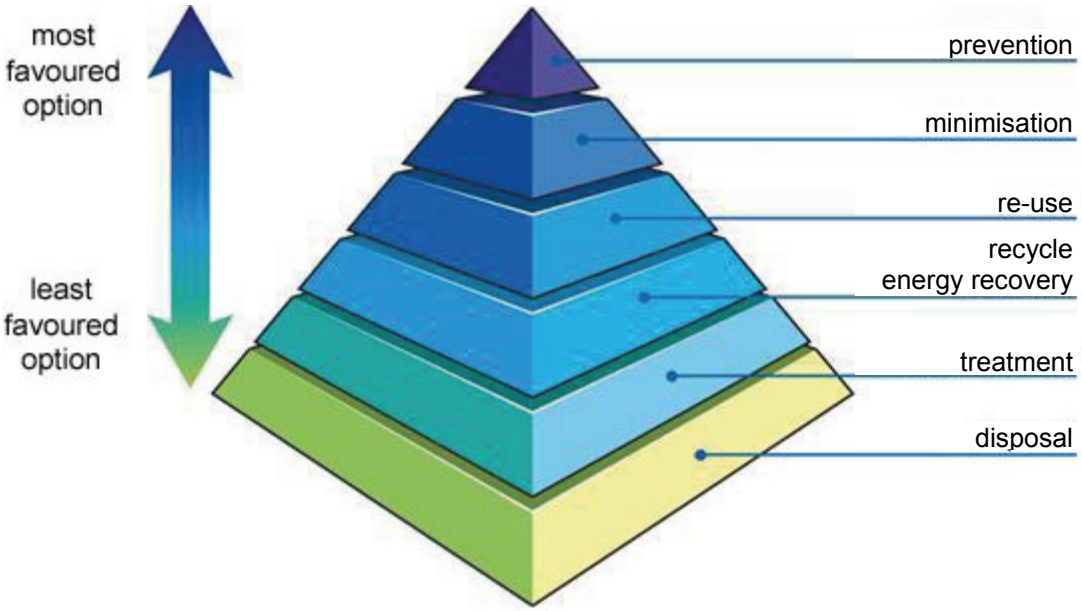


Figure 2-1: Waste Hierarchy

2.2 Waste Management Principles

The following principles are extracted from NEMA and the Minimum Requirements, 2nd Edition (DWAF, 1998).

These principles have far reaching implications. As a generator of waste, the industry holds the responsibility to ensure that the waste it generates is handled and disposed of in a legal and environmentally responsible manner.

All documents are, to some extent, based on the principles contained in NEMA, the National Environmental Management Act (Act No. 107 of 1998).

The key principles that govern the responsibility and handling of waste as described in the *Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste (Second Edition 1998)* and/or the National Environmental Management Act are as follows:

Duty of Care Principle – The industry that generates a waste incurs a duty of care that is owed to society. This means that the generator is responsible for the fate of the generated waste in all circumstances. The generator of the waste is ultimately responsible for ensuring that the waste is handled, stored, transported and disposed of according to the legislation and in an environmentally sound and responsible manner.

Polluter Pays Principle – the person or organisation causing pollution is liable for any costs involved in cleaning-up or rehabilitating its effects. The generator of the waste is thus liable unless able to prove that the transferral of management of the waste was a responsible action.

Precautionary Principle – all waste is assumed to be both highly hazardous and toxic until proven otherwise.

Sustainable Development – sustainable development requires the consideration of all relevant factors, including that waste is avoided, or where it cannot be altogether avoided, is minimised and reused or recycled where possible and otherwise disposed of in a responsible manner.

2.3 Policy and Strategy

Polokwane Declaration
At the first National Waste Summit held in Polokwane in September 2001, the Polokwane Declaration was adopted which commits South Africa to reduce waste generation and disposal by 50% and 25% respectively by 2012 and develop a plan for ZERO WASTE by 2022. Future waste legislation will promote reuse and recycling and require manufacturers to develop products that do not create waste and that can easily be recycled.

National Waste Management Strategy
The NWMSI-project is a direct follow-up of the NWMS strategy and focuses at implementation of Selected National Waste Management Strategy Components. The selected components are Health Care Waste, Recycling and Waste Information System.

The main objective of the NWMS is:

- Reduced generation and environmental impact of all forms of waste, so that the socio-economic development of South Africa, the health of its people, and the quality of its environmental resources are no longer adversely affected by uncontrolled and uncoordinated waste management.

The immediate objectives are:

- Improved Health Care Waste Management: Sustainable and integrated Health Care Waste Management in South Africa established within the frames of the NWMS, covering the full waste stream for all generators of HCW from areas with varying population densities and varying degrees of accessibility.
- Waste Information System established and in use: A Waste Information System (WIS) has been established in DEAT with management and software in place. Minimum reporting requirements have been established for provincial and local level.
- Recycling of waste increased and extended: In the pilot areas, new waste streams are identified, existing initiatives are expanded, and improved and new initiatives are implemented. Appropriate mechanisms are identified and developed that promote sustainable recycling by all members of the recycling chain. Appropriate mechanisms for recycling within specific circumstances will be based on an appraisal of the social, environmental and economic benefits, and costs of recycling in comparison with one-way consumption and disposal.
- DEAT is capacitated to take full control of NWMS: The NWMS is deeply anchored in DEAT who through capacity development and project involvement has been enabled to take full control of future implementation.

2.4 On-site Storage Requirements

The *Minimum Requirements* (2nd Ed, DWAF, 1998) outlines the manner in which hazardous wastes may be temporarily stored on site to reduce the risk and severity of incidents arising from the storage of such waste (such as spills or leaks). These measures, outlined in Table 2-1 on the next page, aim to contain the waste inside the store, and prevent rain and stormwater entering the area. Figure 2.2 has been included to illustrate an example of how a waste store may be constructed, and the considerations to be taken into account when designing the store for both general and hazardous waste.

Table 2-1: Minimum Requirements for on-site storage of hazardous waste

1. Wastes must not be mixed with wastes of a different nature or composition. Highly hazardous waste mixed with a less hazardous or general waste would render both wastes highly hazardous.
2. Once the waste has been collected, the waste container must be clearly marked to prevent risk of wrong identification.
3. The migration of leachate or spillage into the ground and groundwater regime around all temporary waste storage areas must be prevented.
4. A firm waterproof base that is protected from storm water ingress from surrounding areas is required.
5. An effective drainage system to a waterproof spillage collection area is required, where any spillage can be recovered and suitably treated. This area must be clearly demarcated and inaccessible to unauthorised persons.
6. Separate storage of waste from other process chemicals or products. If non-compatible wastes are to be stored together, care should be taken to adequately separate them. Flammable or combustible wastes must in any event be stored separately from other waste materials.
7. A generator of waste may accumulate the following quantities of hazardous waste on site for **90 days or less**:

   Hazard Rating 1: 10 kg

   Hazard Rating 2: 100 kg

   Hazard Rating 3: 1000 kg

   Hazard Rating 4: 10 000 kg

   The methodology used to determine the hazard rating of waste is contained in Section 8 of the Minimum Requirements Document, obtainable from the Department of Water Affairs and Forestry, or downloadable at www.dwaf.gov.za. The substances that would fall within any of the four hazard ratings are poisonous (toxic) and infectious substances.
8. Waste must be stored in such a manner that no pollution of the environment occurs at any time.
9. The date upon which accumulation begins must be clearly marked and visible for inspection on each container.
10. Waste containers or tanks, whilst on site, must be clearly labelled as marked with the words “Hazardous Waste.”
11. All hazardous waste storage areas must be fenced off to prevent unauthorized access.
12. A weatherproof, durable and clearly legible notice-board in official languages must be placed at every entrance of the storage area with the words “Hazardous Waste: unauthorised entry prohibited” must be erected.

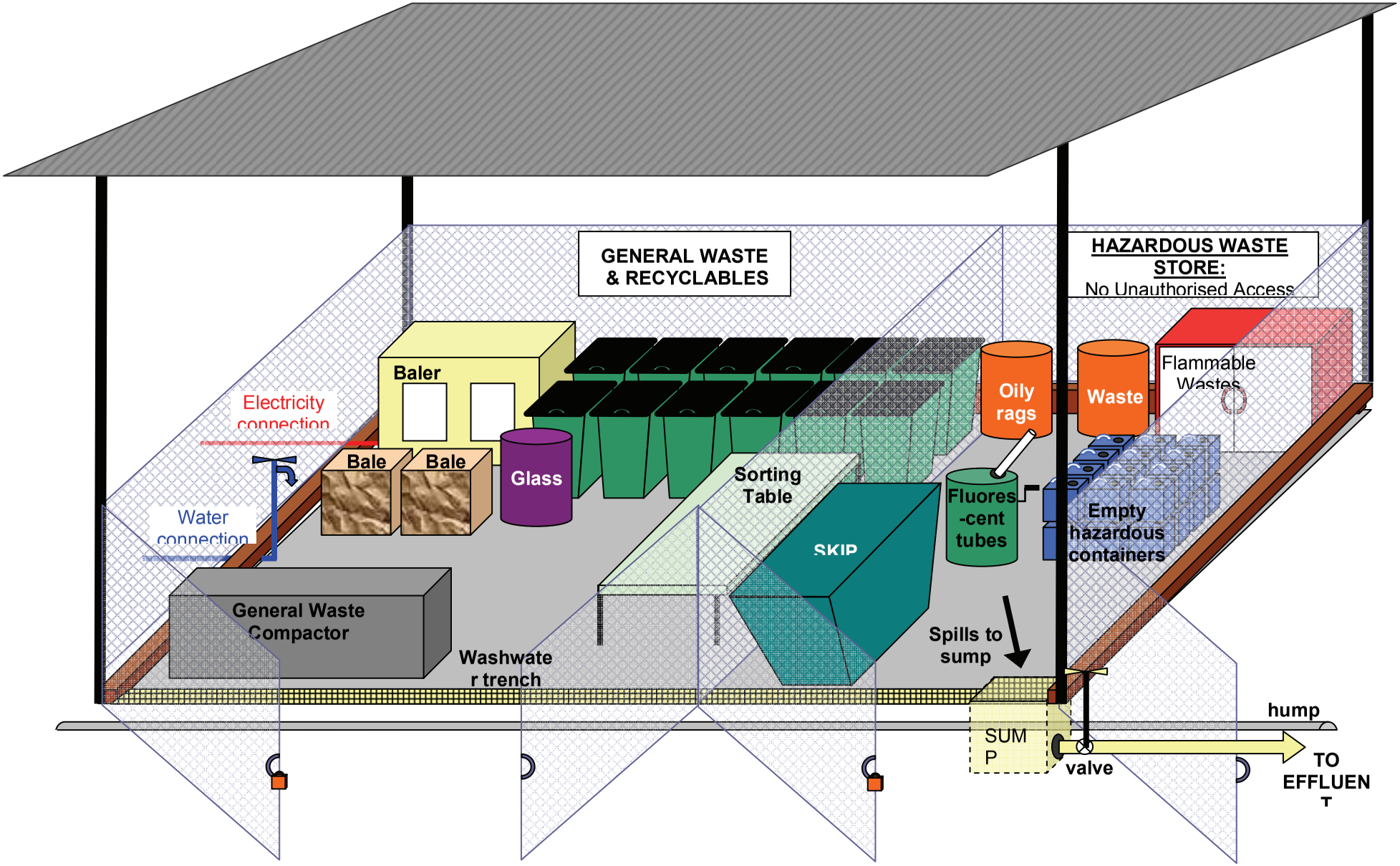


Figure 2.2: General and hazardous waste store design considerations

WASTE STORE DESIGN CONSIDERATIONS	
Infrastructural Components	
Hump	Prevents stormwater ingress into waste area
Concrete floor	Prevents spills leaking to ground (may be coated with protective surface for e.g. acid and chemical spills)
Bund walls	Contains spills inside the store and prevents stormwater ingress
Fence and locks	To prevent unauthorised access and to separate general from hazardous waste
Roof	To prevent rain and stormwater ingress
Trench	To direct washwater and spills to sump
Sump	To contain hazardous waste spills
Valve	To prevent hazardous spills in sump from discharging to effluent (valve only opened when washing floors and effluent does not contain hazardous waste)
Equipment and Machinery	
Sorting table	To sort and separate recyclables
Baler	To compact and bale plastic, paper and cardboard for recycling
General waste compactor	For on site compaction of general waste (as opposed to collection vehicles fitted with compactors lifting 15 x 240 litre wheely bins)
Fluorescent tube crusher	To crush and store fluorescent tubes (must be fitted with rubber seals)
Waste Receptacles	
Wheely bins	Temporary storage of general waste
Skips	For storage of general waste (if not using compactor). Can also be used for hazardous wastes.
Drums	For usage as fluorescent tube crusher, to store waste oil and other hazardous wastes
General Waste Compactor	For compaction of waste
Flammable Store Cupboard	For storage of flammable wastes (paints, solvents etc.)
Facility Connections	
Electricity connection	For bailer and General Waste Compactor
Water connection	To wash waste area , waste bins and skips
Effluent discharge point	To discharge washwater to effluent (discharge quality must be authorised and within prescribed limits)

2.5 Hazard Chemical Substances Regulations

Section 15 of the Hazardous Chemical Substance Regulations under Section 43 of the Occupational Health and Safety Act, No. 85 of 1993 contains further requirements for the disposal of hazardous *chemical substance, which includes hazardous waste.*

'HCS' *or* ***'Hazardous Chemical Substance'*** *means any toxic, harmful, corrosive, irritant or asphyxiant substance or a mixture of such substances for which –*
an occupational exposure limit is prescribed; or
an occupational exposure limit is not prescribed, but which creates a hazard to health.

As far as is reasonably practicable, the following is required:

a. recycle all hazardous chemical waste;
b. ensure that all collected HCS waste is placed into containers that will prevent the exposure during handling;
c. ensure that all vehicles, re-usable containers and covers which have been in contact with HCS waste are cleaned and decontaminated after use such that they do not cause a hazard inside or outside the premises concerned;
d. HCS waste must be disposed of only on sites specifically designated for this purpose in terms of the Environmental Conservation Act, 1989 in such a manner that it does not cause a hazard inside or outside the site concerned;
e. ensure that all employees handling the disposal of HCS waste are provided with suitable personal protective equipment; and
f. ensure that if the services of a waste disposal contractor are used, a provision is incorporated into the contract stating that the contractor shall also comply with the provisions of these regulations.

2.6 Authorisation of Off-site Disposal Sites

All waste disposal sites receiving waste must have been issued with an appropriate permit or exemption in accordance with section 20 of the Environment Conservation Act (Act no. 73 of 1989). This authorisation was previously issued by DWAF, but Section 20 functions have recently changed to DEAT (Oct/Nov 2005).

> ***'Disposal site'*** *means a site used for the accumulation of waste with the purpose of disposing or treatment of such waste, and as such covers any on-site waste accumulation areas the premises.*

Sites requiring authorisation in terms of Section 20 is outlined in the policy developed by DWAF, the *Interpretation of the Definition of Disposal Sites with regard to the Issuing of Permits for Waste Incinerators, Waste Management Facilities and Other Alternative Waste Disposal Technologies and Related Guidelines*. The facilities mentioned in this document are seen as disposal sites because of the "continuous" storage of waste on the premises of these plants or sites before the disposal, removal or handling thereof. The facilities therefore include the following:

- Landfills (hazardous (H:H, H:h, general)
- Incinerators
- Recycling plants
- Transfer stations
- Storage facilities
- Compost plants

DWAF has also developed a waste exemption policy - *Procedure With Regard To The Issuing Of Exemptions under Section 20 of the Environment Conservation Act, 1989 (Act 73 of 1989)* which outlines the procedure to be followed and the type of information to be submitted for consideration for the issuing of an exemption. This policy can be used for the generator when applying for authorisation of the waste storage area.

Note that the permit (or exemption) of waste disposal sites is issued with conditions, which may include certain types of wastes that may or may not be accepted. The site permit and conditions must therefore be reviewed by the generator to ensure waste is being disposed of on the respective site in accordance with the prescribed conditions.

In addition, the waste generator must be able to demonstrate that their waste is treated and disposed of in accordance with the methods prescribed in the Minimum Requirements, and that the quantities of waste can be accounted for (in terms of the Duty of Care and Cradle to Grave principle).

The waste contractors who collect the waste, issue a *Waste Manifest* document and the disposal facilities issue a *Certificate of Safe Disposal*. These documents must be obtained for all waste streams collected to enable reconciliation of quantities of waste leaving the generator's site and the quantity received by the stipulated permitted waste facility.

Note that further permits may be applicable to the site, such as EIA (Environmental Impact Assessment) authorisations or Registration Certificates under the Atmospheric Pollution Prevention Act (for facilities such as incinerators, waste paper possessing facilities, scrap metal recyclers etc.).

2.7 Authorisation of On-site Storage of Waste

Although the Minimum Requirements specifies that hazardous wastes may not be stored on site for longer than three months, the *continual* storage of the waste for longer than three months is considered as an *accumulation* of waste, thereby defining the site as a Disposal Site [*Storage Facility*] in accordance with DWAF's policy outlined in Section 2.4. A permit or exemption will thus be required for on-site storage of waste under section 2001) of the Environmental Conservation Act, 1989.

Small salvage yards and waste storage areas storing **general waste** only fall under the definition for **general communal waste disposal site** (G:C:B^- and G:C:B^+). For these sites, only registration is required, under the following directions:

Extract from Communal Waste Disposal Site Directions, 2001 :

Directions (in terms of Section 20(5)(b) of the Environment Conservation Act, 1989 (Act 73 Of 1989) with regard to the Control and Management of General Communal and General Small Waste Disposal Sites

"**general communal waste disposal site (G:C:B^- and G:C:B^+)**" in these directions means a disposal site –

a) which receives only general waste;
b) which receives less than 25 tons of general waste per day;
c) which does not have any of the fatal flaws as set out in the in the Minimum Requirements for Waste Disposal by Landfill (Second Edition 1998), published by the Department of Water Affairs and Forestry and as amended from time to time.

A person or body who wishes to establish and/or develop, operate, close and rehabilitate a general communal or a general small waste disposal site (hereafter referred to as "the Site") with a negative water balance must register the site in the format as set out in Annexure A of the Directions.

2.8 Local (Municipal) By-laws

Many municipalities have promulgated by-laws for waste management. The by-laws seek to regulate the collection, disposal, treatment and recycling of waste as well as the following topics:

- Transportation and licensing of waste transporters and disposers
- Type and placement of receptacles used for waste storage
- Visibility of waste storage areas and receptacles
- Submission of information regarding generator's wastes
- Litter
- Dumping and abandoning of articles
- Burning of waste

Some of these by-laws also separate waste into the following categories (extract from Johannesburg Waste Management By-laws):

- **bulky waste -** waste which cannot by virtue of its mass, shape, size, or temporary extraordinary generation conveniently be stored in a waste receptacle or container, but shall not include builder's waste or special domestic waste;
- **business waste** - waste generated on premises other than domestic waste, builders waste, bulky waste, industrial waste, special domestic waste, garden waste and special industrial waste which can be removed easily without damage to the waste container, bulk container or waste removal vehicle. (Definition similar to trade waste.);
- **dailies -** putrescible waste generated by hotels, restaurants, food shops, hospitals, and canteens that must be collected on a daily basis to prevent the waste from decomposing and presenting a nuisance or an environmental or health risk;
- **domestic waste** - waste of a kind normally produced or generated on residential premises, and the manure or dung of any animal or bird kept as a domestic pet, but shall not include sand, earth, liquid matter, garden waste, or the carcass of any animal or special domestic waste;
- **garden waste** - waste which is generated as a result of normal gardening activities on any premises, such as grass cuttings, leaves, plants, flowers, weeds, clippings of trees, hedges or fences and other similar small and light matter;
- **industrial waste** - waste generated as a result of manufacturing, maintenance, fabricating and dismantling activities and the activities of railway marshalling yards, but shall not include builders waste, business waste, special industrial waste or domestic waste;
- **special domestic waste -** waste discarded from residential premises which cannot by virtue of its mass, shape or size be conveniently stored in a waste receptacle or container; and
- **special industrial waste** - waste consisting of a liquid or sludge, resulting from a manufacturing process or the pro-treatment for disposal purposes of any industrial or mining liquid waste, which in terms of the Municipality's Drainage by-laws may not be discharged into a drain or sewer.
- **discharge of effluent to sewer (not defined as waste)** - A permit is required to discharge effluent into the Council's sewage system. Illegal discharges must be prevented from entering the sewage system, and the effluent must meet prescribed limits.

3 WASTE CLASSIFICATION AND HAZARD RATING

Before waste is disposed of, the composition, concentration, and toxicity indicators must be determined such that the waste can be classified and rated in accordance with the *Minimum Requirements*. The *Minimum Requirements* sets out a systematic framework for identifying whether a waste stream is hazardous and classifying it in accordance with the degree of risk that it poses. From the classification, requirements are set to ensure Hazardous Waste is treated and safely disposed of. These requirements represent the lowest acceptable standard and are therefore termed the Minimum Requirements.

The initial classification of waste is to determine whether it is a general or hazardous waste (as defined in the glossary). Where there is uncertainty, the precautionary principle requires the waste be classified as hazardous until proven otherwise.

The Minimum Requirements requires all hazardous waste to be classified according to SANS 10228 (The identification and classification of dangerous goods for transport) and assigned a Hazard Rating (1-4) to determine on-site storage limits and which type of disposal facilities may accept the waste.

The SANS 10228 classification[1] determines the type of the waste, dividing all substances into the nine classes as described in Table 3-1. The new Globally Harmonised System is still in draft, SANS 10234 – Globally Harmonised System for the Classification and Labelling of Chemicals, the final draft should be available for comment in June 2006.

Each substance found in SANS 10228 is identified by the UN or SIN (Standard Identification Number).

The Hazard Rating differentiates between the levels of risk associated with the hazardous nature of the waste. The level of risk will determine the type of landfill the waste may be disposed at, as well as on-site storage limits. The Hazard Ratings are described in

Table 3-2 (extracted from MR, 2nd Ed, DWAF, 1998).

The Hazard Rating as assigned based on various parameters, including the following:

- Carcinogenicity, mutagenicity, teratogenicity;
- Toxicity (LD50);
- Ecotoxicity (LC50);
- Biodegradation (COD and DOC);
- Accumulation and persistence potentials; and
- Concentrations of organic and inorganic substances

[1] Previously SABS 0228

Table 3-1: SANS 10228 Classes

Class 1 - Explosives
Division 1.1 - Substances and articles that have a mass explosion hazard.
Division 1.2 - Substances and articles that have a projection hazard, but not a mass explosion hazard.
Division 1.3 - Substances and articles that have a fire hazard and, either a minor blast hazard, a minor projection hazard, or both, but do not have a mass explosion hazard.
Division 1.4 - Substances and articles that present no significant hazard

Class 2 - Gases: compressed, liquefied or dissolved under pressure
Division 2.1 - Flammable gases
Division 2.2 - Non-flammable gases
Division 2.3 - Poisonous gases

Class 3 - Flammable liquids
Division 3.1 - Low flashpoint group of liquids; flashpoint below –18°C closed cup
Division 3.2 - Intermediate flashpoint group of liquids; flashpoint of –18°C up to 23 °C
Division 3.3 - High flashpoint group of liquids; flashpoint of 23°C, up to and including 61°C c.c.

Class 4 - Flammable solids or substances,
Division 4.1 - Flammable Solids
Division 4.2 - Substances liable to spontaneous combustion
Division 4.3 - Substances emitting flammable gases when wet

Class 5 - Oxidizing substances (agents) and organic peroxides
Division 5.1 - Oxidizing substances (agents)
Division 5.2 - Organic peroxides

Class 6 - Poisonous (toxic) and infectious substances
Class 7 - Radioactive substances
Class 8 - Corrosive substances
Class 9 - Miscellaneous dangerous substances

Table 3-2: Hazard Rating

Hazard Rating	Risk	Acceptable Landfill Type	On-site Storage Limit
HR 1	Extreme Risk	H:H	10 kg
HR 2	High Risk	H:H	100 kg
HR 3	Moderate Risk	H:H or H:h	1 000 kg
HR 4	Low Risk	H:H or H:h	10 000 kg
No rating (for General Waste)	Minimal Risk	General	No limit, but must be temporary storage

The Minimum Requirements bases the rating on the LC_{50} (aquatic, 96hr) value of the substance on the fact that the major pollutant pathway goes through water (waste components leaching through the landfill, into the groundwater and into other water courses). However, the third edition makes use of LD_{50} (dermal or oral) or LC_{50} (inhalation) values to evaluate the toxic nature of the waste. Appendix 8.1 of the *Minimum Requirements* (draft 3rd Edition) is used to rate the waste as follows:

Acute Mammalian Toxicity (LD_{50})
Acute mammalian toxicity is expressed as LC_{50} (mg/kg). This indicates the dosage that will, statistically, kill 50% of the test organisms concerned. LD_{50} values are expressed as 'per kg body mass'.

Table 3-3: Acute Mammalian Toxicity

Toxicity category	LD_{50} (Oral) mg/kg	LD_{50} (Dermal) mg/kg	LC_{50} (Inhalation) mg/l
Extreme	< 5	< 40	< 0.5
High	5 to < 50	40 to < 200	0,5 – 2
Moderate	50 to < 500	200 to < 2 000	2 – 10
Low	500 to < 5 000	> 2 000	> 10

Acute Ecotoxicity (LC_{50})

Ecotoxicity refers to the potential to harm animals and plants - but, more specifically, ecosystems constituted by a community with its habitat. It is based on the LC_{50} of specific warm- and cold-water fish or aquatic invertebrate species.

Table 3-4: Acute Ecotoxicity

Toxicity category	LC_{50} (96 hr) mg/l
Extreme	< 1
High	1 to <10
Moderate	10 to < 100
Low	100 to < 1 000

4 THE LANDFILL

Landfills are divided into *hazardous landfills* for hazardous waste, and *general landfills* for general waste. Although general waste may be disposed of in a hazardous landfill, hazardous waste cannot be disposed of in a general landfill.

Hazardous and general landfills are divided into further groups. There are two letters associated with hazardous landfills and three letters associated with the type of general landfill with which we are dealing. The meaning of the letters are indicated in the following table:

Table 4-1: Landfill types

Hazardous Waste Landfill		**General Landfills (e.g. G:L:B^+ or G:M:B^-)**	
H:H	Wastes of HR 1-4 accepted	G	General Waste
H:h	Wastes of HR 3 & 4 accepted	L	Large Landfill
		M	Medium Landfill
		S	Small Landfill
		C	Communal Landfill
		B^-	Water deficit climate, resulting in only sporadic leachate generation
		B^+	Water surplus climate, resulting in significant leachate generation

There are currently three H:H landfills in South Africa – situated in Holfontein in Springs, Vissershok in Cape Town, and Aloes in Port Elizabeth – which are available to most hazardous waste generators. According to the 2005 IWM Buyer's Guide and Directory, a further 29 H:H landfills exist (this list is available on the IWM website: www.iwmsa.co.za). These other sites include private sites, or sites that only accept certain types of hazardous waste. There are currently 28 permitted H:h landfill sites, including sites such as Shongweni and Bulbul Drive in KwaZulu- Natal.

4.1 TCLP Tests and Delisting

Landfills for hazardous waste disposal are lined and have a leachate collection system installed, in order to prevent any toxic elements/components of the hazardous waste leaching out of the waste and into the water and soil regimes. The leachate can contain a variety of substances, depending upon the contents of the waste, including metals, organic compounds, suspended particles, and bacteria.

Most general landfills do not have liners, and hazardous waste is, thus, not accepted. Where general landfills (G:B+ landfills) have been lined - and where the concentration of hazardous elements and compounds that leaches out of the waste in the landfill is sufficiently low enough to pose an acceptably low risk - the waste may be delisted for disposal in a landfill that accepts less hazardous waste or general wastes. Hazardous waste may, therefore, be delisted from an H:H landfill to an H:h or G:B^+ landfill, or from H:h to G:B^+. G:B^+ landfills are general landfills with liner, in addition to a leachate collection system, and are able to accept the delisted waste.

The TCLP test (Toxicity Characteristic Leaching Procedure) determines the concentration that will leach out, and the results thereof are used to establish whether or not a waste delists. This test simulates landfill conditions where the anaerobic degradation of organics in the landfill formulates a weak acid. In a landfill, the acid filters through the waste, rendering some elements in the waste soluble; thereafter, toxic elements leach out of the waste and into the groundwater. This toxic liquid substance is commonly referred to as leachate. The provision of liners, as well as the pumping of leachate in certain landfills, reduces the leachate from entering the soil and groundwater regime, as illustrated in the picture above.

The Acid Rain Leaching Procedure is used to test hazardous waste that is mono-disposed in dedicated landfill sites, wherein only that waste is disposed. Leaching in such sites would, most likely, be due to “Acid Rain” rather than organic acids; therefore, the Acid Rain extraction method is preferred to the TCLP method.

Authorisation is required from DWAF and/or DEAT before any waste can be delisted.

5 DEVELOPMENT OF WASTE STREAM GUIDANCE DOCUMENTS

5.1 Which waste streams are considered in this report?

A workshop was held in 2004 with a number of interested and affected parties, in order to discuss the project, and to determine which waste streams were to be included. The workshop attendees included governmental authorities, consultancies, and representatives of the waste management companies and industry.

In order to assist as wide an industry as possible, the waste streams selected for inclusion in this document were based on the following criteria:

- The focus is on industry as the source and not domestic/household waste streams;
- Waste must be generated by a wide variety of generators;
- Waste streams will not be exclusive to a specific industry or group of industries;
- Properties and composition of the wastes must be limited in their variance;
- Waste must be generated by similar operations of industrial sites, and
- Waste is hazardous (or has the potential to be hazardous).

Based on the outcome of the workshop, the following waste streams were selected for the development of the guidance documents:

Table 5-1: Researched waste streams

Waste Stream	Types/short comment
1. Used oil and other petroleum products	▪ Engine oil; ▪ Transmission fluid; ▪ Lubricating oil; ▪ Hydraulic oil; ▪ Gear oil; ▪ Transformer fluid; ▪ Cutting oil; ▪ Tempering or quenching oil; ▪ Grease; and ▪ Brake fluid.
2. Hydrocarbon Contaminated Waste	Oil contaminated waste can consist of soil, rags, gloves, wood, paper, plastic and cardboard packaging. Materials such as sawdust, and other adsorbent and/or absorbent products, are used to clean oil spills.
3. Polychlorinated Biphenyls (PCBs) and PCB Contaminated Waste	PCBs were used in many different types of products including hydraulic fluid, casting wax, pigments, carbonless copy paper, plasticizer, vacuum pumps, compressors, heat transfer systems and others. Their primary use, however, was as a dielectric fluid in electrical equipment.
4. Edible / Vegetable Oil	Edible/vegetable oil is used in restaurants, canteens, entertainment industry and frying or food preparation establishments.
5. Solvents	The major uses of solvents are in paints and coatings (paints, varnishes, and lacquers), industrial cleaners, adhesives, printing inks, extractive processes and pharmaceuticals. Solvents are also used in a variety of metal, electronic and precision cleaning applications. Chlorinated solvents (i.e. those that contain chlorine, making the solvent potentially more toxic) are commonly found in cleaning and degreasing operations and in the refrigeration industry.
6. Trichloroethylene (TCE)	Used as a degreasing agent and is an ingredient in adhesives, paint removers, spot removers, and as a dry-cleaning solvent.
7. Spent antifreeze	Added to water to lower freezing point in internal combustion engines.

8. Lighting waste	▪ Fluorescent lamps; ▪ Compact fluorescent lamps; ▪ Incandescent bulbs; ▪ HID (High Intensity Discharge) lamps: ◘ high pressure sodium vapour lamps; ◘ low pressure sodium vapour lamps; ◘ mercury vapour lamps; and ◘ metal halide lamps.
9. Electronic waste / e-waste	▪ Computers; ▪ Cell phones; ▪ CRT (cathode ray tube); ▪ Printed circuit boards (PCBs); ▪ Printer and toner cartridges; and ▪ White products – electronic household appliances.
10. Ink and Toner Cartridges	Printers, pens, copiers.
11. Smoke Detectors	A smoke detector is a safety device that detects airborne smoke. Some have a radioactive source.
12. Wet cell batteries	Lead-acid batteries (e.g. for vehicles)
13. Dry cell batteries	▪ Non-rechargeable (disposable) ◘ Zinc carbon and zinc chloride ◘ Alkaline manganese ◘ Mercuric oxide ◘ Zinc air ◘ Silver oxide ◘ Lithium ▪ Rechargeable ◘ Nickel cadmium (NiCd) ◘ Nickel metal hydride (NiMH) ◘ Lithium ion (Li-Ion) or Lithium Polymer (Li-Polymer)
14. Asbestos and asbestos containing waste (ACW)	Asbestos is used in the manufacturing of products such as asbestos cement sheets or pipes, building material, insulation, asbestos rope, and friction products, such as gaskets, brake pads and clutch plates. Asbestos-*contaminated* waste can be derived from the bags used to transport asbestos, equipment, PPE and clothing that have been in contact with asbestos.
15. Boiler ash (and other ash waste)	Industrial processes that involve combustion as part of the production process produce ash as one of the by-products of the process.
16. Medical Waste / Health Care Risk Waste (HCRW)	Public and private hospitals and clinics, labs, pharmaceutical companies. Includes *Health Care Risk Waste* (expired medicines, sharps, contaminated gloves, used bandages, glass, infectious waste, pathological waste, chemical waste, radioactive waste) and *Health Care General Waste* (plastic packaging and paper).
17. Redundant Pesticides	Agriculture, household and commercial use.
18. Paint Waste and Empty Paint Containers	Maintenance of buildings or painting of any surface, article, product, machine etc. that produces residual paint and empty paint containers.
19. Empty and contaminated chemical containers	All manufacturing industries that use chemicals in their processes or for their facilities.
20. Demolition and Construction Waste (Building Rubble)	Waste building materials, dredging materials, tree stumps, and rubble resulting from construction, remodelling, repair, and demolition operations on houses, commercial buildings and other structures, and pavements. May contain lead, asbestos, or other hazardous materials.

5.2 What information has been included in each guidance document?

Each guidance document for the 20 respective waste streams described above contains information on the following topics:

1. Waste Generation Processes / Industrial Application
2. Background Information
3. Classification and Rating
4. Environmental and Health Concerns
5. Unacceptable Disposal Options
6. Acceptable Disposal Options
7. Industry Trends and other Information
8. Illustrative Pictures

USED OIL AND OTHER PETROLEUM PRODUCTS	1

Waste Generation Processes / Industrial Application

Users of oil and oil products include almost all industrial and commercial sectors, as well as many individuals and households, generated from the operation and maintenance of vehicles, equipment and machinery. Oils originating from petroleum crude oil can be processed, blended and formulated to produce numerous ranges of products, including the following: fuels, lubricants, hydraulic, transmission fluids and heat transfer fluids.

The transportation industry is a major user of oil, both as a fuel for many land-based transport systems, as well as a lubricant for the propulsion engines themselves.

Background Information

Types of oil:
- Engine oil;
- Transmission fluid;
- Lubricating oil;
- Hydraulic oil;
- Gear oil;
- Transformer fluid;
- Cutting oil;
- Tempering or quenching oil;
- Grease; and
- Brake fluid.

Waste oil
Waste oil is an organic material but may contain inorganic substances (metals), chlorinated solvents, and organic compounds. The presence of metals, such as aluminium, arsenic, barium, cadmium, chromium and zinc, is usually the result of an engine bearing wear or inclusion of metals in oil additives. Lead can also be found in used oil from leaded fuels; however, the concentration thereof is decreasing as the use of unleaded fuel increases[1]. Other potentially hazardous contaminants include naphthalene, benzo(a)pyrene and TCE. In January 2006, South Africa implemented another Good Clean Habit with the introduction of “cleaner” fuel regulations. This means that leaded fuel, as we know it, will become a thing of the past: only two types of fuel will be available: unleaded petrol (ULP) and lead replacement petrol (LRP).

Any petroleum or synthetic crankcase oil, engine oil, hydraulic fluid, transmission fluid, gear oil, heat transfer fluid or other fluid used for lubricating purposes in machinery or equipment, can be recycled. However, used oil that has been polluted with solvents, cleaning fluids, or other hazardous waste, makes recycling difficult.

[1] Integrated Solid Waste Management, Engineering Principles and Management Issues, Tchobanoglous, Tgiesen, Vigil.

USED OIL AND OTHER PETROLEUM PRODUCTS | 1

Lubricating oil
Lubricating oils (or lube oil) are composed of base oils and additives. Base oils are either mineral oils derived from refined crude oil or synthetic base fluids manufactured in a chemical process plant. Lubricants are fluids that are filled into equipment and machinery, such as engines, gearboxes and hydraulic systems, as well as air compressors.

Once the lubricating oil is drained from the equipment and machinery (such as engines, gearboxes, hydraulic systems, turbines and air compressors):

- the oil is contaminated with wear debris,
- the lubricating base oil has deteriorated and degraded to acids,
- the additives have decomposed into other chemical species, and
- process fluids, degreasers and solvents have mixed into the used oil.

Cutting Oil
Machining or cutting oils are used extensively for metal cutting, machining of components on lathes, and general engineering activities. In many instances, depending on the metal being machined, oils for this purpose are used as an emulsion in water with detergents, biocides, chlorinated paraffin, halogenated and non-halogenated additives, and additives included to improve performance. The waste, which can be substantial in volume, comprises an emulsion of typically 2-5% oil in water. The waste may also contain metal dusts, swarf, and similar contamination.

Oil/water mixtures in emulsion form - such as cutting oils - can be reused to some extent, thus reducing quantities requiring disposal. Simple settlement and filtration of the used material, which removes abrasive material, usually allows reuse many times over.

Contaminants
Elements and compounds that can be tested for in used oil (and which reduce the recyclability of the oils) include:

- *Benzene* - a breakdown product from fuels.
- *Toluene* - a breakdown product from fuels (and a solvent of concern[1]).
- *Xylene* - a breakdown product from fuels (and a solvent of concern).
- *Lead* - from combustion of leaded petrol: organo-lead compounds are used to suppress engine knock.
- *Zinc* - from additives used to stop wear and oxidation in lubricants.
- *Benz(a)pyrene* - carcinogen resulting from combustion in petrol engines.
- *Water* - from contamination of used oil during machine operation, or from storage practices on site.
- *Solvents* - used to clean mechanical parts, and disposed of with used oil.
- *Degreasers* - derived from cleaning workshops and parts, and dumped into used oil tanks.
- *Engine coolant* - leakage into lubrication oil charge during diesel engine operation.
- *Heavy metals* - Cr, Cu, Ni, Pb, Zn, Hg, Cd: from engine wear metals or other contamination.
- *PCBs (polychlorinated biphenyls)* - a stable electrical insulating fluid used in electrical transformers & dumped into used oil stocks.
- *Antifreeze* - added to water to lower freezing point in internal combustion engines, and sometimes dumped into used oil tanks.

[1] Listed as a Solvent of concern in the Minimum Requirements Draft 3rd Ed.

USED OIL AND OTHER PETROLEUM PRODUCTS | 1

Classification and Rating

Hazardous constituent	*SANS 10228 Class*	*SANS10228 UN No.*	*Hazard rating*	*Properties*	*Acceptable exposure (ppm)*
Benzene	*3.2(II)*	*1114*	*2*		*Environmental:0.91 Human health:0.06*
Toluene	*3.2(II)*	*1294*	*3*	*Solvent of concern*	*Environmental:2.6 Human health:7.8*
Xylene	*3.2(II)*	*1307*	*3*	*Solvent of concern*	*Environmental:1.5 Human health:6.3*
PCB's	*9(II)*	*2315*	*1*		*Environmental:0.002 Human health:0.002*
Chromium	*-*	*-*	*3*		*Environmental: 4.7 Human health: n/a*
Copper	*6.1(III)*	*2775*	*2*		*Environmental:0.13 Human health: 2.3*
Nickel	*-*	*-*	*2*		*Environmental:0.75 Human health:0.18*
Lead	*-*	*-*	*2*		*Environmental:0.12 Human health:0.02*
Zinc	*-*	*-*	*2*		*Environmental:0.83 Human health: 11*
Sulphur			*4*		*N/a*
Phosphate derivatives	*4.1(II)*	*1338*	*1*		*Environmental:0.002 Human health:0.001*

Environmental and Health Concerns

- Although the waste oil in itself may not be especially toxic, the contaminants - which include the additives, breakdown products and other substances outlined above, all of which may have become mixed with oils during use - may be toxic, thus rendering the used oil to be considered potentially even more toxic.
- Oils can cause damage to the environment via their persistence and ability to spread over large areas of land or water. Just one litre of used oil can contaminate up to one million litres of fresh water.
- Used oil from one oil change can contaminate about 3 million litres of groundwater, if dumped down a storm drain or directly onto ground. Many countries, and especially South Africa, have towns and communities that rely on underground water for drinking and irrigation purposes.
- Used oil materials contain small quantities of substances that could contaminate air, soil and ground water – these include trace metals, chlorinated solvents, gasoline, glycols and PCBs.
- Used motor oil contains more metals and heavy polycyclic aromatic hydrocarbons (PAHs) (some of which are partly the result of combustion processes) that would contribute to chronic (long-term) hazards, including carcinogenicity.

Unacceptable Disposal Options

The following disposal methods are not considered to be acceptable:

- General landfill – energy value of used oil is lost; used oil will contaminate groundwater.
- Direct burning in boilers – the combustion process may release heavy metals and other hazardous components into the atmosphere. The stack emissions could result in human health problems.
- Storm water or direct dumping on ground – oil will contaminate groundwater, surface and ground.
- Discharge to effluent.

USED OIL AND OTHER PETROLEUM PRODUCTS | 1

Acceptable Disposal Options

The following disposal or treatment options are acceptable:

- Recycle – used lubricating oil. Oil that is recycled could be re-refined to new base oil or treated and sold as fuel oil.
- Re-refining into lubricating oil.
- Incinerate to recover the energy value (the oil will, thus, replace virgin non-renewable fuels)
- Reclamation – of transformer oil, hydraulic oil and turbine oil. Reclamation may take place off-site, where the vendor of the reclamation service drains the existing charge and replaces it with previously reclaimed oil. Generally, reclamation involves cleaning and drying, and may also include adsorption to remove colour, acids and sludge. The reclaiming of lube oil is, essentially, a non-chemical process that restores lube oil for reuse in a system.

Recycling and reclamation - Waste oils that can be reclaimed or recycled include the following[1]: (Separation of different types of oil which make recycling and treatment easier)

Reclamation	**Recycling**
Cutting fluids	Spent lube oils, can't be reclaimed
Hydraulic oils	Engine oils, too contaminated
Turbine oils	Gear oils
Transformer oils	

- Complex reprocessing – can produce a very useful low sulphur fuel, in addition to other valuable industrial fuels, when blended with treated discarded hydrocarbon fluids.
- Used as a fuel for cement and limekilns – burned at temperatures exceeding 1100^{o}C to 1300^{o}C.
- Hazardous landfill.

Industry Trends and other Information

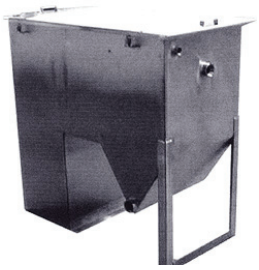
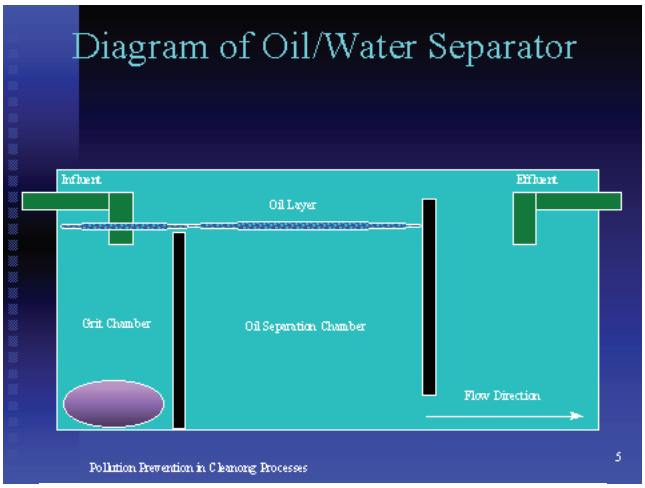
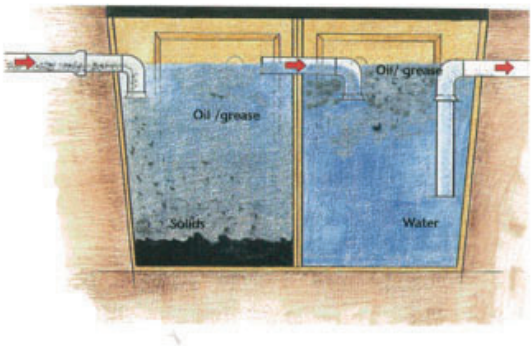
The University of Pretoria has conducted a study on the separation of waste cutting oil and water mixture with filtration technology and ultra membrane filtrations. A great volume of spent cutting oil is usually landfilled. This, however, takes up unnecessary space in a landfill. Yet, there are physical, chemical and membrane technologies available that can be used for the separation of the oil from the effluent. The recovered water should be of suitable quality for discharge into the sewer, and the concentrated oil could be used as a fuel source.

Bioremediation has also developed over the last few years as a highly viable option to consider for treating and cleaning oil contaminated soil.

Organisations and companies that can be contacted for more information regarding oil recycling:
ROSE Foundation
Tel: (021) 448 7492; Fax: (021) 448 7563
E-mail: usedoil@iafrica.com
Website address: www.rosefoundation.org.za
or call: 0860 107 107

The ROSE Foundation has set an objective to increase the collection rate for used oil by 50%, and has also implemented a system for the collection of grease.

[1] ROSE Foundation (http://www.rosefoundation.org.za)

USED OIL AND OTHER PETROLEUM PRODUCTS	1
Illustrative Pictures	
Oil-water separators	 
Diagram of oil/water separators	 
Do not dispose of any used oil in the storm water drain	

HYDROCARBON CONTAMINATED WASTE | 2

Waste Generation Processes / Industrial Application

Oil contaminated waste may include soil, rags, gloves, wood, paper, plastic and cardboard packaging. Sawdust and other oil-absorbent products used for oil spill clean up (such as those based on sphagnum peat moss) must also be disposed of correctly. Furthermore, the oil-contaminated waste may also be contaminated with other compounds.

Background Information

Many different types of absorbents and adsorbents can be used for the cleanup of hydrocarbon gasoline, diesel, as well as lubricating and cutting oil spills. These include the following examples:

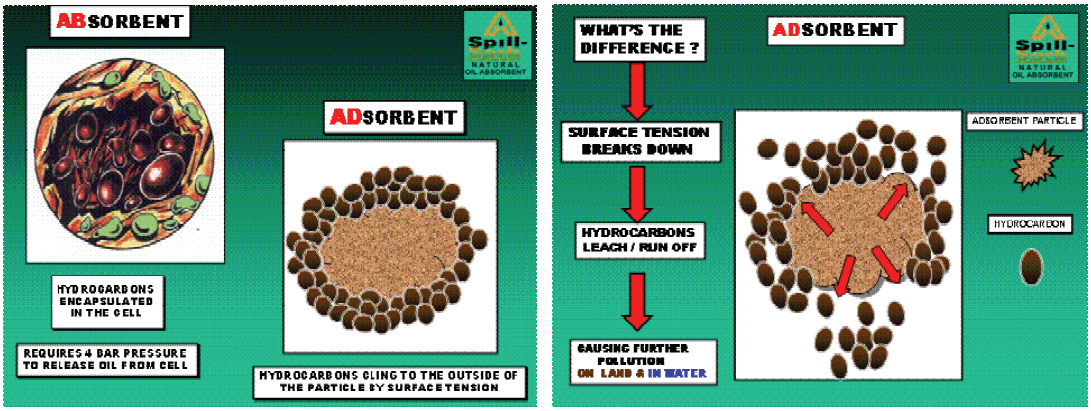
- Polypropylene or other plastic pads, sheets or granules
- Peat (sphagnum peat moss, a partly biodegraded organic matter that has been dried, in order to increase its ability to absorb liquids)
- Cellulose fibre
- Sawdust
- Woodchips
- Cloth towel
- Granular clay
- Diatomaceous earth (naturally occurring, soft, chalk-like, sedimentary rock mineral - made from the crushed fossils of freshwater organisms and marine life)
- Amorphous silica

Difference between adsorbent and absorbent products

An adsorbent (for instance, sawdust) — is probably the cheapest and most common method used to mop up oil spills. While it does adsorb the oil quickly, it does not, unfortunately, bind the pollutant to the fibre. Within a short period of time the oil then starts to leach from the sawdust, especially under pressure, thus polluting the environment once again, or leaching out in the landfill site. Certain other peat products show similar tendencies.

Absorbents (for example, Peat moss) encapsulate the hydrocarbons in the cell, thus preventing leaking. Some absorbents will also start degrading the absorbed compound. (Refer to Illustrative pictures).

Difference between Adsorbent and Absorbent[1]



Absorbents that we use **ab**sorb, whereas sawdust **ad**sorbs. An adsorbent allows the hydrocarbon to coat the surface of sawdust externally, which results in leaching (as mentioned above).

[1] Spill Sorb South Africa & Spill Supply Services; www.spillsorb.co.za

HYDROCARBON CONTAMINATED WASTE 2

Methods to prevent oil spills and leaks include:

- Maintaining machinery
- Placing machinery and oil drums on drip trays
- Storing oil in bunded oil stores
- Ensuring container and drums are kept closed
- Maintaining a stocked emergency spill kit

Classification and Rating

Oil contaminated waste	*SANS10228 Class*	*SANS10228 UN No*	*Hazard Rating*
Oily rags	4.2	1856 (oily rags)	Depend on contaminant
Oil contaminated waste	9(III)	3082 (Environmentally Hazardous Substance, Liquid)	Depend on contaminant

Environmental and Health Concerns

If not properly contained and cleaned, oil spills can have the following effects:

- Just one litre of used oil can contaminate up to one million litres of fresh water.
- Oils have considerable potential to cause environmental damage by virtue of their persistence, and their ability to 'spread' over large areas of land or water.
- Immediate effects of heavy oiling may be evident by the death of plants and animals, due to smothering and toxicity. In some situations, oil may persist for many years, causing less apparent, but more harmful, chronic effects
- Films or coverings of oil substances may reduce or prevent air from reaching life forms of all types within an area of land, water or sea. This can rapidly result in significant degradation of environmental quality in those media.
- Commonly reported effects of petroleum products and Polycyclic Aromatic Hydrocarbons (PAHs) include: impaired reproduction, as well as reduced growth and development for plants and animals.
- Additives, such as zinc dialkyl dithiophosphates, molybdenum disulphide and other organometallic compounds present in lubricants, also contaminate the environment.

Although the oils are, generally, persistent in the environment and do not biodegrade easily, oil spills on soil will, normally, be absorbed by the top layers of soil, where naturally-occurring bacteria will decompose the oil in the top 20 – 30 cm of the soil (i.e. by aerobic processes).

Unacceptable Disposal Options

The following disposal methods are not considered acceptable:

- General landfill
- Uncontrolled burning

Acceptable Disposal Options

The following disposal or treatment options are acceptable:

- Hazardous Landfill
- Bioremediation (Biological treatment) - remediation of oil-contaminated soil in situ with DWAF's permission. At optimum conditions, highly contaminated soils can be cleaned through biological action within weeks, and up to a couple of months.

HYDROCARBON CONTAMINATED WASTE	2

- Currently the disposal of all hydrocarbon waste streams - whether in liquid or in solid form (absorbed into an approved absorbent) - are regulated by DWAF and must be disposed of at sites that can accept hazardous waste.
- H:H landfill delisting must be approved by DWAF for disposal at H:h or G:B+ landfill sites. (Approval may be requested from DWAF for hydrocarbon contaminated waste that does not contain significant amounts of VOCs - and with flash point of >61oC - for disposal in G:B+ Landfill sites. This waste could include: used oil and sludges, combined with sawdust or ash at pH>10; oily rags; oil and water waste at pH>10, and bitumen).
- Incinerate – energy value

Industry Trends and other Information

Bioremediation is a technology that uses biological activity to reduce the concentration or toxicity of a pollutant. It commonly uses processes by which micro-organisms transform or degrade chemicals in the environment[1]. Bioremediation has also developed over the last few years as a very viable option to consider for treating and cleaning oil-contaminated soil.

Illustrative Photos

Oil spill	
Absorbent products (such as those based on peat moss)	

[1] NETAC Bioremediation Panel, 1991, National Environmental Technology Assessment Corporation, Pittsburgh, PA

POLYCHLORINATED BIPHENYL (PCB) WASTE (E.G. TRANSFORMER OIL) | 3

Waste Generation Processes / Industrial Application

Polychlorinated-biphenyls (PCBs) are persistent and potentially toxic chemicals, commonly used as the cooling and dielectric fluid in high voltage transformers and power factor correction equipment (capacitors). Mixtures of PCBs, called Aroclors, were commonly used because of their insulating and fire-resistant properties.

The replacement of the transformer oil will, consequently, result in waste oil that may contain PCBs. Any leaks or spillages of the PCB-containing oil onto surrounding concrete, soil and other materials, as well as capacitors and transformers, will be regarded as PCB-containing waste.

PCBs were also used in the past in many different types of products, including: hydraulic fluid, casting wax, pigments, carbonless copy paper, plasticizer, vacuum pumps, pesticide extenders, microscopy mounting media, adhesives, pigments and printing ink.

Background Information

PCBs are a class of chemicals that are entirely man-made and do not occur naturally.

Registered trade names or brand names used for PCBs include the following:

- Aroclor
- Apirolio
- Acoclor
- Solvol
- Asbestol
- Askarel
- Chlorextol
- Clophen
- Diaclor
- Duncanol
- Dykanol
- Pyranol
- Therminol

PCBs have been used in a wide variety of industrial and consumer applications. The WHO (World Health Organisation) categorised the uses as completely closed, nominally closed and open-ended (IPCS, 1992). The uses included:

- *Completely closed systems*
  - i) electrical transformers,
  - ii) electrical capacitors (including lamp ballasts),
  - iii) electrical switches, relays and other,
  - iv) electrical cables, and
  - v) electric motors and magnets (very small amounts);
- *Nominally closed systems*
  - i) hydraulic systems, and
  - ii) heat transfer systems (heaters, heat exchangers); and

POLYCHLORINATED BIPHENYL (PCB) WASTE (E.G. TRANSFORMER OIL) 3

- *Open-ended systems*
  - i) plasticizer in polyvinyl chloride, neoprene, and other artificial rubbers,
  - ii) ingredient in paint and other coatings,
  - iii) ingredient in ink and carbonless copy paper,
  - iv) ingredient in adhesives,
  - v) pesticide extender,
  - vi) ingredient in lubricants, sealants and caulking material,
  - vii) fire retardant in fabrics, carpets, polyurethane foam, etc. and
  - viii) lubricants (microscope oils, brake linings, cutting oils, other lubricants).

Internationally, PCB-containing materials are classified according to the concentration of PCBs present. There are three classifications of PCB-containing materials[1]:

- PCB containing ≥ 500ppm
- PCB contaminated ≥ 5ppm to < 500ppm
- Non PCB < 5ppm

At present, there is no classification system for PCB-containing oil in South Africa, but the SABS is working on a standard to address the issue. The following (unofficial) classification system is in use by some organisations:

PCB level	**Classification**
Undetectable	PCB free
1 – 20 ppm	Non PCB
21 – 500 ppm	PCB contaminated
> 500 ppm	PCB oil

PCB manufacturing stopped in the 1980's, and oil in transformers was replaced by mineral oil, which is PCB-free. Transformers that were not sufficiently emptied resulted in the contamination of the PCB-free mineral oil.

Classification and Rating

PCB Contaminated waste	**SANS10228 Class**	**SANS10228 UN No**	**Hazard Rating**	***Acceptable exposure (ppm)***
PCB oil	9(II)	2315	1	Acceptable Environmental Exposure - 0.002ppm Acceptable Human Health Exposure - 0.002ppm

Properties:

- Carcinogenic, Mutagenic and Teratogenic Properties: Class B (possible human carcinogen) and listed as a Teratogen.
- PCBs are insoluble in water, but are soluble in hydrophobic media, in organic or hydrocarbon solvents, oils and fats.
- These chemically inert liquids are difficult to burn.

[1] PCB Classifications - EH&S Manual Management of PCBs; http://www.llnl.gov/es_and_h/hsm/doc_14.14/doc14-14.html -

POLYCHLORINATED BIPHENYL (PCB) WASTE (E.G. TRANSFORMER OIL) 3

Environmental and Health Concerns

Health effects of PCBs include skin ailments (called chloracne), reproductive disorders and liver disease. PCBs are a suspected human carcinogen and a known animal carcinogen.

They are resistant to degradation and, therefore, persist for many years in the environment. Furthermore, they bio-accumulate in the food chain, and are stored in the body fat of animals and humans. Bio-magnification can occur through the transfer of PCBs up the food chain, from phytoplankton to fish, and, finally, to humans.

Bioaccumulation to toxic levels in animals and humans can lead to liver or other organ damage, and/or cancer.

When heated, PCBs have the ability to form highly toxic decomposition products (such as halogenated dibenzosuflan). Thus, if burned under unsuitable conditions, they will give rise to highly toxic products of combustion, such as dioxins and dibenzofurans. Products of uncontrolled incineration and incomplete combustion of PCBs include polychlorinated dibenzofurans (PCDFs) and polychlorinated dibenzo-p-dioxins (PCDDs), both of which may be more toxic than PCBs themselves, and have also been associated with embryo-toxicity and teratogenicity reproductive effects.

PCB-contaminated oils are also known to be sold illegally for recycling or reuse, such as in the following applications:

- Used for dipping cattle
- Cutting oil (when PCB is heated, people are exposed to toxic gases)
- Making of candles
- Mixed with tractor fuel
- Used as base oil (less expensive than virgin oil)
- Mixed with cooking and olive oil

Unacceptable Disposal Options

The following disposal methods are considered unacceptable:

- Uncontrolled incineration/burning – creates products of incomplete combustion of PCBs, which may be more toxic than PCBs themselves
- General Landfill
- Mixed with other waste oil
- Sold for recycling or reuse

Acceptable Disposal Options

The following disposal or treatment options are considered acceptable:

- H:H landfill
- Incineration – high temperature; controlled incineration
- Permanent storage – encapsulation in concrete
- Temporary storage: PCBs, PCB-contaminated materials, and PCB-contaminated mineral oils that cannot be treated or disposed of immediately upon their decommissioning must be stored in a manner which:
  - minimizes risks to the environment through transportation;
  - avoids leakages and spillages, and
  - ensures containment of all wastes up until the moment of treatment and disposal.
  - PCB-containing waste in storage must be clearly labelled in order to prevent incorrect identification and inappropriate disposal.

- Any leaks or spillages of the PCB-containing oil onto surrounding concrete, soil or other surfaces must be remediated, and the contaminated waste must be disposed of accordingly.
- Any transformer oil can be regenerated; PCB content will not affect the process but will contaminate the equipment, which can, in turn, contaminate the other oil treated with the same equipment during the regeneration process.

Industry Trends and other Information

The international treaty on Persistent Organic Pollutants, drafted by 122 nations in Johannesburg in December 2000, targeted PCBs as one of the `dirty dozen´ chemicals to be phased out worldwide. Manufacturing of PCBs was stopped in the 1980's, and, thus, the use of PCB oils has been greatly reduced. All oil must be PCB-free by 2025.

The following disposal methods for bulk PCBs and PCB articles have been adopted in the California Standards, and provide a guideline for appropriate disposal options:

Disposal methods for bulk PCBs

Types of bulk PCBs	Appropriate disposal method
1. Mineral oil dielectric fluids (≥500ppm)	Incineration
2. Mineral oil dielectric fluids (≥5 ppm and <500 ppm)	Incineration Chemical landfill High-efficiency boiler Approved landfill site
3. Waste oil[a] (>2 ppm and <50 ppm)	Incineration Approved landfill site
4. Other liquid materials (≥500 ppm)	Incineration
5. Other liquid materials (≥50 ppm and <500 ppm)	Incineration High-efficiency boiler
6. Other liquid materials (≥5 ppm and <50 ppm)	Incineration Chemical landfill High-efficiency boiler Approved landfill site
7. Non-liquid PCBs (≥50 ppm)	Incineration Chemical landfill
8. Dredged materials and sewage sludge (≤50 ppm)	Incineration Chemical landfill Approved landfill site

[a] Waste oil may be burned or marketed only for energy recovery purposes.

Disposal methods for PCB articles

Types of bulk PCBs	Appropriate disposal method
1. PCB transformers	Incineration Chemical landfill (after draining, flushing, and filling with absorbent)
2. Small PCB capacitors[a]	Incineration Chemical landfill in a labpack
3. Large PCB capacitors[a]	Incineration
4. PCB hydraulic machines (≥1000 ppm)	Municipal solid waste facility or salvage (after draining and flushing)
5. PCB hydraulic machines (<1000 ppm)	Municipal solid waste facility or salvage (after draining)

POLYCHLORINATED BIPHENYL (PCB) WASTE (E.G. TRANSFORMER OIL)	3
6. PCB-contaminated electrical equipment	Incineration Chemical landfill in a labpack
7. Other PCB articles (>500 ppm)	Incineration Chemical landfill after draining
8. Other PCB articles (<500 ppm)	Non-regulated after draining
9. PCB container	Incineration Chemical landfill after draining
[a] The definitions for small and large capacitors are provided in 40 CFR 761.3.	
Illustrative Pictures	
Transformer	

EDIBLE / VEGETABLE OIL	4

Waste Generation Processes / Industrial Application

Edible/vegetable oil is used in restaurants, canteens, in the entertainment industry and for frying or food preparation establishments. When oil contains more than specific concentrations of breakdown products, it is classified as "abused oil" or "over-used oil".

Background Information

- Cooking oil is used as a heat-transfer medium in frying foods.
- Cooking oil consists of glycerol esters of fatty acids. It may be of animal or plant origins.
- Vegetable oil and animal fat waste are collected by recycling companies who use them mainly as pig and/or chicken animal feed, in soap manufacturing and, increasingly, for bio-diesel.
- Used cooking or vegetable oil is a major environmental and human health problem. A survey undertaken by the South African Fryer Oil Initiative (SAFOI) concluded that more than 10% of the frying establishments sampled were using 'abused' oil. Furthermore, much of the used oil from such establishments is sold to the informal sector, where it is filtered and resold as 'virgin' oil for use in frying.
- During frying, cooking oil is heated to a temperature of 170-220 degrees Celsius. Upon heating, cooking oil may undergo chemical reactions, hydrolysis, oxidation and polymerization. Degradation products, such as free fatty acids, hydroperoxides and polymerized triglycerides, may be formed. The viscosity of the cooking oil will increase, its colour will go darker and rancidity will also develop, giving rise to unpleasant flavour, as a result of oxidation.

Classification and Rating

Used cooking oil not suitable for human consumption can contain:

Hazardous constituent	*SANS 10228 Class*	*SANS 10228 UN #*	*Hazard Rating*:	*Carcinogenic, Mutagenic and Teratogenic Properties*	*Acceptable Exposure*
Acrolein *CAS #:* 107-02-8	6.1 (I)	1092	1	Class C&D Carcinogen	Environmental exposure: 0.003ppm Human health exposure: 0.02ppm
Fluoranthene (PAH)	9	-	2	Class C&D Carcinogen	Environmental exposure 0.11ppm Human health exposure 0.44 ppm
Pyrene (PAH)	9	-	2	Class C&D Carcinogen	Environmental exposure 0.20ppm Human health exposure 1.1 ppm
Chrysene (PAH)	9	-	1	Class C&D Carcinogen	Environmental exposure 0.1ppm Human health exposure 0.007 ppm

Environmental and Health Concerns

- It has been reported that small amounts of acrolein, a toxic substance to humans, may be found in cooking oil that is repeatedly heated. Breathing large amounts of acrolein damages the lungs. Breathing lower amounts may cause eye watering and burning of the nose and throat, as well as a decreased breathing rate. Animal studies show that breathing in acrolein causes irritation to the nasal cavity, lowered breathing rate, and damage to the lining of the lungs.

- It is not known if eating food or drinking water containing acrolein affects health. However, animals that had swallowed acrolein suffered from stomach irritation, vomiting, stomach ulcers, and bleeding.

- Used cooking oil may also have contaminants such as Polycyclic Aromatic Hydrocarbons (PAHs). If present in used cooking oil, these contaminants may be concentrated upon prolonged heating, or in some cases, present in smoke from the heating process. Some PAHs have been found to be potentially carcinogenic to humans.

- It is generally accepted that when restaurant oils (i.e. used cooking oils and fats) are fit for human consumption, they are also fit to be included into animal feed. However, due to extensive abusive practices in South Africa, which cause restaurant oils to become toxic, it is of extreme importance that the safety and traceability of these oils are assured, before inclusion into animal feed.

- Although legislation does exist to prevent the illegal dumping or recycling of used oil, it is neither effective nor properly implemented. There are several legitimate uses for used vegetable oil, including its use as an industrial raw material (in the chemical industry), conversion to biodiesel (still limited and beset by quality problems), and as an ingredient of animal feed (problems with toxicity).

- Used cooking oil could have an environmental implication, because of high COD (Chemical Oxygen Demand) levels. Discharge into the sewers may, therefore, be problematic in the sewer system and wastewater treatment plants.

The University of Orange Free State has issued the following tips that consumers and commercial concerns alike should adhere to:

- Buy the best quality oil you can afford.
- Ensure that the frying container is cleaned before use, and is comprised of stainless steel.
- Soak raw chips in water before frying - this removes excess starch and sugars which help to make the oil unfit for consumption when it is heated too high or for too long.
- Drain raw chips well before frying in order to prevent foaming, which makes the oil combine with oxygen in the air, and may cause unhealthy compounds to form. Filter the oil afterwards in order to remove food particles and sediment.
- Store the oil in a sealed container in a cool dark place, as oxygen and light speeds the process of oil degradation.
- Use a thermometer to check that the oil temperature does not exceed 190^{o}C since excess heating damages the oil.
- Discard oil when it becomes too dark, stringy and has a bitter, harsh taste and unpleasant odour.
- Do not add new oil to old deteriorated oil, as it will deteriorate even more rapidly.
- Oil should be drained and filtered daily, and the equipment should be cleaned.
- Burnt residues in oil can be a health hazard, and cause oil deterioration. These should, therefore, be removed before frying.

Unacceptable Disposal Options

The following disposal methods are not considered acceptable:

- Sold/given to staff and community
- Disposed of in the municipal sewage system (the discharge limit to the Johannesburg sewer for vegetable oils is 200mg/l)

Acceptable Disposal Options

The following disposal methods are acceptable:

- Recycle – for the material value; recycle into a usable product for other applications, but not for human consumption
- Incinerate – for the energy value
- Landfill – in a sealed container

Industry Trends and other Information

Biodiesel South Africa[1] - Biodiesel is a diesel fuel substitute, produced from renewable sources, such as vegetable oils, animal fats and recycled cooking oils.

Legislation:

Strict regulations have been published in the Foodstuffs, Cosmetics and Disinfectants Act 54 of 1972, GNR.1316 of 16 August 1996: Regulations relating to edible fats and oils make it a criminal offence to use edible oil and fats that contain more than 25% polar compounds and/or 16% polymerized triglycerides to fry foodstuffs in SA.

The Foodstuffs, Cosmetics and Disinfectants Act, 1972 (Act No. 54 of 1972) and Regulations relating to edible fats and oils (GNR.1316 of 16 August 1996) define the following:

[1] Biodiesel South Africa; http://www.biodieselsa.co.za

"Edible fats and oils" *means foodstuffs composed of glycerides of the fatty acids of vegetable or animal origin, and in which other naturally-occurring lipids, such as phosphatides of unsaponifiable constituents and of free fatty acids, may be present.*

"Fatty acids" *means straight-chain compounds, ranging from 2 to 24 carbons, and found in fats and oils in combination with glycerol.*

Illustrative Photos

Do not dispose of any used cooking oil in the sewer system (unless effective fat traps have been installed)

Collect used oil in separate container for recycling or safe disposal.

Used cooking oil is generally a darker colour than the virgin oil.

SOLVENTS 5

Waste Generation Processes / Industrial Application

Solvents are mainly used in paints and coatings (paints, varnishes, and lacquers), industrial cleaners, adhesives, printing inks, extractive processes and pharmaceuticals. They are also used in a variety of metal, electronic and precision cleaning applications.

Tins of paints and varnishes that still contain the original residual contents will, therefore, still contain the solvents, and must be regarded as hazardous waste. Waste will be generated from maintenance, degreasing machinery and equipment.

Chlorinated solvents (i.e. those that contain chlorine, making the solvent potentially more toxic) are commonly found in cleaning and degreasing operations, as well as in the refrigeration industry.

Background Information

Solvents are generally produced from petroleum or alcohol feedstock. They are used to dissolve other substances (the solute) to form a uniformly dispersed mixture (the solution).

The Minimum Requirements lists several *solvents of concern*:

- **Acetone** occurs naturally in the environment (in plants, trees, volcanic gases, forest fires), but is also a manufactured chemical - a by-product of certain industrial processes - and is manufactured for use in plastic, fibres, pharmaceutical, and other chemicals. It is also used to dissolve other substances, such as paint. Acetone is a colourless liquid with a distinct smell and taste. It is volatile, flammable, and dissolves in water. Industrial processes contribute more acetone to the environment than natural processes do. It is present in vehicle exhaust fumes, tobacco smoke, and landfill sites.

- **n-Butyl alcohol** is found in aerosol paint concentrates, herbicides, insecticides, ink, paint thinners, as well as paint and varnish removers.

- **Carbon disulphide** is used in the industrial manufacturing of xanthate intermediates (in the generation of cellulosic products, like viscose rayon and cellophane film) and carbon tetrachloride. Carbon disulphide is also used in the generation of ore flotation chemicals, rubber accelerators, and chain transfer agents in polymerization. Furthermore, it is used for the manufacturing of fungicides, insecticidal and grain fumigants, rodenticide, and in soil treatment (carbon disulphide fumigation). Smaller quantities are used in solvent extraction or are converted into other chemical products. Carbon disulphide is still used for the extraction of fats, oils and waxes, but is increasingly being replaced by less toxic and less flammable solvents.

- **Carbon tetrachloride -** also called carbon chloride, methane tetrachloride, perchloromethane, tetrachloromethane or benziform - is most often found as a colourless gas. It is not flammable and does not dissolve in water very easily. It has been used in the production of refrigeration fluid and propellants for aerosol cans, as a pesticide, a cleaning fluid and degreasing agent, and in fire extinguishers and spot removers.

- **Chlorobenzene** is used as a solvent for some pesticide formulations, as a degreasing agent, and as a chemical intermediate to make several other chemicals.

- **Chloroform** is a clear colourless liquid. The major use of chloroform today is in the production of the freon refrigerant R-22. However, as the Montreal Protocol takes effect, this use can be expected to decline: the R-22 will be replaced by refrigerants that are less liable to result in ozone depletion. Smaller amounts of chloroform are used as a solvent in the pharmaceutical industry, in addition to producing dyes and pesticides.

- **Cresols** are a naturally-occurring and manufactured group of chemicals. In their pure form, they are colourless solids, but may be liquid in mixtures. There are three isomers of cresols that are only slightly different in their chemical structure: ortho-cresol (o-cresol), meta-cresol (m-cresol), and para-cresol (p-cresol). These forms can occur separately or as a mixture. They are used to dissolve other chemicals, such as disinfectants and deodorizers, and to make certain chemicals, like pesticides. Cresols are found in many foods, in wood and tobacco smoke, crude oil, coal tar, and in brown mixtures, such as creosote and cresylic acids, which are wood preservatives. Small organisms in soil and water produce cresols when they break down materials in the environment.

- **Cyclohexanone** - consumer products that could contain this chemical include: aerosol paint concentrates, agricultural chemicals, fungicides, insecticides, lubricating oils, miscellaneous paint-related products, non-structural caulking compounds and sealants, other automotive chemicals and packaging inks. This solvent is largely used by the paints, coatings and adhesives manufacturers.

- **1,2-Dichlorobenzene** is used in acid non-household metal cleaners (liquid), automobile body polish and cleaners, building and construction plastic foam insulation, other specialty cleaning and sanitation products, as well as rugs and bathmats. It is also used as a solvent in paint stripping.

- **Ethyl acetate** is a colourless flammable liquid. It is used as a general solvent in coatings and plastics, organic synthesis, smokeless powders, pharmaceuticals and synthetic fruit essences.

- **Ethyl benzene** - is a colourless, flammable liquid that smells like gasoline. It is found in natural products, such as coal tar and petroleum, and is also found in manufactured products such as inks, insecticides, and paints**.** Ethyl benzene is used primarily to make another chemical, styrene.

SOLVENTS 5

- **Ethyl ether** is an extremely flammable liquid and vapour.

- **Methanol**, a flammable solvent, is likely to be contained in the following products: aerosol paint concentrates, agricultural chemicals, antifreeze preparations, auto refinish paints, incl. primers, automobile body polish and cleaners, automotive windshield washer fluid, disinfectants (non-agricultural), glass window cleaning preparations, household hard surface cleaners (aerosol), household hard surface cleaners (liquid), household liquid laundry detergents, household pesticides, lubricating oils, paint and varnish removers, and paint thinners.

- **Methyl ethyl ketone** is a solvent used by a number of industries, including: adhesive manufacturing, electroplating, metal degreasing, paint manufacturing, pesticide manufacturing, printing, rubber manufacturing, and in wood stains and varnishes.

- **Nitrobenzene** is an industrial chemical. It is an oily yellow liquid with an almond-like odour. It dissolves only slightly in water and will evaporate into the air. It is produced in large quantities for use in industry, where it is used to produce lubricating oils, such as those used in motors and machinery. A small amount of nitrobenzene is used in the manufacturing of dyes, drugs, pesticides, and synthetic rubber.

- **Pyridine** is a colourless liquid with an unpleasant smell. It can be made from crude coal tar or from other chemicals, and is used to make many different products, such as medicines, vitamins, food flavourings, paints, dyes, rubber products, adhesives, insecticides and herbicides. Pyridine can also be formed from the breakdown of many natural materials in the environment.

- **Tetrachloroethylene** is a manufactured chemical that is widely used for dry cleaning of fabrics and for metal-degreasing. It is also used to make other chemicals, and can be utilized in some consumer products. It is a non-flammable liquid.

- **Toluene** is a clear, colourless liquid with a distinctive smell. Toluene occurs naturally in crude oil and in the tolu tree. It is also produced in the process of making gasoline and other fuels from crude oil, as well as making coke from coal. Uses: Lacquers, enamels, inks, varnishes and detergents.

- **1,1,1-Trichloroethane** is a non-flammable liquid, also known a methyl chloroform, and is commonly used as a solvent in a variety of metal, electronic and precision cleaning applications. It is also used in pesticides.

- **Trichloroethylene (TCE) -** *see separate guideline document on TCE waste.*

- **Xylene** - mixtures of o-, p-, and m-xylenes are extensively used in the chemical industry as solvents for various products, including paints, inks, dyes, adhesives, pharmaceuticals and detergents. In the petroleum industry, xylenes are used as antiknock agents in gasoline, and as an intermediate in synthetic reactions.

Classification and Rating

Solvent of Concern	*SANS10228 Class*	*SANS10228 UN No.:*	*Hazard Rating*	*Acceptable Environmental Exposure (ppm)*	*Max Amount landfilled (g/ha/m)*
Acetone	3(II)	1090	4	32	48 485
n-Butyl Alcohol	3(III)	1120	4	3.5	5 303
Carbon Disulphide	3(I)	1131	4	3.5	5 303
Carbon Tetrachloride	6.1(II)	1846	3	0.03	45
Chlorobenzene	3(III)	1134	3	0.7	1 061
Cyclohexanone	3(III)	1915	4	63	95 455
1,2-Dichlorobenzene	6.1(III)	1591	2	0.16	242
Ethylacetate	3(II)	1173	2	10	15 152
Ethylbenzene	3(II)	1175	3	3.4	5 152
Ethyl ether	3(I)	1155	4	7.0	10 606
Methanol	3(II)	1230	4	18	27 273
Methyl ethyl ketone	3(II)	1193	4	21	31 818
Nitrobenzene	6.1(II)	1662	3	0.02	30
Tetrachloroethylene	6.1(III)	1897	2	0.06	102
Toluene	3(II)	1294	3	2.6	3 939
1,1,1-Trichloroethane (TCA)	6.1(III)	2831	3	5.3	8 030
Trichloroethylene (TCE)	6.1(II)	1710	1	0.009	13
Xylene	3(II)	1307	3	1.5	2 273
Chloroform			1	1.96	864

Teratogens, Mutagens and Carcinogen Properties (where known):

Solvent	Teratogen	Class B Carcinogen	Class C&D Carcinogen
Carbon Disulphide	X		
Carbon Tetrachloride		X	
Cyclohexanone	X		X
1,2-Dichlorobenzene	X	X	
Nitrobenzene			X
Tetrachloroethylene	X	X	
Toluene	X	X	
1,1,1-Trichloroethane (TCA)	X		X
Trichloroethylene	X	X	
Xylene			X
Chloroform	X	X	

Environmental and Health Concerns

- Many solvents are highly flammable and can contribute to fire hazards and risks (and must, therefore, be stored separately from other chemicals, in a fire-proof storage area).
- Solvents are toxic by ingestion, skin contact, and vapour inhalation. Solvent vapours can cause irritation, and deprive the lungs of oxygen.
- Long-term or chronic exposure to specific types of solvents can damage vital organs and affect the human immune system. Improperly managed solvents can harm or kill plants, wildlife and aquatic life. Water contaminated by solvents can adversely affect a community water supply system, and, consequently, the health of the community.
- Chlorinated solvents bio-accumulate and are difficult to destroy. Overuse and improper management of chlorinated solvents has resulted in damage to the ozone layer. Chlorinated solvents are also a major groundwater polluter, originating from leaching landfill sites, leaking underground gasoline tanks and industrial activities.

More specific health and environmental affects of some of the listed solvents of concern:

- ***Acetone*** - breathing moderate to high levels of acetone for short periods of time can cause nose, throat, lung, and eye irritation; headaches; light-headedness; confusion; increased pulse rate; effects on blood; nausea; vomiting; unconsciousness and, possibly, coma. Swallowing very high levels of acetone can result in unconsciousness and damage to the skin in the mouth. Acetone can migrate into groundwater from spills or from leachate from landfills sites.
- ***Ethyl Ether*** - symptoms from over-exposure include the following: irritation of nose and throat, vomiting, and irregular respiration, followed by dizziness, drowsiness and unconsciousness. When released into the soil, this material is expected to evaporate quickly. It can leach into groundwater, and is not expected to biodegrade.
- ***Cresols*** - most exposures to cresols are at very low levels that are not harmful. However, when cresols are inhaled, ingested, or applied to the skin at very high levels, they cause irritation and burning of skin, eyes, mouth, and throat; abdominal pain and vomiting; heart damage; anaemia; liver and kidney damage; facial paralysis; coma, and death.
- ***Ethyl acetate*** – harmful if inhaled or swallowed: affects the central nervous system and causes irritation to skin, eyes and respiratory track.
- ***Ethyl benzene*** - breathing very high levels can cause dizziness, as well as throat and eye irritation.
- ***Toluene*** - affects the nervous system. Low to moderate levels can cause tiredness, confusion, weakness, drunken-type actions, memory loss, nausea, and loss of appetite, hearing and colour vision. These symptoms usually disappear when exposure is stopped.
- ***Nitrobenzene*** - repeated exposures to high levels results in a blood disorders**.** A small amount of nitrobenzene may cause mild irritation if in direct contact with the skin or eyes. Repeated exposures to a high concentration of nitrobenzene can result in methemoglobinemia, a condition in which the blood's ability to carry oxygen is reduced. Effects, such as headaches, irritability, dizziness, weakness, and drowsiness, may also occur. There is also some evidence that breathing high concentrations of nitrobenzene may damage the liver.
- ***Pyridine*** - everyone is exposed to very low levels of pyridine in air, water, and food. Very high levels can cause liver damage.
- ***Trichloroethylene*** **-** high concentrations of tetrachloroethylene (particularly in closed, poorly-ventilated areas) can cause dizziness, headache, sleepiness, confusion, nausea, difficulty in speaking and walking, unconsciousness, and death. TCE is also an ozone-depleting substance.
- ***Carbon tetrachloride*** - high exposure can cause liver, kidney, and central nervous system damage. These effects can occur after ingestion or breathing carbon tetrachloride, and possibly from exposure to the skin. This solvent photo-chemically decomposes in the atmosphere, which makes it an ozone-depleting substance.
- ***Dichlorobenzene*** - is an animal carcinogen and a source of VOCs (volatile organic compound) in the indoor environment from airborne pesticides and room deodorizers.

Unacceptable Disposal Options

The following disposal methods are not considered acceptable:

- Empty containers sold/given to staff and community. Tins or containers must not be sold (or given) to scrap metal dealers if they still contain the original solvent-containing (or other hazardous) substance. Recyclers could store the scrap on open ground, and, thus, any residual solvent may spill and seep into the ground.
- Burning
- General landfill - the landfilling of certain solvents is restricted because of their effects on liners and mobilisation of other wastes, as well as 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 they are present even in low amounts. Hence, for the solvents listed in the **MR**, the total load to be disposed of, per hectare of any site, must not exceed the amount listed in gram/ hectare/ month.
- Solvents that are carcinogen or teratogen must not be landfilled on general or H:h sites

Acceptable Disposal Options

The following disposal or treatment options are acceptable:

- Solvents in some processes and applications can be re-used on site.
- H:H Landfill (the total load to be disposed of per hectare of any site must not exceed the amount listed in gram/ hectare/ month in the Minimum Requirements)
- Thermal destruction: controlled thermal destruction at very high temperatures is also feasible for certain solvents, and is practiced by thermal treatment companies in South Africa.
- Recycled for re-use
- Commonly used solvents that can be re-used or recycled[1] include the following:

Hydrocarbons

- *Hexane*
- *Toluene*
- *Kerosene*
- *White spirit*
- *Xylene*
- *Hydrocarbon mixtures*

Chlorinated and Other Halogenated Hydrocarbons

- *Trichloroethylene (Triklone, Trineu)*
- *Tetrachloroethylene (Perchloroethylene, Perclean)*
- *1,1,1 - Trichloroethylene (Chloroethene, Genklene)*
- *Methylene chloride*
- *Tetrabromoethane (TBE)*
- *Chloroform*

Ketones

- *Acetone*
- *Di-isobutyl ketone*
- *Methyl ethyl ketone*
- *Cyclohexanone*
- *Methyl isobutyl ketone*

Miscellaneous Solvents

- *Methylated spirits*
- *Tetrahydrofuran*
- *Iso-propyl alcohol*

Solvent Mixtures

- *Paint thinners*
- *Solvent degreasers*

Industry Trends and other Information

Replacing ozone-depleting solvents in industrial processes, such as 1,1,1-Trichloroethane (TCA).

Recycling or reusing solvents in processes.

Recycling used solvents from printing and automotive industry, producing a cleaning thinners product.

Industry move to using water-based paints and other painting technologies, such as powder coating.

Bioremediation: over the years, bioremediation (done correctly, and using the appropriate microbes) has been demonstrated to be, at least partially, effective in the degradation of various solvents, such as TCE, ethylene and propylene glycol.

[1] University of Western Australia, http://www.uwa.edu.au/

Illustrative Pictures

TRICHLOROETHYLENE (TCE) | 6

Waste Generation Processes / Industrial Application

1,1,2-Trichloroethylene (TCE) is a substance used in metal finishing (e.g. electroplating); as a degreasing agent; an extraction solvent for greases, oils, fats, waxes, and tars; a chemical intermediate in the production of other chemicals, and as a refrigerant.

This compound is an ingredient in adhesives, paint removers, typewriter correction fluids, spot removers, and a dry-cleaning solvent. The dry cleaning industry generates TCE sludge.

Trichloroethylene is used by the textile processing industry, in order to scour cotton, wool, and other fabrics.

Background Information

Synonyms for Trichloroethylene or TCE ($Cl_2C=CHCl$) include the following: Tri, trichloroethene, acetylene trichloride, and ethylene trichloride. Trade names for this industrial solvent include: Benzinol, Circosolve, Flock Flip, Narcogen, Perm-A-Chlor, Tri-clene, and Vestrol.

At room temperature, trichloroethylene is a clear, colourless, non-flammable liquid with a sweet, chloroform-like odour. It is volatile, producing potentially toxic concentrations at room temperature.

Classification and Rating

SANS10228 Class	*SANS10228 UN No.*	*Hazard Rating*	Acceptable Exposure	Teratogen, Mutagen and Carcinogen properties
6.1(III)	1710	1	Environmental: 0.009ppm Health: 13ppm	TCE is a teratogen and listed as a Class B carcinogen.

Environmental and Health Concerns

Acute (short-term) and chronic (long-term) inhalation exposure to trichloroethylene results in central nervous system (CNS) effects in humans, with symptoms such as dizziness, headaches, confusion, euphoria, facial numbness and weakness.

Other effects noted in humans from acute inhalation exposure to trichloroethylene include: effects on the gastrointestinal system, liver, kidneys, and skin. Drinking or breathing high levels of trichloroethylene may cause nervous system effects, liver and lung damage, abnormal heartbeat, coma and, possibly, death. Skin contact with trichloroethylene for short periods may cause skin rashes.

TRICHLOROETHYLENE (TCE) | 6

TCE is highly soluble in water (~ 1.366 g/l at 25°C) and, therefore, poses a significant environmental risk. TCE may also stick to particles in water, which will, eventually, cause it to settle on the bottom sediments.

Because TCE quickly evaporates from surface water, it is commonly found as a vapour in the air. TCE evaporates less easily from the soil than from surface water, and can, therefore, bind to the soil particles and remain in the soil for a long time.

TCE is an ozone-depleting substance and reacts violently with many metals, ozone, potassium nitrate, potassium hydroxide and sodium hydroxide.

Unacceptable Disposal Options

The following disposal methods are not considered acceptable:

- General landfill

Acceptable Disposal Options

The following disposal methods are acceptable:

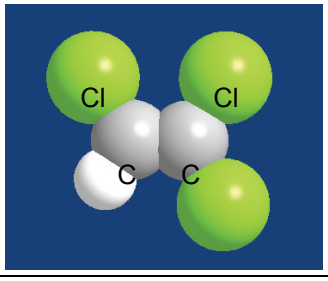
- H:H landfill, after treatment (e.g. ash blend).
- Incineration – mixing with combustible fuel. Combustion to completion is necessary in order to prevent the formation of toxic by-products, such as phosgene, polycyclic aromatic hydrocarbons (PCHs) and perchloroaromatics. An acid scrubber can be used to remove halo-acids produced.
- Temporary storage areas should be cool, well-ventilated, flame-proof, and shielded from direct sunlight, high-temperature surfaces, or sparks.

Industry Trends and other Information

Replacement of TCE with more environmentally friendly solvents, for instance, in degreasers.

Photo-oxidative destruction has been successfully used in conjunction with air-stripping techniques in order to volatilise trichloroethylene from water, and degrade it into non-toxic products.

Illustrative Pictures



SPENT ANTIFREEZE | 7

Waste Generation Processes / Industrial Application

Spent Antifreeze is used in the automotive industry, where it is added to water in order to lower the freezing point in internal combustion engines

Background Information

- Ethylene glycol is the most widely used automotive cooling-system antifreeze, although propylene glycol, methanol, ethanol and isopropyl alcohol are also used.
- The brine used in some commercial refrigeration systems is an antifreeze mixture; it is, typically, a water solution of calcium chloride or propylene glycol.
- Both ethylene glycol and propylene glycol are clear, colourless, odourless, viscous liquids at room temperature, although antifreeze comes in various colours, due to the addition of additives. These additives, typically, contain chemicals that raise and stabilize pH, inhibit rust and corrosion, reduce water scaling, and slow the breakdown of ethylene glycol.
- Both ethylene glycol and propylene glycol compounds are used to make antifreeze and de-icing solutions for cars, airplanes, and boats; to make polyester compounds, and are also used as solvents in the paint and plastics industries.
- Spent antifreeze contains heavy metals that contaminate the antifreeze during service.

Classification and Rating

Hazardous constituent	*SANS10228 Class*	*SANS10228 UN No.*	*Hazard Rating*	*Carcinogenic, Mutagenic & Teratogenic Properties*	*Acceptable Exposure*
Antifreeze Types					
Ethylene glycol CAS# 107-21-1	3	1153	4	Listed as teratogen in MR Colourless liquid,	Acceptable Environmental Exposure 4584 ppm Acceptable Human Health Exposure 70ppm
Propylene glycol CAS# 57-55-6	3	n/a	4	Propylene glycol compounds Listed as teratogen in MR	Acceptable Environmental Exposure 3815 ppm Acceptable Human Health Exposure 18 ppm
Methanol	3	1230	4	Solvent of concern	Acceptable Environmental Exposure 1270ppm Acceptable Human Health Exposure 18ppm
Ethanol	3	1170	4		Acceptable Environmental Exposure 1300ppm
Isopropyl Alcohol	3	1219			
Spent Antifreeze Contaminants (examples)					
Lead	6.1(III)	2291 (Pb compound soluble N.O.S)	2	Class B carcinogen	Acceptable Environmental Exposure 0.12ppm Human Health Exposure 0.02ppm
Cadmium	6.1(III)	2570	1	Class A Carcinogen	Acceptable Environmental Exposure 0.031ppm Human Health Exposure 0.04ppm
Chromium	-	-	3		Environmental Exposure 4.7ppm
Oil	9	3802	n/a	Environmental hazardous substance	-

SPENT ANTIFREEZE 7

Environmental and Health Concerns

- Antifreeze is toxic to humans and animals. Spent antifreeze can be contaminated with heavy metals - such as lead, cadmium, and chromium - from gas or oil that increase the level of hazard posed by ethylene glycol.
- Propylene glycol is less toxic, and is used in other products, such as flavouring extracts, foods and cleansing creams. Used propylene glycol may still, however, contain some of the contaminants, such as gas or oil and heavy metals that make it potentially hazardous.
- Ethylene glycol is a skin, respiratory and severe eye irritant.
- Eating or drinking large amounts can result in nausea, convulsions, slurred speech, disorientation, as well as heart and kidney problems. Ingestion of very large amounts of ethylene glycol can result in death.
- Female animals that ingested large amounts of ethylene glycol had babies with birth defects, while male animals had reduced sperm counts. However, these effects were seen at very high levels and would not be expected in people exposed to lower levels at hazardous waste sites.

Unacceptable Disposal Options

The following disposal methods are not considered acceptable:

- Uncontrolled burning
- General Landfill

Acceptable Disposal Options

The following disposal methods are considered acceptable:

- Hazardous Landfill H:H or H:h (depending on levels of contaminants, such as heavy metals)
- Incineration under controlled conditions.
- Recycling (see industry trends) may be feasible for companies generating substantial quantities of spent antifreeze.

Industry Trends and other Information

Recycling Used Antifreeze – US

Recycling used antifreeze is both cost-effective and saves resources. Ethylene glycol, the primary active ingredient in antifreeze, is produced from natural gas, which is a finite, non-renewable resource. For businesses that use plenty of antifreeze (such as automobile repair shops), setting up an antifreeze recycling program can significantly reduce management costs, and lessen the amount of new materials purchased. Using new technology, businesses are recycling antifreeze on site and reconditioning it with additives, at a cost that is significantly lower than the cost of purchasing new antifreeze.

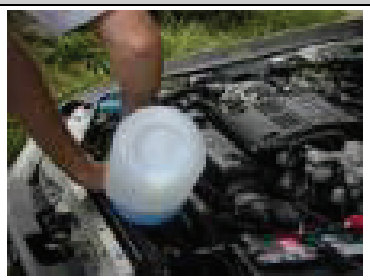
Antifreeze recycling involves two steps:

- Removing contaminants - such as emulsified oils and heavy metals - either by filtration, distillation, reverse osmosis or ion exchange.
- Restoring critical antifreeze properties with additives. Additives typically contain chemicals that raise and stabilize pH, inhibit rust and corrosion, reduce water scaling, and slow the breakdown of ethylene glycol.

SPENT ANTIFREEZE | 7

Illustrative Pictures





LIGHTING WASTE | 8

The most common lighting waste generated by industry, which will be discussed in this guidance document, includes the following types:

- Fluorescent lamps
- Compact fluorescent lamps
- Incandescent bulbs
- HID (High Intensity Discharge) lamps, which includes the following types:
  - high pressure sodium vapour lamps;
  - low pressure sodium vapour lamps;
  - mercury vapour lamps, and
  - metal halide lamps.

Other electric lighting sources (not discussed), include the following:

- *Variations of the above lamps*
- Xenon arc lamps
- Electroluminescent (EL) lamps
- Globar
- Inductive lighting
- LEDs
- Neon and argon lamps
- Sulphur lamp
- Xenon flash lamps
- Infra Red
- Ultra Violet

Waste Generation Processes / Industrial Application

The waste is generated from the spent tubes and lamps that were used for various lighting applications.

- Fluorescent and compact fluorescent lamps (which are simply miniature versions of the full-sized fluorescents) are mostly used in factories, offices, schools, homes, hotels and restaurants. It has been reported that 70% of all artificial light in the world is generated by fluorescent lamps. The success of these lamps can be attributed to their extremely long life of around 12,000 hours (an ordinary light bulb lasts just 1000 hours), and to their cost-effectiveness.
- Incandescent bulbs are mostly used in homes.

LIGHTING WASTE | 8

- HID lamps include:
  - High pressure sodium vapour lamps are smaller than the low pressure lamps, and are used for industrial, security, and street lighting;
  - Low pressure sodium vapour lamps are mostly used for outdoor lighting (e.g. street and security lights);
  - Mercury vapour lamps are widely used for roads, courtyards, factories, mines, gymnasiums, sports arenas;
  - Metal halide lamps are used in areas where bright white light is required, including marine aquariums, street lighting, floodlighting and in motor vehicles.

Background Information

Incandescent lamps consist of a tungsten lamp filament. The other wires - made from molybdenum, copper, iron, and/or nickel - are used as support wires or for electrical connections. Lamp bases may be either brass or aluminium, and contain a lead solder.

Gas discharge lamps are a family of artificial light sources that do not generate light by heating a metal filament until it glows white-hot. Gas discharge lamps send an electric current through a special gas.

A typical fluorescent lamp (a type of discharge lamp) is composed of a phosphor-coated glass tube, with electrodes located at either end. The tube contains mercury, of which only a very small amount is in vapour form. When a voltage is applied, the electrodes energize the mercury vapour, causing it to emit ultraviolet (UV) energy. The phosphor coating absorbs the UV energy, causing the phosphor to fluoresce and emit visible light. Without the mercury vapour to produce UV energy, there would be no light.

A low-pressure sodium lamp contains a U-shaped arc tube. Inside the arc tube there is a mixture of neon and argon gases, which are used to start the lamp, together with pure sodium metal.

High-pressure sodium discharge lamps turn 50% of the electrical energy into visible light. Due to the fact that their output is much more pleasant to look at, they have replaced mercury vapour in streetlight applications. The low-pressure sodium discharge lamp is the most efficient lamp known today: it transforms a full 80% of the electrical energy into light energy. It does, however, require a physically big bulb and its light is monochromatic yellow; this, therefore, limits the number of applications of this highly efficient lamp.

A Mercury-vapour lamp is a gas discharge lamp, which uses mercury in an excited state to produce light. Metal halide lamps are similar to, but far more energy efficient than, the mercury vapour lamps. The colour of light produced by the metal halide lamps is also superior to that of the mercury vapour type, in terms of its suitability to human vision at night (according to ILESA, the Institute for Lighting Engineers of South Africa). There also exists a closely-related lamp design called the Metal halide lamp. Metal halide lamps use other elements in an amalgam with the mercury. Sodium iodide (HR >4) and scandium iodide are commonly used in this instance.

The bulb life affects the volume and frequency of waste requiring disposal, and the efficiency has impact on energy consumption.

LIGHTING WASTE 8

The average bulb life and efficiencies of the respective light bulbs are as follows:

Property	*100W Incandescent*	*Fluorescent*	*Compact Fluorescent*	*Metal Halide*	*Mercury Vapour*	*High pressure Sodium*	*Low pressure Sodium*
Bulb life (hours)	750	12,000 – 20,000	10,000	7,500 - 20,000	24,000	24,000+	18,000
Efficiency (Lumens/watt)	20	100	80	90	50	95	125

Fluorescent tubes, compact fluorescent lamps, high-pressure mercury, high-pressure sodium and metal halide lamps all contain small quantities of mercury. Low-pressure sodium lamps do not contain mercury (or any other heavy metals).

The different lamps contain varying amounts of heavy metals, such as mercury and lead (Osram Technical Department).

Lamp type	***Hazardous constituent***	***Average quantity/lamp***
Fluorescent lamps (standard lamp) Fluorescent (Lumilux Plus Eco)	Mercury	5-15mg 3-5 mg
Compact fluorescent	Mercury	5 mg
Low and High pressure sodium vapour	Sodium as Sodium oxide	Less than 0.2%
Mercury vapour	Mercury	20 – 30 mg
Metal halide	Mercury	10 -15 mg
Incandescent	Lead	Very small quantities

Classification and Rating

The different lighting tube and lamps are classified and rated as follows:

Type	***SANS10228 Class***	***SANS10228 UN No***	***Hazard Rating***
Fluorescent tube	8(III) Mercury	2809 (Mercury Metal)	1
Compact fluorescent tube	8(III) Mercury	2809 (Mercury Metal)	1
Incandescent	n/a Lead	n/a Lead	2
HID (High Intensity Discharge lamps)			
High pressure sodium vapour	Sodium oxide	-	2[1]
Low pressure Sodium vapour	Sodium oxide	-	2[2]
Mercury Vapour lamps	8(III) Mercury	2809 (Mercury Metal)	1
Metal Halide lamps	8(III) Mercury	2809 (Mercury Metal)	1
Metal Halide lamps	Sodium iodide	-	4
Metal Halide lamps	Scandium iodide	-	n/a

[1] (LD50(oral 40mg/kg)

[2] (LD50(oral 40mg/kg)

LIGHTING WASTE | 8

Carcinogenic, Mutagenic and Teratogenic Properties: Mercury is a Class C&D Carcinogen.
Properties: Mercury is Corrosive. The acceptable environmental risk of mercury is 0.024ppm. Acceptable Human Health Exposure: 0.03ppm

DWAF's policy on the handling and disposal of fluorescent tubes, collected in large quantities, states that the acceptable risk level for mercury disposal on an H:H waste site is 0.9 ppb (0.0009 mg/kg or mg/l). Even if the concentration in the waste is lower than this, it may only be disposed of on a H:h landfill site if the concentration in the waste is less than 0,009 ppb ($9x10^{-6}$ mg/kg or mg/l) **AND** the mercury component is less than 1% of the total waste stream, as it is a known carcinogen.

Fluorescent tubes collected in large quantities are considered **extremely hazardous waste**, since they contain a minimum of 2 mg/kg of mercury per tube. They may, therefore, **only be disposed of on an H:H waste disposal site**, and only **after treatment** aimed at fixing the mercury to an immobile state.

Environmental and Health Concerns

Health Effects:

- When the tubes and lamps are broken, the vapours are released. Containers used to store any broken or crushed tubes must, therefore, be sealed, in order to prevent exposure to these vapours.
- Mercury and inorganic compounds are listed as a Class C & D[1] mutagen and carcinogen in the MR.
- Mercury has a high density, is a very volatile vapour and is highly toxic. At high temperatures mercury vaporizes to form extremely toxic fumes. If mercury vapour is inhaled it may cause severe respiratory tract damage. Symptoms include: sore throat, coughing, pain, tightness in chest, breathing difficulties, shortness of breath, headache, muscle weakness, anorexia, gastrointestinal disturbance, ringing in the ear, liver changes, fever, bronchitis and pneumonitis.
- Symptoms of mercury poisoning range from loss of feeling in the limbs to tunnel vision, personality changes and coma.
- Breakage of the lamp may result in some exposure to the phosphor powder dust and to a very little amount of elemental mercury vapour. No adverse affects are expected from occasional exposure to broken lamps, but as a matter of good practice, prolonged or frequent exposure should be avoided through the use of adequate ventilation during disposal of large quantities of lamps.
- Sodium reacts violently with water, liberating extremely flammable gas, and can cause burns. Sodium reacts with water to form sodium hydroxide; sodium levels in lamps are very low and do not pose a real threat to human health.
- Lead can cause reproductive toxicity if ingested, but only in large amounts. The amount of lead in one incandescent lamp is not considered hazardous to human health.
- Hazards are posed by ultraviolet (UV) light exposure from mercury vapour and metal halide lamps, where the outer envelope is damaged. There have been documented cases of lamps being damaged in gymnasiums, resulting in sunburns and eye inflammation.

[1] See Glossary

LIGHTING WASTE | 8

Environmental Effects:

- A fluorescent tube contains enough mercury to pollute water above the currently recognised safe-to-drink level - for SANS (SANS 0241:2001) drinking water standards, which do not allow more than **5 µg/litre Hg**.
- Heavy metals (mercury) are non-degradable and can be very toxic to aquatic organisms, as they bio-accumulate in aquatic organisms.
- Lead in incandescent lamps is in very low quantities and does not pose a threat to human health or the environment. If disposing very large quantities, however, it would be best to dispose at a hazardous landfill site, in order to prevent lead contamination.

Unacceptable Disposal Options

The following disposal methods are not considered acceptable:

- Uncontrolled crushing or breaking of fluorescent and HID lamps.

  *DWAF's policy on disposal of fluorescent tubes states that no fluorescent tubes, collected in large quantities from the premises of industries or commercial activities (i.e. large buildings), may be disposed of **under any circumstances** in a General waste disposal site.*
- Incineration - releases the mercury emissions.

Acceptable Disposal Options

Lamp Type	**Landfill types (large quantities)**
Fluorescent tube	H:H landfill
Compact fluorescent tube	H:H landfill
Incandescent	General landfill
HID (High Intensity Discharge lamps)	
High pressure sodium vapour	H:H landfill (small quantities General landfill)
Low pressure Sodium vapour	H:H landfill (small quantities General landfill)
Mercury Vapour lamps	H:H landfill
Metal Halide lamps	General (small quantities)

- General landfill – for small quantities of lighting, HID lamps and incandescent lamps
- Hazardous landfill sites - H:H and H:h (only delisted waste) waste sites for mercury. All fluorescent tubes originating from industrial or commercial activities are considered (by DWAF) to be fluorescent tubes that should be collected in "large quantities" and must, therefore, be disposed of in a controlled manner.
- Crushing: crushing fluorescent lamps can reduce the volume by approximately 80%. Crushing can also reduce transportation and storage costs, and reduce the risk of releasing mercury vapours if accidentally broken during storage and transportation.
- Recommended crushing method: High quality crushers that utilize mercury filters, or other technology, can be used to reduce the mercury emissions. Crushers without filters must be fitted with rubber seals, in order to prevent the mercury vapour from escaping. The drum or container used to store the tubes must be kept tightly closed and stored in a cool, dry and ventilated area.
- These tubes are, therefore, to be collected in purpose-made tube crushers, usually a 220*l* drum containing the treatment solution with a close fitting cap. This cap is equipped with a small device on top, through which the tubes are pushed into the drum, and crushed inside the drum with a breaking mechanism. Once the drum is full, the cap equipped with the breaking mechanism is removed and the drum is sealed with a tight fitting cap.

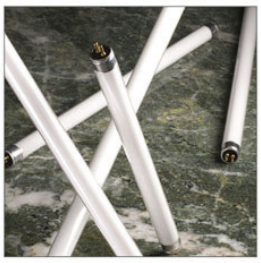
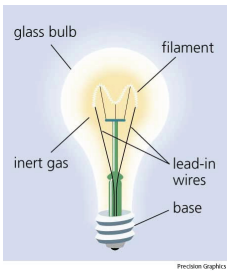
LIGHTING WASTE	8

- Alternative disposal options include recycling and incineration of the tubes and lamps, although this is not currently practised in South Africa

Industry Trends and other Information

- The amount of mercury in the fluorescent lamps has been reduced: the average 4 foot (1.2metre) lamp contains over 75% less mercury than it has in the past (as reported by The National Electrical Manufacturers Association NEMA).
- Although recycling of fluorescent tubes is not currently being carried out in SA, it has taken place for many years in the USA and Europe.

Illustrative Pictures

Fluorescent	 
Compact Fluorescent	 
Incandescent	 
HID (High Intensity Discharge lamps)	
Low pressure sodium vapour	 

LIGHTING WASTE	8
High pressure sodium vapour	 
Mercury vapour	 
Metal halide	 

ELECTRONIC WASTE / E-WASTE	9

Waste Generation Processes / Industrial Application

Electronic waste (E-waste) is generated from commercial, manufacturing and industrial activities at office buildings, households, schools, universities, industries and government departments.

Background Information

A general definition for e-waste is anything that produces, uses or is associated with electricity.

The different types of electronic waste include:

- Computers;
- Cell phones;
- CRTs (cathode ray tube);
- Printed circuit boards (PCBs);
- Printer and toner cartridges (see guideline);
- White and brown goods – electronic household appliances;
- Batteries (see wet cell and dry cell battery guideline);
- Smoke detectors (see smoke detector guideline), and
- Medical electronic and electrical equipment.

ELECTRONIC WASTE / E-WASTE 9

Computers, a common type of e-waste, consist of:

- *Central processing unit (CPU):* a case and all of its contents, such as: the primary printed circuit board (the motherboard) and its components (chips, capacitors, connectors, etc.); additional printed circuit boards (daughter boards); one or more disc drives; a transformer (the power supply); interior wire, and a power cord.
- *Monitor:* a cathode ray tube (CRT), or flat panel display (also known as a liquid crystal display); its case; interior wires, and circuitry.
- *Printer:* a case and its contents, such as an ink or laser cartridge, interior wire, cable to the CPU, and a power cord.
- *Miscellaneous peripheral devices:* keyboard and mouse, scanner, CD writers, web camera, loudspeaker.

These components of e-waste contain several substances of environmental concern:

Substance	Occurrence in e-waste
Halogenated compounds:	
PCB (polychlorinated biphenyls)	Condensers, Transformers
TBBA (tetrabromo-bisphenol-A) PBB (polybrominated biphenyls) PBDE (polybrominated diphenyl ethers)	Fire-retardants for plastics (thermoplastic components, cable insulation) TBBA is, presently, the most widely used flame-retardant in printed wiring boards and casings.
Chlorofluorocarbon (CFC)	Cooling unit, Insulation foam
PVC (polyvinyl chloride)	Cable insulation
Heavy metals and other metals:	
Arsenic	Small quantities in the form of gallium arsenide within light emitting diodes
Barium	Getters in CRT
Beryllium	Power supply boxes which contain silicon-controlled rectifiers and x-ray lenses
Cadmium	Rechargeable NiCd-batteries, fluorescent layer (CRT screens), printer inks and toners, photocopying machines (printer drums)
Chromium VI	Data tapes, floppy-disks
Lead	CRT screens, batteries, printed wiring boards
Lithium	Li-batteries
Mercury	Fluorescent lamps that provide backlighting in LCDs, in some alkaline batteries and mercury-wetted switches
Nickel	Rechargeable NiCd-batteries or NiMH-batteries, electron gun in CRT
Rare Earth elements (Yttrium, Europium)	Fluorescent layer (CRT-screen)
Selenium	Older photocopying-machines (photo drums)
Zinc sulphide	Interior of CRT screens, mixed with rare earth metals
Others:	
Toner Dust	Toner cartridges for laser printers/copiers
Radio-active substances Americium	Medical equipment, active sensing element in smoke detectors

Plastics

- Plastics (such as equipment casings and bases) are the one major category of material components for which recycling opportunities are currently quite limited. This is because:
  1. numerous resin types are used in electronic equipment;
  2. plastic parts are not labelled according to their type;
  3. the presence of chlorine and bromine compounds in some of the plastics requires measures for the protection of human health and the environment, in operations where these plastics are shredded or heated, and
  4. a wide variety of brominated flame-retardants have been used as additives in some of the plastic components in PCs.

ELECTRONIC WASTE / E-WASTE 9

Cell Phones

- The rechargeable batteries that power cell phones; lithium-ion and nickel-metal hydride batteries are increasingly replacing nickel-cadmium.
- The content of mobile phones varies from model to model, and as the technology advances, there will be changes in the composition. Previously published data *(Ref: BT Cellnet and Mobile Takeback sites, Sept 2001)* states that a reasonable average (weight percent) is:
  - Plastic (ABS-PC) 29%
  - Ceramics 16%
  - Copper and compounds 15%
  - Silicon Plastics 10%
  - Epoxy 9%
  - Other Plastics 8%
  - Iron 3%
  - Plastic (PPS) 2%
  - Flame retardant 1%
  - Nickel and compounds 1%
  - Zinc and compounds 1%
  - Silver and compounds 1%
  - Al, Sn, Pb, Au, Pd, Mn, etc. less than 1%

White and brown products

- White products - washing machines, dryers, fridges, freezers, ovens and stoves.
- Brown products – air-conditioners, microwaves, radios, and other audiovisual appliances.
- Fridges, freezers and air-conditioners are appliances that may contain CFCs.
- CFCs are any of several organic compounds composed of carbon, fluorine, chlorine, and hydrogen. CFCs are manufactured under the trade name Freon.
- Halogenated hydrocarbons - notably, trichlorofluoromethane (CFC-11, or F-11) and dichlorodifluoromethane (CFC-12, or F-12) - have been used extensively as aerosol-spray propellants, refrigerants, solvents, and foam-blowing agents.

Classification and Rating

Waste type	*Hazardous Constituent*	*SANS10228 Class & UN No.*	*Hazard Rating*	*Acceptable Exposure*	*Carcinogenic, Mutagenic & Teratogenic Properties*
Computer waste	Arsenic CAS# 7440-38-2	6.1(II) 1558	2	Acceptable Environmental Exposure 0.38ppm Human Health Exposure 0.002ppm	Class A carcinogen
	Lead CAS# 7439-92-1	6.1(III) 2291 (Pb compound soluble N.O.S)	2	Acceptable Environmental Exposure 0.12ppm Human Health Exposure 0.02ppm	Class B carcinogen
	Lithium CAS# 7439-93-2	4.3(I) 1415	n/a		Bio-accumulate in organisms
	Cadmium CAS# 7440-43-9	6.1(III) 2570	1	Acceptable Environmental Exposure 0.031ppm Human Health Exposure 0.04ppm	Class A carcinogen
	Antimony CAS# 7440-36-0	6.1(III) 1549	1	Acceptable Environmental Exposure 0.07ppm Human Health Exposure 0.21ppm	Antimony compounds Group B, and C&D

	Zinc sulphide	-	2	-	-
	Barium CAS# 7440-39-3	4.3(II) 1400	3	Acceptable Environmental Exposure 7.8 ppm Human Health Exposure 0.7ppm	
	Mercury CAS# 7439-97-6	6.1 2025(Hg compound solid N.O.S)	1	Acceptable Environmental Exposure 0.024ppm Human Health Exposure 0.03ppm	
	Nickel CAS# 7440-02-0	-	2	Acceptable Environmental Exposure 0.75ppm Human Health Exposure 0.18ppm	
	Chromium(III) Total CAS# 7440-47-3	-	3	Environmental Exposure 4.7ppm	
	Selenium CAS# 7782-49-2	6.1(I) 3283	2	Environmental Exposure 1.2ppm Human Health Exposure 0.14ppm	Class C&D
	Cobalt CAS# 7440-48-4	-	2	Environmental Exposure 0.97ppm Human Health Exposure 0.70ppm	
Cell phones	Copper CAS# 7440-50-8	-	2	Environmental Exposure 0.13ppm Human Health Exposure 2.3ppm	
	Iron CAS# 7439-89-6	-	3	Environmental Exposure 9ppm -	
	Zinc CAS# 7440-66-4	-	2	Environmental Exposure 0.83ppm Human Health Exposure 11ppm	
	Nickel CAS# 7440-02-0	-	2	Environmental Exposure 0.75ppm Human Health Exposure 0.18ppm	
	Silver CAS# 7740-22-4	-	1	Environmental Exposure 0.001ppm Human Health Exposure 0.18ppm	
White products	Chlorofluoro-carbons - CFC's	2.2	-	-	Ozone depleting substance

Environmental and Health Concerns

Computers

Human health and environmental concerns related to the presence of the substances in a personal computer arise if this used equipment is inappropriately landfilled or incinerated.

Lead

Lead in a CRT or printed circuit board may leach out of the leaded glass under certain land disposal conditions. Incineration can result in release of lead into the air, as well as deposition of lead in the ash, which is then landfilled.

The lead in a CRT or a printed circuit board may be released as lead oxide dust or as lead fume during high-temperature metal processing, such as smelting.

Mercury

Mercury can be released from certain flat panel displays upon the shredding and subsequent handling of this equipment. Landfilling and incineration of flat panel displays can also result in the release of mercury into the environment. The CPU contains trace amounts of mercury, cadmium and other heavy metals that are persistent in the environment.

Cadmium

The small amount of cadmium in plastic (cadmium is used as a plastic stabiliser) may be released in the form of cadmium oxide dust if the plastic is burned prior to, or in the course of, metal reclamation. Cadmium in plated metal contacts and switches may be released as cadmium oxide dust or fume during high-temperature metal processing. Incineration may also result in releases of cadmium into the environment.

Cadmium compounds are classified as toxic, with a possible risk of irreversible effects on human health. Cadmium and cadmium compounds accumulate in the human body, particularly in kidneys. Cadmium is adsorbed through respiration, but is also taken up with food. Cadmium shows a danger of cumulative effects in the environment, due to its acute and chronic toxicity.

In electrical and electronic equipment, cadmium occurs in certain components such as chip resistors, infrared detectors and semiconductors. Older types of cathode ray tubes contain cadmium.

Cadmium in the phosphor coating of some older CRT screens could present an inhalation hazard to workers in CRT glass-breaking operations. The phosphor coatings on CRT glass can present an inhalation hazard if managed in a dry state. Wet processes are often used to remove the phosphors.

Bromine & Chlorine

Bromine in plastics as brominated fire-retardants, or chlorine in PVC insulation, may recombine with carbon and hydrogen in various disposal or recovery processes that involve heat - such as combustion or plastics extrusion - to form other halogenated organic compounds of environmental concern, particularly the chlorinated or brominated dibenzodioxins and furans.

When hard plastic components containing brominated flame-retardants are shredded, workers can be exposed to dust containing these chemicals.

Other metals

- Lithium in a battery will be released if the battery is shredded with the circuit board to which it is attached. When released, it may react with oxygen and moisture, generating heat, and potentially causing fire.
- Antimony contained in the screen glass may leach out under certain land disposal conditions.
- Barium oxide dust can be released during the dismantling and handling of CRTs.
- Beryllium in a copper-beryllium alloy (used in the motherboard) may be released as beryllium oxide dust or fume during high-temperature metal processing.
- Chips and other gold-plated components – chemical stripping using nitric and hydrochloric acid can cause skin irritation and chemical burns, and will affect the acidity of water if released into surface water.

Cell phones

- Brominated flame-retardants are used primarily in the phones' printed wiring boards, cables, and plastic housings. Research indicates that some brominated flame-retardants can be persistent, bio-accumulative and toxic.
- Two categories of flame retardant — polybrominated biphenyls (PBBs) and polybrominated diphenyl ethers (PBDEs) — have been associated with cancer and disruption of the immune and endocrine systems.
- In addition, some of these substances can form dioxins and furans, a group of highly toxic and persistent by-products of combustion, which are produced when products that contain them are incinerated or recycled.

Polyvinyl chloride (PVC)

- Polyvinyl chloride (PVC) is the most widely-used plastic, used in everyday electronics and appliances, household items, pipes, upholstery etc.
- The production and burning of PVC products generates dioxins and furans, which contribute to air pollution and respiratory ailments.
- PVC is hazardous, as it contains up to 56 percent chlorine, which, when burned, produces large quantities of hydrogen chloride gas, which can then combine with water to form hydrochloric acid. This is, in turn, dangerous because, when inhaled, it can lead to respiratory problems.

Fridges and Freezers

- CFCs are ozone-depleting substances, found in the fridges' cooling system, and may also be present in the bubbles in the insulation foam of the fridge casing.

Unacceptable Disposal Options

The following disposal methods are not considered acceptable:

- Uncontrolled burning/incineration
- Landfilling without treatment

Acceptable Disposal Options

The following disposal methods are acceptable:

- Resell
- Re-use
- Recondition – upgrade
- Recycle – material value
- Hazardous Landfill

Technologies for handling e-waste in South Africa are:[1]

- *Manual dismantling*
- *Shredding*
- *Screening and further processing*
- *Heavy fraction recovery*
- *Conditioning*
- *Refining*
- *Final disposal*

Industry Trends and other Information

European Union Electrical and Electronic Product Directives: Directive on Waste Electrical and Electronic Equipment (WEEE).

The WEEE Directive aims to:

- reduce the waste arising from electrical and electronic equipment, and
- improve the environmental performance of all those involved in the lifecycle of electrical and electronic products

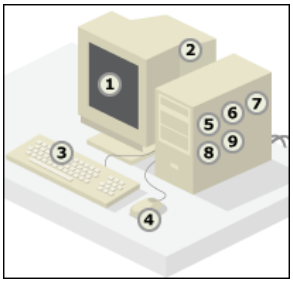
[1] http://www.ewaste.ch/case_study_southafrica/recycling_system/technologies/

ELECTRONIC WASTE / E-WASTE | 9

Manufacturer responsibility and product stewardship is increasing in the electronic products market (where the manufacturer of the product will be responsible for the final and safe disposal at the end of the product's 'lifespan').

Institutions that can be contacted for more information regarding the recycling and disposal of e-waste is:
The Institute of Waste Management SA
National Recycling Forum
e-Waste Association of SA

Illustrative Pictures

Hazardous elements and compounds 1. **Lead** in cathode ray tube and solder 2. **Arsenic** in older cathode ray tubes 3. **Selenium** in circuit boards as power supply rectifier 4. **Polybrominated flame-retardants** in plastic casings, cables and circuit boards 5. **Antimony trioxide** as flame-retardant 6. **Cadmium** in circuit boards and semiconductors 7. **Chromium** in steel as corrosion protection 8. **Cobalt** in steel for structure and magnetivity 9. **Mercury** in switches and housing	 Source: http://www.recycles.org/states/
Old and redundant computer waste	 Source: www.maine.gov/dep/rwm/ewaste/images/pile.jpg
Old and redundant cell phones and equipment	 Source: http://www.abc.net.au/science/features/ewaste/default.htm

INK AND TONER CARTRIDGES | 10

Waste Generation Processes / Industrial Application

Industry, commercial businesses, office buildings, schools and households all generate waste ink and/or toner cartridges, which are required for printers, fax machines and copiers.

Background Information

The two main cartridges used are inkjet cartridge and toner cartridges. Whereas inkjet cartridges are generally compact (and will fit into the palm of your hand), toner cartridges are larger and bulkier.

Inkjet cartridges contain liquid ink, which can consist of:

- Carbon black
- Water soluble organic solvents
- Water soluble dyes: magenta, cyan, yellow.

Black Toner cartridges contain a dry solid powder, which can consist of:

- Carbon black
- Amorphous Silica
- Styrene-Acrylate
- Iron Oxide
- Polymer
- Magnetite
- Polypropylene
- Quaternary Ammonium Compound
- Styrene Acrylate Copolymer

Some reports indicate that colour toners (cyan, yellow and magenta) can contain heavy metals.

Classification and Rating

Hazardous constituent	*SANS10228 Class:*	*SANS10228 UN No.:*	*Hazard Rating*	*Properties:*
Carbon black 1333-86-4	4.2(II)	1361	4	Very fine powder Class B Carcinogen
Printing ink	3	1210	n/a	Flammable, including printing ink thinning or reducting compound.
Iron oxide	9	-	3	
Silica	-	-	3	

INK AND TONER CARTRIDGES | 10

Environmental and Health Concerns

Non-renewable resources are used to manufacture new cartridges (the plastic housing in particular). For every laser cartridge that is dumped, it takes **almost 1 litre of oil** to produce a new cartridge[1].

Inhalation is the primary exposure pathway for carbon black powder, and may lead to respiratory tract irritation.

Colour toners that contain heavy metals may release these heavy metals (such as cadmium) into the environment, if disposed of incorrectly.

The non-degradable plastic housing will accumulate in the landfill sites.

Unacceptable Disposal Options

The following disposal methods are not considered acceptable:

- General landfilling
- Uncontrolled burning

Acceptable Disposal Options

The following disposal methods are acceptable:

- Return to supplier
- Refill of the cartridge
- Refurbish/Recondition the cartridge (and refill)
- Recycle – material value
- Fuel source for energy recovery (in a controlled environment)
- Hazardous landfill

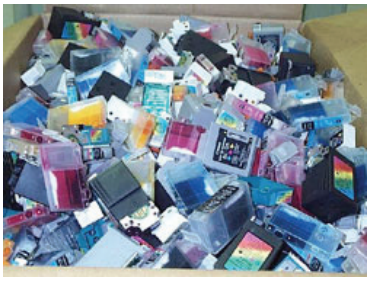
The different types of plastics used to make the cartridges can make plastic recycling difficult.

*Households tend to generate minor quantities of cartridges, which are accepted as part of the general waste stream. Commercial and industrial companies will generate higher quantities, which must be disposed of at a hazardous landfill site.

Industry Trends and Other Information

Refilling, recycling and reconditioning (which reduces waste disposal) are becoming preferred approaches to the common current practises of throwing the cartridges away to be disposed of at the landfill.

Illustrative Photos



[1] RSPB Recycling Appeal; http://recyclingappeal.com/rspb/wex/envirofacts.asp, and Envirotec LTD http://www.sabp-web.co.uk/envirtec/

SMOKE DETECTORS 11

Waste Generation Processes / Industrial Application

A smoke detector is a safety device that detects airborne smoke and issues an audible alarm, thereby alerting nearby people to the danger of fire.

Smoke detectors are used in homes, offices, warehouses and industrial buildings.

Background Information

Smoke alarms contain plastic and electronic circuit boards and, in some cases, batteries (alkaline or lithium). Certain smoke detectors contain a radioactive source.

Most smoke detectors work either by optical detection or by ionisation, but some of them use both detection methods, in order to increase sensitivity to smoke.

Smoke detector types:

- **Ionisation Smoke Detector**

  The most common type of smoke detector is an ionisation detector, which contains a small amount of Americium-241, a synthetic radioactive isotope that emits both alpha and gamma rays. Each smoke detector contains about 1 microcurie (about 1/5000 of a gram) of Americium shielded inside the detector. The vital ingredient of household smoke detectors is a very small quantity (<35 kBq) of americium-241 (Am-241).

  Because of the long half-life of americium-241, the amount of radioactive material in the smoke alarm at the end of its certified useful life will be about the same as when it was bought. On the wall, this material poses little threat; however, when a detector is broken open in an incinerator or a landfill, it can present a health hazard. While ionisation detectors give off less radiation than the human body, sufficient quantities - when stored together - can create harmful amounts of radiation.

- **Optical Smoke Detector**

  This type detects visible smoke particles in a dark chamber of the detector. A light source is projected into the chamber, out of view of a light-sensitive receiver. When smoke enters the chamber, the visible smoke particles reflect this light onto the light-sensitive receiver and trigger the smoke detector. Optical smoke detectors are more efficient at detecting denser smoke produced by smouldering materials, like those found in homes or in general offices where furniture is found.

- **Aspirating Smoke Detector**

  This type of smoke detector "breathes" the air at intake points before pumping this air through a filter, and then into an extremely sensitive chamber, which is far more sensitive than the standard smoke detector's chamber. The air is then exposed to an intense light source and analysed for a smoke-to-air ratio. This information is converted into an electronic signal. This type of detection is expensive but highly accurate, and less susceptible to false alarms.

- **Optical Beam Smoke Detectors**

  Optical beam smoke detectors use an active beam to detect visible smoke between the transmitter and the receiver. If any part of the beam is obscured by smoke, an alarm will be triggered. This type of smoke detector can be mounted up to 25m high, far higher than any other smoke detector.

SMOKE DETECTORS 11

Where the detectors contain circuit boards or batteries, please refer to the respective guidelines on e-waste and batteries. For the ionisation type that contains radioactive material, this guideline establishes whether or not the activity levels are low enough to be disposed of on a landfill.

Naturally occurring radioactive material (NORM) occurs everywhere and is present in the earth's crust, the floors and walls of our homes, schools, offices, and in the food we eat and drink. There are radioactive gases in the air we breathe. Our own bodies (muscles, bones, and tissue) contain naturally occurring radioactive elements. Man has always been exposed to natural radiation arising from the earth, as well as from outside the earth.

Classification and Rating

Hazardous constituent	SANS10228 Class	SANS10228 UN No.	Hazard Rating	Properties
Ionisation Smoke Detectors	2911 (radioactive material, excepted packages, articles)	7 (Radioactive material)	-	Ionisation smoke detector contains small quantity of radioactive isotopes Americium-241

Environmental and Health Concerns

Sealed sources - which emit mainly beta or alpha radiation (such as Strontium-90, Americium-241, Thallium-204 and Plutonium-238) - would not pose a significant external radiation hazard, unless they were of a fairly high activity (greater than 10 GBq). Americium has a very low specific activity.

A radioactive source can emit ionising radiation in a number of different forms. The most penetrating type of ionising radiation is **gamma** radiation, which is capable of passing through the human body and even through concrete walls.

Beta radiation is less penetrating, and can be stopped, for instance, by a few millimetres of perspex.

Alpha radiation is the least penetrating form of ionising radiation, and is not, for example, able to pass through a sheet of paper or through human skin.

Although our senses cannot detect it, ionising radiation can cause physical damage to the human body. Low doses of radiation produce no observable effects, but the probability of the occurrence of long-term effects, like cancer, will increase as the radiation dose increases. A large dose of radiation received over a short period of time can also result in severe short-term effects, such as radiation burns, nausea, internal bleeding and even death.

The alpha particles from the smoke detector do not pose a health hazard themselves, as they are absorbed in a few centimetres of air or by the structure of the detector.

The radiation dose to the occupants of a house from a domestic smoke detector is essentially zero, and, in any case, very much less than that from natural background radiation. The small amount of radioactive material that is used in these detectors is not considered a health hazard.

Even swallowing the radioactive material from a smoke detector would not lead to significant internal absorption of Am-241, since the dioxide is insoluble. It will pass through the digestive tract, without delivering a significant radiation dose (Americium-241 is, however, a potentially dangerous isotope if it is taken into the body in soluble form. It decays by both alpha activity and gamma emissions, and it would concentrate in the skeleton.)

SMOKE DETECTORS 11

Unacceptable Disposal Options

The following disposal methods are not considered acceptable:

- Uncontrolled burning
- Landfill - 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 of as general waste.

Acceptable Disposal Options

The following disposal methods are acceptable:

- It must be stressed that all incidents involving radioactivity should be reported to the Radiation Control Division of the Department of Health.
- Return to supplier – generator must ensure that the waste is handled in an environmentally acceptable manner.
- **One smoke detector** – Landfilling; but it is also recommended that all ionisation smoke detectors are returned to the supplier for proper treatment and safe disposal (Department of Health, Radiation Control).
- **Large quantities of smoke detectors** - Special provision for the disposal of this class of materials has been made in terms of the Nuclear Energy Act, 1999 (Act 46 of 1999). Radioactive waste is 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**.

Industry Trends and other Information

European authorities are phasing out ionisation detectors. In The Netherlands, sale of ionisation smoke detectors was banned from 2005. From the end of 2005, the sale of smoke detectors with a minuscule radiation source was prohibited.

NECSA, SA Nuclear Energy Corporation – radioactive waste

National Nuclear Regulator - For legal and regulatory purposes, radioactive waste is defined as material that contains, or is contaminated with, radionuclides at concentrations or activities greater than clearance levels, as established by the NNR (National Nuclear Regulator), and also has no use. NNR standard 200Bq/kg is regulated radioactive waste.

Illustrative Photos

Ionization smoke detectors
Source: http://www.technoswitch.co.za/series-65.htm

Optical Beam Smoke Detector
Source: http://www.technoswitch.co.za/Fr2000.htm

WET CELL BATTERIES | 12

Waste Generation Processes / Industrial Application

Wet cell batteries, or lead-acid batteries, are used in cars, trucks, motorcycles, boats, miners' cap lamps, and other motorized equipment. Motive power batteries are used in electric forklifts.

Background Information

Lead-acid batteries consist of a polypropylene plastic case, containing lead plates immersed in a sulphuric acid electrolyte. Lead-acid batteries are rechargeable.

The main hazardous constituents in lead-acid batteries are:

- Lead
- Lead oxide
- Lead sulphate
- Sulphuric acid
- Antimony

The average car batteries contain approximately 6.80 – 9.07 kg of lead per battery, and about 3.79 – 7.57 litres of sulphuric acid. The grids are made from a lead-antimony alloy (commonly containing from 0.75 - 5% antimony).

Classification and Rating

Hazardous constituent	*SANS10228 Class*	*SANS10228 UN No*	*Hazard Rating*	*Acceptable Exposure (draft MR 3rd Ed)*
Lead	8(II)	n/a	2	Environmental Exposure 0.12 ppm Human Health Exposure 0.02 ppm
Lead oxide	5.1(III)	1872	2	Environmental Exposure 0.12 ppm
Lead sulphate	8(II)	1794	4	Environmental Exposure 64 ppm
Antimony	6.1(II)	1549	1	Environmental Exposure 0.07 ppm Human Health Exposure 0.21 ppm
Arsenic	6.1(II)	1558	2	Environmental Exposure 0.38 ppm Human Health Exposure 0.002 ppm
Sulphuric acid	8(II)	1830	4	Acceptable Environ. Risk is 10ppm (MR 2nd Ed) Reactive-Oxidizer

Overall Hazard Rating: 2 (or 1 if antimony is used as an alloying metal)

SANS10228 UN no: 2794 (Batteries filled with Acid Class 8)

Environmental and Health Concerns

If the lead-acid batteries are disposed of in a general landfill, or are illegally dumped, batteries may corrode and release lead and lead-contaminated sulphuric acid into the environment. Landfilled batteries can, therefore, pollute drinking water sources, such as rivers, streams and ground water.

Lead-acid batteries burned in incinerators may release lead into the atmosphere, or the lead may remain in high concentrations in the ash (which is landfilled).

Lead is listed as a Class B mutagen and carcinogen, as well as a teratogen in the MR, and is known to cause birth defects or reproductive harm.

Exposure to lead may include:

- Chronic overexposure: Tire easily, loss of appetite, irritability, metallic taste, and insomnia, in addition to it being toxic to the nervous system, kidneys, and reproductive system.
- Acute exposure: Constipation, vomiting, blue line on gums, weak wrists or ankles, weight loss and yellowish skin.

Sulphuric acid is a highly corrosive acid (pH of 0.3), which can cause chemical burns if it comes into contact with skin.

Exposure to sulphuric acid (battery electrolyte) may include:

- Chronic overexposure: Inhalation - erosion of teeth, inflammation of nose, throat and bronchial tubes.
- Acute overexposure: Eyes - severe burns, cornea damage and blindness. Skin – severe irritation, burns, ulceration. Inhalation - respiratory irritation, inflammation of bronchial membranes. Ingestion - severe burns and ulceration of the mouth, throat, and stomach, damage to kidney and intestinal tract.

Unacceptable Disposal Options

The following disposal methods are not considered acceptable:

- Burning
- Illegal dumping
- General landfill

Acceptable Disposal Options

The following disposal or treatment options are acceptable:

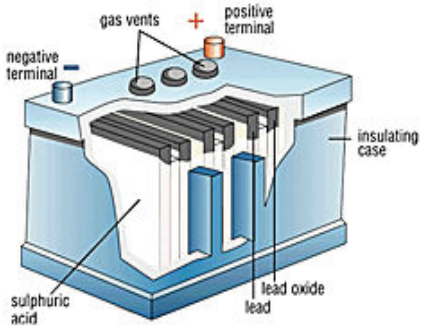
- Return to supplier for recycling. Most manufacturers take back used or old batteries for recycling of the lead and plastic. Recycling must be done in a legal and environmentally responsible manner.
- Hazardous landfill site (with treatment).

Industry Trends and other Information

The recycling process includes the polypropylene plastic components for new cases, the lead and lead oxide for new plates, among other parts. Old battery acid is either neutralised, treated and discharged to the effluent system, or converted into sodium sulphate, an odourless white powder used in laundry detergent, glass and textile manufacturing (thus transforming a noxious substance into a useful reusable product).

About 95% percent of used or old lead-acid batteries are returned to suppliers and recycled.

Illustrative Pictures



The battery has a set of grids immersed in a sulphuric acid electrolyte. One set of grids is made of lead (Pb) and acts as the anode, and the other set is made of lead oxide (PbO_2) and acts as the cathode.
(Image © Research Machines plc)

DRY CELL BATTERIES | 13

Waste Generation Processes / Industrial Application

Non-rechargeable (primary) batteries are well-known consumer batteries, which are used in general household appliances (clocks, radios, torches etc.), and will be disposed of after their single use.

Spent **rechargeable** (secondary) batteries will arise from their use in electric appliances, such as cellular phones, video cameras and portable tools, as well as in some high-power drain applications, such as power tools.

Background Information

Dry Cell Batteries include:

- Non-rechargeable/disposable (Primary)
- Rechargeable (Secondary)

Non-rechargeable: These are the most common types of household batteries.

General household batteries include:

- **Zinc carbon and zinc Chloride,** which are used in low-drainage appliances, such as torches, clocks, shavers and radios.
- **Alkaline manganese** batteries are used in personal stereos. They are less prone to leaking than the above two types, and are longer lasting.
- **Mercuric oxide** used in batteries for hearing aids, pacemakers and photographic equipment. These days they have been replaced by silver oxide and zinc air.
- **Zinc air -** an alternative to mercuric oxide button cells: used for hearing aids and radio pagers.
- **Silver oxide -** used for electronic watches and calculators.
- **Lithium** - used for watches and photographic equipment.

Rechargeable – general-purpose rechargeable batteries are used for the aforementioned applications, as well as in power tools, cordless appliances, mobile phones etc. These include the following:

- **Nickel cadmium (NiCd)** batteries are used for cordless power tools, personal stereos, portable telephones, laptop computers, shavers, motorised toys etc, and, generally, have a lifespan of up to 4-5 years.
- **Nickel metal hydride (NiMH)** batteries are a less environmentally harmful alternative to NiCd, and tend to have a longer life.
- **Lithium ion (Li-Ion) or Lithium Polymer (Li-Polymer) batteries** have a greater energy storage capacity than NiCd and NiMH batteries. They have a high specific energy (the number of hours of operation for a given weight), making them a huge success for mobile applications, such as phones and notebook computers.

The lithium polymer battery represents a new type of technology that, unlike NiMH, NiCd and Li-Ion cells, does not need a metal casing. Instead, the electrodes are covered with flexible plastic or aluminium foil. They also have a very high energy density, so that they can be physically smaller but provide higher performance than other rechargeable batteries. Furthermore, they are easier and cheaper to produce in the medium term than Li-Ion rechargeable batteries. However, like the latter, they are only available in custom-made forms, requiring special chargers.

DRY CELL BATTERIES 13

The following elements and compounds can be found in these batteries:

- Cadmium
- Nickel
- Carbon Black
- Lead
- Manganese dioxide
- Mercury
- Mercury chloride
- Potassium hydroxide
- Tin
- Zinc
- Zinc Chloride

Classification and Rating

Hazardous constituent	*SANS10228 Class*	*SANS10228 UN No*	*Hazard Rating*	*Properties (MR 3rd Ed)*
Non-rechargeable Batteries Constituent Elements and Compounds				
Zinc	n/a	n/a	2	Solid zinc skin irritant. Acceptable Environ. Risk 0.83 ppm. Acceptable Human Health Exposure 11 ppm
Zinc Chloride	8(III)	1840	2	Acceptable Environ. Risk 0.69 ppm
Mercuric oxide	6.1(II)	1641	1	Acceptable Environ. Risk 0.0001ppm
Mercury Chloride	6.1(II)	1624	1	Acceptable Environ. Risk 0.0001 ppm
Mercury	8(III)	2809	1	Acceptable Environ. Risk 0.024 ppm Acceptable Human Health Exposure 0.03 ppm
Manganese	-	-	2	Acceptable Environ. Risk 0.3ppm
Ammonium Chloride	9(III)	8214	2	Acceptable Environ. Risk 0.13ppm
Silver	-	-	1	Acceptable Environ Risk 0.001ppm Acceptable Human Health Risk 0.18ppm
Rechargeable Batteries Constituent Elements and Compounds				
Cadmium (Cd)	6.1 (I)	2570	1	Acceptable Environ. Risk 0.031 ppm, Is a Class A Mutagen and Carcinogen. Used as an electrode in Ni-Cd batteries. Batteries contain about 5 grams of Cd, lethal dose for Cd is 1 gram it's a cumulative poison.
Nickel		2881	2	Acceptable Environ. Risk 0.75 ppm Acceptable Human Health Exposure 0.18 ppm
Lithium	9(II)	3090 (Lithium Battery)	2	Alkali metal, occurring naturally in the environment. Metallic lithium will react with nitrogen, oxygen, and water vapour in air. Flammable

According to the hazardous constituents in different types of batteries the following hazard ratings apply:

Non-Rechargeable		Rechargeable	
Battery Type	**Hazard Rating**	**Battery Type**	**Hazard Rating**
Zinc carbon	2	Nickel cadmium (NiCd)	1
Zinc chloride		Nickel metal hydride (NiMH)	2
Zinc air		Lithium ion (Li-Ion)	2
Mercuric oxide	1		
Alkaline manganese	2		
Silver oxide	1		

DRY CELL BATTERIES | 13

Environmental and Health Concerns

Toxic constituents from the batteries can be released into the environment from municipal landfills and incinerators, thus causing damaging health effects. When corroded, batteries may become hazardous, releasing hazardous materials into the soil, surface water and groundwater.

Cadmium poisoning is very serious, as it can lead to the destruction of red blood cells. Cadmium is a known water and sediment pollutant, and is listed as a possible carcinogen. Open batteries can cause respiratory irritation; cadmium oxide can cause metal fever. Batteries burned in waste combustion facilities can release mercury or cadmium into the air and water, ultimately entering the food chain and posing health threats to people, as well as the environment.

Nickel metallic and alloys have been identified as carcinogen Class B carcinogens in MR.
Solid zinc is a skin irritant, and zinc oxide can cause metal fume fever.

Lithium reacts violently with water, forming highly flammable hydrogen gas and corrosive fumes of lithium hydroxide. Leaking lithium-sulphur dioxide batteries may release sulphur dioxide gas (toxic), lithium hydroxide (corrosive) and methane gas (flammable).

Environmental effects of Lithium - Metallic lithium will react with nitrogen, oxygen, and water vapour in air. Consequently, the lithium surface becomes coated with a mixture of lithium hydroxide (LiOH), lithium carbonate (Li_2CO3), and lithium nitride (Li_3N). Lithium hydroxide represents a potentially significant hazard, because it is extremely corrosive. Special attention should be given to water organisms.

Lithium Explosion: Risk of fire and explosion on contact with combustible substances and water.

- Inhalation: Burning sensation, coughing, laboured breathing, shortness of breath, sore throat. Symptoms may be delayed.
- Skin: Redness, skin burns, pain, blisters. Eyes: Redness, pain, severe deep burns.
- Ingestion: Abdominal cramps, abdominal pain, burning sensation, nausea, shock or collapse, vomiting, weakness. Routes of exposure: the substance can be absorbed into the body by inhalation of its aerosol, and by ingestion.
- Inhalation risk: Evaporation at 20°C is negligible; a harmful concentration of airborne particles can, however, be reached quickly when dispersed. Effects of short-term exposure: the substance is corrosive to the eyes, the skin and the respiratory tract, and is also corrosive on ingestion. Inhalation of the substance may cause lung oedema.

Unacceptable Disposal Options

The following disposal methods are not considered acceptable:

- Incineration: In Ni-Cd batteries, cadmium is volatised and released into the atmosphere when incinerated; metallic cadmium condenses onto the smallest particles of incinerator smoke, which are then difficult to contain by pollution control devices.
- Burning: Li-ion battery can explode if disposed of in fire.
- Crushing or dismantling.

Acceptable Disposal Options

The following disposal methods are acceptable

- H:H waste site - ensure proper leachate management.
- Treatment (e.g. encapsulation) may be required prior to disposal.

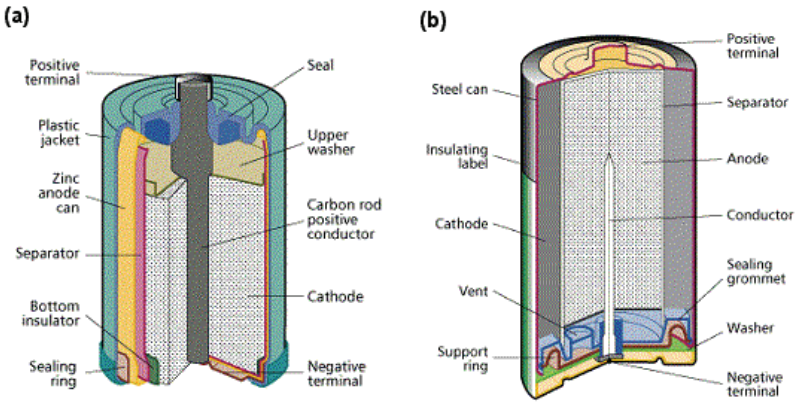
Industry Trends and other Information

International trends include:

- Increased use of rechargeable batteries.
- Recycling and reconditioning of Ni-Cd batteries.
- Reduction of mercury content in batteries.
- Recovery of metal elements.

Illustrative Pictures

Zinc carbon
Zinc chloride
Alkaline
Manganese

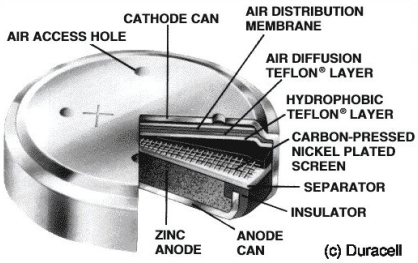


a) Zinc-carbon battery and b) alkaline manganese battery
(Source: www.chemsoc.org)

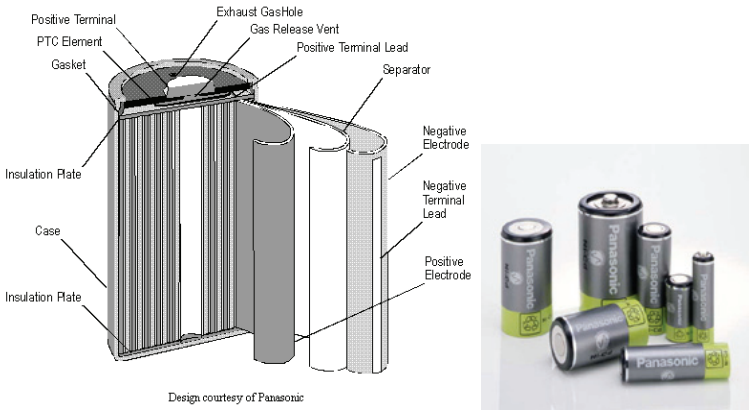
Mercuric Oxide

(Source: www.radioshack.com)

Zinc Air



(Source: www.hometown.aol.com)

DRY CELL BATTERIES	13
Silver Oxide	
Lithium	
Nickel Cadmium	 (Source: www.batteryuniversity.com)
Nickel Metal Hydride	
Lithium Ion	

ASBESTOS AND ASBESTOS CONTAINING WASTE (ACW) | 14

Waste Generation Processes / Industrial Application

Asbestos is used in the manufacturing of products, such as asbestos cement sheets or pipes, building material, insulation, asbestos rope, as well as friction products, such as gaskets, brake pads and clutch plates. Alternative fibres and materials are available to replace most asbestos products.

The demolition or renovation of buildings (or part thereof) - or the removal or replacement of insulation, sheeting, lagging etc. - that contain asbestos may, therefore, result in asbestos waste being generated.

Asbestos-*contaminated* waste can be derived from the bags used to transport asbestos, equipment, PPE and clothing that has been in contact with asbestos.

Background Information

Asbestos is a mineral rock from the earth that is resistant to heat and corrosive chemicals. Asbestos products have been used in many building applications, due to their thermal insulation, chemical and thermal stability, and high tensile strength. The blue (Crocidolite) and white (Chrysotile) asbestos is mostly used in asbestos sheeting and lagging, while white asbestos is used more in friction materials

Mining of asbestos in South Africa started in the Northern Cape and, subsequently, expanded to the Northern Province and Mpumalanga. Mining included all three types of commercial asbestos – white asbestos or chrysotile, blue asbestos or crocidolite and brown asbestos or amosite.

Types of Asbestos (blue/white/brown)

Asbestos minerals are divided into two groups: serpentine and amphibole. The distinction between the groups is based upon the crystalline structure - serpentine minerals have a sheet or layered structure, whereas amphiboles have a chain-like crystal structure.

Asbestos found in the serpentine group:

Chrysotile, the only mineral in the serpentine group, is commonly known as **"white asbestos"**. It is the most commonly used type of asbestos, and accounts for approximately 40% of asbestos-containing materials.

Asbestos found in the amphibole group:

Amosite, the second most likely type to be found in buildings, and is often referred to as **"brown asbestos".**

Crocidolite, or **"blue asbestos"** is an amphibole, which was used in high temperature insulation applications. This is the most common type of asbestos mined in South Africa, mainly in the Northern Cape region.

Blue and brown asbestos can cause a greater health risk than white asbestos, because of their different physical properties. White asbestos has a very high surface area and a low density. It is less hazardous than the other types of asbestos, because it tends to be less aerodynamic and does not get into the lungs that easily. On the other hand, blue asbestos, with its needle shape, tends to penetrate the lungs and become lodged therein very easily. However, in SA, all types of asbestos fall under legislation with the same OEL.

There have been more cases of mesothelioma and cancer reported amongst people working with blue asbestos than with other types of asbestos.

ASBESTOS AND ASBESTOS CONTAINING WASTE (ACW) 14

Types of Asbestos Material (friable/non)

Friable asbestos[1] containing material means:

(a) non-bonded asbestos fabric,

(b) material that contains more than 1% asbestos by weight, and:

i. is in the form of powder

ii. when dry, can be crumbled, pulverized or reduced to powder by hand pressure.

Non-friable asbestos containing material means -

Asbestos material that contains more than 1% asbestos by weight, and in which the asbestos fibres are bonded by cement, vinyl, resin or other similar material. When dry, the material cannot be crumbled, pulverised, or reduced to powder by hand pressure.

Asbestos-Containing Waste (ACW) can be grouped into 4 different classes (Class A-D)[2]

ACW Hazard Class	Examples of ACW
Class A: Any friable ACW	• Raw asbestos (e.g. asbestos damaged in transit or no longer required). • Bags previously used to transport raw asbestos (that have not been melted into a solid mass). • Asbestos insulation, limpet spray of pipe lagging removed from power stations, buildings, boilers or pipe works. • Pure asbestos rope or textiles
Class B: Any non-friable ACW that has become crumbled pulverised or reduced to powder during manufacturing, installation, renovation or demolition operations, such that it is likely to release fibres into the air.	• Dry swarf or cutting dust from the asbestos cement or friction material production process. • Used filter bags from dust extraction units at the workplace. • Asbestos cement that has unavoidably been crumbled, pulverised, or reduced to powder during demolition operations. • Disposal equipment and clothing contaminated with asbestos.
Class C: Any Class B ACW that has been adequately wetted or otherwise encapsulated such that it will not release fibres into the air	• Wet swarf or cutting dust from the asbestos-cement or friction material production process. • Sludge, slurry or wet waste from the production process. • Bags previously used to transport asbestos, which have been melted into a solid mass in an autoclave.
Class D: Any non-friable ACW that is essentially in the same condition as when manufactured and is unlikely to release respirable fibres after being declared a waste product.	• Asbestos cement sheets or pipes. • Off-cuts of asbestos-cement sheets or pipes. • Disused friction products such as gaskets, brake pads or clutch plates.

The risk associated with the release of fibres is highest in class A, and gradually decreases to reach class D.

The accepted action level for determining whether or not an ACW is hazardous is defined in the Occupational Health and Safety Act (Act 85 of 1993) as the ability to release "0,2 *regulated asbestos fibres* per millilitre". The new Asbestos Regulations make provision for an Occupational Exposure Limit of 0,2 regulated asbestos fibres per millilitre of air, averaged over any continuous period of 4 hours, and a short-term exposure limit of 0,6 regulated asbestos fibres per millilitre of air, averaged over any 10 minutes.

[1] EPA Guidelines, Wastes containing asbestos: removal, transport and disposal—September 2004 (www.**epa**.sa.gov.au/pdfs/guide**_asbestos**.pdf)

[2] DWAF Policy on the handling and Disposal of Asbestos and Asbestos containing waste in terms of Section 20 of the Environmental Conservation Act, (ACT 73 of 1989) and the Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste; Appendix 9.3 classification of asbestos containing waste

ASBESTOS AND ASBESTOS CONTAINING WASTE (ACW) | 14

Regulation

The control of asbestos, and its potential exposure to people and the environment, is regulated by the following legislation:

- Mine Health and Safety Act (MHSA), 1997,
- Occupational Health and Safety Act (No 85 of 1993), and
- Asbestos Regulations, 2001 (promulgated under the Occupational Health and Safety Act (No 85 of 1993)).

The Asbestos Regulations are comprehensive, and make provision for:

- Informing and training employees that may be exposed to the health risks of asbestos on how to work safely with this material.
- Assessment of potential exposure
- Air monitoring
- Medical surveillance
- Zoning of asbestos work areas
- Implementation of control measures
- Housekeeping
- Demolition and removal of asbestos

Asbestos can be transported if it is fixed (cement sheets) or labelled and double-bagged, in order to prevent any dangerous fibres from escaping.

The regulations prescribe requirements with regards to the demolition of asbestos containing building material.

"Demolition work" - includes demolition, alteration, stripping, removing, repair, and gleaning any spilt asbestos or high-pressure water jetting of any structure containing asbestos lagging or insulation, but excluding work performed on asbestos cement sheeting and related products, as well as asbestos cement products that form part of the structure of a workplace, building, plant or premises.

Any person who intends to have demolition work carried out, shall, before the commencement of that work, take steps to ensure that-

- demolition work is carried out by a person who is a *registered asbestos contractor* (registered with the Department of Labour);
- all asbestos materials that are likely to become airborne are identified;
- a plan of work is submitted for approval, at least 30 days prior to the commencement of that work, to an *approved asbestos inspection authority* who may at its discretion allow a shorter period of time for such submission, and may approve standardised procedures for routine alterations or repairs; it is provided that the stipulated time period shall not apply if the plan of work is drawn up by an approved asbestos inspection authority;
- a copy of the approved plan of that work - which has been signed by the approved asbestos inspection authority, the employer and, if the person performing that work is not the employer or self-employed person, the mandatory of the employer or self-employed person - is submitted to the provincial director at the Department of Labour, at least 14 days prior to commencement of such demolition work; it is provided that an inspector may allow a shorter period for such submission;
- copies of approved standardised procedures for demolition work are submitted to the provincial director, at least 14 days prior to commencement of that work;
- during and after the completion of demolition work, take steps to ensure that:
  - all asbestos and materials containing asbestos are handled and disposed of in accordance with these regulations;
  - all persons exposed to, or likely to be exposed to, asbestos are issued with appropriate personal protective equipment, and that such equipment is used properly, and

- the premises, structure or area are thoroughly checked, in order to ensure that all asbestos waste has been removed.

Classification and Rating

Type	*SANS10228 Class*	*SANS10228 UN No*	*Hazard Rating*	*Properties*
Asbestos blue CAS # 1332-21-4	9(II)	2212	1	Class A Carcinogen (known human carcinogen)
Asbestos white CAS # 12001-29-5	9(III)	2590	1	
Asbestos brown CAS # 1332-21-4	9(II)	2212	1	Class A Carcinogen (known human carcinogen)

Environmental and Health Concerns

Asbestos-containing materials do not necessarily pose a problem unless fibres from these materials are released into the air and inhaled. The *inhalation* of asbestos fibres is the cause of asbestosis and lung cancers. Therefore, any waste generated and disposed must be done so in a way that prevents the release of the asbestos fibres.

The International Agency for Research on Cancer (IARC) has classified asbestos as a class 1 carcinogen (Class 1 in IARC and Class A in MR are *known human carcinogen* substances).

Health effects of asbestos

The incurable diseases caused by asbestos are asbestosis and cancer, in addition to mesothelioma from blue asbestos. It can take from 10 to 40 years for a person to develop an asbestos-related disease.

There are three main disease states associated with the inhalation of asbestos fibre:

- Asbestosis, or scarring of lung tissue, results from inhaling significant amounts of asbestos over a period of years. The symptoms include shortness of breath and a dry cough. Many patients may experience years of poor quality of life and disability. They may die of shortness of breath or heart failure, due to the increased strain on the heart.
- Lung cancer is related to the amount of asbestos fibre inhaled, and the risk is increased considerably in people who smoke cigarettes.
- Mesothelioma is a rare cancer involving the pleura (outer lining of the lung) or, less commonly, the peritoneum (lining of the chest cavity).

Unacceptable Disposal Options

The following disposal methods are not considered acceptable:

- Landfilling, whereby the asbestos fibres may be separated and diffused.
- Open containers allowing the release of fibres.
- Asbestos waste mixed with general waste.
-

Acceptable Disposal Options

The following disposal methods are acceptable:

- Hazardous Landfill
- General landfill, whereby the landfill permit allows for acceptance of asbestos waste, and waste is disposed of in sealed double bag.
- Solidification, immobilisation (e.g. wetting), and then Landfilling.

Treatment options include:

- wetting normally with water, in order to immobilise the asbestos fibres, and
- solidification by cement or other fixation agents.

All fibrous material falling into asbestos waste containing classes A to C must be double-bagged in plastic bags, with a minimum thickness of 75 microns, before the waste is transported to the landfill.[1]

Industry Trends and other Information

Draft regulations were published in the Government Gazette in November 2005, to ban the import and export of all asbestos products, along with new measures to phase out the local manufacture and use of asbestos-containing products.

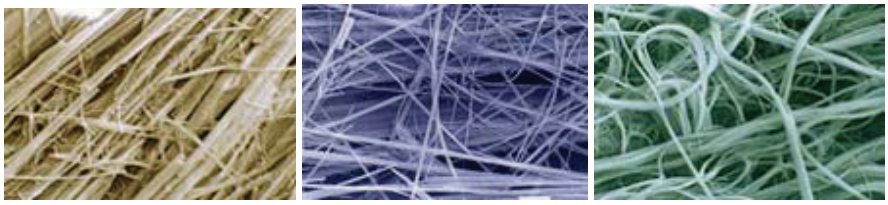
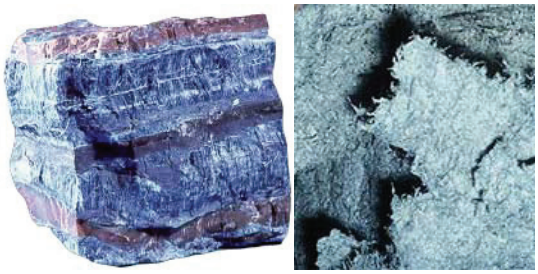
Safer and stricter standards are in place for workers involved in asbestos handling and removal.

Many countries have banned the use of new asbestos. Based on the available information, it can be concluded that the strategic approach being adopted by most countries involves a three-phase transitional phasing out of asbestos from their economies and societies:[2]

- ***Phase 1:*** *Ban all new uses of amphibole fibres (i.e. crocidolite and amosite), but allow the continued use of chrysotile asbestos.* Many countries adopted this approach during the late 1970's and early 1980's.
- ***Phase 2:*** *Restrict the use of chrysotile asbestos.* Many countries began pursuing this approach during the mid 1980's and early 1990's.
- ***Phase 3:*** *Ban all new uses of all types of asbestos fibres*. A number of countries began pursuing this option from the mid 1990's onwards.

Developments at cement sheeting manufacturers include the replacement of asbestos in their sheeting with cellulose and PVA.

Illustrative Pictures

Amosite, Crocidolite, Chrysotile	
Raw and processed blue asbestos	

[1] DWAF Policy on the Handling and Disposal of Asbestos and Asbestos containing waste in terms of Section 20 of the Environmental Conservation Act, (ACT 73 of 1989)

[2] International Trends In the Regulations and Control of Asbestos, (National Economic Development and Labour Council; www.nedlac.org.za/research/fridge/asbestos/app-3.pdf)

ASBESTOS AND ASBESTOS CONTAINING WASTE (ACW)	14
Asbestos lagging	
Asbestos cement roofing	

BOILER ASH (AND OTHER ASH WASTE) 15

Waste Generation Processes / Industrial Application

Industrial processes, which involve combustion as part of the production process, produce ash as one of the by-products. Ash produced in industrial processes is either bottom ash (heavier ash particle) or fly ash (powdery material, released during coal combustion).

For many years, ash has been stockpiled on land and used for other purposes, such as spreading on driveways, road surfacing material, or recycling into other products, without taking any precautionary measures. The fact that boiler ash is an industrial waste, with a potential risk to the environment and human health, has been neglected over the past years.

Background Information

Different types of boiler ash include:

- Coal boiler bottom ash
- Power station fly ash
- Medical incinerator ash.

The composition of the ash will depend on the source of the ash. Ash from coal combustion consists of limestone, iron, aluminium, silica sand and clay. Depending on the origin and the coal composition, it can contain some trace elements. Such trace elements typically include the following: arsenic, boron, cadmium, chromium, copper, lead and zinc.

Fly ash is a by-product of coal combustion. Fly ash is fine powder - light to dark grey or shades of brown - and is insoluble in water. Ash particles can consist of silica, alumina, oxides of iron, calcium, and magnesium, and toxic heavy metals like lead, arsenic, cobalt, and copper.

Bottom ash is a granular material removed from the bottom of dry boilers. It is much coarser than fly ash, even though it is also formed during the combustion of coal.

BOILER ASH (AND OTHER ASH WASTE) 15

Mercury in Boiler Ash: Mercury emissions are impacted by factors such as: coal type, type of environmental control equipment installed on the unit, boiler operation and fly ash characteristics. The average mercury concentration in coal combustion by-product (ash) is ~0.01 - 0.2 mg/kg. Most of the mercury in coal is released as mercury vapour during combustion. Results to date have shown that the mercury concentration in all leachates of coal combustion by-product samples was less than the drinking water standard for mercury (2 ppb).[1]

Ash from boilers that use alternative fuels, e.g. sunflower husks and bagasse, have a different leaching pattern to coal. Sunflower husk ash contains high amounts of potassium and is potentially useful as a fertiliser.

Classification and Rating

Hazardous Constituents	SANS10228 Class	SANS10228 UN No.	Hazard Rating	Properties
Lead CAS # 7439-92-1	6.1(III)	2291	2	Heavy metal
Cadmium CAS # 7440-43-9	6.1(III)	2570	1	Heavy metal
Mercury CAS # 7439-97-6	8 (III)	2809	1	Heavy metal
Arsenic CAS # 7440-38-2	6.1 (II)	1558	2	Heavy metal
Boron CAS # 7440-42-8	-	-	3	
Chromium(III) Total CAS # 7440-47-3	-	-	3	

If ash contains cadmium or mercury it will have a hazard rating of 1, and should be disposed of at a H:H landfill site, unless the EEC (estimated environmental concentration) is less than the acceptable exposure limits, such that the ash waste delists for disposal at an H:h or G:B^+ site. The ash must, therefore, be tested (TCLP tests) in order to establish the concentrations that will leach out of the waste.

Environmental and Health Concerns

- Boiler ash can contain heavy metals, particularly lead, cadmium and mercury, and other inorganic elements. Heavy metals are persistent pollutants that do not biodegrade.
- The inhalation of ash can cause irritation to the nose, throat and respiratory tract, thus causing coughing and sneezing.
- The repeated inhalation of dust containing crystalline silica can cause bronchitis, silicosis (scarring of the lung) and lung cancer. It may also increase the risk of scleroderma (a disease affecting the connective tissue of the skin, joints, blood vessels and internal organs). Studies have shown that smoking increases the risk of bronchitis, silicosis and lung cancer in persons exposed to crystalline silica.
- Inhalation of high levels of fly ash dust may result in severe inflammation of the small airways of the lung, and asthma-like symptoms.
- Ash generated from incinerators may produce highly toxic fly ash and bottom ash. Air pollution control equipment will prevent/reduce the release of toxic particles in the smoke and emissions, and, thus, the ash (and filters) may be highly contaminated with heavy metals, PCBs, dioxins and furans, as well as numerous other toxic by-products of combustion.

[1] Coal Combustion Residues and Mercury Control, www.epa.gov/ORD/NRMRL/pubs/600r01109/600R01109chap9.pdf
Factors Controlling the Solubility of Mercury Adsorbed on Fly Ash, www.netl.doe.gov/coal/E&WR/cub/pdf/2005Task3_HgSolubility.pdf

Unacceptable Disposal Options

The ash must not be re-used, or disposed of on a general landfill, if the hazardous composition of the ash is not known. Ash must not be disposed of on site, without the necessary authorisation from DEAT and DWAF.

Acceptable Disposal Options

All ash must be tested for hazardous material before disposal or reuse. Any handling and treatment options of **boiler ash** should be in line with the DWAF Guideline on Handling and Disposal of Boiler Ash.

This policy requires that the boiler ash must be approved for land disposal or other uses. A classification report must be submitted to the Department (DWAF), confirming whether it is considered hazardous or non-hazardous, and must include the following information:

- Classification of the ash, based on the laboratory analysis. DWAF require a complete inorganic and organic analysis, followed by the Toxicity Characteristic Leaching Procedure (TCLP) for classification of boiler ash waste.
- Source(s) of ash in question.
- Quantity to be disposed of or used in other processes.
- A copy of a proof of compliance, in the form of an approval or exemptions, with other legal requirements e.g. S.A.B.S specifications and E.I.A Regulations.
- Identification of the site on which the ash is intended to be disposed of, or the identity of an alternative use of the ash.
- The boiler ash must be disposed of on a Hazardous Landfill (H:H or H:h), if it is classified as hazardous waste, or if the hazardous composition is not known. Disposal on a general landfill is not permitted if the Hazard Rating is greater than 4.

Fly-ash or bottom ash can be used for the following purposes as an alternative to landfilling:

- *Ash-blending* – where the ash is mixed with hazardous waste in an attempt to reduce the toxicity of the waste (by preventing or restricting the hazardous components from leaching out the waste).
- *Cover for landfill* – landfills are required to cover the waste with sand on a daily basis. If approved, the ash may be used as an alternative.
- *Construction Industry* – uses in cement manufacturing and building materials.

According to the Department of Water Affairs (DWAF) *incinerator* ash is hazardous waste, which must be disposed of in a hazardous waste landfill site.

Alternative uses are generally preferred to landfilling.

Approval for the disposal of ash at a general landfill and for all alternative uses of ash must be obtained from DWAF. DWAF requires a complete inorganic and organic analysis, followed by the Toxicity Characteristic Leaching Procedure (TCLP) for classification of boiler ash waste.

Industry Trends and other Information

Boiler ash is reused as a raw material in the cement industry. The use of ash in cement has several benefits (including increased strength, decreased permeability and increased chemical resistance). The biggest use for power station fly ash is as an extender in cement.

Illustrative Pictures


Bottom Ash

Fly Ash

MEDICAL WASTE / HEALTH CARE WASTE (HCW) — 16

Generation Processes / Industrial Application

The generators of medical waste are generally grouped into two categories that represent *major generators,* such as hospitals and clinics, and *minor generators,* such as health practitioners, dentists, pharmacies, etc.

Large scale Health Care risk waste (HCRW) generators include:

- Public and private hospitals and clinics
- Blood transfusion centres

Small scale HCRW generators include:

- Medical labs
- Pharmaceutical industries
- Pharmacies
- Medical general practitioners
- Dentist
- Veterinary hospitals and surgeons
- Prisons
- Mortuaries
- Private homes
- On site medical facilities at industrial and mining sites
- Onsite clinic or medical facility

Background Information

Medical waste - also referred to as health care waste (HCW) - is a combination of Health Care General Waste (HCGW) (similar to domestic waste), and Health Care Risk Waste (HCRW), which is considered to be the hazardous component of HCW. HCRW is further made up of a number of components, such as infectious waste (including sharps), chemical waste (including pharmaceutical waste), and radioactive waste. See Figure 1 below for more detail on the types of HCW.

Waste type specifics:

- Infectious wastes - cultures and stocks of infectious agents; wastes from infected patients; wastes contaminated with blood and its derivatives; discarded diagnostic samples; infected animals from laboratories, and contaminated materials (swabs, bandages) and equipment (disposable medical devices etc.).
- Anatomic - recognizable body parts and animal carcasses.
- Sharps - syringes, disposable scalpels and blades etc.
- Chemicals – such as solvents and disinfectants.

- Pharmaceuticals - expired, unused, and contaminated: the drugs themselves (sometimes toxic and powerful chemicals) or their metabolites, vaccines and sera.
- Genotoxic waste - highly hazardous, mutagenic, teratogenic or carcinogenic, such as cytotoxic drugs used in cancer treatment, and their metabolites.
- Radioactive matter, such as glassware contaminated with radioactive diagnostic material or radiotherapeutic materials.
- Wastes with high heavy metal content, such as broken mercury thermometers.

In Gauteng, it was found that approximately 30% of material being processed as dangerous healthcare waste (called healthcare risk waste) could, by improved classification and sorting, be treated quite safely as ordinary waste, according to the Chief Technical Advisor on Sustainable Healthcare Waste Management to the Gauteng Provincial Government[1]. This type of waste material includes the plastic and cardboard packaging.

Classification and Rating

Hazardous constituent	SANS10228 Class	SANS10228 UN No.	Hazard Rating
Infectious waste	6.2 (II)	3291	1

Environmental and Health Concerns

There is a major concern where infectious waste is not disposed of responsibly – it is often mixed with general waste and disposed of at a general landfill or is illegally dumped.

Incorrect disposal of sharps

The unsafe disposal of health-care waste (contaminated syringes and needles) poses public health risks. Contaminated needles and syringes represent a particular threat, as the failure to dispose of them safely may lead to dangerous recycling and repackaging, which can, in turn, lead to unsafe reuse. Contaminated injection equipment may be scavenged from waste areas and dumpsites, and can be either reused or sold for reuse.

WHO estimated that, in 2000, contaminated injections with contaminated syringes caused:

- 21 million hepatitis B virus (HBV) infections (32% of all new infections).
- Two million hepatitis C virus (HCV) infections (40% of all new infections).
- At least 260 000 HIV infections (5% of all new infections).

Health Impacts

Health-care waste is a reservoir of potentially harmful micro-organisms, which can infect hospital patients, health-care workers and the general public. Other potential infectious risks include the spread of, sometimes resistant, micro-organisms from health-care establishments into the environment. These risks have, thus far, been poorly investigated.

Wastes and by-products can also cause injuries, for example: radiation burns, sharps-inflicted injuries, poisoning, disease and pollution.

Further hazards include:

- Unwanted or expired medicines or pharmaceuticals could be harmful to children or adults. Unused pharmaceuticals found in the trash may be stolen for unregulated use.
- Antibiotics poured down the drain can kill beneficial microbes and bacteria in water-treatment systems.
- Gases from incinerating can cause air pollution, if the incinerator is not operating properly.

[1] Standards South Africa, **Technical Communiqué – September 2004, http://www.stansa.co.za**

MEDICAL WASTE / HEALTH CARE WASTE (HCW) | 16

HCW treatment

Inadequate incineration, or incineration of materials unsuitable for incineration, can result in the release of pollutants into the air.

Unacceptable Disposal Options

The following disposal methods are considered unacceptable:

- General landfill site (mixed with general waste)
- Hazardous landfill site
- Uncontrolled Burning and ineffective incineration
- The incineration of materials containing chlorine can generate dioxins and furans, which are classified as possible human carcinogens, and have been associated with a range of adverse effects. Incineration of heavy metals or materials with high metal contents (particularly lead, mercury and cadmium) can lead to the spread of heavy metals in the environment. Dioxins, furans and metals are persistent and accumulate in the environment. Only incinerators that have the necessary permits and authorizations may treat medical waste.
- Illegal dumping

Acceptable Disposal Options

The following disposal and treatment methods are considered acceptable:

- Incinerate – decontaminate
- Sterilisation (e.g. autoclaving or Logmed)
- Chemical disinfection
- Landfill **after** acceptable treatment
- DWAF policy on the disposal of medical waste states that, should there be technological options other than incineration available for the treatment of bio-hazardous waste (excluding anatomical parts, radioactive waste and chemotherapeutic waste) - which will have final results, with regard to impacts to the environment and human health similar to, or better than, that of incineration - the Department will consider motivations to use these technologies. This implies that all infection risk/potential should be completely eliminated over time, **and** that the waste should no longer be recognisable as of medical origin.

Industry Trends and other Information

Non-burn technologies (e.g. autoclaving).

Legislation, new regulations – Gauteng Health Care Waste Management Regulations were promulgated in 2004.

SANS 10248 (2004) Management of Health Care Waste, colour-coding requirements for containers as follows:

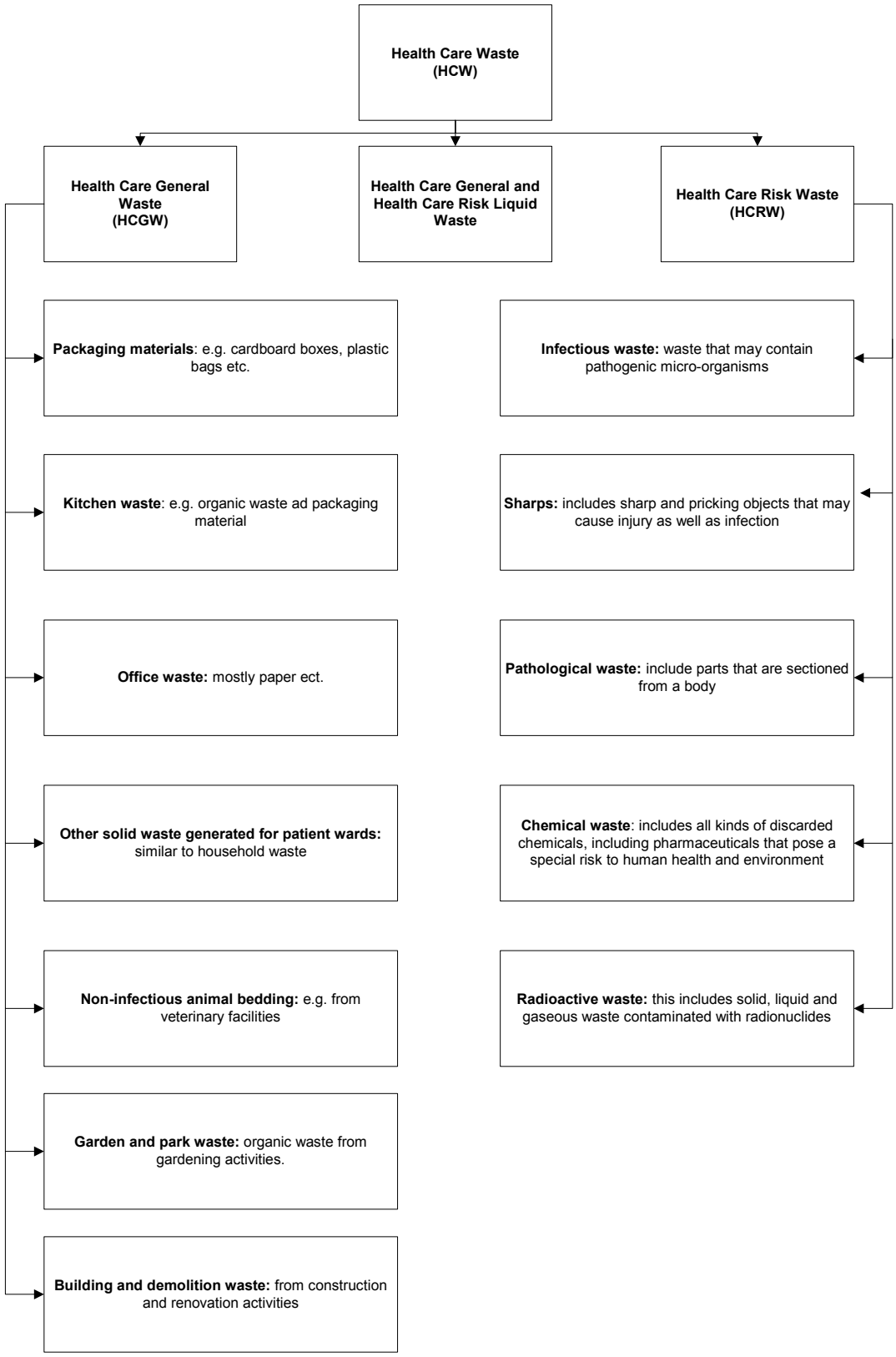
- Human anatomical – red
- Infectious non-anatomical waste – yellow

Illustrative Photos

Medical waste mixed with general waste, disposed at general landfill sites	

MEDICAL WASTE / HEALTH CARE WASTE (HCW)	16
Sharps containers	

FIGURE 1: PRIMARY HEALTH CARE WASTE CATEGORIES



REDUNDANT PESTICIDES | 17

Waste Generation Processes / Industrial Application

Pesticide waste is generated by agriculture, household and commercial use.

Background Information

"Pesticides" is a general term that includes insecticides (for insect control), herbicides (for weed control), rodenticides (for rodent control), fungicides (for control of plant disease fungi), miticides (for mite control), as well as wood preservatives, disinfectants, and products that control algae. A more complete list includes the following:

Pesticide type	Target Organism
Acaricide	Mites
Algicide	Algae
Avicide	Birds
Bacteriacide	Bacteria
Disinfectant	Microorganisms
Fungicide	Fungi
Herbicide	Plants
Insecticide	Insects
Larvicide	Insect larvae
Molluscicide	Snails, slugs
Nematicide	Nematodes
Piscicide	Fish
Rodenticide	Rodents

In brief, a pesticide is any substance, or mixture of substances, used to kill, drive away or prevent a pest.[1]

A pesticide is more accurately defined by the Department of Agriculture, in the Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act, 1947 (Act 36 of 1947) as follows:

"Any chemical substance or biological remedy, or any mixture or combination of any substance or remedy intended or offered to be used:

i. for the destruction, control, repelling, attraction or prevention of any undesired microbe, alga, nematode, fungus, insect, plant, vertebrate, invertebrate, or any product thereof, but excluding any chemical substance, biological remedy or other remedy, in so far as it is controlled under the Medicines and Related Substances Control Act, 1965 (Act No. 101 of 1965), or the Hazardous Substances Act, 1973 (Act No. 15 of 1973; or

i. *as plant growth regulator, defoliant, desiccant or legume inoculant, and anything else which the Minister of Agriculture has by notice in the Gazette declared an agricultural remedy for the purposes of Act 36 of 1947."*

[1] http://www.doh.gov.za/department/foodcontrol/pesticides/summary.html

REDUNDANT PESTICIDES 17

Some commonly redundant and/or stockpiled pesticides are:

- Alachlor
- Atrazine
- Carbofuran
- Carbaryl (Sevin)
- Chlordane
- Chlorpyrifos
- Diazinon
- Dichlorvos
- Dimethoate
- Endrin
- Glyphosphate
- Heptachlor
- Lindane
- Metaldehyde
- Methoxychlor
- Malathion
- Propetamphos
- Pyrethrins

Legislation

The Fertilizers, Farm Feeds, Agricultural Remedies and Stock Remedies Act of 1947 controls the sale and registration of veterinary and agricultural remedies, and sets certain standards for pesticide residues on the export of fruit.

African Stockpile Project

The aim of this project is to clean up obsolete pesticides in African countries, prevent future toxic threats and protect human health and the environment. There were some projects in SA focussed on the collection and destruction of stockpiled pesticides. However, the best way to dispose of the pesticide waste, currently, is through hazardous waste companies.

The following partners are currently involved in the development of the African Stockpiles Programme, or are expected to participate:

World Bank, The African Union, Basel Convention, Food and Agricultural Organization, Pesticide Action Network, Croplife International, World Wildlife Fund, and the World Health Organization.

Classification and Rating

Pesticide	Hazardous constitute	SANS 10228 UN no.	SANS 10228 Class	Hazard Rating	Properties
Alachlor	Chloracetamide	1993	3	n/a	Flammable liquid
Atrazine	Triazine	2764	3	3[1]	Liquid toxic, flammable
Carbofuran Carbaryl (Sevin) Propoxur	Carbamate	2992	6.1	3[2]	Liquid toxic
Chlordane Endrin, Heptachlor Methoxychlor	Cyclodiene DDT type	2761	6.1(III)	1[3]	Toxic
Chlorpyrifos Diazinon	Type B organophosphate	3017	6.1	1[4]	Toxic
Lindane	Organochlorine	2996	6.1	2[5]	Toxic

Pesticide SANS 10228 Classification

General classification	SANS 10228	SANS 10228 Class	Properties

[1] LC50 96hr 13.5mg/l

[2] LC50 96hr 18mg/l

[3] LC50 96hr 0.22mg/l

[4] LC50 96hr 0.007 mg/kg

[5] LD50 (oral rat) 76 mg/kg

REDUNDANT PESTICIDES			17
	UN no.		
Pesticide liquid	3021	3	Liquid flammable
Pesticide liquid	2903	6.1	Liquid toxic
Pesticide Solid	2588	6.1	Solid toxic
Pesticide aerosol	1950	9	Toxic

Environmental and Health Concerns

Stockpiling of old and unused pesticide is a *hazard to human health,* and can lead to *contamination of water sources* and/or *long-term contamination of soil and other natural resources*.

Pesticides must, therefore, not be stored in places where flooding is possible, or in places where they might spill or leak into boreholes, drains, ground water or surface water.

Pesticide priority pollutants generally constitute chlorinated hydrocarbons, including compounds such as aldrin, dieldrin, DDT, DDD, endosulfan, endrin, heptachlor, lindane and chlordane. These pesticides bio-accumulate in body fats and can move up the food chain. All but three of the 12 POPs (*Persistent Organic Pollutants)* listed in the Stockholm Convention are pesticides, some of which feature prominently in obsolete pesticide stockpiles.

Pesticides and the environment:

The impact of pesticides on the abiotic environment can be summarised as follows:

- Pesticides can move from their target area due to drift/volatilisation, leaching and runoff. Drift usually occurs during ground or aerial spraying, and as much as 30 % of spray applications can move greater than 15 m from the intended site. Thus, pesticides can impregnate the soil, leach into groundwater and flow into water systems, thus impacting on the soil/water fauna and flora.
- Leaching of pesticides to the soil can have a variety of negative effects. It may lead to the contamination of groundwater and potable water, making them unfit for human consumption. The contamination of groundwater can be more severe in areas with high rainfall. The leaching of herbicides is a serious problem, as they are directly applied to soil and are water soluble, thereby rendering them more mobile

Pesticide constituents and their health concerns:

Carbaryl is severely restricted for use as a pesticide because it is gonadotoxic, embryotoxic, mutagenic, persistent, can cause impaired reproductive function, and is likely to form the carcinogen n-nitrosocarbaryl.

The following uses of *carbofuran* are prohibited: 1) on vegetables, tea, fruit trees and herbs; 2) against insects that are harmful to the health of humans and animals; and, 3) for rat control, except when formulated as a rodenticide. Carbofuran is only permitted as a seed dressing in ditches, or in the form of powder for the treatment of soil - it must be applied with an appropriate tool or gloves. It is prohibited as a spraying agent.

Many *carbamates* have carcinogenic, teratogenic and mutagenic properties. The N-alkyl-carbamates can react with nitrite to form N-nitroso compounds. In Third World Countries, poisoning is mainly caused by organophosphate and carbamates, especially since the replacement of organochlorine pesticides.

Arsenicals are no longer permitted for use in agriculture, and are restricted to use by industrial plants for wood treatment. The control action applies to arsenical insecticides. These substances are banned for production and use as pesticides. Non-agricultural uses are still allowed. Arsenic and its compounds are highly toxic.

Arsenical has the following adverse effects of concern: mutagenicity, teratogenicity, fetotoxicity, acute toxicity, and human epidemiological studies have indicated that it may cause carcinogenic effects. Mutagenic tests have shown that sodium arsenite has the potential to cause chromosomal changes in humans. Its solubility and toxicity make it a hazard to water supplies.

Aldrin is persistent in the environment, is bio-accumulative and produces food-chain effects.

DDT is prohibited for use or place on the market in all plant protection products. DDT is persistent in the environment. It is likely to bio-accumulate and produce food chain effects on terrestrial and aquatic organisms. DDT has been classified as a B-carcinogen (possible carcinogenic to humans).

Dieldrin is persistent in the environment. It is also likely to bio-accumulate and produce food-chain effects on terrestrial and aquatic organisms. Dieldrin has been classified as a class C&D carcinogen (MR).

Endosulfan is banned and has no remaining uses. Endosulfan has a low LD50 and is, thus, characterised as highly toxic. Endosulfan has high persistence in soil, and is extremely toxic to fish and bees. Some cases of intoxication among workers have been reported.

Heptachlor is prohibited for use as a pesticide. It is highly toxic to both warm-water and cold-water fish species, as well as birds, and is persistent and hazardous to human health.

Chlordane: prohibition on the sale, acquisition, disposal or use of chlordane in any form. Chlordane is not a single chemical, but is a mixture of many related chemicals, of which about 10 are major components. It is typically used to control termites in homes; however, it is also used as a pesticide on agricultural crops, lawns and gardens and as a fumigating agent. Due to concerns about cancer risk, evidence of human exposure and build-up in body fat, persistence in the environment, as well as danger to wildlife, the use of this substance was banned in the United States in 1978**.**

Trade names of Chlordane include the following: *Ortho-Klor (Chevron), Kow-Klor (Dow), Belt, Chlordan, Gamma Chlordan, Kypchlor, Corodane, Dowchlor, Oktaterr, Topichlor, Snyklor, Octacholor, and Velsicol 1068.*

Unacceptable Disposal Options

The following disposal methods are not considered acceptable:

- Sold/given to staff and community
- General landfill
- Open burning
- Discharge down sewage or storm-water drains
- Aerosol dispensers should never be punctured or heated, and are not recycled.

Acceptable Disposal Options

The following disposal methods are acceptable:

The SANS 10206:2005 handling, storage and disposal of pesticides Standard specifies the procedure and requirements for the handling, storage and disposal of pesticides by household users, farmers, pest control operators, distributors, manufacturers, formulators and packers, in order to ensure the least risk to health and safety, as well as to property and the environment.

- High-temperature incineration – decontamination and thermal destruction
- Encapsulation – macro-encapsulating the organic pollutants
- H:H landfill
- Chemical treatment
- Empty pesticide containers:

- Triple-rinsing empty container, recycling and recovery of containers is preferred.
- Controlled incineration for energy recovery.
- Cutting or puncturing of other empty pesticide containers made of metal or plastic, (where the container is not destroyed), should be carried out, in order to prevent reusing (for other applications).

Empty triple-rinsed pesticide containers (plastic) that have been rendered unserviceable could be considered for processing (recycling) into other products, such as building construction material.

Industry Trends and other Information

Use of biodegradable products such as bio-pesticides and bio-fertilizers.

Triple-rinsing is the minimum requirement for decanting the containers, and is promoted by all Croplife International member associations and leading companies. Croplife International represents the plant science industry.

Triple-rinsing refers to partly filling the empty container with water three times, and emptying it into a sprayer, prior to application to the crop. With containers made of appropriate material (such as High Density Polyethylene), triple-rinsing removes more than 99.99% of contaminating residue. Similar results can be achieved with integrated pressure rinsing, using specialised equipment incorporated in some modern, self-propelled spray application equipment.

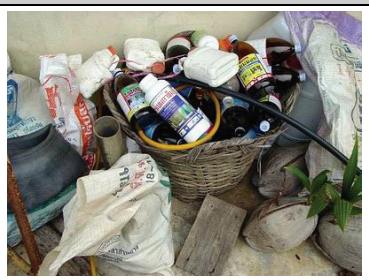
Recycling or recovery of containers is the preferable disposal option. However, this may, currently, not be possible in all countries. Recycling can take a number of different approaches:

- Recycle through re-use of multi-trip containers – these are especially suitable for big container volumes.
- Recycling of the material - especially plastics - into other products, such as fence posts, or aggregate in recovery of energy from containers, for example: thermal recovery in approved cement kilns.
- Chemical conversion in methanol production.

Developments in bioremediation options are researched for the degradation of certain pesticides, like DDT.

The new pesticide management policy for South Africa is available for public comment. Government Gazette, 13 April 2006, Notice 499 of 2006, No. 28711.

Illustrative Photos

Empty pesticide containers	   

PAINT WASTE AND EMPTY PAINT CONTAINERS | 18

Waste Generation Processes / Industrial Application

Waste paint and empty paint containers are generated by:

- The paint manufacturing and car manufacturing industry.
- Maintenance of buildings or painting of any surface, article, product, machine etc that produces residual paint and empty paint containers.
- Decorators and sign-writers.

Background Information

Different types of paint:

- Water-based: latex.
- Oil-based: enamel, lacquer, shellac and varnish - contains solvents.
- Hobby or artist: colouring paints - may contain solvents or heavy metals.
- Aerosols: spray paints - contain solvents and propellants.

Different uses:

- Consumer paints; interior and exterior paint (water-based and solvent-based).
- Paints for industry; solvent-based and water-based paint.
- Paints for special surfaces; primers and varnishes for tiles, metal, galvanised iron, wood and plaster surfaces.

Most paint has four components: *resin, solvent, pigment and additives.*

- The **resin** is the main ingredient and forms a coating or film on the surface being painted. This typically non-hazardous component includes linseed, acrylic or other synthetic resins.
- The **solvent** keeps the paint in a liquid form, until the solvent evaporates after the paint is applied. The solvent in oil-based paint is derived from a petroleum distillate and can include hazardous ingredients, such as mineral spirits, toluene and xylene. The solvent in water-based paint is water.
- **Pigments** provide the colour and covering power. The major pigments used presently are titanium oxide, iron oxide, calcium sulphate, clay or silicates. These pigments are relatively non-toxic. Some highly coloured pigments may contain heavy metals, such as lead, chromium, cadmium or arsenic. Lead is still used as a pigment in some darker coloured paints.
- **Additives** are the substances added, in small quantities, to a coating material, in order to improve or modify one or more properties. Some types of additives include stabilizers that prevent paint deterioration in the can, dryers that assist in the formation of the paint coating, thickeners that aid in application, and preservatives that inhibit the growth of moulds. Additives are the specialist components of paint: they are used in small quantities to improve production and storage properties of the liquid paint product, as well as application and other performance properties of the paint film.

Some typical additives that are used are:

Wetting/Dispersing agents - used to facilitate wetting of the pigment particles, and dispersion of coarse aggregated pigment particles to the degree of fineness required.
Anti-settling agents - used to reduce settling of pigment particles during storage.
Anti-skinning agents - used to prevent the formation of a tough skin film on the liquid paint during storage.
Drying/Curing agents - used to improve and control the drying properties of the paint film.
Stabilisers - used to improve long-term storage properties of the liquid paint.
Anti-foaming agents - used to prevent foaming of water-based paints during manufacture and application.

Anti-marring agents - are usually silicone-based compounds that are used to improve resistance to scratching and marring of the paint film.
Anti-mould agents - used to reduce mould growth on the paint film in very damp and humid environments.

Water-based paints can be identified by the words on labels such as: clean with soap and water, latex, vinyl, acrylic.

Solvent-based paint may have words on the labels like: alkyl, oil-based, urethanes, varnish, clean with thinners, contain petroleum distillates, combustible.

Lead is one of the commonest elements on earth and is very widely distributed. It is for this reason that it is difficult to call anything “LEAD FREE", and some manufacturers prefer to use the term "NO ADDED LEAD" when referring to the subject.

SANS and EC (European) procedures require that preparations containing lead at levels >0.5% be labelled TOXIC. Lead is encountered in various forms. The more toxic forms are those that are soluble, especially in acid. This is because the digestive system uses acids in the stomach and, thus, if the compound is soluble in acid, the body can easily absorb it.

The solubility of lead compounds encountered in the paint industry, past and present, are:

- Oxides litharge and red lead — Highly soluble
- Carbonates white lead — Highly soluble
- Sulphate white lead (artists colours - historical) — Highly Soluble
- Chromates red, orange, yellow and green pigments. — Low Solubility
- Plumbates: calcium plumbate — Moderately Soluble
- Driers lead salts of various organic acids — Low Solubility

When evaluating lead levels in paint, this must be done on a basis of soluble lead and total lead.
Total lead on total paint - levels greater than 0.5 % require labels to warn users (SANS 10265/CHIP3).

Total lead on solid paint - any paint containing >5% soluble lead is classified by, and its use restricted by, the Lead Regulations, promulgated under the Occupational Health and Safety Act.

There are three ways in which lead can penetrate a surface coating by intent:

1. The first is its use as a **catalyst** in the manufacturing of the synthetic resin, as well as its use as a catalyst in assisting the drying process. Over the years, these have been reduced or eliminated, and if the level of lead is above 0.15% then the label should carry the warning "Contains Lead. Not to be used on surfaces likely to be sucked or chewed by children". Reputable manufacturers do not supply such paints for the domestic market. In any case, the quantity of lead is extremely low - usually below 0,15% - on solid paint.

2. The second is its use as a **primer**.
   a) White lead has excellent preservative properties when used on wood. This is now only of historical interest, as its use has been discontinued as a result of toxicity - only very old buildings will still have remains of these primers. The soluble lead content of the lead compound used is relatively high. With a total lead content of ±80%, the soluble level is also ±80%. Besides its use in primer, White lead was, at one time, used as a white pigment. This is no longer the case, as it is more economical to use titanium oxide, which is more effective in terms of colour, durability and cost. White lead began to be phased out in the 1940's. The only place where paints containing this lead pigment would be present today is in very old buildings, which would, probably, also be of wooden construction.

b) Red lead has given excellent results when used on steel structures. Its use has also fallen away, due to toxicity concerns, not only in manufacture and application, but also in removal. One way to re-coat a structure painted with Red lead is to remove the old coatings with abrasive (sand) blasting and contain the resultant dust. Some operators resort to wet sand blasting. This lowers the dust problem, but the run-off must be contained and disposed of as hazardous waste. This is difficult and costly. As in the previous case, the soluble lead content of the lead compound used is relatively high: with a total lead content of ±90% the soluble level is also ±90%. It is doubtful that Red Lead was ever used as a colorant, as it is too expensive, compared to iron oxides.

c) Calcium plumbate is still used as a substitute for red lead in primers, especially for galvanised iron. As this is a very specialised application, its use is very limited. With a total lead content of ±60%, the soluble level is also ±60%.

3. **Pigments**. Lead pigments are still the best choice for yellow, orange, red & green (yellow/blue mix), and these are in the form of lead chromate complexes, often with molybdate ions. These pigments contain fairly high total lead levels, but very low soluble lead levels. The toxicity is more related to the chromate content than the lead content, and this makes them more hazardous (in the powder form) to the manufacturer, rather than to the end user. It must be borne in mind that the lead is encapsulated in the pigment and this is, in turn, encapsulated in the paint; therefore, risks to the paint user are relatively low, unless the paint is sanded or abraded.

4. Nevertheless, mindful of the less than 0.15% rule, the use of these pigments in the decorative market has been virtually eliminated.

Guidelines for lead containing waste

Note - CHIP Chemical Handling Information for Packaging
References to icons and safety phrases are based upon UK [EC] requirements.

Lead levels

A.	>0.15% soluble lead *"Contains Lead. Should not be used on articles likely to be sucked or chewed by children*".	CHIP requirement - NOT an EC risk phrase. EC Phrases not required.
B	>0.5% <10% total lead chromate	CHIP requirement "T" R61, 33
C	>10% lead chromate	CHIP requirement "T" R61, 33,40
D	>0.5% <25% total lead	CHIP requirement "T" R61, 33
E	>25% total lead	CHIP requirement "T" R61, 20/22,33
F	>1.0% total lead - "Contains Lead".	SAPMA label requirement
G	>5% Sol lead on NV "LEAD PAINT"	OHS Act, Lead regulation, label requirement

In the UK, lead usage is controlled by the Safety at Work Act - Lead Regulations. This is in line with the South African OHS Act - Lead Regulations.

A paint with < 1% but >0.5% lead would not be subject to the lead regulations, but would still be subject to the CHIP requirements.

PAINT WASTE AND EMPTY PAINT CONTAINERS | 18

Labels

Any paint containing more than 0.15% total lead supplied should carry the following warning: "Contains Lead - not to be used on surfaces liable to be sucked or chewed by children." This is a requirement of the South Africa Paint Manufacturers Association (SAPMA) for mandatory label requirements.

Paints and similar materials having a total lead content in excess of 0.15 %, calculated on the total material as supplied, will carry the legend:

"CONTAINS LEAD. *SHOULD NOT BE USED ON SURFACES LIABLE TO BE CHEWED OR SUCKED BY CHILDREN".*

This is in addition to any phrases allocated for other components.

Paints and similar materials having a total lead content greater than 0.5% on the total weight of the material as supplied.

The "TOXIC" Icon and the aforementioned legend should be used, along with the phrases:

R20/22	Harmful by inhalation and if swallowed.
R33	Danger of Cumulative effects
R61	May cause harm to unborn child

Those materials with a soluble lead content greater than 5% on the non-volatile content of the material must, in addition to the requirements given above, also carry the legend: "LEAD PAINT".

Classification and Rating

	SANS10228 UN No's	***SANS10228 Class***
Paint	**1263** – Paint	3(II)
Paint and paint related material	**3066** – Paint or Paint Related Material	8(III)

Paint can contain the following hazardous constituents:

Hazardous constituents	***SANS 10228 UN No***	***SANS 10228 Class***	***Hazard Rating***	***Acceptable exposure***
Ethylbenzene 100-41-4	1175	3(II)	3	Environmental Exposure: 11.5ppm Human Health Exposure: 3.4ppm
Toluene 108-88-3	1294	3(II)	3	Environmental Exposure: 2.6ppm Human Health Exposure: 7.8ppm
Xylene(mixed isomers) 1330-20-7	1307	3(II)	3	Environmental Exposure: 1.5ppm Human Health Exposure: 6.3ppm
N-Dibutyl Phthalate 84-74-2	-	9	4[1]	-
Lead 7439-92-1	2291(Lead Compound)	6(III)	2	Environmental Exposure: 0.12ppm Human Health Exposure: 0.02ppm
Lead(II) Sulfate 7446-14-2	1794	8(II)	4	Environmental Exposure: 64ppm

[1] LD50 oral 8000mg/kg DOSE

Lead Chromate 7758-97-6	-	6.1(III)	4[1]	-
Titanium oxide 13463677	-	9	4	>1000000ug/l (LC50 96hr) 1000mg/l
Iron oxide 1309-37-1	-	9	3	>40ppm LD50
Calcium sulphate 7778189	-	9	4	2980000ug/l LC50 96hr 2890 mg/l
Lead containing paint	1263	3(II)	2	
Solvent containing paint	1263	3(II)	3	
Water based paints	1263	3(II)	4	

Environmental and Health Concerns

Water-based paints discharged into stormwater can pollute waterways. These paints contain a solid pigment that can increase turbidity of water, releasing particles that can clog the gills of fish, and blocking out sunlight, which will reduce the photosynthesis of the plants. The paints also contain biodegradable substances, such as surfactants and cellulose-thickeners, which, as they break down, reduce the oxygen levels of the water, thus adversely affecting the survival of the aquatic organisms.

Solvent-based paint can cause pollution if discharged into stormwater or sewage. The organic solvents, and other organic compounds, mix with water and use up valuable oxygen as they break down.

Heavy metals in the pigment will also lead to contamination of the water source and/or soil.

Paint and empty paint containers may only be burned under controlled circumstances, in order to prevent toxic gasses, such as Volatile Organic Compounds (VOC), from being released.

Large amounts of ingested lead or lead chromate can accumulate in the body. Bioaccumulation of lead chromate may occur along the food chain, for instance in fish, plants and mammals.

Unacceptable Disposal Options

- Discharged into stormwater
- Discharged into effluent (especially flammable solvent-based paints)
- Burning - especially solvent-based paint (releases VOC emissions during combustion)

Acceptable Disposal Options

- General Landfill- dried and solidified water-based paint (small quantities)
- H:H landfill – large quantities of waste
- H:H landfill - solvent/oil-based.
- Re-used on site - excess paint
- Recycle – all empty and dry paint metal containers are recyclable. However, one must ensure that recycling is carried out in a manner that does not pollute the environment. For example, residual paint in a container stored at a metal recycler may spill out of the container and seep into the ground and groundwater regime – this must be avoided.

[1] LD50 oral 12000mg/kg DOSE

PAINT WASTE AND EMPTY PAINT CONTAINERS | 18

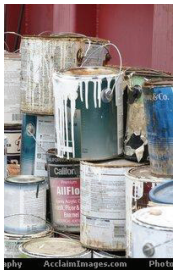
- Note that flammable paint waste must be stored separately from other wastes.

Industry Trends and other Information

Low VOC formula paints.
Eliminating/decreasing lead content in dark coloured paints.
Increase the use of water-based paints for different applications.

Illustrative Photos

Empty paint containers (metal & plastic)



USED AND CONTAMINATED CHEMICAL CONTAINERS | 19

Waste Generation Processes / Industrial Application

All industries that use oils, chemicals and hazardous substances in their processes, or for their facilities, will generate empty and used containers and contaminated packaging.

Background Information

Used and empty containers, as well as contaminated packaging containing residues from previous contents that can pose serious risks to people and the environment, if they are not cleaned and handled responsibly.

Current production quantities of drums and containers in South Africa are estimated at[1]:

- 210 litre steel ± 2 million
- 25 litre steel ± 8 million
- 210 litre plastic ± 0.6 million
- 25 litre plastic ± 10 million

[1] RCMASA (Responsible Container Management Association of South Africa)

USED AND CONTAMINATED CHEMICAL CONTAINERS	19

- Intermediate Bulk Containers (IBC's) ± 10 000
- Imports & traders = exact figure not known.

Responsible Container Management is a process that follows the entire lifecycle of a container. Its purpose is to address economic, legal and regulatory concerns associated with container use.

Re-processing of used containers (whether carried out by original manufacturers, product fillers, recyclers, or re-conditioners who offer for re-use) includes the following activities:

- Washing/cleaning for re-use
- Reconditioning
- Refurbishment
- Routine maintenance
- Repair

Re-processors of Previously Certified Packaging shall be audited against the National Standard SANS 10406 (Transport of Dangerous Goods), in order to ensure their ability to:

- Reprocess & test, in terms of international best practice.
- Ensure quality, integrity & safety of packaging offered for re-use.
- Comply with the law.

General procedures for reprocessing plastic drums state:

- Plastic drums that previously contained pesticides or animal health products are currently excluded.
- Plastic drums that have contained other products may be re-manufactured or re-conditioned.
- Re-manufacturing shall be done in accordance with requirements of SANS 10229 for the original manufacture of that type of drum.
- All previous contents shall be removed.
- Minimal absorption of previous contents is acceptable, provided that it does not impact structural integrity or cause compatibility problems with future contents.

General procedures for reprocessing steel drums and IBCs:

- Steel containers may be washed by the company or by re-processors.
- Washed and tested.
- Must go to registered re-conditioner.

Decontamination by washing is not recommended by the community/public because:

- Containers may not be washed at all (by the public /community);
- Containers are not checked by the company to establish if they have been cleaned sufficiently;
- The containers' material (e.g. some plastics) absorbs the chemical substance, and releases it again when filled with water (or other substances); thus, washing will not decontaminate the container adequately.

Classification and Rating

Classification and Hazard Rating will depend on the original or decanted substance stored in the container.

Environmental and Health Concerns

USED AND CONTAMINATED CHEMICAL CONTAINERS | 19

Containers are often given or sold to the staff and community, who will then use the containers for water or food storage. The containers can contain residual toxic chemicals, which can pose a serious health risk to people.

Used and contaminated containers that are not stored properly and are exposed to the elements (sun and rain) can leak and contaminate surrounding soil, water and groundwater.

Unacceptable Disposal Options

The following disposal methods are not considered acceptable:

- Inefficient incineration or burning of containers can release highly toxic substances (e.g. chlorides from PVC plastics) into the atmosphere.
- Sold/given to staff and community.
- General landfill.

Acceptable Disposal Options

The disposal option will depend on the hazard rating of the original contents of the container.

The following disposal methods are acceptable:

- Return to supplier
- Re-use on site
- Re-condition (send to drum registered re-conditioners (steel) or re-processors (steel & plastic))
- Recycle – material value
- Incinerate – decontaminate, thermal destruction
- Incinerate– energy value of plastic containers (e.g. cement kilns)
- Hazardous Landfill

Considerations for minimisation of generation of container waste:

- Minimising generation of container waste - using bulk re-usable containers (especially if supplier is not able to take back empty containers for re-use).
- Crushing, drilling and punching holes into container, when there is a risk of staff taking containers for their personal use (risk of poisoning).

Industry Trends and Other Information

Re-conditioning of containers, or returning containers to supplier for reuse/recycling, are becoming preferred approaches.

Where chemicals are decanted into containers, ensure that the containers are labelled correctly.

Section 15 of the Hazardous Chemical Substance Regulations, under section 43 of the Occupational Health And Safety Act, No. 85 Of 1993, requires all vehicles, re-usable containers and covers that have been in contact with HCS (hazard chemical substances) waste to be cleaned and decontaminated after use, so as to ensure that they do not cause a hazard inside or outside the premises concerned.

DEAT is introducing producer responsibility into new standards and policies as part of the national waste management strategy.

USED AND CONTAMINATED CHEMICAL CONTAINERS	19
Illustrative Photos	
Plastic chemical container	 
IBCs (intermediate bulk containers)	 
Metal drum	

CONSTRUCTION AND DEMOLITION WASTE (BUILDING RUBBLE)	20
Waste Generation Processes / Industrial Application	
This waste stream includes waste building materials, dredging materials, tree stumps, rubble resulting from construction, remodelling, repair, pavements, as well as demolition operations on houses, commercial buildings and other structures. Demolition sites generate more concrete, asphalt and metals, while construction generates more corrugated containers, wood and gypsum wallboard. Demolition and remodelling activities are more prone to generate asbestos and lead-contaminated materials.	
Background Information	
Large quantities of materials are used in building construction. Every day old buildings are being demolished and replaced by new ones. The debris from these demolished buildings can be used as cover material for landfills, but is often illegally dumped, thus causing environmental degradation. Waste material generated during the demolition of a building includes: soil, sand, gravel, concrete, stone, bricks, wood, metals, glass, plastics, paper, board and textiles. Demolition and construction waste may contain lead, asbestos or other hazardous materials.	

CONSTRUCTION AND DEMOLITION WASTE (BUILDING RUBBLE) 20

Construction and demolition waste generation varies on building projects, according to the type of construction and the stage of construction. Typically, the waste generated from clearing a new site in preparation for development, and also during construction, is likely to be mostly soil, clay and stone, together with smaller amounts of damaged or substandard building materials. Oil spills during operations on site contaminate soil.

Concrete, brick and masonry waste from construction and demolition sites is both reusable and recyclable. None of it should end up in landfill sites. Many of the waste materials from construction and demolition projects can be reused or recycled into new materials. For instance:

- Wood
- Drywall
- Metal
- Rubble
- Cardboard/paper
- Concrete

The primary motivation for reducing and recycling construction waste is, generally, economic. Contractors should evaluate the potential for recycling construction waste, in order to determine if recycling is economically viable.

Limiting Factors on expanding the Reuse and Recycling of C & D Wastes:
Inconsistency of materials - with wastes coming from different sources and containing different materials in different proportions - render reuse and recycling difficult.
Hazardous components in construction waste can include material and substances like asbestos, chemical and oil spills, and electronic waste. Hazardous constituents that can be found in construction and demolition waste are detailed in the table below:

Types of Hazardous constituents in C&DW		
	Waste Streams	**Examples**
1	Some C&DW streams are hazardous because the materials originally used contained a high proportion of materials, which were themselves hazardous.	Examples include asbestos, lead, tars, paint and preservative residues, adhesives, bonding agents, sealants and certain plastics.
2	Some materials become hazardous as a direct result of the environment in which they have existed for many years.	An example would be a factory where surface reactions between the originally non-hazardous building materials and chemicals carried in air (or water) pollution, associated with the processes in, or near, the factory resulted in parts of the building's fabric becoming hazardous, and requiring special handling or treatment.
3	Some C&DW streams become hazardous if hazardous materials are left in them and/or subsequently get mixed with them.	The classic example concerns lead-based paint tins thrown onto a pile of bricks and concrete, making the whole pile hazardous waste.

Classification and Rating

SANS10228 Class & UN No: depends on content.
Demolition and construction waste may contain lead, asbestos, or other hazardous materials.

CONSTRUCTION AND DEMOLITION WASTE (BUILDING RUBBLE) 20

Environmental and Health Concerns

Construction and demolition (C&D) waste is generally bulky and dense, taking up more landfill space than other materials.

Why Recycle C & D wastes?

- C & D wastes are mostly unsuitable for other routes, such as incineration and composting.
- Emissions generated during transportation.
- Expensive transportation and disposal costs.
- They use up a great deal of landfill space.

Benefits of recycling construction and demolition wastes are:

Reduced environmental impacts.
Reduced volume of waste going to landfill sites.
Reclamation of valuable items, like metals and bricks.
Avoided extraction of virgin materials by using old concrete and stones.
Reduced transport costs to landfill sites.
Safer construction sites.

Unacceptable Disposal Options

Illegal dumping

Acceptable Disposal Options

The following disposal methods are acceptable:

- Re-use – on site
- Recycle – material value
- Landfill
- Separation of potentially hazardous waste from building rubble before disposal.

Possible reuses for C & D wastes include:

- Landfill – used for daily and final cover.
- Landfill temporary access roads.
- Fill for road and airport embankments.
- Land reclamation.
- Cover and bedding materials for landfill liners.
- Construction drainage control.

Industry Trends and other Information

Demolition sites contaminated with oil or other spills must be properly cleaned or removed before demolition or disposed with hazardous waste.

Old buildings may contain asbestos-containing material that must be safely removed before any demolition.

Alternative uses for construction and demolition waste that is recovered for re-use include: bulk fill, landscaping, alternative informal housing materials, and landfill engineering.

CONSTRUCTION AND DEMOLITION WASTE (BUILDING RUBBLE) 20

At present, recycling activity is limited to two operations in Durban and Cape Town. The process of recycling converts low value construction and demolition waste into secondary construction materials, including various aggregate grades, road material (G2 and G5), and aggregate fines (dust).

These materials are used in construction applications, such as: road construction, backfill for retaining walls, fresh concrete production, drainage and brickwork, and block work for low-cost housing.

Cement waste is reused internationally by the cement companies, but in SA there is an opportunity to increase the volumes for reuse.

Illustrative Pictures

Rubble

Wood waste

6 SUMMARY TABLE – 20 WASTE STREAMS

No.	Waste Stream	Hazardous Constituents *(Element or compound that may be present in waste stream)*	SANS10228 Class and UN no.	Hazard Rating *(Min Req'ts)*	Disposal Options	Other Treatment Options
1	Used Oil ▪ Engine oil; ▪ Lubricating oil; ▪ Gear oil; ▪ Cutting oil; ▪ Hydraulic oil; ▪ Turbine oil ▪ Transformer oil	Inorganic substances, chlorinated solvents, and organic compounds. Metals such as aluminium, arsenic, barium, cadmium, chromium and zinc. Lead is also found in used oil from leaded fuels	Class 9 UN 3082 (Environmentally hazardous substance, liquid)	1	H:H landfill Recycle Reclamation	Alternative fuel Re-refining into lubricating oil Filtration
2	Hydrocarbon contaminated waste		Class 9(II) UN 3077 (Environmentally Hazardous Substance, solid)	1	H:H landfill G:B+ (must be tested and delisted, approval obtained from DWAF)	
3	Polychlorinated Biphenyls (PCBs)		Class 9(II) UN 2315	1	H:H landfill PCB destruction	PCB destruction
4	Edible/Vegetable oil	PAH	Class 9(II) UN 3082	1	Recycle (not for human consumption) Currently accepted at general landfills with food waste	
5	Solvents 1. Acetone 2. n-Butyl Alcohol	These solvents (solvents of concern) are restricted to landfill because of their	1. Class 3(II); UN 1090 2. Class 3(III); UN 1120	4 4	H:H landfill (HR1-4) H:h landfill (HR3-4)	Recycle Reuse

No.	Waste Stream	Hazardous Constituents *(Element or compound that may be present in waste stream)*	SANS10228 Class and UN no.	Hazard Rating *(Min Req'ts)*	Disposal Options	Other Treatment Options
	3. Carbon disulphide 4. Carbon Tetrachloride 5. Chlorobenzene 6. Cyclohexanone 7. 1,2-Dichlorobenzene 8. Ethylacetate 9. Ethylbenzene 10. Ethyl ether 11. Methanol 12. Methyl ethyl ketone 13. Nitrobenzene 14. Tetrachloroethylene 15. Toluene 16. 1,1,1-Trichloroethane 17. Trichloroethylene 18. Xylene	effect on liners.	3. Class 3(I); UN 1131 4. Class 6.1(II) UN1846 5. Class 3(III); UN 1134 6. Class 3(III); UN 1915 7. Class 6.1(III) UN1591 8. Class 3(II); UN 1173 9. Class 3(II); UN 1175 10. Class 3(I) UN 1155 11. Class 3(II); UN 1230 12. Class 3(II); UN 1193 13. Class 6.1(II) UN 1662 14. Class 6.1(III) UN1897 15. Class 3(II); UN 1294 16. Class 6.1(III) UN2831 17. Class 6.1(III) UN1710 18. Class 3(II); UN 1307	4 3 3 4 2 2 3 4 4 4 3 2 3 3 1 3		
6	Trichloroethylene (TCE)		Class 6.1(III) UN 1710	1	Recycle H:H landfill	
7	Spent Antifreeze	Ethylene glycol Propylene	Class 3 UN 1153	4	H:H landfill H:h landfill	
8	Lighting waste	Mercury (Hg) Lead (Pb)	8(III) 2809(Mercury)	1	H:H landfill H:h landfill (must be tested and delisted, approval obtained from DWAF)	
9	Electronic waste/e-waste		Class 9 UN 3077	1	Reuse Recycle	Reuse Recycle

No.	Waste Stream	Hazardous Constituents *(Element or compound that may be present in waste stream)*	SANS10228 Class and UN no.	Hazard Rating *(Min Req'ts)*	Disposal Options	Other Treatment Options
			(Environmentally Hazardous Substance, solid)		H:H landfill	
10	Ink and Toner Cartridges	Carbon black	Class 9(II) UN 3082 (liquid) UN 3077(solid)	3-4	Reuse Recycle H:H landfill	Reuse Recycle
11	Smoke detectors	Americium (radioactive)	Class 7 UN 2911	n/a	Return to supplier for safe disposal	
12	Wet cell batteries	Lead (Pb) Sulphuric acid	8 2794	2	Return to supplier Recycle	
13	Dry cell batteries	Cadmium (Cd)	Nickel-cadmium 6.1 2570	1	H:H landfill	Recycle Use rechargeable
		Zinc Mercury Lithium Manganese	Other 9 3077	2		
14	Asbestos and asbestos containing waste (ACW)		Asbestos blue & brown 9(II) 2212	1	H:H landfill Permitted landfill site	All fibrous material falling into ACW class A to C, must be double-bagged in plastic bags with a minimum thickness of 75 microns before the waste is transported to landfill
			Asbestos white 9(II) 2590			

No.	Waste Stream	Hazardous Constituents *(Element or compound that may be present in waste stream)*	SANS10228 Class and UN no.	Hazard Rating *(Min Req'ts)*	Disposal Options	Other Treatment Options
15	Boilers ash Different types: ▪ Domestic ash from households; ▪ Boiler ash from paper industries, mines, power stations, etc.; and ▪ Medical incinerator ash.	Can contain some trace elements depending on the coal composition: arsenic, boron, cadmium, chromium, copper, lead and zinc.	9 3077 (Environmentally Hazardous Substance, solid)	Depend on content	H:H Landfill H:h / G:B+ (Delisted boiler ash)	Any handling and treatment options of **boiler ash** should be in line with the DWAF Guideline on Handling and Disposal of Boiler Ash.
16	Medical waste categories ▪ Health Care Risk Waste (HCRW) ▪ Health Care General waste (HCGW)	 -Infectious waste -Sharps -Pathological waste -Chemical waste (pharmaceuticals) -Radioactive waste -Office paper waste -Packaging mater	Class 6.2(II) UN 3291	1	Incinerate Sterilisation (e.g. autoclaving or Logmed) General landfill (If properly sorted and separated from HCRW)	 General landfill Recycle – paper, plastic, glass
17	Redundant Pesticides 1. Pesticide liquid (Flammable) 2. Pesticide liquid (Toxic) 3. Pesticide solid 4. Pesticide aerosol	Alachlor Atrazine Carbofuran Carbaryl Chlordane	1. Class 3 UN 3021 2. Class 6.1; UN 2903 3. Class 6.1; UN 2588 4. Class 9; UN 1950	Depends on content (1-3)	H:H landfill	Thermal destruction (at approved and permitted site)

No.	Waste Stream	Hazardous Constituents *(Element or compound that may be present in waste stream)*	SANS10228 Class and UN no.	Hazard Rating *(Min Req'ts)*	Disposal Options	Other Treatment Options
		Chlorpyrifos Diazinon Dichlorvos Dimethoate Endrin Glyphosphate Heptachlor Lindane Metaldehyde Methoxychlor Malathion Propetamphos Propoxur Pyrethrins				
18	Paint waste Paint and empty paint containers	Solvent-based paint may have words on the labels like; alkyl, oil-based, urethanes, varnish, clean with thinners, contain petroleum distillates, combustible Water based paints can be identified by the words on labels such as – clean with soap and water, latex, vinyl, acrylic.	Lead containing paint Class 3(II) UN 1263	2	H:H landfill (wet paint) General landfill (dry paint containers) G:B+ (must be tested and delisted , approval obtained from DWAF)	Recycle (dry paint containers)
			Solvent based paint Class 3(II) UN 1263	3		
			Water based paint Class 3(II) UN 1263	4		

No.	Waste Stream	Hazardous Constituents *(Element or compound that may be present in waste stream)*	SANS10228 Class and UN no.	Hazard Rating *(Min Req'ts)*	Disposal Options	Other Treatment Options
19	Empty and near empty chemical containers	Toxic; Flammable; or Volatile chemicals	Class 9(II) UN 3077 (Environmentally Hazardous Substance, solid)	Depend on content	H:H landfill	Return to supplier Re-use – on site Re-condition (send to drum re-conditioners) Recycle – material value Incinerate – decontaminate, thermal destruction Incinerate– energy value of plastic containers (e.g. cement kilns)
20	Demolition and Construction waste (Building Rubble)	Asbestos and lead-contaminated materials Chemical and oil spills, electronic waste.	Class 9(II) Class 3077 (Environmentally Hazardous Substance, solid)	1-4	Permitted landfill Recycle and Reuse Asbestos (see No. 6)	Reuse Recycle Reuse as cover material

GLOSSARY AND ABBREVIATIONS

GLOSSARY

Acceptable Environmental Risk	The concentration of a substance that will have a minimal effect on the environment. This is represented by the $LC_{50,}$ multiplied by a chosen safety factor of 10% (0,1 x LC_{50}).
Acceptable Exposure	The concentration of a substance that will have a minimal effect on the environment or human health.
Acute Toxicity	Short-term toxicity of a product.
Bioaccumulation	The combined intake of pollutants from food and water by organisms.
Biodegradation	The process that breaks down a xenobiotic into a simpler form. Ultimately, the biodegradation of organics results in the release of CO_2 and H_2O into the environment.
Bio-magnification	Pollutants, such as metals, do not bio-accumulate in the food chain, and are "diluted" on the way up to the top of the food chain. Conversely, mercury and pesticides increase in concentration as they accumulate up to the top of the food chain. This is called bio-magnification.
Biotransformation	Compounds are often transformed into other materials by the various metabolic systems that reduce or alter the toxicity of materials introduced into the body.
Carcinogen	A substance or agent producing or inciting cancer. These substances can be grouped as **Class A** – carcinogenic to humans; **Class B(a)**- probably carcinogenic to humans; **Class B(b)** – possibly carcinogenic to humans; **Class C and D** – probably not a carcinogenic or not classifiable as carcinogenic to humans.
Chronic toxicity	Long-term toxicity of product in small repeated doses. The effects of prolonged exposure of organisms or of man to a chemical substance.
Ecotoxicity	The potential to harm animals, plants, ecosystems or environmental processes.
Generator	An industry, or other party, whose activities result in the production of waste. The responsibility for hazardous waste remains, from cradle-to-grave, with the generator of that waste. The Generator is held liable for any damage that the waste may cause to humans or to the environment.

Hazard Rating	A system for classifying and ranking Hazardous waste, according to the degree of hazard they present. This is based on Mammalian Acute and Chronic Toxicity, Ecotoxicity and Environmental Fate. Based on this, Hazardous waste is classified as: Extreme Hazard, Hazard Rating 1; High Hazard, Hazard Rating 2; Moderate Hazard, Hazard Rating 3; and Low Hazard, Hazard Rating 4.
Incineration	Incineration is both a form of treatment and a form of disposal. It is simply the controlled combustion of waste materials to a non-combustible residue or ash, and exhaust gases, such as carbon dioxide and water.
Minimum Requirements	Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste, Department of Water Affairs and Forestry.
Mutagen	Agents causing genetic mutations.
Ozone layer	A layer in the atmosphere, at an altitude of approximately 10-15km, where a relatively strong concentration of ozone shields the earth from excessive ultraviolet radiation.
Recycle	The use, re-use, or reclamation of a material so that it re-enters the industrial process, rather than becoming a waste.
Teratogens	Substances that have the capacity to cause birth defects.
Total Load Capacity	The capacity of a landfill site to accept a certain substance or the amount of a substance, which can be safely disposed of at a certain site. The total load capacity is influenced by the concentration level and mobility of the waste, and by the landfill practice and design.

ABBREVIATIONS

ACW	Asbestos containing waste
CFC	Chlorofluorocarbons
CHIP	Chemical Handling Information for Packaging
CPU	Central Processing Unit
CRT	Cathode Ray Tube
DDT	Dichloro-diphenyl-trichloroethane
DEAT	Department of Environmental Affairs and Tourism
DWAF	Department of Water Affairs and Forestry
EBS	Environmental Business Strategies (Pty) Ltd
EEC	Estimated Environmental Concentration
EIA	Environmental Impact Assessment
HCS	Hazardous Chemical Substances
HCW	Health Care Waste
HCRW	Health Care Risk Waste

HCGW	Health Care General Waste
HID	High Intensity Discharge
HR	Hazard Rating
IBC	Intermediate Bulk Containers
LC50	The median lethal dose is a statistical estimate of the amount of chemical, which will kill 50% of a given population of aquatic organisms under standard control conditions. The LC50 is expressed in mg/λ. There are many source documents available for determining the LC50. A recent and reliable source is "The Dictionary of Substances and their Effects" (see list of references). In cases where toxicological data are not available or doubtful, models should be used to derive a defensible hazardousness, in which case a qualified toxicologist should be approached.
LD50	The median lethal dose is a statistical estimate of the amount of chemical, which will kill 50% of a given population of animals (e.g., rats) under standard control conditions.
MAC	Maximum acceptable concentration
MR	Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste, Department of Water Affairs and Forestry
MSDS	Material safety data sheet
OEL	Occupation Exposure Level
OHS Act	Occupational Health and Safety Act
PAH	Polycyclic Aromatic Hydrocarbons
PC	Personal computer
PCBs	Polychlorinated biphenyl
ppb	parts per billion: One part per billion is 1 part in 1,000,000,000
ppm	parts per million: A unit of concentration often used when measuring levels of pollutants in air, water, body fluids, etc. One ppm is 1 part in 1,000,000. The common unit is **mg/litre.**
PPE	Personal protective equipment
PVC	Polyvinyl Chloride
SAFOI	South African Fryer Oil Initiative
SABS	South African Bureau of Standards
SANS	South African National Standards
SANS 10228	Identification and Classification of Dangerous Goods for Transport
SIN	Standard Identification Number
SME	Small and Medium Enterprises
TCE	Trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
UV	Ultraviolet
VOC	Volatile Organic Compounds
WHO	World Health Organisation
WRC	Water Research Commission

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- University of Pretoria, Department of Chemical Engineering Water Utilisation Division, Prof J Schoeman
- Used oil Toxicity: (www.nature.nps.gov/toxic/**oil**used.pdf) Acute Toxicity, Oil in Water Emulsion (mg/L):

Genus/Species	96h LC50
Juvenile American Flay-fish	4.85 #1
(sic) Flat-fish	0.827 #2

#1. Static test
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- http://www.planetnatural.com/site/xdpy/kb/hps-lamps.html
- http://en.wikipedia.org/wiki/Light-emitting_diode

9. Electronic Products
- Dell; http://www1.us.dell.com/content/topics/global.aspx/corp/environment/en/index?c=us&l=en&s=corp
- Directive on Waste Electrical and Electronic Equipment (WEEE); http://www.dti.gov.uk/sustainability/sus/index.htm
- DESCO Electronic Recyclers; http://www.desco.co.za
- E-Waste Guide; http://www.ewaste.ch/case_study_southafrica/
- U.S Environmental Protection Agency, http://www.epa.gov/
- Just say no to e-waste: Background Document on hazards and waste from computers; http://www.svtc.org/cleancc/pubs/sayno.htm#intro.htm
- LexMark South Africa http://www.lexmark.co.za/
- Ray Lombard; http://www.ewaste.ch/
- Technical Guidance for the Environmentally Sound Management of Specific Waste Streams: Used and Scrap Personal Computers; Basel Document

10. Inks and resins
- MSDS for:
  - Lexmark E210 Toner used for Laser Printer
  - HP 2500 PhotPrecise Chemical Toner, Laser Printer
  - HP5000 – 500B
  - Minolta SP310 Toner-310B
  - SX250B\275B-SG SX SuperGraphics 1
  - PC/FC 300/310/330 (E16) PC330-100B Copier Toner
- HP; http://www.hp.com/hpinfo/globalcitizenship/environment/recycle/index.html
- HP Environment; http://www.hp.com/hpinfo/globalcitizenship/environment/productdata/index.html

11. Smoke Detectors
- National Nuclear Regulator - The National Nuclear Regulator (NNR) issues licenses to industries and institutions generating or using significant quantities of radioactive substances (>10kg/annum). http://www.nnr.co.za/default.aspx
- Nuclear Energy Corporation of South Africa (NECSA); http://www.necsa.co.za/
- Department of Health, Radiation Control, http://196.36.153.56/doh/department/radiation/01.html
- Ziton South Africa, www.ziton.com
- Technoswitch (PTY) LTD, www.technoswitch.co.za
- Smoke Detectors and Americium, http://www.uic.com.au/nip35.htm
- Ionization Detectors: Ionizing Radiation, http://science.howstuffworks.com/smoke2.htm

12&13. Batteries (Wet cell and Dry cell)
- The Integrated Waste Management Board (IWMB), www.ciwmb.ca.gov/Publications/

- MSDSs from Dixon, Willard, Panasonic and First National Battery.
- Lead-acid batteries (http://www.ldaint.org/technotes4.htm#Lead-acid%20batteries)
- First National Battery; www.battery.co.za
- http://nautilus.fis.uc.pt/st2.5/scenes-e/elem/e00390.html
- Waste Watch; http://www.wastewatch.org.uk/
- Recycling of Household Batteries, http://www.waste.nl/
- Battery Council International; http://www.batterycouncil.org/index.html
- Olympus SA; http://www.olympus.co.za/consumer/digimg/knowledge/library/l.cfm

14. Asbestos waste
    - Department of Water Affairs and Forestry (DWAF) Policy
    - A guide to working with asbestos-cement products; The Occupational Safety and Health Service Department of Labour, Wellington, New Zealand; Dec 1998.
    - Asbestos Regulations under the Occupational Health and Safety Act (Act 85 of 1993)
    - EPA South Australia, EPA Guideline, Waste Containing Asbestos – removal, transport and disposal, Sept 2004
    - ACC – Prevention, Care, Recovery New Zealand; http://www.acc.co.nz/injury-prevention/safer-industries/construction/chemicals/asbestos
    - Disposal, Maintenance and Management of Asbestos Conference; Basel Convention Regional Centre Pretoria; http://www.baselpretoria.org.za/index1.htm
    - DWAF Policy on the handling and Disposal Of Asbestos and Asbestos containing waste in terms of Section 20 of the Environmental Conservation Act, (ACT 73 of 1989)
    - Minimum Requirements for the Handling, Classification and Disposal of Hazardous Waste, DWAF, 3rd Ed. 2005, Appendix 9.3
    - ACC Think-safe; http://www.acc.co.nz/injury-prevention/safer-industries/construction/chemicals/asbestos
    - http://www.epsco98.com/Introduction%20to%20Asbestos.htm
    - Environment, Health and Safety online; http://www.ehso.com/Asbestos/asbestos.php
    - Asbestos: the facts (http://www.health-e.org.za/news/article.php?uid=20010617)
    - Occupational Hygienist COH, Koos Roets, 082 456 0275
    - The Mercury, November 3, 2005; Total ban on asbestos

15. Boiler ash (and other ash waste)
    - Guideline with regard to the handling and disposal of (boiler) ash; DWAF
    - 2003 International Ash Utilisation symposium, Centre for applied energy research, University of Kentucky, Paper #39, Conversion of Coal prep-waste into Portland cements, http://www.flyash.info
    - New Zealand Journal of Agricultural Research 1995, Vol. 38, Chemical properties of fluidised bed boiler ash relevant to its use a liming material and fertiliser

    - Hazardous chemical substances regulations, GN R1179, Occupational exposure limits – Control limits for hazardous chemical substances

16. Medical waste
    - GDACE http://www.nwmsi.co.za/GDACE/hcrw.html
    - http://www.csir.co.za/ciwm/hcrw
    - http://www.gdace.gpg.gov.za/main.asp?inc=docs/pr/2003/pr0624.html
    - SANS 10248 (2004), *Management of healthcare waste*
    - Wastes from health-care activities http://www.who.int/mediacentre/factsheets/fs253/en/

- DEAT National Waste Management Strategy, Health Care Waste, http://www.nwmsi.co.za/hcw.html
- Health Care Waste Management in Gauteng, http://www.nwmsi.co.za/GDACE/hcrw.html
- Integrated strategy and action plans for sustainable health care risk waste management in Gauteng, the Government of Gauteng Province, October 2003

17. Redundant Pesticides
    - Consolidated List of products, whose consumption and/or sale have been banned, withdrawn, severely restricted, or not approved by governments; 9th issue; United Nations, New York 2004.
    - Croplife International, Container Management, Safe and Effective disposal of empty crop protection product containers, http://www.croplife.org
    - Department of Agriculture, list of registered agricultural remedies http://www.nda.agric.za/act36/AR%20lists.htm; Mr Pretorius 012 319 6000.
    - SANS 10206, "The handling, storage and disposal of pesticides", Published 2005.
    - Information excerpted from *Toxicological Profile for Chlordane May 1994 Update - Agency for Toxic Substances and Disease Registry United States Public Health Services*
    - SIRI, Safety Information Resource Inc. http://siri.org/msds/tox/f/q45/q327.html
    - EPA ECOTOX Database, http://www.epa.gov/ecotox/
    - WRC Report – Survey and Preliminary Investigation into Biodegradation of Pesticide waste, March 2001, Pollution Research Group
    - Relevant International Treaties (http://www.africastockpiles.org/treaties.html)

18. Paint waste
    - Paint Waste, New South Wales EPA, http://www.epa.nsw.gov.au/mao/paintwastes.htm; http://www.epa.nsw.gov.au/mao/leadbasedpaint.htm;
    - Dulux paint, http://www.dulux.co.za
    - http://www.optica.co.za/industrial.htm
    - EPA Ecotox database, http://www.epa.gov/ecotox/
    - Lead in paints (Les Fisher FTSC and Mike Russell FTC Feb 2004) http://www.occa.org.za/paintopedia/pigments/leadpigments.htm
    - Guidelines for lead containing paint, http://www.sapma.org.za/leadpaint.html

19. Waste containers
    - U.S Environmental Protection Agency, http://www.epa.gov/
    - Responsible Container Management Association of South Africa (RCMASA), http://www.rcmasa.org.za

20. Demolition and Construction waste
    - CSIR Building and Construction Technology; http://www.csir.co.za
    - Centre for Research in the Built Environment, Welsh School of Architecture, Cardiff University, case study, Construction Waste Minimisation in Housing http://www.cardiff.ac.uk/archi/programmes/cost8/case/waste/constructionwaste.html