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Ministry for the Environment and Transport Baden-Württemberg

Handbook “How to apply the European Waste List 2001/118/EC”



Proposals for classifying wastes in accordance with the EWL, for waste disposal and recovery as well as description of waste generating processes and material flow for selected branches of industry

Part B: Sub-chapter 11 01 through 19 13



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1 Processes

The purpose of surface treatment is to protect work pieces from corrosion or to produce a decorative coating. To accomplish this, the pieces are immersed in different process solutions one after another (**fig 1**).

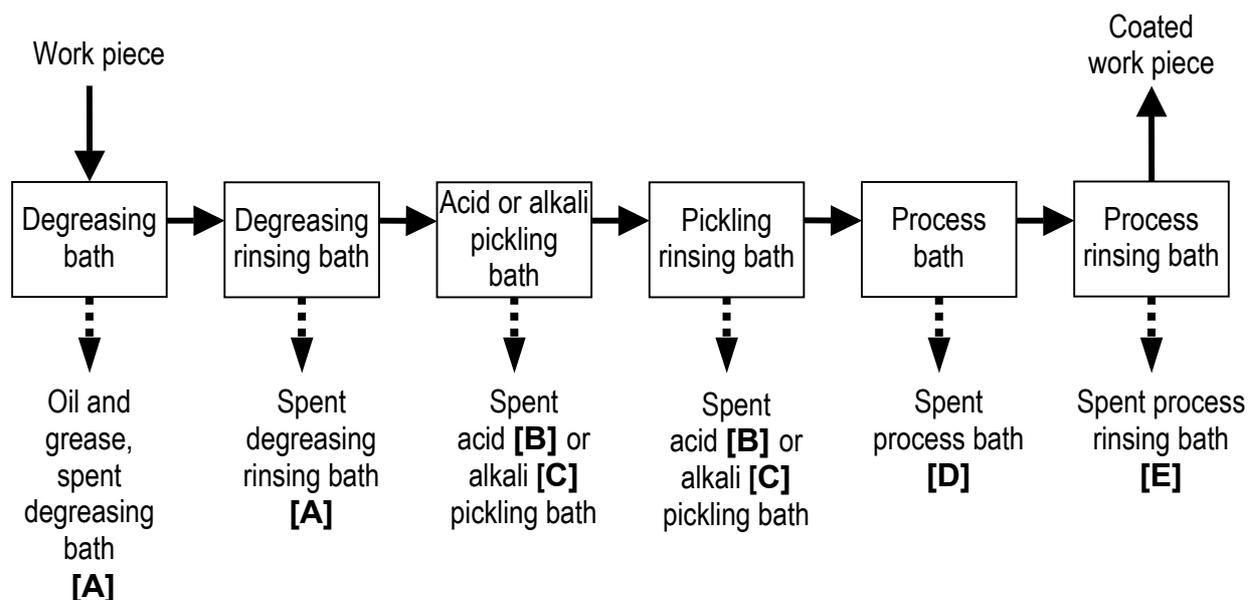


Fig 1: An example representation of a galvanising process line and the possible types of waste

In order to achieve an optimal quality in the subsequent coating process, the surface of the work pieces is first of all pre-treated i.e. freed of grease, oils, oxides and salts. This is carried out with the use of degreasing and pickling solutions. If the piece is to be painted, the surface is roughened by chromatising or phosphate coating to obtain a better paint adhesion. When the product is removed from the process bath, a thin liquid film remains stuck to the surface of the piece and is dragged out. This liquid film is subsequently removed in a stage counterflow rinsing system.

1.1 Galvanising

The term galvanising is taken to mean the electro-chemical production of thin metal layers on the surface of the piece. The layer of metal being applied lies as positive ions in an electrolyte. By applying an external source of direct current, the piece is charged and becomes the cathode, so that the metal ions on its surface are discharged and deposited. In pure chemical electrolytes, the required electrons come not from an external power source but from an electrolyte-containing reducing agent.

1.2 Chromating/Passivating

In order to increase resistance to corrosion and improve paint adhesion, work pieces containing zinc and aluminium are passivated using watery solutions of complex zircon fluorides as well as organic polymers and copper salts, and chrome plated using solutions containing chrome-VI.

1.3 Phosphatising

In order to increase resistance to corrosion and improve paint adhesion, work pieces containing iron are iron or zinc phosphate coated. Iron phosphate coating essentially uses phosphoric acid, zinc phosphate coating includes zinc and nickel or copper ions, as well as nitrate and chlorate as catalysts and hydrogen peroxide as oxidants.

1.4 Anodising

Anodising is a process whereby an oxidised protective coating is applied to an aluminium surface to improve its resistance to corrosion. This process also takes place with the use of electricity, but here the piece is charged and becomes the anode. After anodising, there is a follow-up treatment (painting, sealing).

2 Waste

2.1 Wastes from process lines

Spent degreasing baths [A]

Used acid degreasing baths contain dilute salt and phosphoric acid, emulsifiers, protective rust inhibitors as well as free and emulsified oils and grease. Spent alkali degreasing baths contain sodium hydroxide, carbonate, phosphate, silicate and surfactant as well as free and emulsified oils and grease. Acid and alkali degreasing baths are normally classified as dangerous and are therefore especially in need of monitoring.

Classification of waste in accordance with EWL -classification:

- 11 01 13* degreasing wastes containing dangerous substances (as a rule)
- 11 01 14 degreasing wastes other than those mentioned in 11 01 13 (exceptions)

Notes on recycling, utilization and disposal:

Incineration of the separated oil phases.

Otherwise chemical-physical treatment (CPT) of the degreasing bath using precipitation/flocculation and filtration processes (see chapter 19 08, par. 2.5) to neutralise and separate out the water phase which can then be fed into the sewerage system.

Spent degreasing rinsing baths [A]

After degreasing, the rinsing baths are strongly diluted degreasing baths so it makes sense to dispose of or treat them together with spent degreasing baths.

Classification of waste in accordance with EWL -classification:

- 11 01 13* degreasing wastes containing dangerous substances
- 11 01 14 degreasing wastes other than those mentioned in 11 01 13

Notes on recycling, utilization and disposal:

As a rule, chemical-physical treatment (CPT) together with the spent degreasing baths using precipitation/flocculation and filtration processes (see chapter 19 08, par. 2.5) to neutralise and separate out the water phase which can then be fed into the sewerage system.

Spent acid pickling baths [B]

Spent acid pickling solutions essentially contain free residual acids (hydrochloric, sulphuric, nitric, phosphoric, hydrofluoric, chromic and mixed acids) and their salts from the alloy components of the pickled metal surfaces (iron, chrome, nickel, zinc, copper) and in some cases pickling inhibitors.

Classification of waste in accordance with EWL -classification:

- 11 01 05* pickling acids

Notes on recycling, utilization and disposal:

Spent sulphuric acid pickling solutions are normally reprocessed to fresh acid by rotary kiln processes.

Otherwise chemical-physical treatment (CPT) using precipitation / flocculation and filtration processes (see chapter 19 08, par. 2.5) to detoxify, if necessary, neutralise and separate out the water phase which can then be fed into the sewerage system. After CPT sludges containing metals can possibly be metallurgically processed.

Spent alkali pickling baths [C]

During pickling of aluminium, base solutions (sodium hydroxide) are used. Spent alkali pickling solutions essentially contain sodium hydroxide and alloy components from the pickled aluminium alloys.

Classification of waste in accordance with EWL -classification:

11 01 07* pickling bases

Notes on recycling, utilization and disposal:

As a rule, chemical-physical treatment (CPT) using precipitation / flocculation and filtration processes (see chapter 19 08, par. 2.5) to neutralise and separate out the water phase which can then be fed into the sewerage system. After CPT sludges containing aluminium can possibly be metallurgically processed.

Spent pickling rinsing baths [B] [C]

After pickling, the rinsing baths are strongly diluted pickling baths so it makes sense to dispose of or treat them together with spent pickling baths.

Classification of waste in accordance with EWL -classification:

11 01 05* pickling acids

11 01 07* pickling bases

Notes on recycling, utilization and disposal:

As a rule, chemical-physical treatment (CPT) together with the spent pickling baths using precipitation / flocculation and filtration processes (see chapter 19 08, par. 2.5) to detoxify, if necessary, neutralise and separate out the water phase which can then be fed into the sewerage system.

Spent process baths [D]

Modern galvanic metalising electrolytes have a very long life span as long as the requisite bath care measures are carried out. They accumulate contaminants from the constant compensation for evaporated water and used chemicals, and the drag out of contaminants on the pieces as well as from dissolving of the raw material. If these are not removed through bath care measures, the electrolyte will have to be exchanged and disposed of.

Metal carrying process solutions (pickling and activating solutions), chromatiser and externally precipitated electrolyte change during their use in production and have to be replaced when a specific concentration of contaminants is reached. Because of this, they have a relatively short life-span compared to galvanising electrolytes.

The process solutions normally comprise a mixture of inorganic components: acids or alkalis, as well as metallic and non-metallic salts. To some extent, the electrolytes contain small quantities of organic additives. Some galvanic electrolytes, in addition, work with cyanide additives.

Classification of waste in accordance with EWL:

11 01 05* pickling acids

11 01 07* pickling bases

Notes on recycling, utilization and disposal:

As a rule, chemical-physical treatment (CPT) using precipitation / flocculation and filtration processes (see chapter 19 08, par. 2.5) to detoxify, if necessary, neutralise and separate out the water phase which can then be fed into the sewerage system. After CPT sludges containing metals can possibly be metallurgically processed.

Rinsing water [E]

Rinsing water comes from the rinsing off of process solutions, which adhere to the goods. Irrespective of the technical conditions required for the process, (e.g. required dilution) and the rinsing technology being used, the dragged out elements from the process bath are present in varying concentrations (0.01-10%) in the rinsing water.

Classification of waste in accordance with EWL:

11 01 11* aqueous rinsing liquids containing dangerous substances

11 01 12 aqueous rinsing liquids other than those mentioned in 11 01 11

Notes on recycling, utilization and disposal:

As a rule, chemical-physical treatment (CPT) together with the spent process solutions using precipitation / flocculation and filtration processes (see chapter 19 08, par. 2.5) to detoxify, if necessary, neutralise and separate out the water phase which can then be fed into the sewerage system.

2.2 Waste from on-site wastewater treatment

If the liquid waste is transferred to a company's internal wastewater treatment plant (**fig 2**), the dissolved metal waste will be changed into a form, which is not water soluble in a precipitation process. The resulting sludges or semisolid filter cake then comprise the largest proportion of waste. Alternatively, if there is a small amount of wastewater, vaporizer technology may be used.

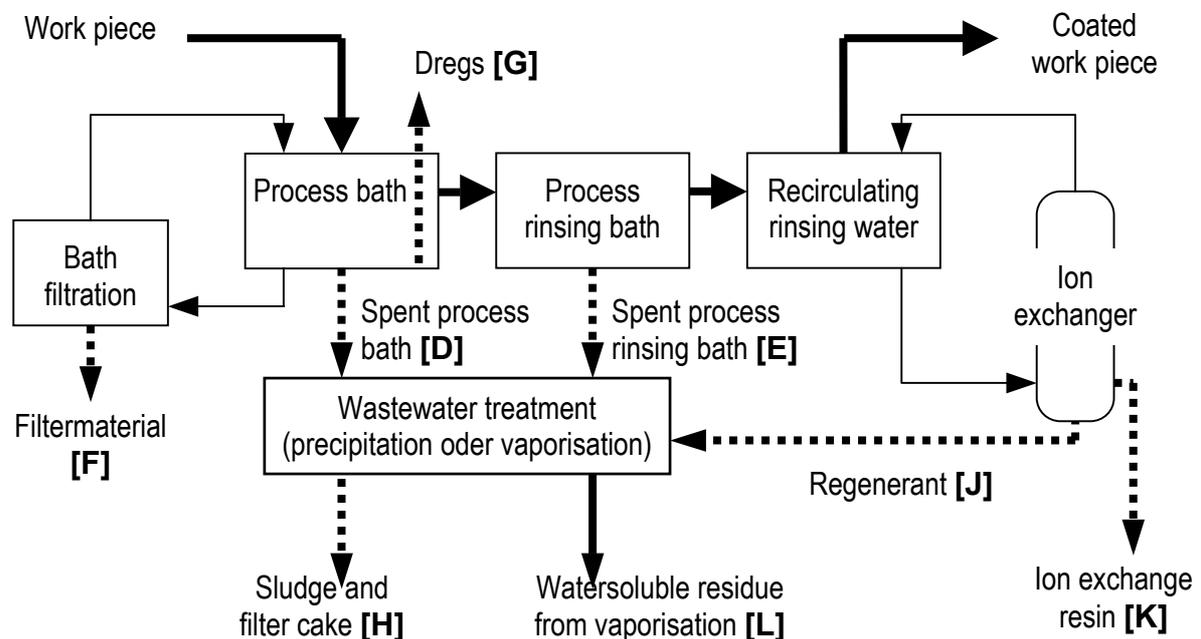


Fig 2: Waste production during wastewater treatment from chemical and electro-chemical metal treatment and coating

Residue from bath filtration [F]

Most process baths are filtered in order to remove undissolved contaminants. For this, both disposable filters (e.g. filter candles) as well as reusable filter material (e.g. filter pipes, filter cloths) are used. Contaminated filter materials as well as filter aids

(e.g. kieselguhr) appear as waste with the electrolyte residue. Oil filters don't arise in galvanising processes.

Classification of waste in accordance with EWL:

15 02 02* absorbents, filter materials (including oil filters not otherwise specified),
wiping cloths, protective clothing contaminated by dangerous
substances

Notes on recycling, utilization and disposal:

There are at present no viable treatment processes known.

Disposal of solid filter materials (e.g. disposable filter candles) and filter aids (e.g. kieselguhr) to landfill as hazardous waste. First removal of adherent electrolyte residues (e.g. by a rinsing process).

Dregs from process baths [G]

With a few electrolytes (e.g. with certain demetalising electrolytes) and during Zn-phosphating it is difficult to dissolve dregs accumulate over a period of time in the process bath. They must be removed regularly.

Classification of waste in accordance with EWL:

06 03 11* solid salts and solutions containing cyanide
06 03 13* solid salts and solutions containing heavy metals
06 03 14 solid salts and solutions other than those mentioned in 06 03 11 and
06 03 13
11 01 08* phosphatising sludges

Notes on recycling, utilization and disposal:

There are at present no viable treatment processes known.

As a rule, together with spent process solutions: Chemical-physical treatment (CPT) using precipitation / flocculation and filtration processes (see chapter 19 08, par. 2.5) to detoxify, if necessary, neutralise and separate out the water phase which can then be fed into the sewerage system.

Otherwise disposing (if necessary after vaporisation or drying); as a rule, in case of a high water solubility of the concentrate disposing in UGL.

11 01 08*: In case of semisolid sludge disposing in HWL.

Filter cake from the in-house wastewater treatment plant [H]

During wastewater treatment, the precipitants used for heavy metals are usually sodium hydroxide and calcium hydroxide. The resulting difficult to dissolve sediment settles to a thin sludge with approx. 3-5% solid content.

The composition of the sludge depends on the composition of the treatment process or rinsing solutions, as well as the added treatment chemicals. As a rule, it normally comprises various metal hydroxides and difficult to dissolve calcium compounds (hydroxide, sulphate, phosphate, silicate, fluoride). Occasionally, the metals are precipitated as metal-sulphides.

As a rule, a company's in-house wastewater treatment plant also includes the subsequent filtration of the thin sludge, usually by means of chamber filter presses. The

resulting filter cake has a semisolid consistency and is approx. 30-40% solid. In some cases, a further thermal drying to a solid content of 70% follows (see chapter 19 02, par. 2.1). The composition of the solids corresponds to that of the thin sludge.

Classification of waste in accordance with EWL:

11 01 09* sludges and filter cakes containing dangerous substances

11 01 10 sludges and filter cakes other than those mentioned in 11 01 09

Notes on recycling, utilization and disposal:

Sludges containing metals can possibly metallurgically processed.

Disposal to landfill; without dangerous substances together with municipal waste.

Regenerant from ion exchangers [J]

Rinsing water from running rinses normally contains a very high level of dilution (up to 0.01% of the process bath concentration). In order to save water, this rinsing water is normally recycled through an ion exchanger. The elements in the rinsing water are thereby absorbed in the ion exchanger while the cleaned water is returned to the rinsing process.

During the regeneration of the ion exchange resins, there is an accumulation of regenerant which contains the separated rinsing water elements in concentrated form. The elements of the regenerant and their concentration are similar to their waste process solutions.

Classification of waste in accordance with EWL:

11 01 15* eluate and sludges from membrane systems or ion exchange systems containing dangerous substances

Notes on recycling, utilization and disposal:

As a rule, together with spent process solutions chemical-physical treatment (CPT) using precipitation / flocculation and filtration processes (see chapter 19 08, par. 2.5) to detoxify, if necessary, neutralise and separate out the water phase which can then be fed into the sewerage system.

Sludges containing metals can possibly be metallurgically processed.

Saturated and spent ion exchange resins [K]

In case of saturated (loaded) resins don't be in-house regenerated, normally the regeneration can be carried out externally (e.g. by the plant manufacturer).

After a certain time ion exchange resins become unusable and have to be completely disposed of. (Beyond that see chapter 19 08, par. 2.2.)

Classification of waste in accordance with EWL:

11 01 16* saturated or spent ion exchange resins

Notes on recycling, utilization and disposal:

External regeneration of saturated resins.

Incineration as hazardous waste.

Ion exchange resins which cannot be regenerated, can metallurgically be processed (e.g. for the recovery of precious metals).

Salts from in-house evaporation of process solutions [L]

If a company produces only a small amount of wastewater, it may be reasonable to pass it through an internal evaporation plant instead of using the wastewater treatment process mentioned above. In the evaporation process salts contained in the solution crystallise out.

Classification of waste in accordance with EWL:

- 06 03 11* solid salts and solutions containing cyanide
- 06 03 13* solid salts and solutions containing heavy metals
- 06 03 14 solid salts and solutions other than those mentioned in 06 03 11 and 06 03 13

Notes on recycling, utilization and disposal:

Disposal to landfill; as a rule, in case of a high water solubility of the concentrate disposing in UGL.

Phosphate coating sludges [M]

During zinc phosphate coating, iron from the work material as well as metals from the phosphate coating solution go into solution which is classified as difficult to dissolve phosphate sludge. As a rule, the rinsing water and spent process solutions produced during phosphate coating have to be passed to a specialised internal water treatment plant or disposed of as hazardous waste.

Classification of waste in accordance with EWL:

- 11 01 08* phosphatising sludges

Notes on recycling, utilization and disposal:

In case of high water contents: As a rule, together with spent process solutions chemical-physical treatment (CPT) using precipitation / flocculation and filtration processes (see chapter 19 08, par. 2.5) to neutralise and separate out the water phase which can then be fed into the sewerage system.

In case of semisolid sludges: Disposal to landfill as hazardous waste.

3 Overview of waste classification - material flow

Extract from EWL	Material flow	Treatment
11 01 Wastes from chemical surface treatment and coating of metals and other materials (for example galvanic processes, zinc coating processes, pickling processes, etching, phosphating, alkaline degreasing, anodising)		
11 01 05* pickling acids	B, D	Recycling, CPT
11 01 06* acids not otherwise specified	Not normally required	
11 01 07* pickling bases	C, D	Recycling, CPT
11 01 08* phosphatising sludges	G, M	CPT, HWL
11 01 09* sludges and filter cakes containing dangerous substances	H	Recycling, HWL
11 01 10 sludges and filter cakes other than those mentioned in 11 01 09	H	With municipal waste
11 01 11* aqueous rinsing liquids containing dangerous substances	E	CPT
11 01 12 aqueous rinsing liquids other than those mentioned in 11 01 11	E	CPT
11 01 13* degreasing wastes containing dangerous substances	A	CPT, Incineration
11 01 14 degreasing wastes other than those mentioned in 11 01 13	A	CPT
11 01 15* eluate and sludges from membrane systems or ion exchange systems containing dangerous substances	J	Recycling, CPT
11 01 16* saturated or spent ion exchange resins	K	Recycling, incineration
11 01 98* other wastes containing dangerous substances	Not normally required	
11 01 99 wastes not otherwise specified	Not normally required	
Wastes from chemical surface treatment and coating of metals and other materials to be classified under other waste categories		
06 03 11* solid salts and solutions containing cyanides	G ----- G, L	CPT ----- UGL

06 03 13*	solid salts and solutions containing heavy metals	G	CPT
		G, L	UGL
06 03 14	solid salts and solutions other than those mentioned in 06 03 11 and 06 03 13	G	CPT
		G, L	With municipal waste
15 02 02*	absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	F	HWL

11 02 Waste from non-ferrous hydrometallurgical processes

1	Processes	1
1.1	<i>General.....</i>	<i>1</i>
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1.4	<i>Other non-ferrous metal processes</i>	<i>3</i>
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1 Processes

1.1 General

Hydrometallurgical processes for primary and secondary metallurgical extraction of non-ferrous metals and refining of impure raw metals are mainly used to produce copper, zinc, nickel, tin and precious metals. Other non-ferrous metals such as wolfram, tantal, niob, etc. will not be detailed in this paper due to the small quantity which is produced within Europe and therefore their limited significance in terms of waste. The production process shown with the resultant types of waste can in principle be applied to other processes.

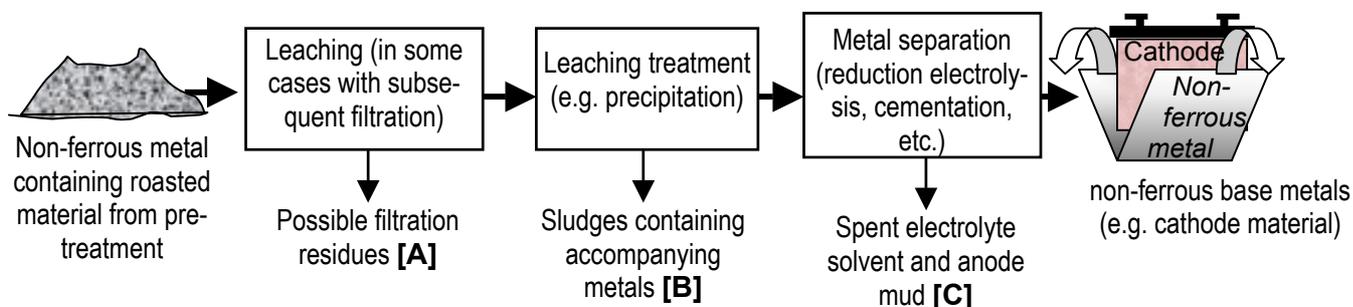


Fig. 1: Schematic representation of hydrometallurgical non-ferrous metal production

In general, hydrometallurgical non-ferrous metal production processes can be divided as shown in **fig. 1**:

1. Pretreatment, physical (e.g. crushing of raw materials) as well as chemical (e.g. oxidizing, sulfatizing or chlorinating roasting, see subchapter 10 04 – 10 08, paragraph 1.2).
2. Forming a solution (leaching, disintegration), mainly in sulphuric acid or ammonia solvents, in some cases under oxidising conditions to oxidise sulphurous material in the ore (e.g. by using iron (III) sulphate). Solid – liquid separation (e.g. filtration) to separate the mainly mineral residue follows.
3. Solution treatment (leaching treatment), e.g. precipitating of accompanying metals and subsequent solid – liquid separation (as a rule filtration). In some cases selective enrichment of the non-ferrous base metal, e.g. using ion exchangers or solvent extraction processes.
4. Metal separation, as a rule using cementation or electrolytic processes, precipitation or crystallisation. Electrolyte solution is acidic (as a rule sulphuric acid) or more rarely alkali (e.g. sodium alkali used in the recovery of tin). In electrolytic separation processes there are more precious metals present in the anode mud.

The impure base metals extracted in this way subsequently undergo hydrometallurgical refining processes (in some cases electrolytic refining, see paragraph 1.3) or the precipitated non-ferrous metal compounds are processed using thermal reduction (e.g. fire-refining).

Secondary metallurgy also uses hydrometallurgy for processing non-ferrous waste (mono-sludges, solutions and salts) containing sufficient metal (e.g. approx. 2% for copper, 60% for zinc) and further processing of mineral non-ferrous metal compounds. Here, the more complexity of these materials determines the economic possibility of recovery. Mineral raw materials are extracted by pressure leaching, while sludges and salts are extracted with the addition of sulphuric acid. Using oxidation and precipitation processes, the raw leach is then purified of the accompanying metals which, as valuable by-products, are, as a rule, recycled.

1.2 Zinc extraction

In principle, the hydrometallurgical extraction of zinc follows the same process as described in paragraph 1.1 (see **fig. 1**).

Zinc is extracted from aqueous zinc salt solution, as a rule sulphuric acid zinc sulphate solution. Similar to the thermal process (see subchapter 10 05), zinc electrolysis is carried out using oxidised raw materials. The most commonly used raw material, zinc blende (ZnS) has to be first of all converted into an oxide using oxidising roasting in a sintering process (see subchapter 10 04 – 10 08, paragraph 1.2).

Iron contained in zinc blende is a problematic element in zinc electrolysis. Due to the higher acid concentration, it is almost completely dissolved and must therefore be removed as hydroxide from the zinc salt solution using precipitation (jarosite, goethite, haematite process) before electrolysis. Thereby **sludges from zinc production [B]** arise.

1.3 *Copper extraction*

Using hydrometallurgical methods copper is extracted, either in the form of pure cathodes by electrolysis or as impure powdery cement copper by cementation. The leaching agent used, irrespective of the raw material (e.g. pyritiferous or oxidic ores), is usually dilute sulphuric acid but may also be iron (III) sulphate solution or ammonia solution. After cleaning the solution of solids or precipitated impurities using various solid – liquid separation processes and thereby creating **sludges from copper extraction [A] [B]**, metal enrichment is carried out in these solutions using ion exchange or solvent extraction processes which in turn lead to **wastes from ion exchange processes [D]**.

Pure copper (99,99%) is extracted by electrolytic refining. During electrolysis copper is present at the anode in solution, moves to the cathode and is deposited at the cathode as electrolyte copper. Precious accompanying elements (precious metals, selenium and tellurium) collect in the **anode mud [E]**. During the process soluble impurities (e.g. nickel and arsenic) collect in the sulphuric acid electrolytic solution so that a part material flow, so-called **end-electrolyte [F]**, is continuously taken off and reprocessed.

1.4 *Other non-ferrous metal processes*

As a rule, only two systems are used in the industrial hydrometallurgical extraction of nickel: ammonia leaching under atmospheric pressure and pressure leaching with sulphuric acid.

Hydrometallurgical processes play a minor role in tin extraction in terms of primary metallurgy (ore dressing and refining) due to the low economical value compared to the high electrolysis costs. As a high proportion of tin is processed to form tinplate in secondary metallurgy, the recovery of tin from tinplate waste is of great importance. Usually alkali electrolytic processes are used for this. In some cases solvents are used to remove paint layers from the tinplate thus producing **paint sludge [G]**.

The hydrometallurgical processes used to extract precious metals use acid leaching and electrolytic refining which result in various residue acids (e.g. salt, saltpetre, sulphuric acid, as well as aqua regia from gold extraction). In addition, cementation processes are used in the recovery of silver. The most widely used method of producing fine silver is electrolytic refining which results in almost 100% pure silver. For silver recovery from photo-chemical processes and rinsing baths, see subchapter 09 01, paragraph 1.7. As a rule, silver recovered in this way, as well as old silver and precious metal scrap, is pyrometallurgically treated.

2 Wastes

2.1 Sludges from zinc extraction [A], [B]

As a rule, during zinc hydrometallurgy, sludges arise from solid – liquid separation during leaching and leaching treatment processes. In addition to mineral material they contain accompanying elements (mainly lead, cadmium, as well as iron) normally as sulphur compounds.

Leaching residue from the jarosite process are present as ammonia compounds and contain substantial amounts of sulphur in addition to iron and zinc. Leaching residue from the goethite process contains fluoride and chlorine due to their adsorption qualities.

Classification of waste in accordance with EWL:

11 02 02* sludges from zinc hydrometallurgy (including jarosite, goethite)

Notes on recycling, utilization and disposal:

Residue arising from leaching and subsequent leaching agent treatment is normally metallurgically reprocessed, in accordance with the metals present.

Otherwise, disposal to HWL (especially chemically stable iron hydroxide residue from the jarosite and goethite processes).

2.2 Sludges from copper extraction [A], [B]

As a rule, during copper hydrometallurgy, sludges arise from solid – liquid separation during leaching and leaching agent treatment processes. In addition to mineral material, these sludges contain accompanying elements (e.g. nickel, cobalt, zinc) which, depending on the leaching process, are normally present as sulphur or ammonia compounds.

Classification of waste in accordance with EWL:

11 02 05* wastes from copper hydrometallurgical processes containing dangerous substances

11 02 06 wastes from copper hydrometallurgical processes other than those mentioned in 11 02 05

Notes on recycling, utilization and disposal:

Residue from leaching and subsequent treatment of leaching agent is normally reprocessed in accordance with the metals it contains.

Otherwise, disposal to HWL; if it does not contain dangerous substances together with municipal waste.

2.3 Waste from electrolytic refining of copper [E], [F]

The composition of **anode mud [E]** varies to reflect the input material. In addition to the base metal, copper, it contains precious metals (mainly silver) and a large number of compounds (e.g. selenide and telluride) which precipitate from the electrolyte.

Electrolytic solutions are present as so-called **end electrolyte [F]** and as a rule are copper sulphate solutions that contain nickel and arsenic.

Classification of waste in accordance with EWL:

- 11 02 03 wastes from the production of anodes for aqueous electrolytical processes
- 11 02 05* wastes from copper hydrometallurgical processes containing dangerous substances

Notes on recycling, utilization and disposal:

Anode mud from copper refining is normally used as the input material for the extraction of selenium.

Otherwise, disposal to HWL; if it does not contain dangerous substances, together with municipal waste.

As a rule **spent electrolytic solutions** are reprocessed in further electrolytic processes or evaporation processes. Separated accompanying elements are, as a rule, returned to the non-ferrous metal extraction processes.

Otherwise it is treated in chemical physical treatment plants (CPT) using precipitation/flocculation and filtration processes (see subchapter 19 08, paragraph 2.5) to neutralise and separate the water phase so that it can be fed into the sewerage system.

2.4 Wastes from other non-ferrous metal processes [A], [B]

Waste from leaching and leach treatment processes in nickel extraction contain the accompanying metals cobalt, chrome and iron. The resulting sludges are ammonia or sulphur compounds depending on the leaching process used.

As a rule waste from tin recovery contains a high percentage of the leaching metals lead, antimony and copper which are normally present as sulphur compounds (e.g. as lead sulphate).

Waste from precious metal extraction (e.g. gold and silver) may contain cyanide or mercury depending on the leaching process used. In addition, copper, lead, etc. are present as accompanying elements.

Classification of waste in accordance with EWL:

- 11 02 07* other wastes containing dangerous substances

Notes on recycling, utilization and disposal:

The residue arising from leaching and subsequent leaching agent treatment is normally metallurgically reprocessed in accordance with the metals present.

Otherwise disposal to HWL, in some cases UGL.

2.5 Spent electrolytic solutions and anode mud [C]

As a rule spent electrolytic solutions exist as sulphuric acid, but sometimes also as salt or saltpetre. They contain additives such as colloids which through deposition provide a smooth surface for the precipitated metal, and frothers (e.g. cresylic acid), to prevent sulphuric acid from evaporating. In zinc electrolysis strontium carbonate reduces the lead content of the cathode zinc.

The impurities in anode mud are mainly metal compounds of precious accompanying elements.

Classification of waste in accordance with EWL:

- 11 01 05* pickling acids
- 11 02 03 wastes from the production of anodes for aqueous electrolytical processes
- 11 02 07* other wastes containing dangerous substances

Notes on recycling, utilization and disposal:

11 01 05*: Spent electrolytic solutions are normally recycled to the leaching process or reprocessed in additional electrolytic processes, evaporation processes, etc. As a rule, separated accompanying elements are recycled to non-ferrous metal extraction.

Otherwise, chemical physical treatment (CPT) using precipitation/flocculation and filtration processes (see subchapter 19 08, paragraph 2.5) to neutralise and separate the water phase so that it can be fed into the sewerage system.

11 02 03 and 11 02 07*: Anode mud is normally returned to metallurgical recovery processes.

Otherwise, disposal to HWL; if it does not contain dangerous substances, together with municipal waste.

2.6 Waste from ion exchange processes for metal enrichment [D]

Regenerate, containing concentrated dissolved accompanying metals, from the regeneration of ion exchange resins arises. After several regeneration cycles, ion exchange resins are useless and have to be completely renewed (see subchapter 19 08, paragraph 2.2).

Classification of waste in accordance with EWL:

- 11 01 15* eluate and sludges from membrane systems or ion exchange systems containing dangerous substances
- 11 01 16* saturated or spent ion exchange resins

Notes on recycling, utilization and disposal:

11 01 15*: As a rule, regenerate containing metal is metallurgically reprocessed.

Otherwise, chemical physical treatment (CPT) using precipitation/flocculation and filtration processes (see subchapter 19 08, paragraph 2.5) to neutralise, and in some cases detoxify, and separate the water phase so that it can be fed into the sewerage system.

11 01 16*: External regeneration of laden resins.

Ion exchange resins which cannot be regenerated are normally metallurgically reprocessed.

Otherwise, incineration as hazardous waste.

2.7 Paint sludge from tin recovery [G]

Paint sludge from tin recovery includes mainly paint residue, leaches containing paint sludge (as a rule sodium alkali) or paint sludge containing solvents. Depending on

the paint removal chemicals used and the paint that is removed, the waste has to be classified as hazardous (e.g. from chromate and heavy metals from paint pigments).

Classification of waste in accordance with EWL:

- 08 01 17* wastes from paint or varnish removal containing organic solvents or other dangerous substances
- 11 01 07* pickling bases

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

- 08 01 17*: In the case of mainly organic components, thermal treatment in waste incineration plants.
- Otherwise, disposal to HWL.
- 11 01 07*: In the case of aqueous alkaline processes, chemical physical treatment (CPT) using precipitation/flocculation and filtration processes (see sub-chapter 19 08, paragraph 2.5) to neutralise and separate the water phase.

3 Overview of waste classification - material flow

Extract from EWL	Material flow	Treatment
11 02 waste from non-ferrous hydrometallurgical processes		
11 02 02* sludges from zinc hydrometallurgy (including jarosite, goethite)	A, B	1) material use, 2) HWL
11 02 03 wastes from the production of anodes for aqueous electrolytical processes	C, E, F	1) material use, 2) with municipal waste
11 02 05* wastes from copper hydrometallurgical processes containing dangerous substances	A, B, E, F	1) material use, 2) HWL
11 02 06 wastes from copper hydrometallurgical processes other than those mentioned in 11 02 05	A, B	1) material use, 2) with municipal waste
11 02 07* other wastes containing dangerous substances	A, B, C	1) material use, 2) HWL, UGL
11 02 99 wastes not otherwise specified	not normally required	

waste from non-ferrous hydrometallurgical processes to be classified under other waste categories		
08 01 17* wastes from paint or varnish removal containing organic solvents or other dangerous substances	G	1) HWI, 2) HWL
11 01 05* pickling acids	C	1) material use, 2) CPT
11 01 07* pickling bases	G	CPT
11 01 15* eluate and sludges from membrane systems or ion exchange systems containing dangerous substances	D	1) material use, 2) CPT
11 01 16* saturated or spent ion exchange resins	D	1) regeneration, 2) material use, 3) HWI

11 03 Sludges and solids from tempering processes

1	Process	1
2	Wastes	3
2.1	<i>Wastes from pre-treatment [A].....</i>	3
2.2	<i>Spent tempering salts containing cyanide [B]</i>	3
2.3	<i>Spent tempering salts free of cyanide [C].....</i>	3
2.4	<i>Wastes from tempering furnace maintenance [D].....</i>	4
2.5	<i>Spent quenching and tempering oils [E].....</i>	4
2.6	<i>Spent quenching salt melt [F], [G].....</i>	5
2.7	<i>Spent aqueous quenching media [H]</i>	5
2.8	<i>Waste from on-site wastewater treatment [J]</i>	5
2.9	<i>Wastes from tempering processes [K].....</i>	6
2.10	<i>Wastes from used air treatment [L]</i>	6
3	Overview of waste classification - material flow	8

1 Process

The conventional tempering process, mainly for iron but also for non-ferrous metals such as copper, aluminium, titanium and precious metals, can be divided into two stages: Austenitisation (heating to a hardening temperature between 760 and 1300°C) and the following quenching, whereby the hard structure (martensite) is produced. Irrespective of the required properties, the work piece is in some cases again heated to a temperature of between 150 and 650°C (tempering) after quenching. Before the actual tempering process and at the end, the work piece is cleaned (**fig. 1**).

Alternatively, hard layers can be achieved by chemically changing the surface. These so-called thermo-chemical tempering processes include carburizing, carbonitriding, nitriding and nitrocarburisation, boriding, as well as the rarer aluminizing, silicizing and chromizing. The purpose of the solid, liquid or gas tempering agent used is heat transmission and the provision of reaction agents to bring about chemical changes in the outer layer. Solid tempering agents are, for example, powder or granulate on a base of charcoal and alkali or alkaline-earth carbonate. Liquid agents are mixed salt melts such as alkali nitrite, nitrate, cyanate, cyanide and carbonate as well as alkali and alkaline-earth chloride. In order to protect the metal surface from changes, protective gases such as nitrogen, argon, exogas (exothermic cracked town gas), etc. or even a vacuum are used. With reaction gases such as ammonia, methane or endogas (propane), certain changes on the metal surface are achieved.

Quenching, depending on circumstances (e.g. material strength of the work pieces) and requirements (e.g. speed of quenching), takes place in water (as a rule with inorganic, organic or even polymer additives), in mineral oil, in a salt melt (for warm bath cooling in order to equalise the temperature in the work piece before martensite formation or in gases (in some cases liquidised).

Under the specific tempering EWL sub-chapter only two waste categories are listed which refer to the differentiation between waste containing cyanide and waste not containing cyanide, especially salt bath tempering. Other warm treatment processes, such as plasma or induction tempering are not explicitly listed in the EWL due to their minimal waste significance.

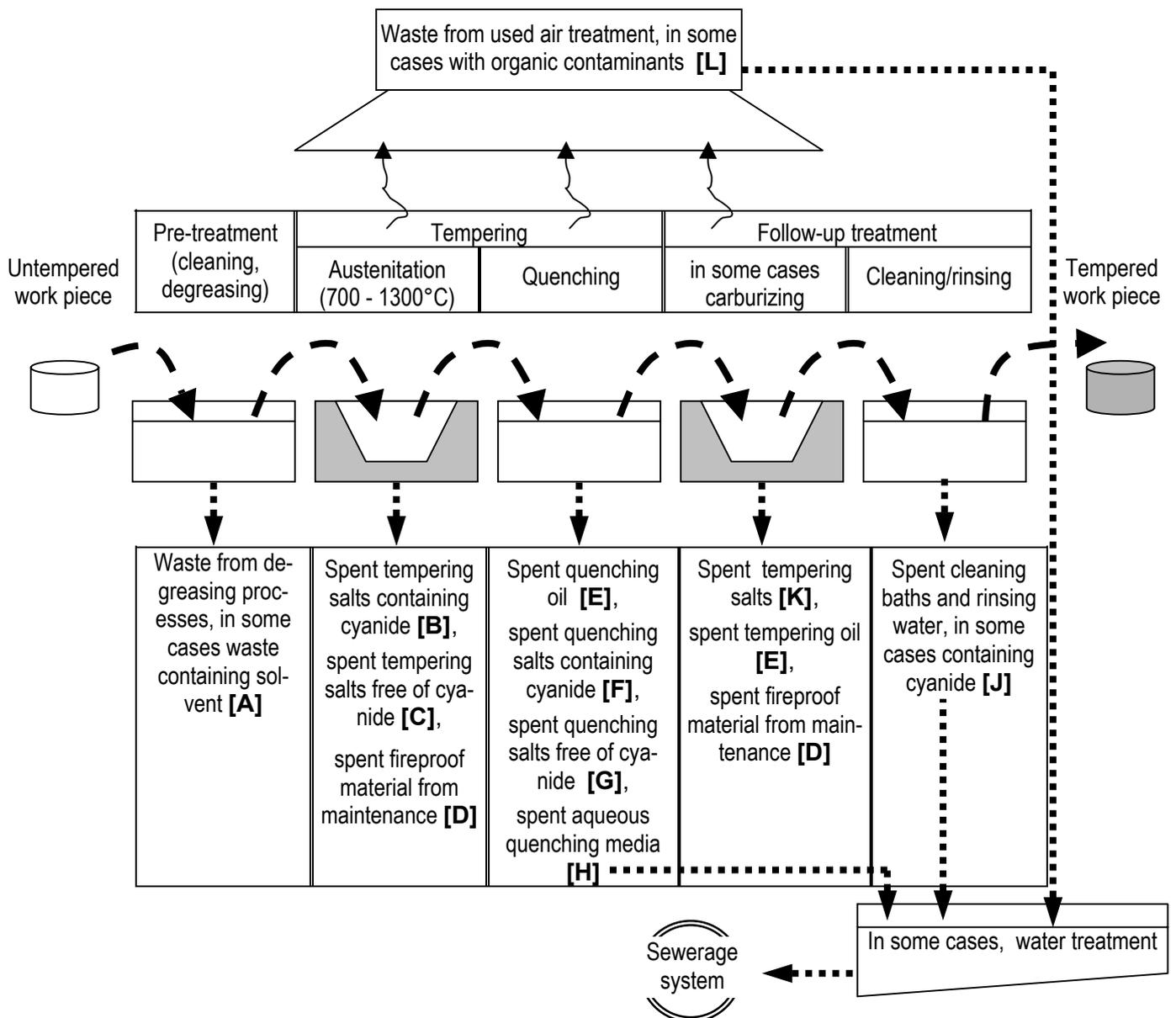


Fig. 1: Schematic representation of salt bath tempering processes

2 Wastes

2.1 Wastes from pre-treatment [A]

Pre-treatment mainly involves washing processes using aqueous or organic washing media.

Degreasing solvents used in aqueous systems contain mainly diluted salt and phosphoric acid, emulsifiers, corrosion protective inhibitors as well as free and emulsified oil and fat. Spent aqueous alkali degreasing baths contain mainly sodium hydroxide, carbonate, phosphate, silicate and tenside as well as free and emulsified oil and fat.

In organic washing systems, solvents (in some cases containing halogens) are used for part-cleaning. These, contaminated with oil and fat, are generally identified as hazardous waste.

Classification of waste in accordance with EWL:

For waste from aqueous degreasing processes:

- 11 01 13* degreasing wastes containing dangerous substances (*rule*)
- 11 01 14 degreasing wastes containing dangerous substances (*exception*)

For solvent waste:

- 14 06 04* sludges or solid wastes containing halogenated solvents (*exception*)
- 14 06 05* sludges or solid wastes containing (*rule*)

Notes on recycling, utilization and disposal:

11 01 13* and 11 01 14: As a rule, chemical physical treatment (CPT) with precipitation / flocculation and filtration processes (see also chapter 19 08, paragraph 2.5) to neutralise as well as separate the water phase so it can be fed into the sewerage system.

14 06 04* and 14 06 05*: Incineration, as a rule in HWI.

2.2 Spent tempering salts containing cyanide [B]

During thermo-chemical treatment in salt baths, tempering salts containing cyanide are sometimes used. These become exhausted during their lifetime and because of contamination, mainly from alloy components in the material being tempered, they collect as spent tempering salts containing cyanide.

Classification of waste in accordance with EWL:

- 11 03 01* waste containing cyanide

Notes on recycling, utilization and disposal:

Reprocessing (as a rule through collection systems operated by tempering salt manufacturers).

Otherwise disposal to landfill, as a rule UGL.

2.3 Spent tempering salts free of cyanide [C]

Nowadays, tempering salts free of cyanide are being increasingly used in salt bath tempering. However, these still contain dangerous substances and are, as a rule,

poisonous (e.g. through barium chloride additives). These salt baths, which become exhausted over their lifetime and also because of the contaminants arising mainly from alloy components from the work piece being tempered, are identified as spent tempering salts free of cyanide.

Classification of waste in accordance with EWL:

11 03 02* other wastes

Notes on recycling, utilization and disposal:

Reprocessing (as a rule through collection systems operated by tempering salt manufacturers).

Otherwise, disposal to landfill, as a rule UGL.

2.4 Wastes from tempering furnace maintenance [D]

Waste of fireproof material from tempering furnaces arises during maintenance and repair work. It may contain dangerous substances, for example asbestos.

Classification of waste in accordance with EWL:

16 11 03* other linings and refractories from metallurgical processes containing dangerous substances

16 11 04 other linings and refractories from metallurgical processes other than those mentioned in 16 11 03

Notes on recycling, utilization and disposal:

Asbestos free material from the maintenance of tempering furnaces is usually used in the manufacture of fireproof material.

Disposal to landfill, in some cases UGL; supplementary regulations must be followed when handling materials containing asbestos.

If waste does not contain dangerous substances, disposal to landfill together with municipal waste.

2.5 Spent quenching and tempering oils [E]

Mineral oils are used for quenching as well as tempering processes and also to protect against corrosion. Warm work pieces that are quenched in oil are, as a rule, mechanically de-oiled and then cleaned in alkali washing leach. In some cases emulsifiers have already been added to quenching oils so that they can subsequently be washed out with water.

As a rule, oil from mechanical de-oiling can be reused in the process. Quenching oil becomes contaminated during its lifetime (e.g. with tempering salts). Oil-in-water emulsions arise in the washing processes described above.

Classification of waste in accordance with EWL:

12 01 07* mineral-based machining oils free of halogens (except emulsions and solutions)

12 01 09* machining emulsions and solutions free of halogens

Notes on recycling, utilization and disposal:

- 12 01 07*: Reprocessing to base oils in accordance with used oil legislation.
Otherwise, incineration.
- 12 01 09*: As a rule, chemical physical treatment (CPT) of the oil-in-water emulsion in emulsion cracking plants to separate the oil phase. The water phase is fed into the sewerage system, after precipitation / flocculation and filtration processes (see chapter 19 08, par. 2.5) to neutralise and in some cases detoxify.

2.6 Spent quenching salt melt [F], [G]

As a rule, salt melts for warm bath cooling (180 - 550°C) contain nitrite and/or nitrate and sometimes cyanide and during their lifetime there is a build up of iron compounds, especially cyanocomplexes. During the treatment of high alloy steel or non-ferrous metals, they may also contain other heavy metals.

Classification of waste in accordance with EWL:

- 11 03 01* waste containing cyanide
11 03 02* other wastes

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

Disposal to landfill, as a rule, UGL.

2.7 Spent aqueous quenching media [H]

Aqueous quenching media contain additives (e.g. on salt, soda, alcohol or polymer basis) to, among other things, prevent the formation of gas bubbles on the metal surface. In addition, spent quenching water is also contaminated with substances from the salt baths which as a rule contain barium chloride and in some cases cyanide. As a rule, quenching water from tempering processes contains nitrite or nitrates.

Classification of waste in accordance with EWL:

- 16 10 01* aqueous liquid wastes containing dangerous substances.

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

As a rule, chemical physical treatment (CPT) using precipitation and filtration processes (see also chapter 19 08, par.2.5) to neutralise, detoxify and separate the water phase so it can be fed into the sewerage system. For on-site wastewater treatment see [J].

2.8 Waste from on-site wastewater treatment [J]

Waste water production arises from aqueous quenching baths, alkali washing and rinsing baths, in some cases aqueous residue from used air washers as well as cleaning and floor wastewater. In addition to treatment processes to precipitate and neutralise wastewater, it is necessary to carry out measures to remove poisons of cyanide and nitrite so that water from the processes described above can be fed into the sewerage system.

However, the technology used in on-site wastewater treatment are evaporation plants with heat exchange system. The solid residue is (untreated) salt phase.

Classification of waste in accordance with EWL:

For sludges from chemical physical treatment:

06 05 02* sludges from on-site effluent treatment containing dangerous solutions

For solid residue from evaporation processes:

06 03 11* other wastes

06 03 13* solid salts and solutions containing heavy metals

Notes on recycling, utilization and disposal:

Salts which are collected in the rinsing system can be reprocessed as mixed salts (as a rule through collection systems operated by tempering salt manufacturers).

Otherwise, disposal to landfill as hazardous waste, in some cases UGL.

2.9 Wastes from tempering processes [K]

During tempering processes in salt baths, tempering salts containing nitrite and nitrate are used. These become exhausted over their lifetime and, also because of the contaminants arising mainly from alloy components from the work piece being tempered, are identified as spent tempering salts.

Classification of waste in accordance with EWL:

11 03 02* other wastes

Notes on recycling, utilization and disposal:

In some cases reprocessing via recycling businesses (as a rule through collection systems operated by tempering salt manufacturers)..

Otherwise, disposal to landfill, as a rule UGL.

2.10 Wastes from used air treatment [L]

Contaminants from the salt baths (e.g. cyanide or barium chloride) are drawn out in the steam which is produced in tempering processes. They must, therefore, be sucked up and passed through a used air treatment plant (e.g. dry filter or used air washers). Wastes from used air washers may in some cases include organic contaminants, for example oil from quenching or tempering processes (dry filters are unsuitable here).

Classification of waste in accordance with EWL:

From dry filters:

11 03 01* waste containing cyanide

11 03 02* other wastes

From used air washers classification should be in accordance with the material being tempered, steel, aluminium, copper or precious metal:

From iron and steel tempering:

10 02 13* sludges from on-site effluent treatment containing dangerous solutions

From aluminium tempering:

10 03 25* sludges and filter cakes from gas treatment containing dangerous substances

From copper tempering:

10 06 07* sludges and filter cakes from gas treatment

From precious metal tempering:

10 07 05* sludges and filter cakes from gas treatment

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes..

Before being disposed of, sludges from used air washers should be subject to a chemical physical treatment (CPT) using precipitation / flocculation and filtration processes (see chapter 19 08, par. 2.5) to neutralise , detoxify, separate and return the water phase to the used air washers or in some cases feed it into the sewerage system. For residue from used air washers containing contaminants in the form of emulsions containing oil, see paragraph 2.5.

For solid residue from dry filters, disposal to landfill, as a rule UGL.

3 Overview of waste classification - material flow

	Extract from EWL	Material flow	Treatment
11 03	Sludges and solids from tempering processes		
11 03 01*	waste containing cyanide	B, F, L	1) processing, 2) UGL
11 03 02*	other wastes	C, G, K, L	1) processing, 2) UGL

	Sludges and solids from tempering processes to be classified under other waste categories		
06 03 11*	solid salts and solutions containing cyanides	J	1) processing, 2) UGL
06 03 13*	solid salts and solutions containing heavy metals	J	1) processing, 2) UGL
06 05 02*	sludges from on-site effluent treatment containing dangerous solutions	J	HWL
10 02 13*	sludges and filter cakes from gas treatment containing dangerous substances	L	CPT
10 03 25*	sludges and filter cakes from gas treatment containing dangerous substances	L	CPT
10 06 07*	sludges and filter cakes from gas treatment	L	CPT
10 07 05*	sludges and filter cakes from gas treatment	L	CPT
11 01 13*	degreasing wastes containing dangerous substances	A	CPT
11 01 14	degreasing wastes other than those mentioned in 11 01 13	A	CPT
12 01 07*	mineral-based machining oils free of halogens (except emulsions and solutions)	E	incineration
12 01 09*	machining emulsions and solutions free of halogens	E	CPT
14 06 04*	sludges or solid wastes containing halogenated solvents	A	1) incineration, 2) HWI
14 06 05*	sludges or solid wastes containing other solvents	A	1) incineration, 2) HWI
16 10 01*	aqueous liquid wastes containing dangerous substances	H	CPT

16 11 03*	other linings and refractories from metallurgical processes containing dangerous substances	D	1) material use, 2) HWL, UGL
16 11 04	other linings and refractories from metallurgical processes other than those mentioned in 16 11 03	D	1) material use, 2) with municipal waste

11 05 Wastes from hot galvanizing processes

1	Process	1
2	Wastes	2
3	Overview of waste classification – material flow	5

1 Process

Hot-dip zinc galvanizing is a metallurgical process for applying zinc coatings to steel pieces by immersion in molten zinc. Between the molten zinc and the metallurgically bright steel surface, layers of iron-zinc alloy are formed which provide a good adhesion for the zinc coating.

The hot galvanizing process is divided into two steps, material preparation and immersion in a zinc bath (**fig 1**). All the steps are immersion processes.

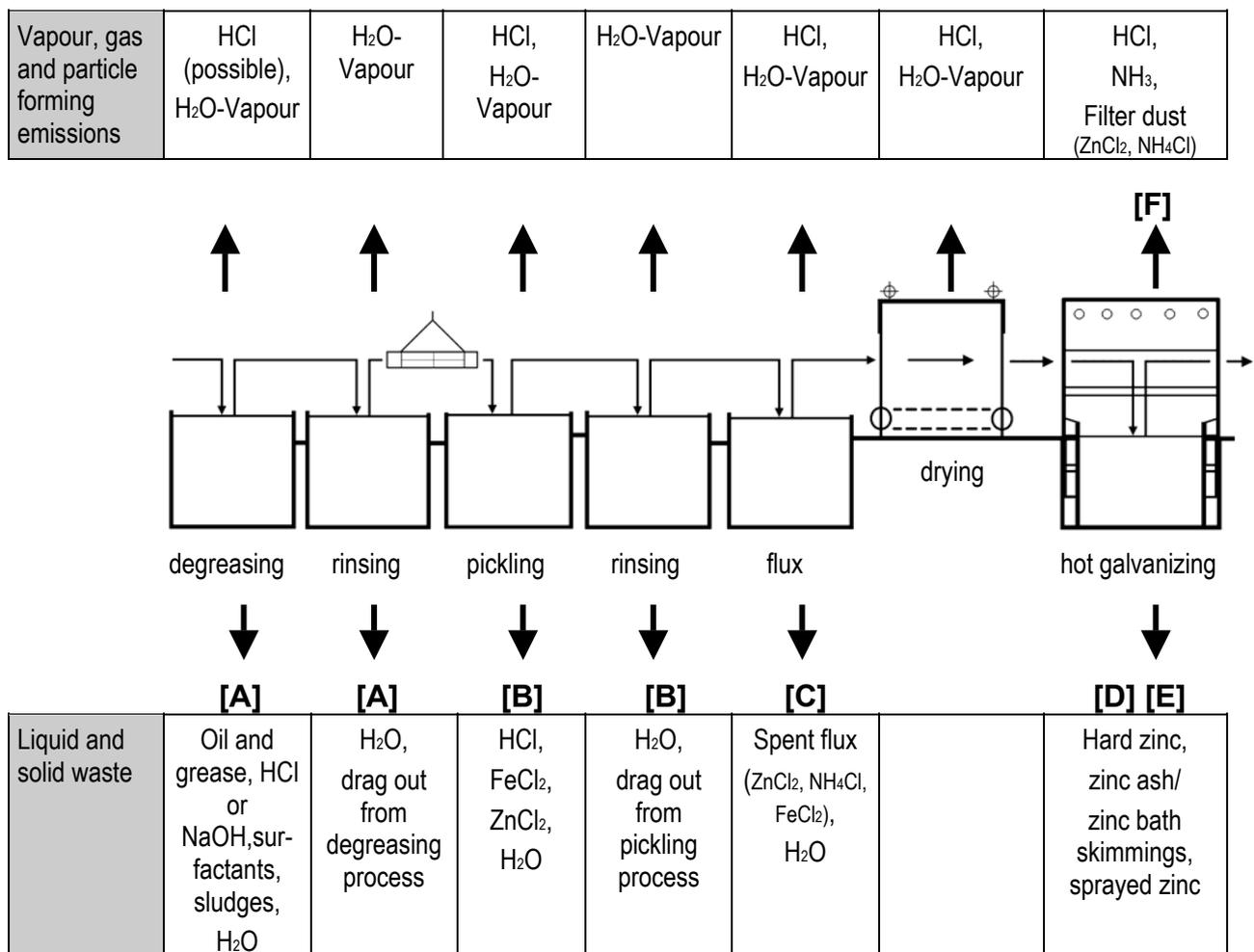


fig 1: An example representation of a hot galvanizing process (job galvanizing) and the possible waste and emissions

The steel parts to be galvanized are covered in varying amounts of iron-oxide (rust and scale), oil and grease. For hot galvanizing, a metallically bright surface is a prerequisite, so the steel parts are cleaned of oil and grease in an acid or alkali degreasing bath. Following alkali degreasing and often after acid degreasing too, there is usually a rinsing stage. The pickling process (usually hydrochloric pickling acid) removes all the iron-oxide layers from the steel pieces. Following the pickling bath, there are one or more rinsings. The immersion in flux provides an optimal covering of the pieces in the molten zinc bath. The flux normally consists of ammonium and zinc chloride.

During the hot galvanizing of pieces in a molten zinc bath (approx. 450°C), the flux undergoes a change and leads predominately to dust emissions, which are separated out in filters. Sometimes, the pieces are dried before being galvanized and cooled in a water bath after the hot galvanizing process.

2 Wastes

Wastes are produced during the material preparation (degreasing, pickling) as well as during the hot galvanizing process itself. As far as the material preparation is concerned, this includes waste process baths and wastes from cleaning the process baths, which can be classified under EWL-classification 11 01.

Spent degreasing baths [A]

Used acid degreasing baths contain diluted hydrochloric and phosphoric acid, emulsifiers, corrosion inhibitors as well as free and emulsified oils and grease. Spent alkali degreasing baths contain sodium hydroxide, carbonate, phosphate, silicate and surfactants as well as free and emulsified oils and grease. Spent acid and alkali degreasing baths are normally classified as hazardous waste.

Classification of waste in accordance with EWL -classification:

- 11 01 13* degreasing wastes containing dangerous substances (as a rule)
- 11 01 14 degreasing wastes other than those mentioned in 11 01 13 (exceptions)

Notes on recycling, utilization and disposal:

Incineration of the separated oil phases.

Otherwise chemical-physical treatment (CPT) of the degreasing bath using precipitation/flocculation and filtration processes (see chapter 19 08, par. 2.5) to neutralise and separate out the water phase which can then be fed into the sewerage system.

Spent degreasing rinsing baths [A]

After degreasing, the rinsing baths are strongly diluted degreasing baths, so it makes sense to dispose off or treat them together with spent degreasing baths.

Classification of waste in accordance with EWL:

- 11 01 13* degreasing wastes containing dangerous substances (as a rule)
- 11 01 14 degreasing wastes other than those mentioned in 11 01 13 (exceptions)

Notes on recycling, utilization and disposal:

As a rule, chemical-physical treatment (CPT) together with the spent degreasing baths using precipitation/flocculation and filtration processes (see chapter 19 08, par. 2.5) to neutralise and separate out the water phase which can then be fed into the sewerage system.

Spent pickling baths [B]

Used pickling baths essentially contain free residual acids, iron chloride, zinc chloride, alloy components from the pickled steels, and in some cases pickling inhibitors. If combined degreasing/pickling agents are used to pretreat the pieces, a process that is no longer the state of the art, the old pickling solution also contains large quantities of free and emulsified oils and grease too. Spent pickling baths are normally classified as hazardous waste.

Classification of waste in accordance with EWL:

11 01 05* pickling acids

Notes on recycling, utilization and disposal:

Pickling baths containing zinc are possibly reprocessed hydro-metallurgically or used for production of fluxes.

Otherwise chemical-physical treatment (CPT) using precipitation / flocculation and filtration processes (see chapter 19 08, par. 2.5) to neutralise and separate out the water phase which can then be fed into the sewerage system.

Spent pickling rinsing baths [B]

After pickling, the rinsing baths are strongly diluted pickling baths, so it makes sense to dispose off or treat them together with spent pickling baths.

Classification of waste in accordance with EWL:

11 01 05* pickling acids

Notes on recycling, utilization and disposal:

As a rule, chemical-physical treatment (CPT) together with the spent pickling baths using precipitation / flocculation and filtration processes (see chapter 19 08, par. 2.5) to neutralise and separate out the water phase which can then be fed into the sewerage system.

Spent flux baths [C]

Over a period of time, flux baths accumulate acids and iron through contamination. When a certain concentration is reached, the effectiveness of the flux is so reduced that the bath has to be cleaned. Spent flux is classified as hazardous waste, but it can normally be reprocessed centrally at flux manufacturers, or more rarely in hot galvanizing workshops themselves.

Classification of waste in accordance with EWL:

11 05 04* spent flux

Notes on recycling, utilization and disposal:

Spent flux baths are normally reprocessed and used for production of fresh flux.

Otherwise chemical-physical treatment (CPT) using precipitation / flocculation and filtration processes (see chapter 19 08, par. 2.5) to neutralise and separate out the water phase which can then be fed into the sewerage system.

Hard zinc [D]

Hard zinc is an iron-zinc alloy, which, because of its higher specific weight, is deposited on the bottom of the galvanizing bath and must be removed at regular intervals. Depending on working practices, hard zinc contains between 95 and 98% zinc and is normally given to zinc refineries for re-processing.

Classification of waste in accordance with EWL:

11 05 01 hard zinc

Notes on recycling, utilization and disposal:

In general hard zinc is reprocessed metallurgically.

Zinc ash/zinc bath skimming [E]

Zinc ash results from zinc being in contact with oxygen in the air as well as by reactions with flux, and mainly consists of zinc oxide and zinc chloride. Because of its lower specific weight, it floats to the surface of the molten zinc. The zinc ash is removed with a zinc bath skimmer. During this process relatively large quantities of zinc are also removed, so that the zinc content lies between 80 and 90%. Zinc ash is also normally given to zinc refineries for re-processing.

Classification of waste in accordance with EWL:

11 05 02 Zinc ash

Notes on recycling, utilization and disposal:

Zinc recycling

Filter dusts [F]

Dust that has been deposited in the exhaust air filters mainly consists of ammonium chloride and zinc chloride.

During zinc galvanizing, flux reacts with the molten zinc. Some of the products from this reaction are emitted as gases (e.g. hydrochloric acid, ammonia) or smoke particles (e.g. ammonium and zinc chloride). The components of the emissions depend on the composition of the flux. If oil and grease are dragged out as far as the zinc bath (e.g. incomplete degreasing, regreasing), the dusts could contain up to 10% oil and grease. As a result, there is a possibility of dioxin in the filter dusts, which restricts the use of the filter dusts as raw material for flux.

Classification of waste in accordance with EWL:

11 05 03* solid waste from gas treatment

Notes on recycling, utilization and disposal:

The dust can be used from the manufacturers as raw material in the production of flux.

Otherwise disposal to landfill, possibly in UGL.

3 Overview of waste classification – material flow

Extract from EWL		Material flow	Treatment
11 05	Wastes from hot galvanizing processes		
11 05 01	hard zinc	D	Recycling
11 05 02	zinc ash	E	Recycling
11 05 03*	solid waste from gas treatment	F	HWL, UGL
11 05 04*	spent flux	C	Recycling, CPT
11 05 99	waste not otherwise specified	Not normally required	

	Wastes from hot galvanizing processes, which should be classified under other waste categories		
11 01 05*	pickling acids	B	Recycling, CPT
11 01 13*	degreasing wastes containing dangerous substances	A	CPT, incineration
11 01 14	degreasing wastes other than those mentioned in 11 01 13	A	CPT

12 01 Wastes from shaping and physical and mechanical surface treatment of metals and plastics

1	Process	1
1.1	<i>Mechanical shaping</i>	1
1.2	<i>Cutting processes</i>	1
1.3	<i>Surface treatment</i>	2
2	Waste	3
2.1	<i>Turnings and filings [A], [B]</i>	3
2.2	<i>Machining sludge containing oil and metal [D]</i>	4
2.3	<i>Metal dust particles [H]</i>	5
2.4	<i>Plastic parts [A], [B]</i>	6
2.5	<i>Spent machining lubricants [E], [F]</i>	6
2.6	<i>Spent waxes and fats [I]</i>	7
2.7	<i>Spent bodies and grinding materials [K]</i>	8
2.8	<i>Waste blasting material [L]</i>	8
2.9	<i>Scale [G]</i>	9
2.10	<i>Contaminated filter materials [C]</i>	9
2.11	<i>Welding waste [M]</i>	10
3	Overview of waste classification - material flow	11

1 Process

1.1 Mechanical shaping

Semi-manufactured products (blanks, sheets, strips) are turned into the required forms using shaping tools (e.g. forging dies, rollers, deep drawing shapes) under high mechanical power. During separation, protruding parts are cut off and become waste in the form of turnings/stamping remains (see **fig. 2**). To assist this process, (lubrication, cooling) mould release agents, drawing medium or oil are applied to the semi-manufactured products. These auxiliary materials are to some extent recycled, but during mechanical post forming they are lost.

1.2 Cutting processes

The machining of parts is carried out with cutting tools (e.g. drills, saw-blades, turning chisels). There are usually several work steps, during which, filings are removed until the required form is produced (see **fig. 1**). In the majority of cases, machining lubricants (oil, emulsions, solutions) are added to optimise the process (cooling, lubricat-

ing, removal of filings). During sparc eroding processes the removal of material is carried out by the used eroding dielectrics (water or synthetic hydrocarbons) .

As a rule, these process auxiliary materials are recycled. The turnings and filings are removed using sedimentation or suitable filtration processes.

1.3 Surface treatment

Using an abrasive or cutting auxiliary material or tool, a defined surface form and/or surface quality is achieved. The dividing line between this and cutting operations is unclear.

During mechanical processes (grinding, honing, lapping, up to polishing), very fine filings are removed from the work piece (see **fig. 3**), and these combined with the added process auxiliary materials (e.g. machining lubricants, slide grinding compounds, lapping pastes, blasting material) are then removed in a suitable filtration system. With suitable tooling machines and tools some cutting processes may also be carried out dry, ie without machining lubricants (dry machining).

During blasting, an abrasive material (blasting material, eg corundum) is applied to the working piece in a jet of air resulting in the removal of the top surface of the piece or perhaps only achieving a certain surface property.

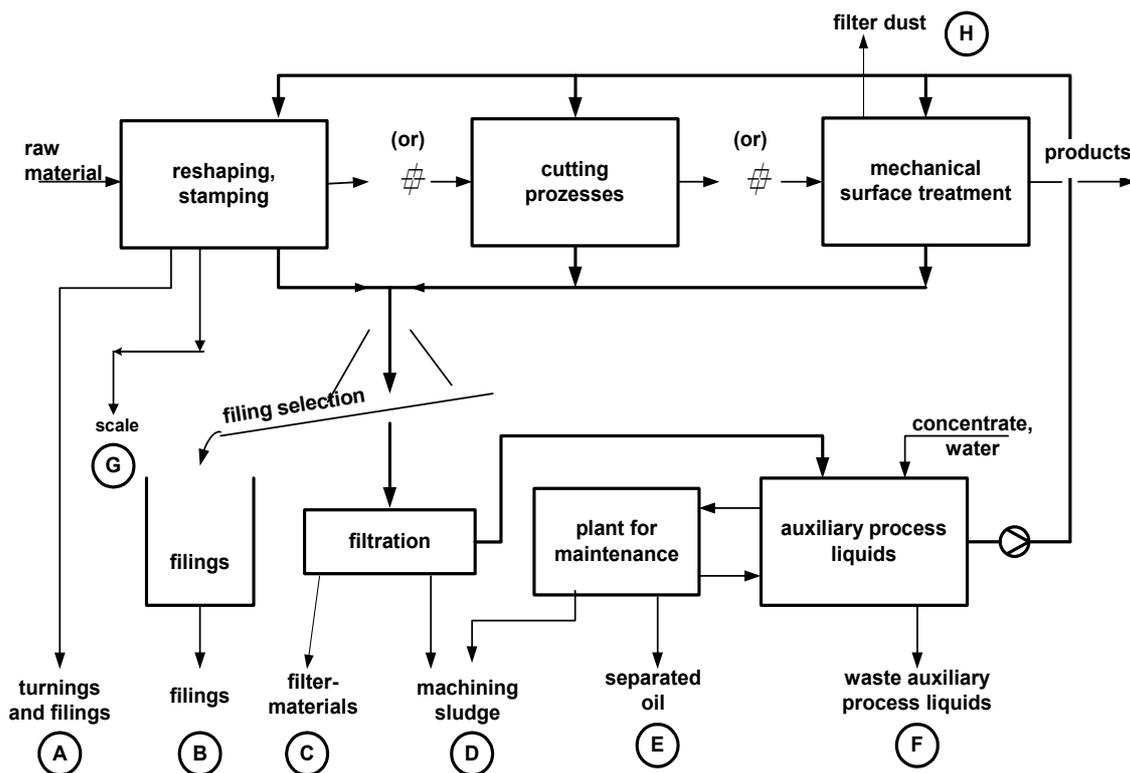


Fig 1: Shaping processes and surface treatment with (liquid, circulatory) auxiliary process materials

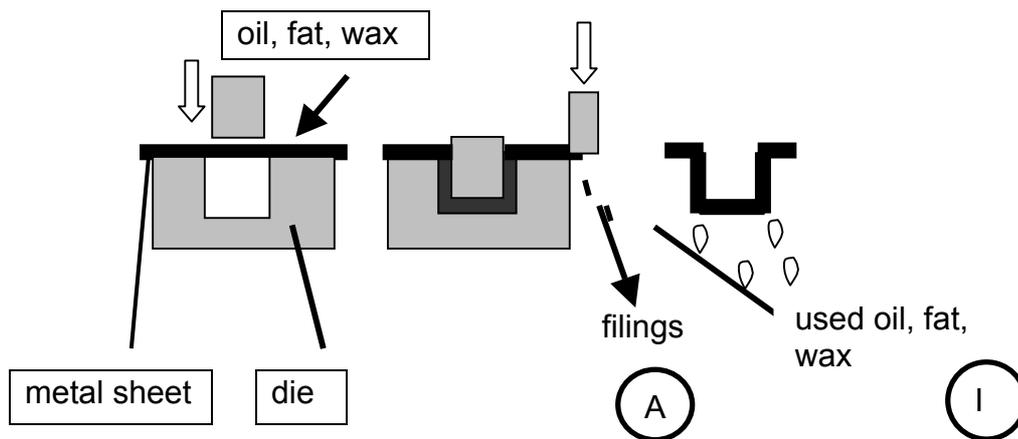


Fig 2: Post forming process with lost lubricants

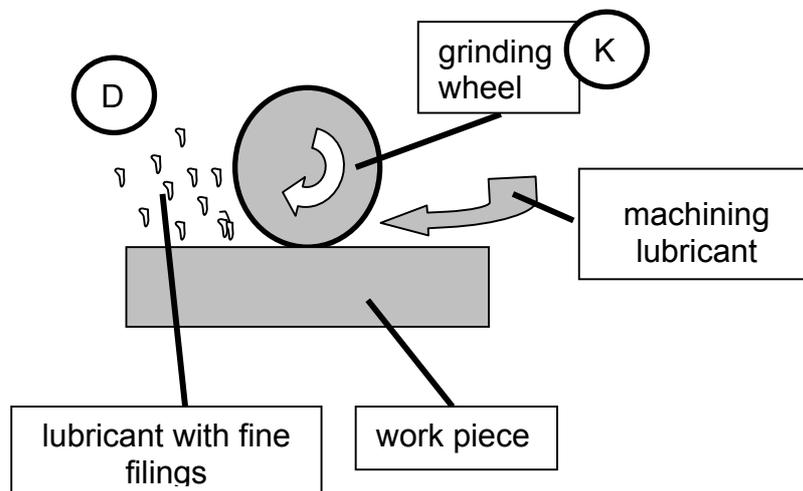


Fig 3: Grinding process

2 Waste

2.1 Turnings and filings [A], [B]

Cuttings are mainly produced during shaping processes (e.g. stamping, cutting). Metal filings and turnings are produced during machining processes such as turning, drilling, milling, sawing etc. (see **fig. 4**).

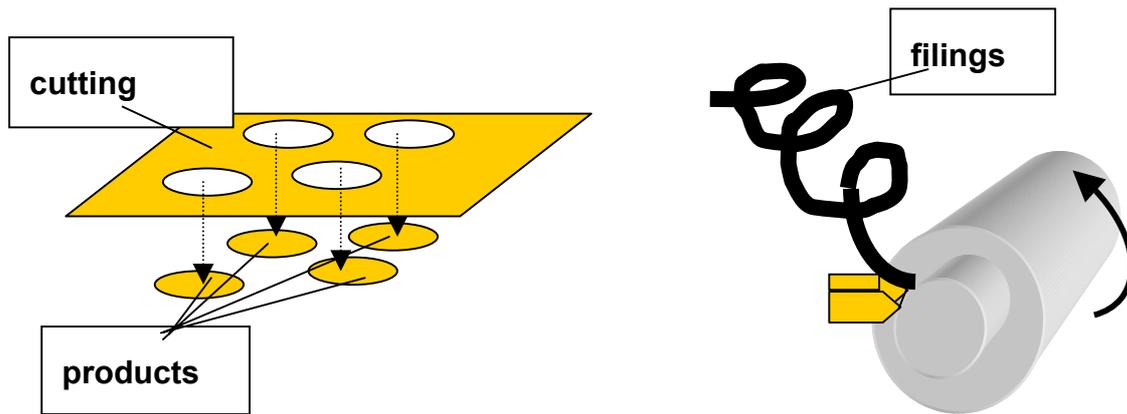


Fig 4: Cutting and filing processes

If machining lubricants are used, the waste is affected by them. Depending on the shape and fineness of the filings, the oil content lies between 0 and 3% and in some cases is considerably higher.

Classification of waste in accordance with EWL:

12 01 01 ferrous metal filings and turnings

12 01 03 non-ferrous metal filings and turnings

with increased contents of oil:

12 01 18* metal sludge (grinding, honing and lapping sludge) containing oil

Notes on recycling, utilization and disposal:

12 01 01/

12 01 03: Recycling in steel mills or secondary metallurgy via scrap metal dealers.

12 01 18*: De-oiling and pre-treatment in CPT (e.g. centrifuging, pressing, briquetting) and subsequent processing in the secondary metallurgy.

Otherwise disposal to HWL or HWI, according to the oil content.

2.2 Machining sludge containing oil and metal [D]

The fine filings which are produced are washed from the site together with the rubbed off grinding material in the machining lubricant and, subsequently, sluiced out of the process by a filtration process. The composition of this sludge shows a very broad spectrum, but typically has a significant oil content. Composition: metal content 10-80%; grinding material 2-75%; oil content (depending on the lubricant used) 1-50%; water content 5-75%; filter material and other contaminants.

With spark eroding, eroding sludges arise from the filtration of fine metal particles from the dielectric. In the case of wire eroding this sludge contains oil.

The danger to the environment results mainly from the machining lubricants, the often present heavy metals because of the high ability of fine particles to elute and the

unknown contaminants which are contained in the sludge. As with the categorisation of machining lubricants, a classification as hazardous waste is also proposed here.

Classification of waste in accordance with EWL:

for metal sludge such as grinding, honing, lapping and eroding sludge with low oil content up to 3% (dry content):

12 01 02 ferrous metal dust and particles

12 01 04 non-ferrous metal dust and particles

for metal sludge with oil content >3%:

12 01 18* metal sludge (grinding, honing and lapping sludge) containing oil

for machining sludge e.g. slide grinding sludge, polishing sludge or grinding sludge with a high concentration of filter auxiliary materials which usually show a low metal content (<10%):

12 01 14* machining sludges containing dangerous substances (*rule*)

12 01 15 machining sludges other than those mentioned in 12 01 14

Notes on recycling, utilization and disposal:

12 01 02/

12 01 04: Recycling in steel mills or secondary metallurgy via scrap metal dealers, if necessary after pre-treatment (e.g. pelletising, pressing). Otherwise disposal to landfill. If it does not contain dangerous substances, together with municipal waste.

12 01 14*/

12 01 15: After pre-treatment (de-oiling, dewatering) in rare case (e.g. grinding sludges) material use in building and construction industry. As a rule, disposal to HWL or HWI, according to the oil content. If it does not contain dangerous substances, together with municipal waste.

12 01 18*: De-oiling and pre-treatment in CPT (e.g. centrifuging, pressing, briquetting) and subsequent processing in the secondary metallurgy.

Otherwise disposal to HWL or HWI, according to the oil content.

2.3 Metal dust particles [H]

During cutting processes without machining lubricants (dry machining), e.g. during dry belt sanding, fine filings and rubbed off grinding material are produced as dust particles. They are removed or sucked away from the site of production and separated out in a filter plant.

During surface treatment using blasting, the fine particles produced are sluiced out of the blasting material circulation by way of a filter plant.

Classification of waste in accordance with EWL:

12 01 02 ferrous metal dust and particles

12 01 04 non-ferrous metal dust and particles

Notes on recycling, utilization and disposal:

12 01 02/

12 01 04: Recycling in steel works or secondary metallurgy via scrap metal dealers, if necessary after pre-treatment (e.g. pelletising, pressing).

Otherwise disposal to landfill. If it does not contain dangerous substances, together with municipal waste.

2.4 Plastic parts [A], [B]

During the formation of plastic parts using mechanical machining processes (eg turning, milling, drilling), plastic filings and turnings, which have to be disposed of separately, are produced. As a rule, plastics are dry machined.

Classification of waste in accordance with EWL:

12 01 05 plastics shavings and turnings

Notes on recycling, utilization and disposal:

Recycling for sheer fractions.

Otherwise disposal to landfill or incineration. If it does not contain dangerous substances, together with municipal waste.

2.5 Spent machining lubricants [E], [F]

During most cutting processes and also during post forming, machining lubricants are added. The machining lubricants are circulated (see **fig. 1**). Due to contaminants, they become unusable over a period of time and have to be exchanged. Both, pure machining oil (based on mineral, synthetic and native oil) as well as water-based systems (emulsions, solutions) can be used. Machining lubricants can consist of up to 30 components: base oil and additives (e.g. sulphur and phosphorous containing additives, chloride paraffin, biozides, salts etc.). In addition, contaminants (e.g. rubbings, metals, chemicals, dirt) are carried into the lubricant. Waste machining lubricants, therefore, have a considerable potential to pollute the environment and are generally classified as hazardous waste.

2.5.1 Non-water-miscible machining lubricants (machining oil)

Non-water-miscible machining lubricants (machining oil) can be sent for recovery or disposal (e.g. re-processing, second oil refinery, energy production, incineration of hazardous waste) without being pre-treated.

Classification of waste in accordance with EWL:

for non-water-miscible machining lubricants containing halogenated additives of mineral or synthetic oil base:

12 01 06* mineral-based machining oils containing halogens (except emulsions and solutions)

for halogen-free, non-water-miscible machining lubricants of mineral oil base:

12 01 07* mineral-based machining oils free of halogens (except emulsions and solutions)

for halogen-free, synthetic machining oils:

12 01 10* synthetic machining oils

Notes on recycling, utilization and disposal:

12 01 06*: At present there are no known viable treatment processes. Thermal treatment in HWI.

12 01 07*/

12 01 10*: Reprocessing as base oil according to waste oil directive. Otherwise incineration.

2.5.2 Machining oils of native base

Machining oils of native basis, especially esters, are growing in importance. In order to achieve high quality reconditioning, a separate category is of fundamental importance. Despite, compared to mineral oils, a better biodegradability and thereby less danger to water pollution, a categorisation as hazardous waste is proposed, because additives and possibly dangerous substances from machining processes (see sub-chapter 2.5) pose a considerable potential threat to the environment.

Classification of waste in accordance with EWL:

12 01 19* readily biodegradable machining oil

Notes on recycling, utilization and disposal:

Reprocessing as base products, normally via take-back systems of the producers. Otherwise incineration.

2.5.3 Water-miscible machining lubricants (emulsions and solutions)

As a rule, disposed water-mixed machining lubricants consists of up to more than 90% water. Because of this, they have to be pre-treated to remove the water. In contrast to lubricating emulsions, lubricating solutions, which are preferable for grinding, cannot be treated in the usual emulsion-separating process (eg ultrafiltration, inorganic and organic separation). A separate category and treatment is therefore advisable.

Classification of waste in accordance with EWL:

12 01 08* machining emulsions and solutions containing halogens

12 01 09* machining emulsions and solutions free of halogens

Notes on recycling, utilization and disposal:

12 01 08*: CPT to separate out the water phase which can be fed into the sewerage system.
Otherwise thermal treatment in HWI

12 01 09*: CPT to separate out the water phase which can be fed into the sewerage system.

2.6 Spent waxes and fats [!]

Especially during post forming processes, waxes and fats are used as auxiliary process materials. During the process, there is additional contamination from rub-off and impurities (see **fig. 2**).

Classification of waste in accordance with EWL:

12 01 12* spent waxes and fats

Notes on recycling, utilization and disposal:

In rare cases reprocessing as base products, normally via take-back systems of the producers. Otherwise incineration.

2.7 Spent bodies and grinding materials [K]

When the permitted degree of wear has been reached the grinding bodies have to be exchanged. This applies equally to grinding wheels as well as the chips from slide grinding processes. The contents are the grinding material (ceramic, e.g. corundum, aluminium oxide etc) and the binder (organic or ceramic). Porous materials may, in addition, also be contaminated with machining lubricants and their contents (see chapter 2.5).

Classification of waste in accordance with EWL:

12 01 20* spent grinding bodies and grinding materials containing dangerous substances

12 01 21 spent grinding bodies and grinding materials other than those mentioned in 12 01 20

Notes on recycling, utilization and disposal:

Material use for the production of grinding materials.

Otherwise disposal to landfill. If it does not contain dangerous substances, together with municipal waste.

2.8 Waste blasting material [L]

Blasting materials which have a mineral or metal base e.g. slags, corundum and steel grit, are predominantly used for blasting metal surfaces in fixed plants. For special applications, blasting material made of plastic and natural hard material (e.g. nut shells) is used. Usually in a metal-working plant, blasting material is circulated and fine particles are sluiced out in a filter plant. Possible dangerous substances come primarily from the blasting of coatings and paint. The corrosion protector and paint coatings may contain heavy metals (eg lead, zinc) as well as dangerous substances from paint pigments. During the blasting of new parts, only the metal rub-off is carried into the blasting material.

Classification of waste in accordance with EWL:

for waste metal blasting material (e.g. steel grit):

12 01 02 ferrous metal dust and particles

for other waste blasting material:

12 01 16* waste blasting material containing dangerous substances

12 01 17 waste blasting material other than those mentioned in 12 01 16

Mineral blasting material is primarily used by mobile plant during the renovation of plant and construction sites (bridges, masts, ships etc.). Increasingly, an attempt is made to recycle the blasting material. Possible hazardous substances come primarily from the coatings which are removed and especially during the removal of old zinc and lead-containing corrosion preservatives there is a potential danger to the environment.

Classification of waste in accordance with EWL:

- 12 01 16* waste blasting material containing dangerous substances (*rule*)
- 12 01 17 waste blasting material other than those mentioned in 12 01 16

Notes on recycling, utilization and disposal:

- 12 01 02: Recycling in steel mills or secondary metallurgy via scrap metal dealers, if necessary after pre-treatment (e.g. pelletising, pressing).

Otherwise disposal to landfill. If it does not contain dangerous substances, together with municipal waste.

12 01 16*/

- 12 01 17: Material use in cement works.
Otherwise disposal to landfill. If it does not contain dangerous substances, together with municipal waste.

2.9 Scale [G]

During hot post-forming processes, e.g. forging and hot milling, scale, which can also contain oil, may be produced. Large quantities are produced mainly in iron and steel production's associated intermediate mills (e.g. hot rolling mills). A suitable classification is contained in subchapter 10 02.

Classification of waste in accordance with EWL:

- 10 02 10 mill scales

for oil-containing scale (sludge) with an oil content > 3%:

- 12 01 14* machining sludges containing dangerous substances

Notes on recycling, utilization and disposal:

- 10 02 10: Processing in steel mills for the manufacture of pig iron, normally after pre-treatment (pelletising, sintering).

Otherwise disposal to landfill. If it does not contain dangerous substances, together with municipal waste.

- 12 01 14*: Processing in steel mills for the manufacture of pig iron, after pre-treatment (de-oiling, pelletising, sintering).

Otherwise thermal treatment in HWI.

2.10 Contaminated filter materials [C]

Liquid process auxiliary materials (e.g. machining lubricants, spark erosion dielectrics), which are in circulation, have to be cleaned of impurities in order to maintain their usefulness. To remove solid impurities (rub-off, fine shavings, dirt), a wide vari-

ety of filtration processes are used. These normally use disposable filter materials e.g. filter fleece or filter cartridges. Waste filter material as well as cleaning cloths are full of inorganic impurities (e.g. grinding rub-off, metal sludge) and organic impurities (e.g. machining lubricants, oil) and has to be classified, accordingly, as hazardous waste.

Classification of waste in accordance with EWL:

- 15 02 02* absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances (*rule*)
- 15 02 03 absorbents, filter materials, wiping cloths and protective clothing other than those mentioned in 15 02 02

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

As a rule incineration. If it does not contain dangerous substances, together with municipal waste.

2.11 Welding waste [M]

During welding, welding slag, metal particles, scale and electrode remains arise. Separate classification is normally not possible.

Classification of waste in accordance with EWL:

- 12 01 13 welding wastes

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

Disposal to landfill. If it does not contain dangerous substances, together with municipal waste.

Overview of waste classification - material flow

Extract from EWL		Material flow	Treatment
12 01	Wastes from shaping and physical and mechanical surface treatment of metals and plastics		
12 01 01	ferrous metal filings and turnings	A,B	Recycling
12 01 02	ferrous metal dust and particles	D,H	1) recycling, 2) with municipal waste
12 01 03	non-ferrous metal filings and turnings	A,B	Recycling
12 01 04	non-ferrous metal dust and particles	D,H	1) recycling, 2) with municipal waste
12 01 05	plastics shavings and turnings	A,B	1) recycling, 2) incineration, 3) with municipal waste
12 01 06*	mineral-based machining oils containing halogens (except emulsions and solutions)	E,F	HWI
12 01 07*	mineral-based machining oils free of halogens (except emulsions and solutions)	E,F	1) recycling, 2) incineration
12 01 08*	machining emulsions and solutions containing halogens	E,F	CPT
12 01 09*	machining emulsions and solutions free of halogens	E,F	CPT
12 01 10*	synthetic machining oils	E,F	1) recycling, 2) incineration
12 01 12*	spent waxes and fats	I	1) material use, 2) incineration
12 01 13	welding wastes	M	With municipal waste
12 01 14*	machining sludges containing dangerous substances	D	1) material use, 2) HWL, HWI
12 01 15	machining sludges other than those mentioned in 12 01 14	D	1) material use, 2) with municipal

			waste
12 01 16*	waste blasting material containing dangerous substances	L	1) material use, 2) HWL
12 01 17	waste blasting material other than those mentioned in 12 01 16	L	1) material use, 2) with municipal waste
12 01 18*	metal sludge (grinding, honing and lapping sludge) containing oil	D, [A, B]	1) CPT 2) HWL, HWI
12 01 19*	readily biodegradable machining oil	E,F	1) recycling, 2) incineration
12 01 20*	spent grinding bodies and grinding materials containing dangerous substances	K	1) material use, 2) HWL
12 01 21	spent grinding bodies and grinding materials other than those mentioned in 12 01 20	K	1) material use, 2) with municipal waste
12 01 99	wastes not otherwise specified	Not normally required	

Wastes from shaping and physical and mechanical surface treatment of metals and plastics, to be classified in other subchapters			
10 02 10	mill scales	G	1) recycling, 2) with municipal waste
15 02 02*	absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	C	HWI
15 02 03	absorbents, filter materials, wiping cloths and protective clothing other than those mentioned in 15 02 02	C	1) incineration, 2) with municipal waste

12 03 Wastes from water and steam degreasing processes (except 11)

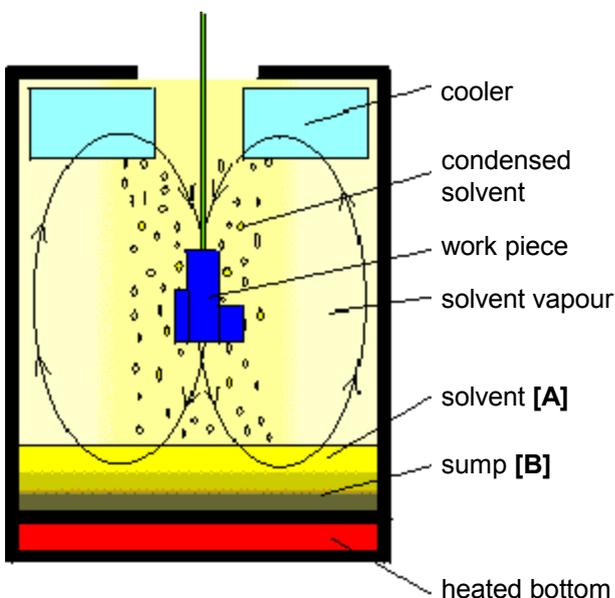
1	PROCESS	1
1.1	Vapour degreasing	1
1.2	Steam degreasing.....	2
2	WASTES	2
3	OVERVIEW OF WASTE CLASSIFICATION – MATERIAL FLOW.....	4

1 Process

This group of wastes covers wastes from special processes to degrease work pieces in vapour phase. The general processes for degreasing work pieces are dealt with in chapters 11 and 14.

1.1 Vapour degreasing

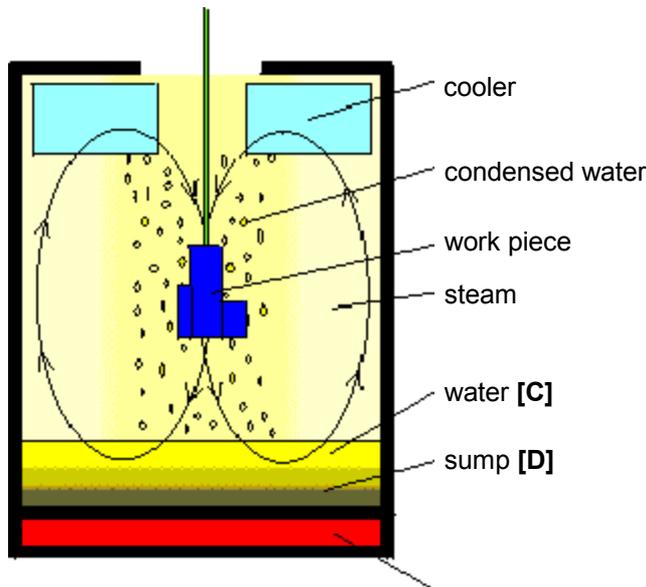
Vapour degreasing is carried out in a sealed or open-topped container in which a heating element brings solvent to boiling point. The solvents used are usually chlorinated or non-chlorinated hydrocarbons or alcohol. The resulting solvent vapour is heavier than air thus squeezing the air out of the vapour area. The work piece to be degreased is hung in the vapour.



Due to the difference in temperature between the hot vapour and the cold work piece, the solvent condenses on the surface of the work piece. It dissolves the contaminants and then drips into the vapour sump. As the solvent boiling point lies below that of the dissolved contaminants, only pure solvent vaporises and condenses on the work piece while the dirt collects in the sump (distillation principle). Vapour degreasing allows the complete removal of oils, fat, emulsions, dust, polishing pastes, etc. .

Fig. 1: Diagrammatic representation of vapour degreasing

1.2 Steam degreasing



Steam degreasing uses water instead of organic solvents as cleaning agents. This process can be used when the contaminants are water soluble and when hygienic effects (e.g. sterilisation) are required (achieved through the higher boiling point of water compared to organic solvents).

Fig. 2: Diagrammatic representation of steam degreasing

2 Wastes

Contaminated solvents [A]

Organic substances such as fats and oil build up in the solvent so that the solvent has to be changed regularly.

Classification of waste in accordance with EWL:

- 14 06 02* other halogenated solvents and solvent mixtures
- 14 06 03* other solvents and solvent mixtures

Notes on recycling, utilization and disposal:

Spent solvent can be reprocessed by distillation, and recycled.

Otherwise thermal treatment in HWI, or incineration of halogen-free waste.

Sump [B]

Organic components with a high boiling point and contaminant particles removed from the work pieces build up in the sump.

Classification of waste in accordance with EWL:

- 12 03 02* steam degreasing wastes

Notes on recycling, utilization and disposal:

The solvent sump can to some extent be reprocessed by distillation, and the recovered solvent reused.

Otherwise thermal treatment in HWI, or incineration of halogen-free waste.

Contaminated water [C]

Organic substances such as fats and oil build up in water. As a result, the water is regularly changed.

Classification of waste in accordance with EWL:

12 03 01* aqueous washing liquids

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

As a rule, treatment in chemical physical treatment plants (CPT) using precipitation/flocculation and filtration processes (see chapter 19 08, paragraph 2.5) to neutralise and separate out the water phase to be subsequently fed into the sewage system.

Sump from steam degreasing [D]

Organic components with a high boiling point and contaminant particles removed from the work pieces build up in the sump.

Classification of waste in accordance with EWL:

11 01 13* degreasing wastes containing dangerous substances

11 01 14 degreasing wastes other than those mentioned in 11 01 13

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

As a rule, treatment in chemical physical treatment plants (CPT) using precipitation/flocculation and filtration processes (see chapter 19 08, paragraph 2.5) to neutralise and separate out the water phase to be subsequently fed into the sewage system.

3 Overview of waste classification – material flow

Extract from EWL	Material flow	Treatment
12 03 wastes from water and steam degreasing processes (except 11)		
12 03 01* aqueous washing liquids	C	CPB
12 03 02* steam degreasing wastes	B	1) Distillation, 2) Incineration

wastes from water and steam degreasing processes to be classified under other waste categories		
11 01 13* degreasing wastes containing dangerous substances	D	CPT
11 01 14 degreasing wastes other than those mentioned in 11 01 13	D	CPT
14 06 02* other halogenated solvents and solvent mixtures	A	1) Distillation, 2) HWI
14 06 03* other solvents and solvent mixtures	A	1) Distillation, 2) Incineration

13 05 Oil/water separator contents

1	Process	1
1.1	<i>Waste water treatment plants for oil/water mixes</i>	1
1.2	<i>Cleaning vehicles for grit chambers and oil/water separators</i>	2
1.3	<i>Interceptors in road drainage system</i>	2
2	Waste	3
2.1	<i>Grit chamber sediment [A]</i>	3
2.2	<i>Oil phase from oil/water separators [B]</i>	3
2.3	<i>Fine fraction (oily sludge) from oil/water separators [C]</i>	4
2.4	<i>Water phase from grit chambers and oil/water separators [D]</i>	4
2.5	<i>Mixture from grit chambers and oil/water separators [E]</i>	4
2.6	<i>Solids from interceptors [F]</i>	5
3	Overview of waste classification – material flow	6

1 Process

1.1 Waste water treatment plants for oil/water mixes

In every industrial and commercial sector where oil/water mix is produced, waste-water treatment plants in the form of oil/water separators (see **fig. 2**) are prescribed to prevent water pollution in the sewage system or waters. This is relevant to surface water from areas where oil or oil containing substances are processed or used as well as areas where oil polluted equipment and vehicles are cleaned.

As a rule, the waste water is contaminated with solids (sand (containing oil), metal fragments, organic materials) so that, in addition, a solids separator (grit chamber) has to be installed (see **fig. 1**). The most significant sites where this arises are:

- areas for vehicle cleaning and servicing
- storage and trade centres for mediums containing oil
- metal-working industry

The purpose of grit chambers and oil/water separators is, to a large extent, to separate solids and oil from waste water before it is fed in.

It is based on the principle of sedimentation of solids as well as the floatation of (non-emulsified!) oils in the settling area of the separator. To improve oil separation, an additional coalescence separator is often installed. Oil/water separators are fundamentally not suitable for separating emulsified oils. Grit chambers and oil/water separators are normally connected in sequence. Systems are often combined in a compact plant.

The separated phases (oil, solids, oily sludge) are collected in the respective chambers of the separator. The types of waste described in the following chapter 2

arise during the required, periodic emptying and cleaning of these plants (every 6 months to 2 years depending on the level of water pollution). The quantity of waste is only a fraction (less than 0,1%) of the total amount of waste water.

1.2 *Cleaning vehicles for grit chambers and oil/water separators*

The grit collectors and oil/water separators are regularly, or when full, emptied and cleaned by cleaning vehicles (suction vehicles). A range of technology is used for this purpose. The waste which is removed is taken for further treatment in physico/chemical treatment plants or direct to disposal plants.

1.2.1 *Single-chamber vehicles*

When emptying and cleaning is done with single-chamber vehicles, all the contents of the grit chamber and/or the oil/water separators are mixed and sucked up. The waste then consists of a mixture of solids, oils and water phase. This mixture can only be treated (i.e. separated) in chemical/physical treatment plants which are designed for this purpose.

1.2.2 *Multiple-chamber vehicles*

When emptying and cleaning is done with multiple-chamber vehicles, the phases from the grit chamber and oil/water separators (see **fig. 1 and 2**) are taken separately and fed into different chambers of the vehicle. The ability of the separator to separate is thereby preserved and the following waste results: solid phase (sand phase), oil phase and water phase. A large part of the water phase from the separator may be returned to replenish the separator after physical treatment.

1.3 *Interceptors in road drainage system*

Interceptors of in road drainage systems often are installed with simple collection baskets to collect washed-in solids. Emptying and collection is normally carried out by vehicles belonging to town cleaning companies or municipal road maintenance departments.

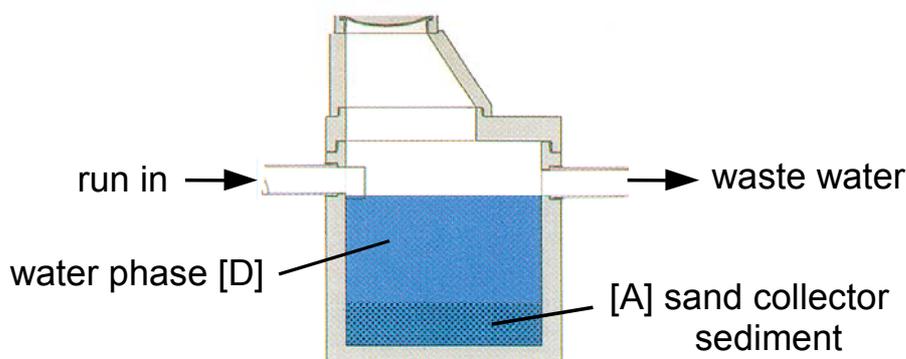


Fig 1: Grit chamber

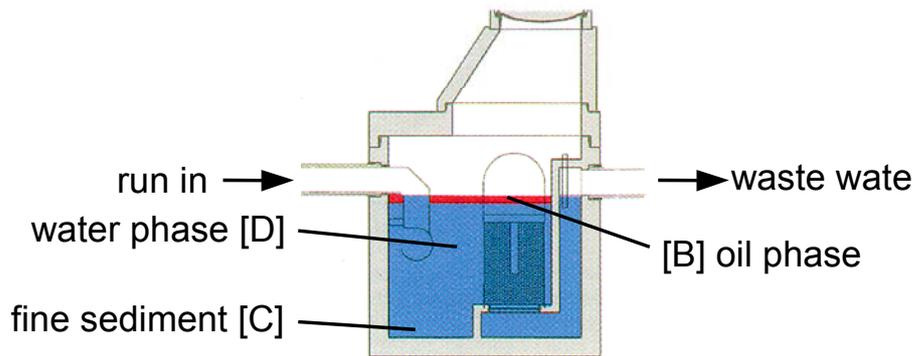


Fig. 2: Oil/water separator with coalescence separator

2 Waste

2.1 Grit chamber sediment [A]

Larger solid particles which are carried in the flow of waste water settle on the bottom of the grit chamber by sedimentation (see **fig. 1**). Depending on size, surface composition and the degree of oil contamination in the waste water these particles are contaminated with oil (normally less than 1 to 5%).

Classification of waste in accordance with EWL:

13 05 01* solids from grit chambers and oil/water separators

Notes on recycling, utilization and disposal:

After treatment in (soil-) clean-up plants to reduce the oil content, possibly processing in building and construction industry.

Otherwise disposal to landfill. If it does not contain dangerous substances, together with municipal waste.

2.2 Oil phase from oil/water separators [B]

Oil phase (see **fig. 2**) forms a layer of oil on the surface of the separator and can be removed separately using appropriate means. The composition depends on the type of oil discharge and other dirt.

Classification of waste in accordance with EWL:

13 05 06* oil from oil/water separators

Notes on recycling, utilization and disposal:

Reprocessing as base oil in secondary oil refineries.

Otherwise incineration.

2.3 Fine fraction (oily sludge) from oil/water separators [C]

If the fine solid fraction carried in the flow of waste water is not held back in a grit chamber, it settles on the bottom of the oil/water separator (see **fig 2**). As a rule, there is a considerable oil content (normally 10 to 30%) but in terms of the total quantity it is normally negligible.

Classification of waste in accordance with EWL:

13 05 02* sludges from oil/water separators

Notes on recycling, utilization and disposal:

Use as a fuel or material use in cement works.

Otherwise incineration, as a rule in HWI.

2.4 Water phase from grit chambers and oil/water separators [D]

In well-run plants, water phase is only minimally contaminated after a certain time in the system.

During emptying and cleaning, however, there is an inevitable mixing effect so that the water phase removed from the system is usually contaminated with oil and, in some cases, fine solid particles.

Classification of waste in accordance with EWL:

13 05 07* oily water from oil/water separators

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

CPT to separate oil and solid materials from the water phase which can be fed into the sewerage system.

2.5 Mixture from grit chambers and oil/water separators [E]

With the regular practice today of emptying and cleaning grit chambers and oil/water separators with single-chamber vehicles, the whole contents of the system, i.e. all phases (sand phase, oil phase, oily sludge and water phase) are sucked out together and taken away. The phases are thereby so mixed together that they can only be treated in chemical/physical treatment plants specially equipped for this purpose. This means separating out the individual fractions once again.

Classification of waste in accordance with EWL:

13 05 08* mixtures of wastes from grit chambers and oil/water separators

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

CPT to separate the different phases: sand phase, oil phase, oily sludge and water phase.

2.6 Solids from interceptors installed before oil/water separators [F]

The collection baskets installed in interceptors hold back solids thereby reducing the amount of contamination into the purification plant and to prevent water pollution. The sludge removed during emptying contains solids (e.g. leaves, sand, litter etc.) as well as washed-off oil and to some extent heavy metals (e.g. brake lining and tyre tread).

Classification of waste in accordance with EWL:

13 05 03* interceptor sludges

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

As a rule disposal to landfill (HWL).

2.7 Solids from interceptors in road drainage systems [G]

For interceptor sludges obtaining from routine cleaning of normal interceptors (e.g. public places) which do not contain any hazardous components.

Classification of waste in accordance with EWL:

20 03 03 street-cleaning residues

Notes on recycling, utilization and disposal:

Use in road construction or in building and construction industry.

As a rule disposal to landfill, possibly together with municipal waste.

3 Overview of waste classification – material flow

Extract from EWL		Material flow	Treatment
13 05	oil/water separator contents		
13 05 01*	solids from grit chambers and oil/water separators	A, C	1) CPT 2) with municipal waste
13 05 02*	sludges from oil/water separators	C	1) material use 2) HWI
13 05 03*	interceptor sludges	A, F	HWL
13 05 06*	oil from oil/water separators	B	1) recycling 2) incineration
13 05 07*	oily water from oil/water separators	D	CPT
13 05 08*	mixtures of wastes from grit chambers and oil/water separators	E	CPT

oil/water separator contents, to be classified in other subchapters		Material flow	Treatment
20 03 03	street-cleaning residues	G	1) with municipal waste 2) material use

16 02 Wastes from electrical and electronic equipment

1	Process	1
1.1	<i>Pre-dismantling of electrical and electronic equipment</i>	1
1.2	<i>Treatment of transformers and hydraulic systems containing PCBs</i>	2
2	Waste	2
3	Overview of waste classification – material flow	8

1 Process

1.1 Pre-dismantling of electrical and electronic equipment

Electrical and electronic equipment from private households, such as refrigerators, television sets, personal computers, night storage heaters, fuse boxes, etc. which arises from commercial or municipal bulky waste collections, should be left to specialist firms to dispose of in accordance with regulations. In addition to dismantling problematic materials and parts such as cathode ray tubes, mercury switches, accumulators, etc. suitable parts such as steel pieces, circuit boards containing precious metal, etc. should be removed for further use. This should be carried out using the latest technical and commercially viable procedures (fig 1).

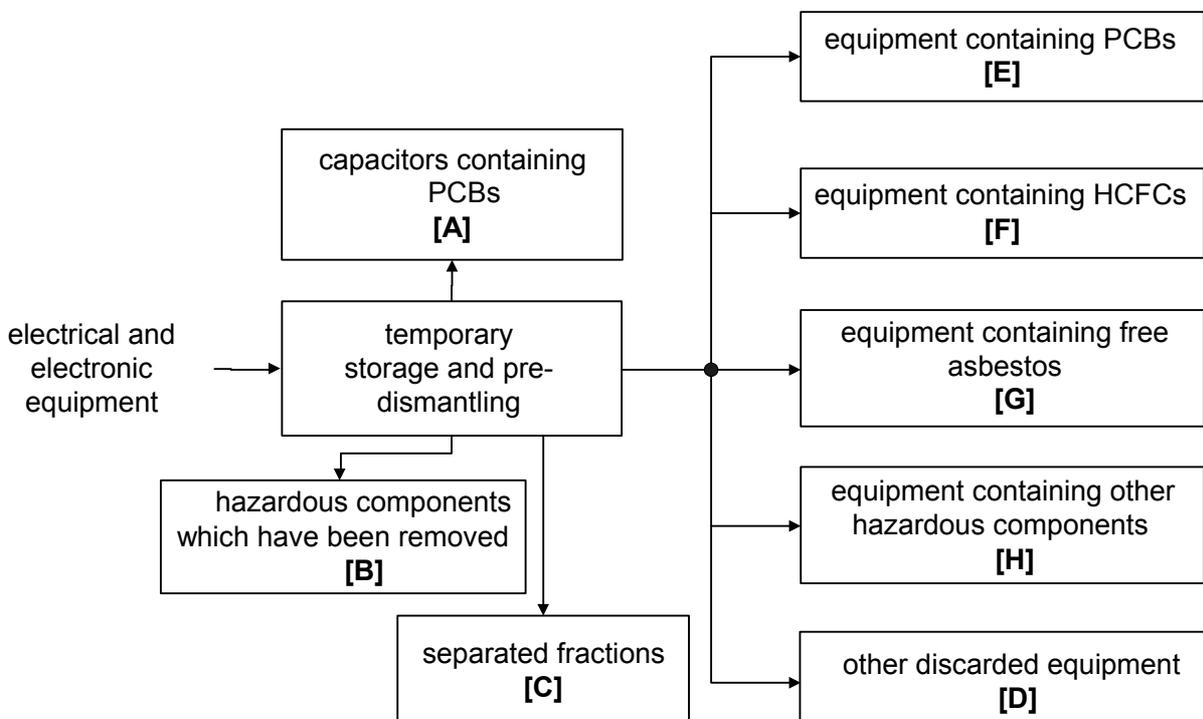


Fig 1: Categorisation of waste from electrical and electronic equipment

1.2 Treatment of transformers and hydraulic systems containing PCBs

Equipment such as high-capacity transformers or hydraulic systems from mining either containing or contaminated with PCBs are collected by authorised disposal companies, then, treated and cleaned of PCBs. First of all, PCBs are pumped out into special containers. After that, the emptied pieces of equipment or contaminated surfaces are cleaned in a washing system. The cleaning fluid containing PCBs is treated in a separator so that the cleaning fluid can be recycled. As a rule, the separated PCBs are disposed of in a special waste incinerator.

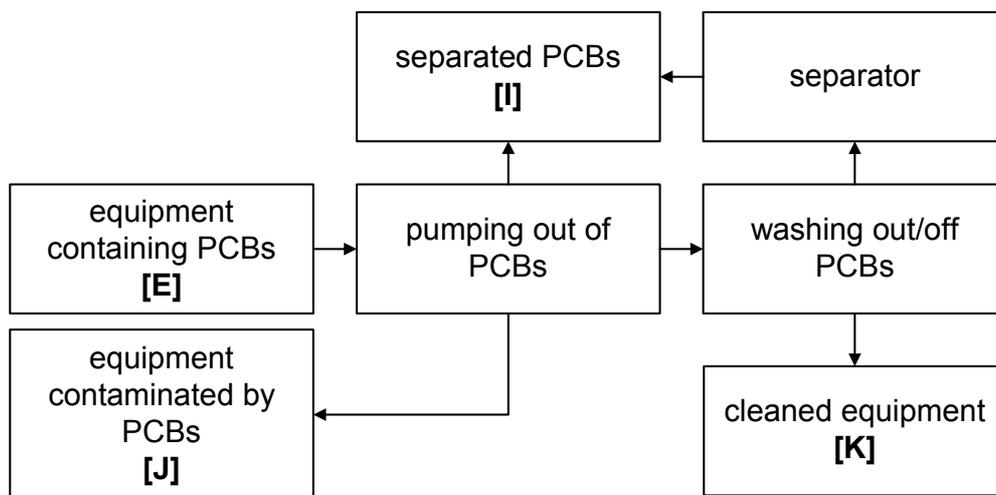


Fig 2: Treatment of equipment containing or contaminated with PCBs

2 Waste

Capacitors containing PCBs [A]

Capacitors containing PCBs can be found, for example, in fluorescent lamps and in older electricity generators. PCBs are materials that are carcinogenic, are classified in water risk factor 3 and can produce dioxin in thermal waste disposal plants.

Classification of waste in accordance with EWL:

16 02 09* transformers and capacitors containing PCBs

Notes on recycling and disposal:

At present there are no known recycling processes.

As a rule, capacitors containing PCBs are disposed of in underground landfill.

Hazardous components which have been removed [B]

If hazardous components are removed during the pre-dismantling of equipment, they have to be declared as hazardous waste. Hazardous components include coolant, picture tubes, accumulators, batteries containing dangerous substances (see 16 06),

activated glass, bromide circuit boards which have been partly or completely dismantled, untreated polyurethane plastics (insulation foam) as well as treated insulation foam with a remaining concentration of HCFCs >0.1 % weight, etc.

Classification of waste in accordance with EWL:

- 14 06 01* chlorofluorocarbons, HCFC, HFC
- 16 02 15* hazardous components removed from discarded equipment

Special categorisation for dangerous components:

- 16 06 01* lead batteries
- 16 06 02* Ni-Cd-batteries
- 16 06 03* mercury-containing batteries
- 20 01 21* fluorescent tubes and other mercury-containing waste
- 20 01 33* batteries and accumulators included in 16 06 01, 16 06 02 or 16 06 03 and unsorted batteries and accumulators containing these batteries

Notes on recycling and disposal:

- 14 06 01* (coolant and insulation foam with HCFCs >0.1 % weight): HWI
- 16 02 15* body and screen glass: used in the production of picture tubes and in lead works, otherwise HWL.
Circuit boards: metallurgical recycling or HWL.
Batteries: metallurgical recycling or HWL.
Fluorescent tubes (containing Hg): mercury removal.

Separated fractions [C]

Parts/materials removed from discarded equipment which are not considered to be hazardous are to be classified under 16 02 16, unless other chapters in the waste list contain appropriate categories; these should be found in 19 12.

Classification of waste in accordance with EWL:

- 16 02 16 components removed from discarded equipment other than those mentioned in 16 02 15
- 19 12 02 ferrous metal
- 19 12 03 non-ferrous metal
- 19 12 04 plastic and rubber
- 19 12 05 glass

Notes on recycling and disposal:

As a rule, composite material is shredded and separated into ferrous metal fraction, other metals and light shredder fraction.

The metal, plastic and glass fractions can normally be recycled.

Otherwise, incineration or disposal with municipal waste.

Other discarded equipment [D]

Equipment not containing parts or materials which are to be classified as hazardous waste or from which hazardous materials have already been dismantled and removed.

Classification of waste in accordance with EWL:

In so far as the equipment is taken back through commercial outlets out with public waste disposal:

16 02 14 discarded equipment other than those mentioned in 16 02 09 to
16 02 13

In so far as the equipment is collected separately from household refuse through official public disposal bodies or their agents:

20 01 36 discarded equipment other than those mentioned in 16 02 09 to
16 02 13

Notes on recycling and disposal:

As a rule, pre-treatment by shredding to separate into a metal, plastic and a light shredder fraction.

As a rule, the metal fraction is recycled.

Otherwise, see group 19 10.

Equipment containing PCBs [E]

Equipment which was filled with liquid containing PCBs with at least 50 mg/kg is to be regarded as "equipment containing PCBs". Large pieces of equipment containing PCBs, for example transformers and hydraulic systems, normally undergo a cleaning process as described in chapter "1.2 Treatment of transformers and hydraulic systems containing PCBs". If no cleaning process is carried out, the whole piece of equipment contaminated with PCBs must be declared as waste particularly requiring monitoring.

Classification of waste in accordance with EWL:

16 02 09* transformers and capacitors containing PCBs

16 02 10* discarded equipment containing or contaminated by PCBs other than
those mentioned in 16 02 09

Notes on recycling and disposal:

At present there are no known recycling processes. Equipment containing PCBs are either cleaned of PCBs (see paragraph 1.2) or disposed of in underground landfill.

Equipment containing HCFCs [F]

Equipment containing chlorofluorocarbons, HCFC, HFC includes for example refrigerators or other cooling systems. HCFCs present a high potential to cause damage to the ozone layer.

Classification of waste in accordance with EWL:

In so far as the equipment is taken back through commercial outlets out with public waste disposal:

16 02 11* discarded equipment containing chlorofluorocarbons, HCFC, HFC

In so far as the equipment is collected separately from household refuse through official public disposal bodies or their agents:

20 01 23* discarded equipment containing chlorofluorocarbons

Notes on recycling and disposal:

At present there are no known recycling processes.

Removal (draining, suction) of HCFC (the equipment can then be disposed of as HCFC free) or thermal treatment of the whole piece of equipment in an incineration plant.

Equipment containing free asbestos [G]

Equipment, for example night-storage heaters and laboratory equipment with thermal insulation containing asbestos, where the housing is damaged contains free asbestos. This equipment is classified under its own waste category. Asbestos is classified as carcinogenic.

Classification of waste in accordance with EWL:

16 02 12* discarded equipment containing free asbestos

17 06 01* insulation materials containing asbestos

Notes on recycling and disposal:

At present there are no known recycling processes.

Asbestos fibres can be packed in dustproof "Big-bags" or immobilised by cementing in.

Equipment containing other hazardous components [H]

Electrical and electronic equipment from which not all hazardous parts/materials have been removed, such as accumulators and batteries, glass from cathode ray tubes, activated glass, bromide circuit boards.

Classification of waste in accordance with EWL:

In so far as the equipment is taken back through commercial outlets out with public waste disposal:

16 02 13* discarded equipment containing hazardous components other than those mentioned in 16 02 09 to 16 02 12

In so far as the equipment is collected separately from household refuse through official public disposal bodies or their agents:

20 01 35* discarded electrical and electronic equipment other than those mentioned in 20 01 21 and 20 01 23 containing hazardous components

Notes on recycling and disposal:

Treatment by dismantling and separating components with dangerous materials (see paragraph 1.1).

Otherwise HWI or HWL.

Separated PCBs [I]

Liquids removed containing more than 50 mg/kg PCB are to be classified and disposed of as hazardous waste.

Classification of waste in accordance with EWL:

13 03 01* insulating or heat transmission oils containing PCBs

Notes on recycling and disposal:

At present there are no known recycling processes.

As a rule, liquid PCB waste is disposed of in special waste incineration plants (HWI).

Equipment contaminated by PCBs [J]

Equipment from which PCB or PCB mediums have been drained off or from which PCB contamination has not been fully cleaned off is regarded as PCB contaminated.

Classification of waste in accordance with EWL:

16 02 09* transformers and capacitors containing PCBs

16 02 10* discarded equipment containing or contaminated by PCBs other than those mentioned in 16 02 09

Notes on recycling and disposal:

It is not possible to smelt metals contaminated with PCBs because there are no licensed plants to do this (see technical requirements and the cleaning and disposal of transformers with mineral oil or synthetic insulation liquids containing PCBs or contaminated with PCBs).

As a rule, (see chapter 1.2) sent for PCB contamination removal.

Otherwise, disposal in underground landfill.

Cleaned equipment [K]

Equipment can either be re-filled or disposed of using a suitable process. In the case of re-filling, the level of 50 mg/kg PCB in circulating coolant must not be exceeded, even after a long lifetime.

Classification of waste in accordance with EWL:

- 16 02 14 discarded equipment other than those mentioned in 16 02 09 to 16 02 13
- 19 12 02 ferrous metal
- 19 12 03 non-ferrous metal
- 19 12 04 plastic and rubber
- 19 12 05 glass

Notes on recycling and disposal:

Pre-treatment to separate into valuable fractions, eg. by manual dismantling or shredding.

As a rule, the metal, plastic and glass fractions can be recycled.

Light shredder fraction: see group 19 10.

Otherwise, incineration or disposal to landfill together with municipal waste.

3 Overview of waste classification – material flow

Extract from EWL		Material flow	Treatment
1602	Wastes from electrical and electronic equipment		
16 02 09*	transformers and capacitors containing PCBs	A, E, J	Cleaning, UGL
16 02 10*	discarded equipment containing or contaminated by PCBs other than those mentioned in 16 02 09	E, J	Cleaning, UGL
16 02 11*	discarded equipment containing chlorofluorocarbons, HCFC, HFC	F	Removal of HCFC, HWI
16 02 12*	discarded equipment containing free asbestos	G	HWL, UGL (immobilised)
16 02 13*	discarded equipment containing hazardous components ⁽¹⁾ other than those mentioned in 16 02 09 to 16 02 12	H	Dismantling, HWL, HWI
16 02 14	discarded equipment other than those mentioned in 16 02 09 to 16 02 13	D, K	1) Shredder, Recycling 2) with municipal waste
16 02 15*	hazardous components removed from discarded equipment	B	closed Shredder, Recycling, HWL, HWI, UGL
16 02 16	components removed from discarded equipment other than those mentioned in 16 02 15	C	1) Shredder, Recycling 2) with municipal waste

Wastes from electrical and electronic equipment, to be classified under other waste categories			
13 03 01*	insulating or heat transmission oils containing PCBs	I	HWI
14 06 01*	chlorofluorocarbons, HCFC, HFC	B	HWI
16 06 01*	lead batteries	B	Recycling, HWL
16 06 02*	Ni-Cd batteries	B	Recycling, HWL

¹ Hazardous components from electrical and electronic equipment may include accumulators and batteries mentioned in 16 06 and marked as hazardous; mercury switches, glass from cathode ray tubes and other activated glass, etc.

16 06 03*	mercury-containing batteries	B	Recycling, HWL
17 06 01*	insulation materials containing asbestos	G	HWL, HMD (immobilised)
19 12 02	ferrous metal	C, K	Recycling
19 12 03	non-ferrous metal	C, K	Recycling
19 12 04	plastic and rubber	C, K	1) Recycling, 2) Incineration, 3) with municipal waste
19 12 05	glass	C, K	1) Recycling 2) with municipal waste
20 01 21*	fluorescent tubes and other mercury-containing waste	B	Recycling, HWL, UGL
20 01 23*	discarded equipment containing chlorofluorocarbons	F	Removal of HCFC, HWI
20 01 33*	batteries and accumulators included in 16 06 01, 16 06 02 or 16 06 03 and unsorted batteries and accumulators containing these batteries	B	Sorting, Recycling, HWL
20 01 35*	discarded electrical and electronic equipment other than those mentioned in 20 01 21 and 20 01 23 containing hazardous components	H	Dismantling, HWL, HWI
20 01 36	discarded electrical and electronic equipment other than those mentioned in 20 01 21, 20 01 23 and 20 01 35	D	1) Shredder, Recycling, 2) Incineration, 3) with municipal waste

16 06 Batteries and accumulators

1	Process.....	1
2	Waste	2
3	Overview of waste classification – material flow.....	5

1 Process

Return of spent batteries

The return and disposal of spent batteries and accumulators is carried out in accordance with battery legislation. Since October 1998, manufacturers and distributors are required to take back and dispose of spent batteries. The return of spent batteries is achieved either through a manufacturer's own scheme or in a joint venture between several manufacturers. The end-user can return batteries to any sales point. For lead batteries (starter batteries) which are used principally in motor vehicles, there are separate regulations regarding the return of batteries to sales points. A high rate of return should be guaranteed with a return deposit. The batteries collected by the various methods of return normally have to be passed on for subsequent recycling or sorting (fig 1).

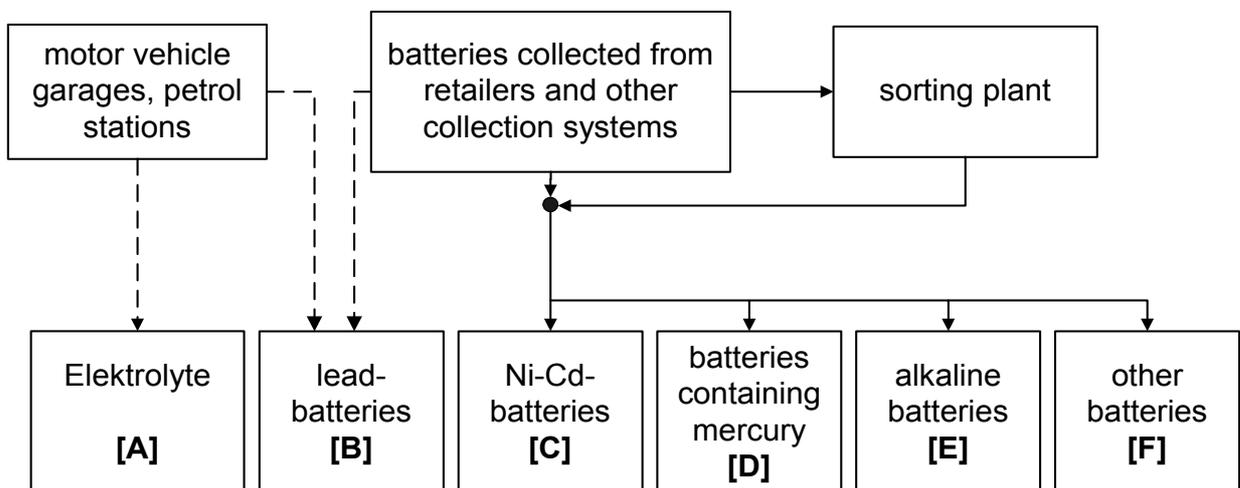


Figure 1: schematic representation of spent battery collection systems

2 Waste

Electrolyte [A]

Separately collected electrolyte originates from lead starter batteries from motor vehicles and consists of aqueous sulphuric acid. Electrolyte is produced during maintenance or disposal of leaking lead starter batteries. In the case of leaking lead accumulators, the electrolyte (sulphuric acid) is transferred to specifically designated containers.

Classification of waste in accordance with EWL:

16 06 06* separately collected electrolyte from batteries and accumulators

Notes on recycling, utilization and disposal:

Aqueous sulphuric acid is usually reprocessed in sulphuric acid recycling facilities.

Otherwise treatment and neutralisation in CPT.

Lead batteries [B]

Lead batteries come in a wide variety of sizes and models for a wide range of uses. The best known are starter batteries for motor vehicles. The cathode consists of lead plates, the anode of lead oxide. In the lead battery there is an electrode framework made of hard lead alloy. This alloy contains arsenic, copper and tin. Spreading means such as Lignin sulfone acids and Lignin sulfates or barium sulphate may be added. The electrode plates are held apart by separators which may be made of rubber, sintered plastic, impregnated paper, plastic felt or plastic silicic acid mixture. The electrolyte consists of aqueous sulphuric acid. The battery housing is made almost exclusively of polypropylene (PP). Disposal takes place in secondary lead smelting works. Lead batteries are taken back by trade and sales outlets separate to the existing collection system for household batteries.

Classification of waste in accordance with EWL:

16 06 01* lead batteries

20 01 33* batteries and accumulators included in 16 06 01, 16 06 02 or 16 06 03 and unsorted batteries and accumulators containing these batteries

Notes on recycling, utilization and disposal:

After pre-treatment (sorting, separation of acid from plastic materials) usually reprocessing in secondary metallurgy.

Otherwise disposal to landfill (HWL).

Nickel-Cadmium-Batteries [C]

The negative electrode of nickel-cadmium batteries consists of cadmium, the positive of nickel oxide hydroxide. Ni-Cd batteries contain conductors such as nickel foil, graphite, as well as cobalt sulphate. The separator system is made of paper or synthetic compounds. The electrolyte used is usually potassium hydroxide (KOH). The housing is made of iron. The only meaningful method of recycling Ni-Cd batteries up to now has been thermal processing. As a rule, the cadmium is distilled

off in a vacuum or inert atmosphere and the remaining steel-nickel mix is sent to be used in steel production.

Classification of waste in accordance with EWL:

- 16 06 02* Ni-Cd-Batteries
- 20 01 33* batteries and accumulators included in 16 06 01, 16 06 02 or 16 06 03 and unsorted batteries and accumulators containing these batteries

Notes on recycling, utilization and disposal:

Reprocessing in secondary metallurgy (if necessary after sorting). At present only thermal processes are relevant for the recycling of Ni-Cd-batteries. Normally cadmium is separated by vacuum or inert-gas distillation. The remaining steel-nickel mixture is processed in steel works.

Otherwise disposal to landfill.

Mercury-containing batteries [D]

Mercury-containing batteries consist of a zinc cathode which is amalgamated to resist corrosion. The anode is mercuric oxide and graphite. The mercuric oxide portion of the anode is 92%. The proportion of mercury in the whole cell is 40 to 45%. The separator system consists of several layers of parchment, thick paper or synthetic fleece. Aqueous calcium or sodium hydroxide saturated with zinc oxide is used as the electrolyte. The housing is made of steel.

Note: In accordance with directive 98/101/EC, from 1st January 2001 it is forbidden to put certain batteries and accumulators on the market because of their mercury content. The permitted level of mercury in batteries and accumulators must be reduced to 0.0005 percentage weight in all member states.

Classification of waste in accordance with EWL:

- 16 06 03* mercury-containing batteries
- 20 01 33* batteries and accumulators included in 16 06 01, 16 06 02 or 16 06 03 and unsorted batteries and accumulators containing these batteries

Notes on recycling, utilization and disposal:

As a rule pre-treatment for the separation of mercury (thermal- vacuum process). Demercurised metals can be recycled.

Otherwise disposal to HWL.

Alkaline/manganese batteries [E]

The negative electrode is made of manganese dioxide. The anode is made of zinc powder or zinc foil soaked with calcium hydroxide. The anode is covered in a synthetic fleece bag which serves as a separator. Cellulose, rayon, PVC, nylon, polyvinylalcohol or polypropylene fibres are used as separator materials. The housing is made of steel.

Classification of waste in accordance with EWL:

- 16 06 04 alkaline batteries (except 16 06 03)
- 20 01 34 batteries and accumulators other than those mentioned in 20 01 33

Notes on recycling, utilization and disposal:

As a rule, recycling in secondary metal industry (if necessary after sorting).
Otherwise disposal together with municipal waste.

Other batteries [F]

Other batteries include a mixture of batteries and accumulators (primary and secondary batteries) which cannot be classified in one of the EWL categories above. These include, for example, zinc carbon, lithium manganese oxide, zinc silver oxide batteries etc. These batteries are classified as non hazardous waste.

Classification of waste in accordance with EWL:

16 06 05 other batteries und accumulators

20 01 34 batteries and accumulators other than those mentioned in 20 01 33

Notes on recycling, utilization and disposal:

As a rule, separation of zinc carbon, alkaline, lithium and zinc silver oxide batteries and subsequent recycling in secondary metal industry.

Otherwise disposal together with municipal waste.

3 Overview of waste classification – material flow

Extract from EWL		Material flow	Treatment
16 06	Batteries and accumulators		
16 06 01*	lead batteries	B	1) recycling, 2) HWL
16 06 02*	Ni-Cd-Batteries	C	1) recycling, 2) HWL
16 06 03*	mercury containing batteries	D	1) recycling, 2) HWL
16 06 04	alkaline batteries (except 16 06 03)	E	1) recycling, 2) with municipal waste
16 06 05	other batteries und accumulators	F	1) sorting/recycling, 2) with municipal waste
16 06 06*	separately collected electrolyte from batteries and accumulators	A	1) recycling, 2) CPT

Wastes of batteries and accumulators to be classified in other subchapters			
20 01 33*	batteries and accumulators included in 16 06 01, 16 06 02 or 16 06 03 and unsorted batteries and accumulators containing these batteries	B, C, D	1) sorting/recycling, 2) HWL
20 01 34	batteries and accumulators other than those mentioned in 20 01 33	E, F	1) sorting/recycling, 2) with municipal waste

16 08 Spent catalysts

1. THE APPLICATION OF CATALYSTS.....	1
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1. The application of catalysts

Catalysts have the property of speeding up certain chemical reactions without themselves changing. Catalysts are used either as liquids in solution (homogenous catalysis) or as solids (heterogeneous catalysis), mainly in the chemical or petrochemical industry or in flue-gas treatment (see **tab. 1**). Except in chemical technology, catalysts in the form of enzymes also play a significant role in biochemical processes, however, these will not be considered in this paper.

Catalysts lose their ability to function effectively over time due to sintering on the surface (growth of crystals), phase changes, irreversible poisoning of the active areas with catalyst poison (see **tab. 1**), as well as blocking or covering with rust, liquid polymers, etc.

2. Catalysts in the chemical and petrochemical industry

At present, around 75% of all chemicals are produced using catalysts and over 90% of all newly commissioned, high capacity production plants use catalytic processes. The economic importance is reflected in the petrochemical and chemical industry's annual catalyst requirement (348 million US\$, source: Ullman).

Process	Catalyst	Catalyst poison
Chemical Industry		
Manufacture of hydrogen and ammonia, steam reforming	Ni, Fe	Compounds of S, Se, Te, P, As, Halogens
Hydrogenation of edible oils, mineral oils, hydrogenation of olefins in ethylene plants	25% Ni in oil, Ni-Cr, Pd on Al ₂ O ₃	S, Se, Te, P, As, Halogens, compounds of Hg and Pb, O ₂ , CO
Dehydrogenation, butadiene from butane, styrene from ethyl benzol	Cr-Al-Oxide, Fe-Oxide	
Oxidation, ethylene oxide, HNO ₃ from NH ₃ , contact - H ₂ SO ₄ , vehicle exhaust catalytic converter	Ag-carriers, Pt-Rh, V ₂ O ₅	Compounds of P, As, Sb, Pb, Zn, Cd, Bi, S
Ammonia oxidation, acrylonitrile from propylene	U-Sb-Oxide, Pt-Rh	Compounds of P, As, Sb; also Pb, Zn, Cd, Bi, Rust
Oxy chlorination, vinyl chloride	CuCl ₂	
Organic syntheses, "Friedel-Crafts"	AlCl ₃	
Polymerisation, Stereo-Polymere, Urethane-Foam, cumol, tetramer	Ti, V-Verb., Al-Alkyl, Cr, Tert. Amine, H ₃ PO ₄ on silica gel	
Petrochemical Industry		
Catalytic Cracking	Zeolite, amorphous aluminium silicate	Amine, H ₂ O
Catalytic reforming	Mono-Bimetal-catalysts	
Hydrogen treatment	Co-Mo, Ni-Mo, Ni-W	
Hydrocracking	Precious metal on amorphous carriers, nonprecious metals on molecular sieve	
Alkylation	H ₂ SO ₄ , HF,	

Tab. 1: Examples of catalysts used in chemical and petrochemical processes (Source: following Ullmann)

2.1 Catalysts from cracking processes

2.1.1 Process

Catalytic or catalyst supported cracking processes (see fig. 1) play an important role in the petrochemical industry, enabling more useful, highly refined fractions to be made; in other words larger molecules can be cracked. As a rule, zeolite-based catalysts are used as they allow the cracking of hydrocarbons at lower temperatures. Zeolite catalysts are built on a system of hollow spaces (mesh width 0.3 to 1.0 nm), thereby offering a large active surface area. After cracking, the fractions are separated in the fractionating column. From time to time **catalysts from cracking processes [A]** arise for disposal.

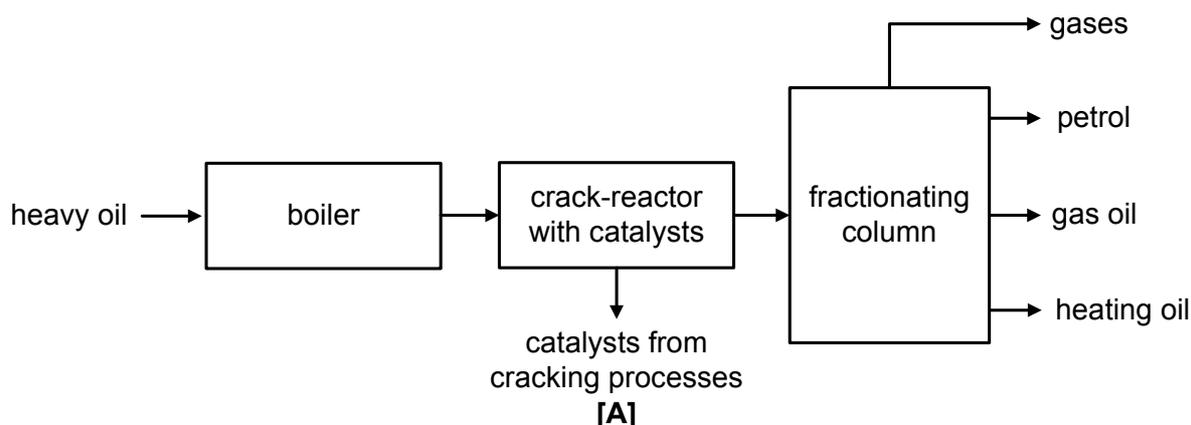


Fig. 1: Diagrammatic representation of catalytic cracking processes

2.1.2 Wastes

Catalysts from cracking processes [A]

Zeolite is crystallised aluminium silicate with the general formula : $Me_{2/n} * Al_2O_3 * nSiO_2 * pH_2O$, in which „Me“ symbolises a monovalent alkali metal (n=1), a bivalent alkali metal (n=2) or other specially added metals (eg. Se, Ni, Mo, Pt and Pd). Up to 85% of the aluminium can be replaced by silicon, so that a large part of zeolite X or zeolite Y is silicon. Significant hazardous materials are especially organic contaminants (hydrocarbons) which, if present in certain concentrations, result in waste which particularly requires monitoring.

Classification of waste in accordance with EWL:

- 16 08 04 spent fluid catalytic cracking catalysts (except 16 08 07)
- 16 08 07* spent catalysts contaminated with dangerous substances

Notes on recycling, utilization and disposal:

Precious metal and heavy metal contents can be recycled.

Otherwise, thermal treatment in waste incineration plants or disposal to landfill, together with municipal waste if it does not contain dangerous substances.

2.2 Alkylation of aromatic compounds

2.2.1 Process

In principle, two hydrocarbon molecules are bonded so that the hydrocarbon chain is extended, i.e. the hydrocarbon ring is extended. Olefine, alkyl-halides, alcohol, ether and alkyl-ester may be used as catalysts in addition to sulphuric acid (H_2SO_4) or hydrofluoric acid (HF). **Liquid catalysts [B]** arise for disposal.

2.2.2 Wastes

Liquid catalysts [B]

Liquid catalysts from the alkylation of petrochemicals may be contaminated with organic substances and to be classified as hazardous waste.

Classification of waste in accordance with EWL:

16 08 06* spent liquids used as catalysts

Notes on recycling, utilization and disposal:

As a rule, liquid catalysts from inorganic acids are fed to acid recycling, or, when there is a high organic component, oil recycling.

Otherwise, neutralisation in CPT plants or thermal treatment in waste incineration plants (HWI).

2.3 Catalysts containing phosphoric acid

2.3.1 Process

Catalysts containing phosphoric acid [C], such as boron-tri-fluoride phosphoric acid ($\text{BF}_3 + \text{H}_3\text{PO}_4$) can be used in selective reactions with a variety of organic reactions (as catalyst or co-catalyst). Examples of applications in the chemical, petrochemical and pharmaceutical industry include: dimerization, trimerization, oligomerization, polymerization, alkylation, acylation, carbonylation.

2.3.2 Wastes

Catalysts containing phosphoric acid [C]

In addition to the named acids, substitute substances, such as boron, fluoride, etc., may be present. They have the desired catalytic effect in the relevant process. In addition, organic contaminants may be present in catalysts containing phosphoric acid which, for example, are discharged from processes in the petrochemical industry.

Classification of waste in accordance with EWL:

16 08 05* spent catalysts containing phosphoric acid

Notes on recycling, utilization and disposal:

At present there are known any viable treatment processes.

As a rule disposal by neutralisation in CPT plants.

3. Catalysts from flue-gas treatment

3.1 Catalysts from SCR processes for the treatment of industrial flue-gas

3.1.1 Process

In **Selective-Catalytic-Reduction** processes, (**SCR**) nitrogen oxide (NO_x) is reduced to nitrogen (N_2) and water (H_2O) with the help of ammonia (NH_3). This reaction takes place using catalysts at a temperature of about 250 °C. From time to time, **spent catalysts from SCR flue-gas treatment [D]** are exchanged during maintenance work.

3.1.2 Wastes

spent catalysts from SCR flue-gas treatment [D]

The main constituent of SCR catalysts is, as a rule, titanium dioxide as well as vanadium, tungsten and occasionally molybdenum compounds and as a result, these catalysts have to be classified as hazardous waste.

Classification of waste in accordance with EWL:

- | | |
|-----------|--|
| 16 08 02* | spent catalysts containing dangerous transition metals or dangerous transition metal compounds |
| 16 08 03 | spent catalysts containing transition metals or transition metal compounds not otherwise specified |

Notes on recycling, utilization and disposal:

Metal recycling.

Otherwise disposal of waste to landfill; if it does not contain dangerous substances together with municipal waste.

3.2 Motor vehicle exhaust treatment using catalysts

3.2.1 Process

The vehicle exhaust catalytic converter (see **fig. 2**) consists of a ceramic or metal inset with fine honeycombed passages coated in steamed platinum, rhodium and palladium. To protect the housing from thermal pressures and the ceramic monoliths from the high danger of breakage, an insulating material made of mineral fibres (expanded mica and aluminium-silicate fibres) is pressed between the monolith and the housing.

The optimal operational temperature to minimise dangerous substances in a catalytic converter is around 850 °C at which temperature nitrogen oxide (NO_x) is reduced to nitrogen (N_2), oxidised carbon monoxide (CO) to carbon dioxide (CO_2), and hydrocarbons (C_xH_y) to water vapour (H_2O) and carbon dioxide (CO_2). Due to thermal ageing or poisoning of the active areas, catalytic converters have to be replaced and disposed of.

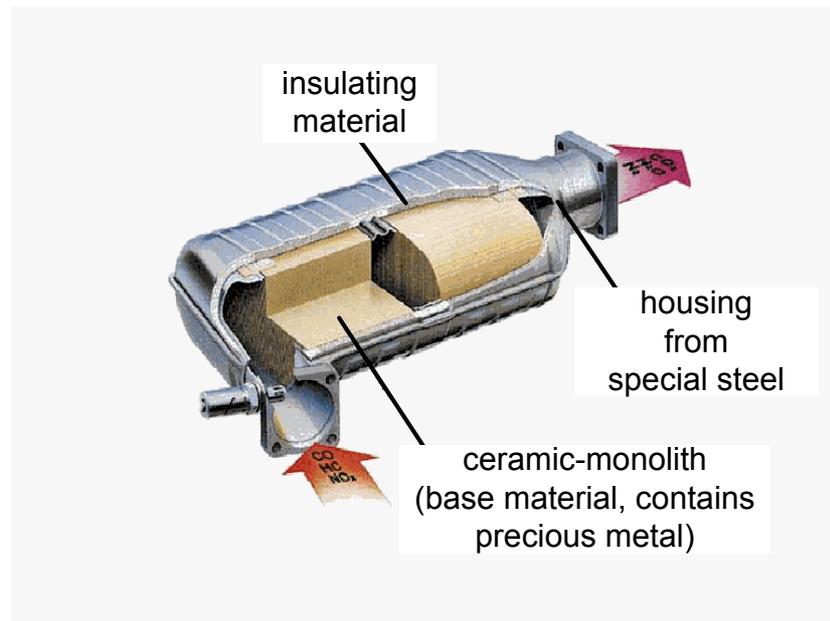


Fig. 2: Diagrammatic representation of a motor vehicle exhaust catalytic converter (source: Uni-Erlangen)

3.2.2 Wastes

Catalytic converters [E]

As well as precious metals, catalytic converters may contain hydrocarbons (C_xH_y), lead (Pb), phosphorus (P), sulphur (S) and other substances. The insulating material of mineral fibres is classified almost entirely as carcinogenic. As a rule the proportion lies $> 0,1$ % weight. As a result, catalytic converters are normally to be seen as dangerous car components and are to be classified as hazardous waste.

Classification of waste in accordance with EWL:

- 16 08 01 spent catalysts containing gold, silver, rhenium, rhodium, palladium, iridium or platinum (except 16 08 07)
- 16 08 07* spent catalysts contaminated with dangerous substances (as a rule)

Notes on recycling, utilization and disposal:

Dismantling and precious metal recycling.

Otherwise, disposal to landfill; if there are no dangerous substances together with municipal waste.

4. Overview of waste classification – material flow

Extract from EWL		Material flow	Treatment
16 08	spent catalysts		
16 08 01	spent catalysts containing gold, silver, rhenium, rhodium, palladium, iridium or platinum (except 16 08 07)	E	1) Recycling, 2) with municipal waste
16 08 02*	spent catalysts containing dangerous transition metals or dangerous transition metal compounds	D	Recycling, HWL
16 08 03	spent catalysts containing transition metals or transition metal compounds not otherwise specified	D	1) Recycling, 2) with municipal waste
16 08 04	spent fluid catalytic cracking catalysts (except 16 08 07)	A	1) Recycling, 2) with municipal waste
16 08 05*	spent catalysts containing phosphoric acid	C	CPT
16 08 06*	spent liquids used as catalysts	B	Recycling, CPT, HWI
16 08 07*	spent catalysts contaminated with dangerous substances	A, E	Recycling, HWL, HWI

16 11 Waste linings and refractories

1	Process	1
1.1	<i>Metallurgical processes</i>	1
1.2	<i>Non-metallurgical processes</i>	1
2	Waste	2
2.1	<i>Waste from metallurgical processes</i>	2
2.2	<i>Waste from non-metallurgical processes</i>	3
3	Overview of waste classification – material flow	4

1 Process

1.1 Metallurgical processes

The most significant metallurgical processes during which fireproof materials arise are the casting of iron and steel (see waste category 10 09), the casting of non-ferrous metals (see waste category 10 10) and the primary and secondary production of aluminium (see waste category 10 03). During these processes, various different types of furnace are used, e.g. blast furnace, electro arc furnace, crucible furnace, rotary kilns and hearth furnaces.

During maintenance and repair work and depending on the raw material used and the operation of the specific type of furnace, nickel, lead, copper, zinc and chromium oxides (introduced in cast smelting) may be present in linings and refractories, especially in the case of non-ferrous metal casting. These are, consequently, to be classified as hazardous waste.

1.2 Non-metallurgical processes

Fireproof waste from non-metallurgical processes originates principally in power stations and other incineration plants, for example, waste incineration (see waste category 10 01), production of glass and ceramics (see waste category 10 11 and 10 12) as well as during the production of cement, lime, and plaster.

Fireproof waste arising during maintenance and repair work on the different incineration plants, steam boilers, incineration and smelting furnaces as well as driers contain some hazardous substances. These originate not only from the incineration process (e.g. sulphur), and from the thermally treated materials, especially waste, but also from pigment or glazing raw materials used in ceramic and glass production processes.

2 Waste

2.1 Waste from metallurgical processes

Waste from ferrous and non-ferrous metal smelting plants [A]

Spent linings and refractories from furnaces and pots arise while removing the fireproof linings and burnt on material, which have to be renewed regularly. Fireproof linings are basic, acidic or neutral. Basic linings contain mainly basic metal oxide such as magnesite, chrome magnesite, chromite, dolomite or limestone. Acidic linings contain mainly quartz. Neutral linings contain mainly aluminium oxide with silicon oxide. Fireproof materials are mineral or ceramic materials, which remain stable at high temperatures. Other components of fireproof products are carbon, graphite and silicon carbide. Metal sticking to the furnace and pot linings can be used as scrap in secondary metallurgy once it has been separated.

Classification of waste in accordance with EWL:

- 16 11 03* other linings and refractories from metallurgical processes containing dangerous substances (*exception for smelting plants for ferrous and non-ferrous metal*)
- 16 11 04 other linings and refractories from metallurgical processes other than those mentioned in 16 11 03 (*rule for smelting plants for ferrous and non-ferrous metals*)

Notes on recycling, utilization and disposal:

Pre-treatment for separation of recyclable metal parts.

Normally recycling for production of fireproof materials.

Otherwise disposal to landfill; without dangerous substances together with municipal waste.

Waste from primary aluminium production [B]

During regular maintenance and repair of electrolytic cells, linings and refractories, containing among other things cathode graphite and parts of the fireproof materials, arise. In addition, they contain metallic aluminium, aluminium oxide, fluoride, nitride and cyanide (see report in 10 03).

As a rule, waste from primary aluminium smelting is therefore to be classified as hazardous.

Classification of waste in accordance with EWL:

- 16 11 01* carbon-based linings and refractories from metallurgical processes containing dangerous substances (*rule for primary aluminium production*)
- 16 11 02 carbon-based linings and refractories from metallurgical processes other than those mentioned in 16 11 01 (*exception for primary aluminium production*)

Notes on recycling, utilization and disposal:

Pre-treatment for separation of adherent aluminium and aluminium oxide for use in the secondary aluminium production.

Possibly recycling of cyanide free wastes for production of fireproof materials.

Otherwise disposal to landfill, possibly in UGL.

Without dangerous substances, disposal to landfill together with municipal waste.

2.2 Waste from non-metallurgical processes

Waste from maintenance of furnaces, steam boilers, incinerators and driers [C]

During the periodic maintenance and repair work on furnaces and steam boilers in power stations and other incineration plants, fireproof linings and sediment as well as insulation linings arise. These may contain, for example, asbestos or deposits from the incineration process containing hazardous substances. Waste from drier insulation linings or from fireproof materials from non-metallurgical process furnaces as used in glass and ceramic production, also arise during maintenance and repair work and may contain glazes and pigment remains containing heavy metals in addition to the hazardous materials mentioned above.

Classification of waste in accordance with EWL:

- | | |
|-----------|--|
| 16 11 05* | linings and refractories from non-metallurgical processes containing dangerous substances |
| 16 11 06 | linings and refractories from non-metallurgical processes other than those mentioned in 16 11 05 |

Notes on recycling, utilization and disposal:

Asbestos free wastes from maintenance of boiler firing area and steam boiler are normally used by recycling companies for production of fireproof materials.

Otherwise disposal to landfill; when dealing with asbestos containing material on landfills additional requirements have to be met.

Without dangerous substances, disposal to landfill together with municipal waste.

3 Overview of waste classification – material flow

Extract from EWL		Material flow	Treatment
16 11	waste linings and refractories		
16 11 01*	carbon-based linings and refractories from metallurgical processes containing dangerous substances	B	1) Recycling, 2) HWL, UGL
16 11 02	carbon-based linings and refractories from metallurgical processes other than those mentioned in 16 11 01	B	1) Recycling, 2) with municipal waste
16 11 03*	other linings and refractories from metallurgical processes containing dangerous substances	A	1) Recycling, 2) HWL
16 11 04	other linings and refractories from metallurgical processes other than those mentioned in 16 11 03	A	1) Recycling, 2) with municipal waste
16 11 05*	linings and refractories from non-metallurgical processes containing dangerous substances	C	1) Recycling, 2) HWL
16 11 06	linings and refractories from non-metallurgical processes other than those mentioned in 16 11 05	C	1) Recycling, 2) with municipal waste

19 01 Wastes from incineration or pyrolysis of waste

1. PROCESS	1
1.1 Incineration of waste in waste incinerators	1
1.2 Treatment of waste in pyrolysis plants	2
1.3 Incineration of waste in fluidized bed incinerators	3
1.4 Flue-gas treatment	3
2. WASTE.....	7
3. OVERVIEW OF WASTE CLASSIFICATION – MATERIAL FLOW.....	11

1. Process

In incineration plants, municipal waste (commercial or domestic) and special waste is thermally treated in order to reduce the quantity of waste, to make organic matter inert, to destroy persistent, dangerous, organic materials and to utilise the calorific value of waste. Commercial waste that is similar to household waste, and municipal waste differ very little in terms of composition except for the biodegradable element in household waste (approx. 30%). They consist to a large extent of plastic, rubber, leather, cardboard, paper, wood, glass, textiles, metals or composite materials.

Hazardous wastes with a high organic component has to be incinerated or gasified using pyrolysis processes. Significant organic substances are, for example, halogenated hydrocarbons and solvents which may also be present in oil, paint, varnish, sprayers, insulation foam, etc containing PCBs. Other substances that may be contained in hazardous waste include heavy metals, such as Cd, Hg and Pb.

1.1 Incineration of waste in waste incinerators

As a rule, waste is placed in an incinerator (see **fig. 1**) where substances in the waste are incinerated between 850 °C and 1250 °C. The flue-gas contains fly ash and gaseous metals with a low boiling point (eg. lead, cadmium, mercury). Part of the fly ash settles on the walls of the incinerator where it builds so-called **boiler dust [A]** which is regularly chipped off and collected separately. The flue-gas with fly ash and gaseous dangerous materials is passed on to a flue-gas treatment plant. **Ash and slag [B]** remaining on the grate are shaken off and passed through a magnetic separator to sort out **ferrous materials [C]** for recycling. Grate screenings are normally collected and fed back to the incineration process in order to achieve complete incineration of the waste.

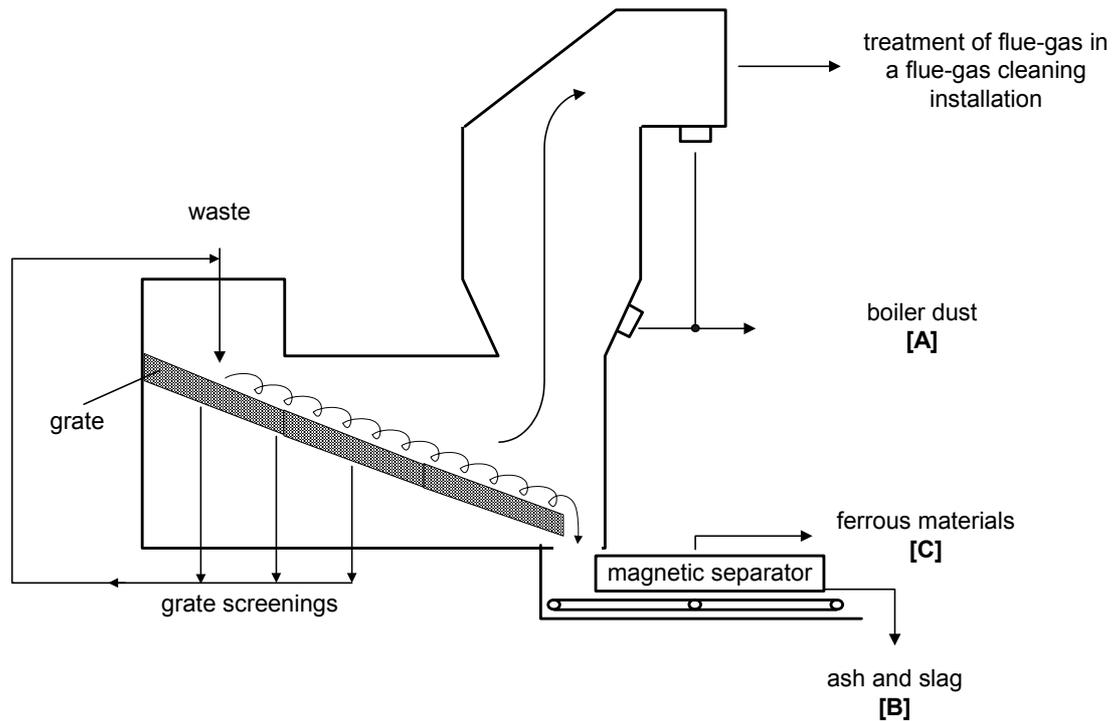


Fig. 1: Diagram of a waste incinerator

1.2 Treatment of waste in pyrolysis plants

During pyrolysis (see **fig. 2**), normally solid or pasty organic waste is gasified in a rotating, indirectly heated reactor, without oxygen, between 450 °C und 650 °C.

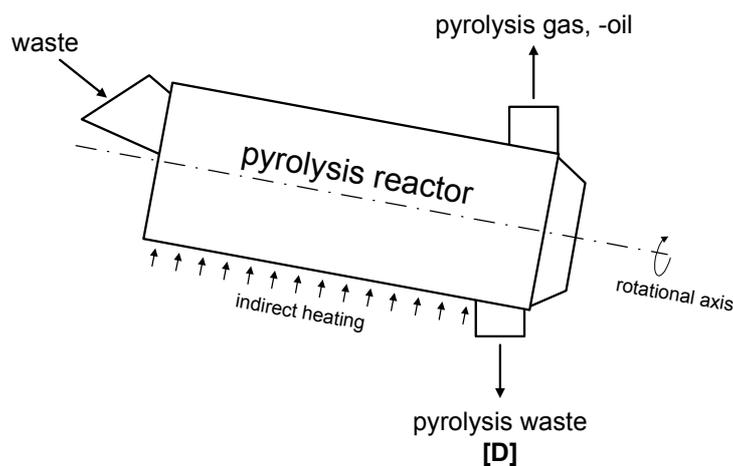


Fig. 2: Diagram of pyrolysis process

Synthetic gas and oil produced during this process can be used, for example, for methanol production, as fuel in gas and steam power stations or as a substitute for natural gas in industrial processes. **Pyrolysis waste [D]** consists of mineralised slag

(pyrolysis coke) containing metal and with considerable amounts of residue organic material adhering to it.

1.3 Incineration of waste in fluidized bed incinerators

In fluidised bed incineration, (see **fig. 3**), liquid, pasty or ready cut up waste is incinerated in a reactor with jet bottom. Normally sand is added to improve heat exchange. Air is blown in from below so that the mixture is whirled up and held in an almost floating state (fluid bed).

Flue-gases together with fly ash particles are cleaned in a flue-gas treatment plant (see chapter **1.4**). Sand from **Fluidized Bed Incineration [E]** has to be disposed of regularly due to the build up of bottom ash.

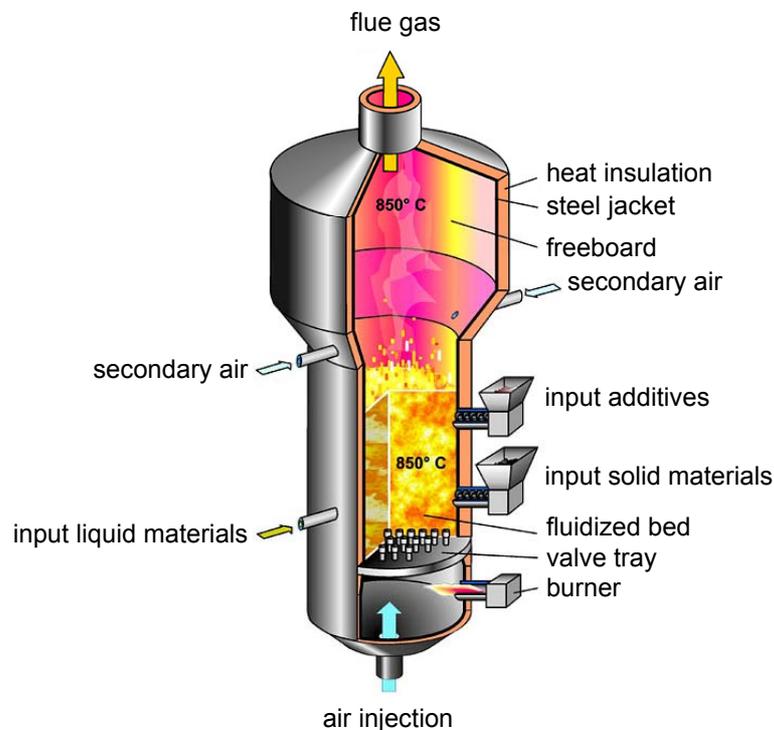


Fig. 3: Diagram of fluidized bed incineration plant for solid and liquid waste (source RMT)

1.4 Flue-gas treatment

Waste incineration plants are subject to EU regulations 2000/76/EG or national regulations (eg. 17. BImSchV in Germany), which, among other things, set air emission levels. Depending on the composition of waste, flue-gases containing dangerous substances with fly ash (including SO_2 , CO , HCl , HF , NO_x , PCDD/PCDF) are produced. These go through the treatment process stages (see **fig. 4**) of (pre-) dust removal, wet absorption, alternative spray absorption (quasi-dry absorption), selective-catalytic-reduction (SCR) and activated carbon packed bed adsorption.

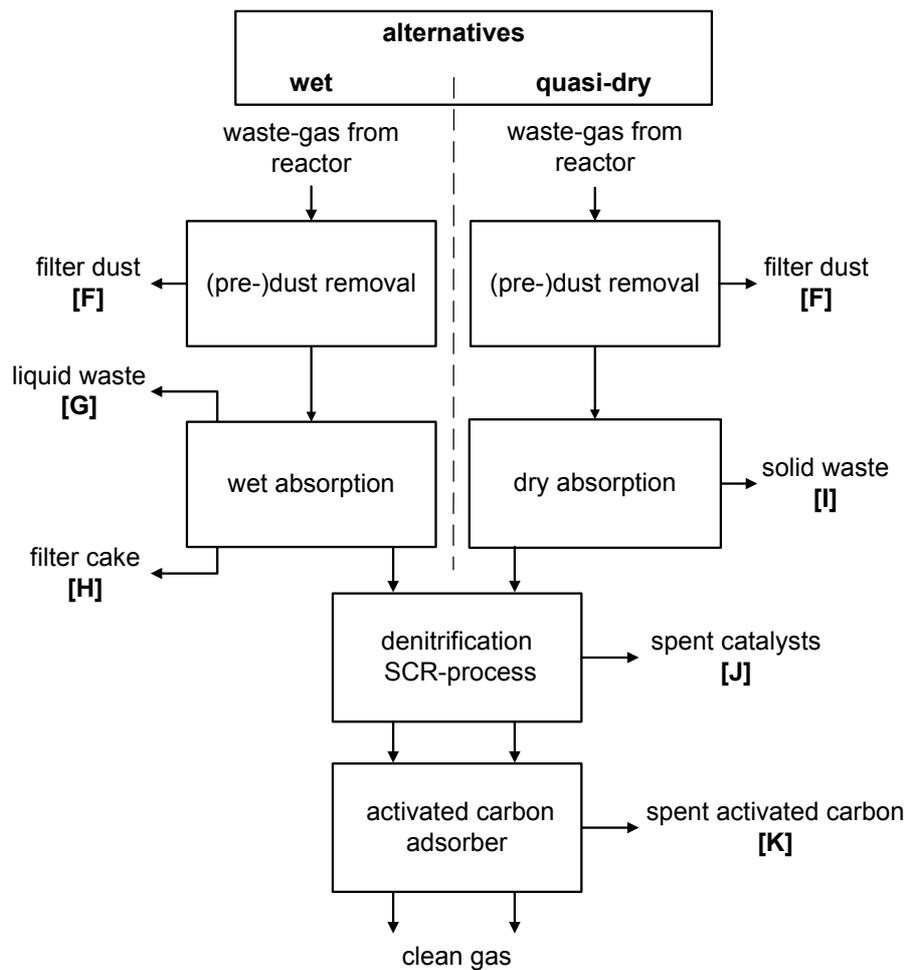


Fig. 4: Possible stages in flue-gas treatment

(Pre-)Dust removal

In accordance with the national regulations (eg. 17. BImSchV), air emission values of, for example, 10 mg/m^3 total dust on a daily average have to be met. The three process stages are:

- Cyclones

Cyclones are principally used in pre-separation. Based on the centrifugal and gravity principles, solid particles over $3 \mu\text{m}$ are continually separated in a rotating flue-gas stream. This separation principle is not adequate for contaminants of smaller particle size.

- Electrostatic filters

Electrostatic filters are used to clean flue-gas stream to about 100 mg/m^3 dust content. Electric fields polarise the dust particles so that they can be separated on oppositely charged electrodes and collected in filter dust silos. The efficiency of separation depends mainly on how well the dust can be polarised. Dust particles of $0,1 \mu\text{m}$ can be separated.

- Textile filters

Textile filters can separate out fine dust particles over 0,1 μm . Efficiency in separating such fine particles increases with the degree of deposits on the filter textile, as the dust which is held back increasingly reduces the pore size.

In all three processes, **filter dust [F]** is separated out.

Wet sorption

In wet sorption (acid and alkali), specialised washers (venturi-, centrifugal-, plate columns-, packed-bed columns-, spray tower washers) scrub the flue-gas stream intensively with washing water so that water-soluble, dangerous substances, such as HF, HCl, SO₂, are absorbed and removed (see **fig. 5**). At the same time, the flue-gas stream is shock-cooled (quenched) to 60 °C to 70 °C to suppress the formation of dioxins/furanes. The washing water arises as **(aqueous) liquid waste [G]** which is treated in on-site CPT plants and, as a rule, recycled. During the second stage (neutralisation), absorption reagents (calcium hydrate, limestone, caustic soda) are added. This brings about the precipitation of reaction products (including salts, gypsum), which can be filtered out as **filter cake [H]** in a chamber filter press.

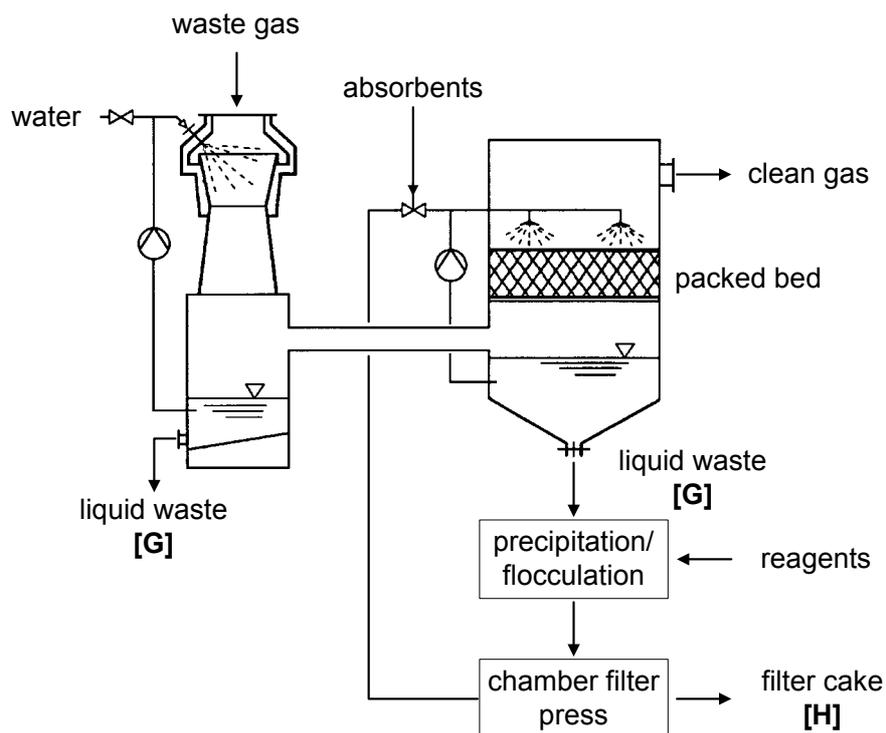


Fig. 5: Diagram of wet absorption

Spray absorption (quasi-dry absorption)

Spray absorption (see **fig. 6**), also known as quasi-dry absorption, combines dry absorption with wet absorption, whereby dangerous substances, such as HF, HCl and SO₂, are treated similarly as in wet absorption. In spray absorption, either caustic soda or limewater are sprayed as absorption materials. These completely evaporate

(quasi-dry) due to the flue-gas temperature. The flue-gas component reacts with the help of absorption materials to form salts which fall as **solid waste [I]** (dry and crumbly) into the waste hopper of the spray absorber and are then collected in silos.

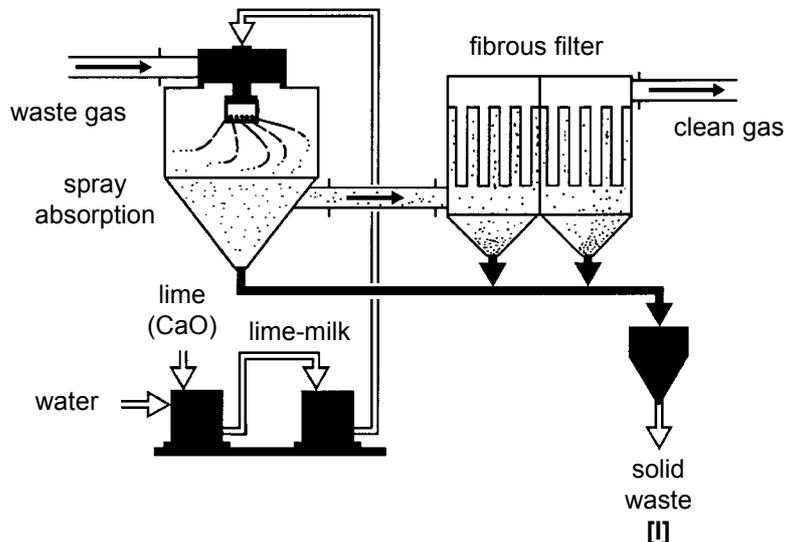


Fig. 6: Diagram of Quasi-dry absorption (source: FZKA)

Selective-Catalytic-Reduction (SCR)

In the **SCR** process (see **fig. 7**), nitric oxide (NO_x) is reduced to nitrogen and water vapour with the help of ammonia. The process is also known as catalytic denitrification. The reaction takes place using catalysts at a temperature of approx 250 °C.

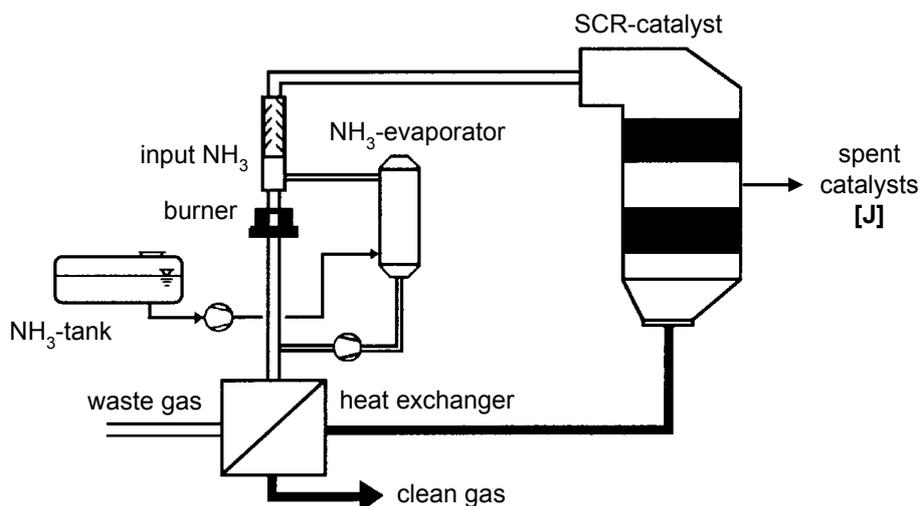


Fig. 7: SCR process for catalytic denitrification - (source: FZKA)

Due to sintering of the catalyst surface (crystal growth), phase changes, blocking of activated areas by irreversible catalyst poisoning and soot (see 16 08, spent catalysts), the catalysts have to be replaced regularly. **Spent catalysts [J]** arise as waste.

Activated carbon packed-bed adsorbers

Flue-gas flows through an activated carbon layer (eg. coke) where mercury and dangerous organic substances (incl. dioxins/furanes) are adsorbed (see **fig. 8**). The adsorbent must be disposed of as **spent activated carbon [K]** irrespective of the amount of adsorbed substances.

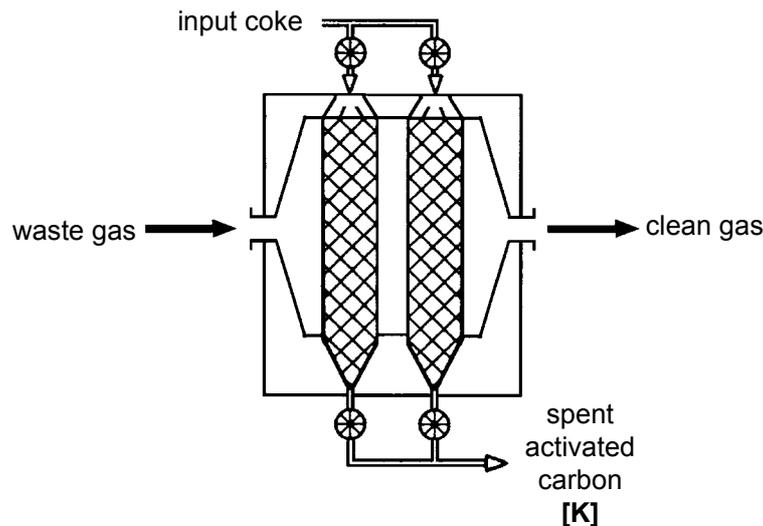


Fig. 8: Diagram of activated carbon packed bed adsorber (source: FZKA)

2. Waste

Boiler dust [A]

Dangerous substances in boiler dust are mainly heavy metals (eg. Cd, Hg, Pb) and their compounds, as well as fluoride or chlorine compounds (HCl, HF, PCDD/PCDF), so that, as a rule, boiler dust from waste incineration plants has to be classified as hazardous waste.

Classification of waste in accordance with EWL:

- 19 01 15* boiler dust containing dangerous substances(*rule*)
- 19 01 16 boiler dust other than those mentioned in 19 01 15 (*exception*)

Notes on recycling, utilization and disposal:

At present there are known any viable treatment processes.

- 19 01 15*: As a rule disposal to landfill (HWL or UGL).
- 19 01 16: Disposal, if applicable together with municipal waste.

Ash and slag [B]

As a rule, there are no dangerous substances to be expected in ash and slag if complete incineration has taken place. In the case of hazardous waste incineration plants, heavy metals and their compounds in ash and slag create hazardous waste.

Classification of waste in accordance with EWL:

- 19 01 11* bottom ash and slag containing dangerous substances (*exception in the case of incineration of municipal waste*)
- 19 01 12 bottom ash and slag other than those mentioned in 19 01 11 (*rule, in the case of incineration of municipal waste*)

Notes on recycling, utilization and disposal:

- 19 01 11*: Disposal to landfill (HWL), if applicable UGL.
- 19 01 12: Use of slag in road building or in the building industry.
Otherwise, disposal to landfill, if applicable together with municipal waste.

Ferrous materials [C]

Ferrous metal fraction separated from bottom ash by magnet separator.

Classification of waste in accordance with EWL:

- 19 01 02 ferrous materials removed from bottom ash

Notes on recycling, utilization and disposal:

As a rule, sent for metal recycling without any pre-treatment.
Otherwise disposal to landfill, if applicable together with municipal waste.

Pyrolysis waste [D]

Waste which cannot undergo pyrolysis consists of solid carbon, ferrous and non-ferrous slag which is mixed with mineral oxides. Residue organic matter, heavy metals, salts, sulphur compounds, etc. may lead to hazardous waste.

Classification of waste in accordance with EWL:

- 19 01 17* pyrolysis wastes containing dangerous substances
- 19 01 18 pyrolysis wastes other than those mentioned in 19 01 17

Notes on recycling, utilization and disposal:

- 19 01 17*: Disposal to landfill (HWL).
- 19 01 18: As a rule, disposal to landfill, if applicable together with municipal waste.

Sands from fluidized beds [E]

Sands mixed with bed ash consist mainly of mineral phase, such as CaO, SiO, MgO etc., which contain metal oxides (Fe-, Al-, Cu-, etc.). With complete incineration, sands from fluidised beds are, in principle, not to be classified as hazardous waste.

Classification of waste in accordance with EWL:

19 01 19 sands from fluidised beds

Notes on recycling, utilization and disposal:

As a rule, used in road building or building industry.

Otherwise, disposal to landfill, if applicable together with municipal waste.

Filter dust [F]

Environmentally significant substances in filter dust are mainly heavy metals and their compounds as well as fluoride and chlorine compounds (for example PCDD/PCDF) which have to be classified as hazardous waste.

Classification of waste in accordance with EWL:

19 01 13* fly ash containing dangerous substances (*rule*)

19 01 14 fly ash other than those mentioned in 19 01 13 (*exception*)

Notes on recycling, utilization and disposal:

At present there are no known recycling processes.

19 01 13*: Disposal to landfill (preferably HWL, otherwise UGL).

19 01 14: Disposal to landfill, if applicable together with municipal waste.

Liquid waste [G]

Dangerous substances contained in washing water from wet absorption are heavy metals and their compounds as well as organic compounds that have been condensed out, acids containing chlorine and fluoride (eg. HCl, HF) and sulphur dioxide (SO₂).

Classification of waste in accordance with EWL:

19 01 06* aqueous liquid wastes from gas treatment and other aqueous liquid wastes

Notes on recycling, utilization and disposal:

At present there are known any viable treatment processes.

As a rule, treatment in on-site CPT plants to neutralise the water phase for feeding into the sewage system.

Filter cake [H]

Filter cake from chamber filter presses in wet absorption plants (see fig 5) contains, among other things, sludges containing metal hydroxide, as well as phosphate, sulphate, silicate and organic components.

Classification of waste in accordance with EWL:

19 01 05* filter cake from gas treatment.

Notes on recycling, utilization and disposal:

At present there are known any viable treatment processes.

Disposal to landfill (HWL).

Solid waste [I]

Solid waste from spray absorption consists of salts containing chloride, fluoride and sulphur, as well as chalk and dust mixtures and is to be classified as hazardous waste.

Classification of waste in accordance with EWL:

19 01 07* solid wastes from gas treatment

Notes on recycling, utilization and disposal:

At present there are known any viable treatment processes.

As a rule, disposal to UGL.

Spent catalysts [J]

Catalysts from denitrification are either made from metal oxides (incl. V_2O_5 , TiO_2) or are built up on zeolite. Catalysts are to be classified as hazardous waste if they contain dangerous transition metals or are contaminated with dangerous process materials (see 16 08, spent catalysts)

Classification of waste in accordance with EWL:

16 08 02* spent catalysts containing dangerous transition metals (17) or dangerous transition metal compounds (*exception*)

16 08 03 spent catalysts containing transition metals or transition metal compounds not otherwise specified (*rule*)

16 08 07* spent catalysts contaminated with dangerous substances (*exception*)

Notes on recycling, utilization and disposal:

At present there are known any viable treatment processes.

16 08 02*, 16 08 07*: As a rule, disposal to landfill (HWL).

16 08 03: As a rule, disposal, if applicable together with municipal waste.

Spent activated carbon [K]

Mainly dangerous organic substances, dioxins/furanes (PCDD/PCDF), as well as mercury build up on the activated carbon from solid bed adsorbers, so that, as a rule, they contain dangerous substances.

Classification of waste in accordance with EWL:

19 01 10* spent activated carbon from flue-gas treatment

Notes on recycling, utilization and disposal:

As a rule incineration in waste incinerators (HWI).

Otherwise, disposal to landfill (HWL).

3. Overview of waste classification – material flow

	Extract from EWL	Material flow	Treatment
1901	Wastes from incineration or pyrolysis of waste		
19 01 02	ferrous materials removed from bottom ash	C	1) Recycling, 2) with municipal waste
19 01 05*	filter cake from gas treatment	H	HWL (mono-landfill)
19 01 06*	aqueous liquid wastes from gas treatment and other aqueous liquid wastes	G	CPT
19 01 07*	solid wastes from gas treatment	I	UGL
19 01 10*	spent activated carbon from flue-gas treatment	K	HWL, HWI
19 01 11*	bottom ash and slag containing dangerous substances	B	HWL, UGL (mono-landfill)
19 01 12	bottom ash and slag other than those mentioned in 19 01 11	B	1) Recycling, 2) with municipal waste
19 01 13*	fly ash containing dangerous substances	F	HWL, UGL
19 01 14	fly ash other than those mentioned in 19 01 13	F	with municipal waste
19 01 15*	boiler dust containing dangerous substances	A	HWL, UGL
19 01 16	boiler dust other than those mentioned in 19 01 15	A	with municipal waste
19 01 17*	pyrolysis wastes containing dangerous	D	HWL, UGL

	substances		(Mono-landfill)
19 01 18	pyrolysis wastes other than those mentioned in 19 01 17	D	with municipal waste
19 01 19	sands from fluidised beds	E	1) Recycling, 2) with municipal waste
19 01 99	wastes not otherwise specified	not normally required	

	Wastes from incineration or pyrolysis of waste to be classified under other waste categories		
16 08 02*	spent catalysts containing dangerous transition metals (17) or dangerous transition metal compounds	J	HWL
16 08 03	spent catalysts containing transition metals or transition metal compounds not otherwise specified	J	with municipal waste
16 08 07*	spent catalysts contaminated with dangerous substances	J	HWL

19 02 Wastes from physico/chemical treatments of waste (including dechromatation, decyanidation, neutralisation)

1	Processes.....	1
1.1	<i>Inorganic treatment process.....</i>	<i>1</i>
1.2	<i>Organic treatment process</i>	<i>2</i>
2	Waste	4
2.1	<i>Waste from inorganic treatment process [A]</i>	<i>4</i>
2.2	<i>Wastes from organic treatment process.....</i>	<i>4</i>
3	Overview of waste classification – material flow.....	7

1 Processes

Waste often requires pre-treatment before it can be finally recycled or disposed of. For various reasons (cost, organisation, efficiency), the plant required for this process is often operated by a central disposal company rather than by the original waste producer. Plants work with appropriate combinations of chemical and/or physical process stages, whereby the treatment of organic and inorganic waste is carried out in separate treatment processes.

As the treatment of liquid waste and thin sludge predominates, the paper presented here deals exclusively with the new waste resulting from treatment. The descriptions of types of waste 19 02 03 and 19 02 04 (premixed wastes) have been dispensed with.

1.1 Inorganic treatment process

In the inorganic treatment process, liquid waste and thin sludge from a variety of sources are treated according to their constituent parts. The sources could be for example (respective EWL codes for the plant input are given in brackets):

- Leather and textile industry (04 01, 04 02)
- Inorganic chemical processes (06 01, 06 02, 06 03)
- Photographic industry (09 01)
- Metal working and coating (11 01)

After oxidation, which may or may not be necessary, and reduction of cyanides, nitrates and chromates held in the waste, heavy metals are transferred in an insoluble form, separated, and the pH-value adjusted.

Figure 1 shows a schematic representation of the most important treatment stages.

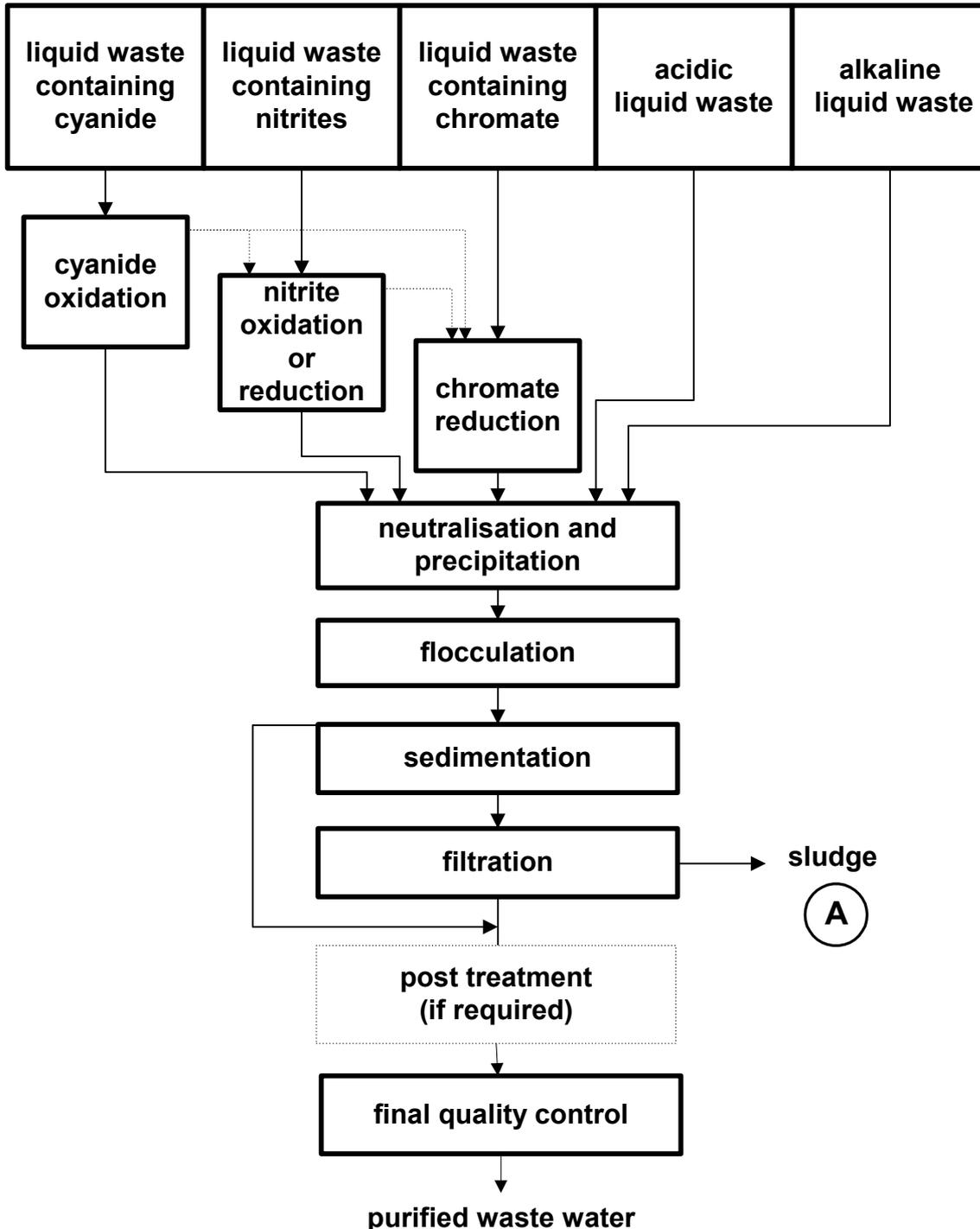


Fig. 1: Possible process stages of chemical/physical treatment of liquid waste containing inorganic matter

1.2 Organic treatment process

In the organic treatment process, oil/water mixtures and emulsions as well as thin sludges containing oil from different sources are treated. As a rule this is mixed, so the resulting waste from the treatment varies in composition. The treated waste can originate from (respective EWL codes for the plant input are given in brackets):

- Oil/water separators (13 05)
- Oil/water mixtures from, for example, shipping and tank cleaning (13 04, 16 07)
- Emulsions and solutions from, for example, mechanical shaping and surface treatment (12 01, 13 01)
- Miscellaneous organic waste water from industrial and commercial plants (05 08, 07 01, 07 02, 07 03, 07 06, 0801, 08 03, 12 03, 13 01)

Figure 2 shows a schematic representation of the most important treatment stages and the resulting waste.

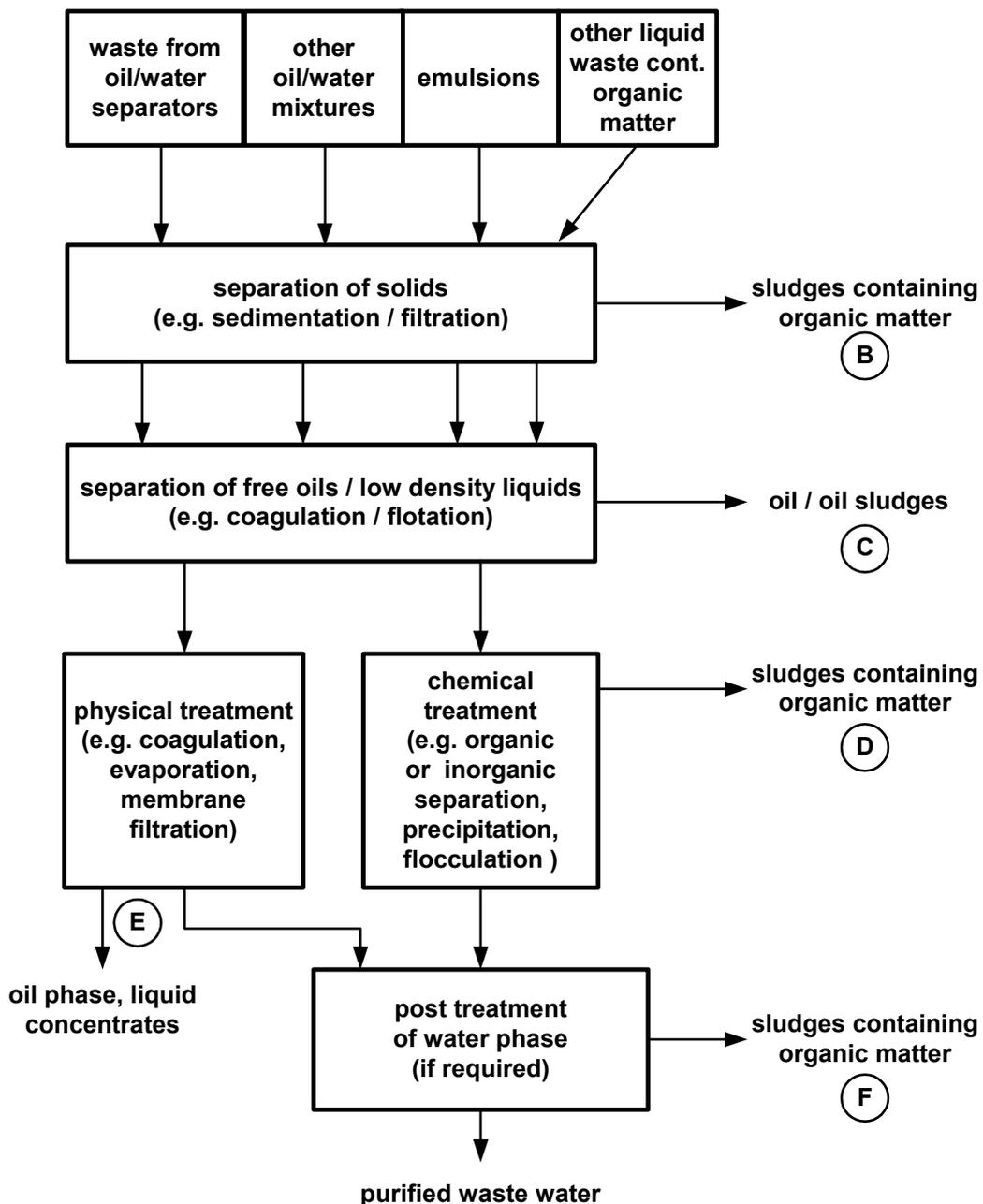


Fig. 2: Process stages of chemical/physical treatment of liquid waste containing organic matter

2 Waste

2.1 Waste from inorganic treatment process [A]

To treat liquid waste containing mainly inorganic matter and pollutants, sodium-hydroxide and calcium-hydroxide are normally used as precipitants to separate out the heavy metals. Alternatively, the metals are precipitated as metal-sulphides. The resulting sediment, which is difficult to dissolve, is subsequently filtered and pressed, usually in chamber filter presses (see **fig 1**).

The filter cake has a solid/water-tight consistency with approx. 30-40% solid content. In some cases, a further thermal drying to a solid content up to 70% follows. The composition of the sludge mainly depends on the input, i.e. on the composition of the treated waste, as well as on the treatment chemicals added. It normally comprises various metal hydroxides or sulphides and difficult to dissolve calcium compounds (hydroxide, sulphate, phosphate, silicate, fluoride).

Classification of waste in accordance with EWL:

- 19 02 05* sludges from physico/chemical treatment containing dangerous substances (*rule*)
- 19 02 06 sludges from physico/chemical treatment other than those mentioned in 19 02 05 (*exception*)

Notes on recycling, utilization and disposal:

Sludges containing metals can possibly metallurgically processed.

Otherwise disposal to landfill as hazardous waste; without dangerous substances together with municipal waste.

2.2 Wastes from organic treatment process

Figure 2 shows the different process stages with the resulting waste.

Depending on the wide range of possible input waste and treatment chemicals used (e.g. cracking agent, flocculent, precipitating agent), the subsequent waste contains different types and quantities of dangerous substances.

2.2.1 Sludges from the separation of solids [B]

Solids present in the waste to be treated are normally separated in the first stage of the treatment process using sedimentation or filtration. The types of solid present (e.g. sand in the case of oil/water separators, fine metal shavings in the case of lubricating coolant emulsions) depend on the origin of the plant input. Dangerous pollutants are primarily organic (oil and fats, etc. still adhering).

Classification of waste in accordance with EWL:

- 19 02 05* sludges from physico/chemical treatment containing dangerous substances
- 19 02 06 sludges from physico/chemical treatment other than those mentioned in 19 02 05

For plants treating mainly waste from oil/water separators (compare subchapter 13 05):

- 13 05 01* solids from grit chambers and oil/water separators
- 13 05 02* sludges from oil/water separators

Notes on recycling, utilization and disposal:

Incineration of the separated sludges with mainly organic contamination.

Otherwise disposal to landfill of the solid, mainly inorganic wastes, e.g. from grit chambers.

Without dangerous substances, disposing together with municipal waste.

2.2.2 Oil from low density liquid separation [C]

Free, i.e. non-emulsified or dissolved oils or fats are separated by using the differences in density supported by coagulation or flotation equipment. As a rule, the resulting oil phase can be recycled directly.

Classification of waste in accordance with EWL:

- 19 02 07* oil and concentrates from separation

For plants treating mainly waste from oil/water separators (compare subchapter 13 05):

- 13 05 06* oil from oil/water separators

Notes on recycling, utilization and disposal:

Incineration.

2.2.3 Sludges from the chemical treatment stage [D]

Organic components which cannot be separated by mechanical/physical means can be removed in a chemical process. The chemicals used for this (e.g. acids, salts, flocculants) allow the separation of organic constituents from the water phase by pH-reduction, flocculation and precipitation. As a rule, dehydrated sludge from flotation or chamber filter presses contains a high concentration of organic matter (10 - 50%). The addition of organic cracking agent makes the separated phase fluid.

Classification of waste in accordance with EWL:

- 19 02 05* sludges from physico/chemical treatment containing dangerous substances (*rule*)
- 19 02 06 sludges from physico/chemical treatment other than those mentioned in 19 02 05 (*exception*)
- 19 02 08* liquid combustible wastes containing dangerous substances
- 19 02 09* solid combustible wastes containing dangerous substances

Notes on recycling, utilization and disposal:

Incineration.

Without dangerous substances, disposal together with municipal waste.

2.2.4 Oil/concentrate from the physical treatment stage [E]

In physical treatment stages such as membrane processes (ultra-filtration, reverse osmosis), evaporation and electro-coagulation, organic parts are separated out from the water phase. During evaporation and reverse osmosis, dissolved organic, heavy metal and salt parts are also separated out. So, depending on the plant input, the resulting concentrate shows the separated dangerous substances such as salts, heavy metal, etc in addition to the dissolved organic component.

Classification of waste in accordance with EWL:

19 02 07* oil and concentrates from separation

Notes on recycling, utilization and disposal:

Incineration.

2.2.5 Sludges from waste water post treatment [F]

In order to meet and safeguard local discharge criteria, the water phase is treated again if necessary. Absorption processes (using activated carbon or aluminium hydroxide compounds) or ion exchangers are used here (see also EWL subchapter 19 08). The resulting sludge therefore contains organic matter and heavy metals depending on the input and treatment stages used.

Classification of waste in accordance with EWL:

19 02 11* other wastes containing dangerous substances

19 08 06* saturated or spent ion exchange resins

19 08 13* sludges containing dangerous substances from other treatment of industrial waste water

19 08 14 sludges from other treatment of industrial waste water other than those mentioned in 19 08 13

19 09 04 spent activated carbon

Notes on recycling, utilization and disposal:

Incineration in case of mainly organic contamination and of ion exchange resins, which are saturated with dangerous substances (e.g. heavy metals).

Otherwise disposal to landfill as hazardous waste; without dangerous substances together with municipal waste.

3 Overview of waste classification – material flow

Extract from EWL		Material flow	Treatment
19 02	Wastes from physico/chemical treatments of waste (including dechromatation, decyanidation, neutralisation)		
19 02 03	premixed wastes composed only of non-hazardous wastes	self explanatory	With municipal waste
19 02 04*	premixed wastes composed of at least one hazardous waste	self explanatory	1) HWL, 2) incineration
19 02 05*	sludges from physico/chemical treatment containing dangerous substances	A, B, D	HWL
		B, D	Incineration
19 02 06	sludges from physico/chemical treatment other than those mentioned in 19 02 05	A, B, D	With municipal waste
19 02 07*	oil and concentrates from separation	C, E	Incineration
19 02 08*	liquid combustible wastes containing dangerous substances	D	Incineration
19 02 09*	solid combustible wastes containing dangerous substances	D	Incineration
19 02 10	combustible wastes other than those mentioned in 19 02 08 and 19 02 09	not normally applicable	1) Incineration, 2) with municipal waste
19 02 11*	other wastes containing dangerous substances	F	1) Incineration, 2) HWL
19 02 99	Wastes not otherwise specified	not normally required	

Wastes from physico/chemical treatments of waste to be classified under other waste categories			
13 05 01*	solids from grid chambers and oil/water separators	B	1) HWL, 2) incineration
13 05 02*	sludges from oil/water separators	B	Incineration
13 05 06*	oil from oil/water separators	C	Incineration
19 08 06*	saturated or spent ion exchange resins	F	Incineration
19 08 13*	sludges containing dangerous substances from other treatment of industrial waste water	F	1) HWL, 2) incineration
19 08 14	sludges from other treatment of industrial waste water other than those mentioned in 19 08 13	F	With municipal waste
19 09 04	spent activated carbon	F	1) Incineration, 2) with municipal waste

19 03 Stabilised/solidified wastes

1	PROCESSES	1
1.1	Stabilising processes	1
1.2	Solidification processes.....	2
2	WASTES	3
3	OVERVIEW OF WASTE CLASSIFICATION - MATERIAL FLOW	5

1 Processes

The purpose of solidifying and stabilising processes is to improve the handling and disposal of waste.

Stabilising processes chemically change hazardous components in the waste into non-hazardous components or chemically bind them in order to improve their leach resistance. In this way a hazardous waste can be made non-hazardous.

Solidifying waste aims to make the waste more mechanically stable, e.g. vane shear strength, axial distortion and pressure resistance. At the same time there is a reduction in hazardous substances being transported in water and washed out. Solidification processes do not aim to change the chemical properties of hazardous substances. As a rule, solidified waste is classified in the same category as the original material.

1.1 Stabilising processes

First of all the waste is sorted and foreign matter removed. Then it is ground up and homogenised. Depending on the type and composition of the hazardous substances, chemical change is achieved using different reagents. Hydrogen peroxide and iron(II) are used in the oxidation of organic components and the mineralisation of ammonia and cyanide, while the reduction of nitrite is carried out with amidosulphuric acid. Heavy metals are present as sulphides.

Irrespective of the range of hazardous substances present, this chemical stabilisation is normally followed by solidification, achieved by the addition and mixing of selective additives (e.g. zeolite, aluminium silicate, calcium stearate, bituminous emulsions, polymer solvents).

These processes are employed, for example in the treatment of soil containing heavy metals.

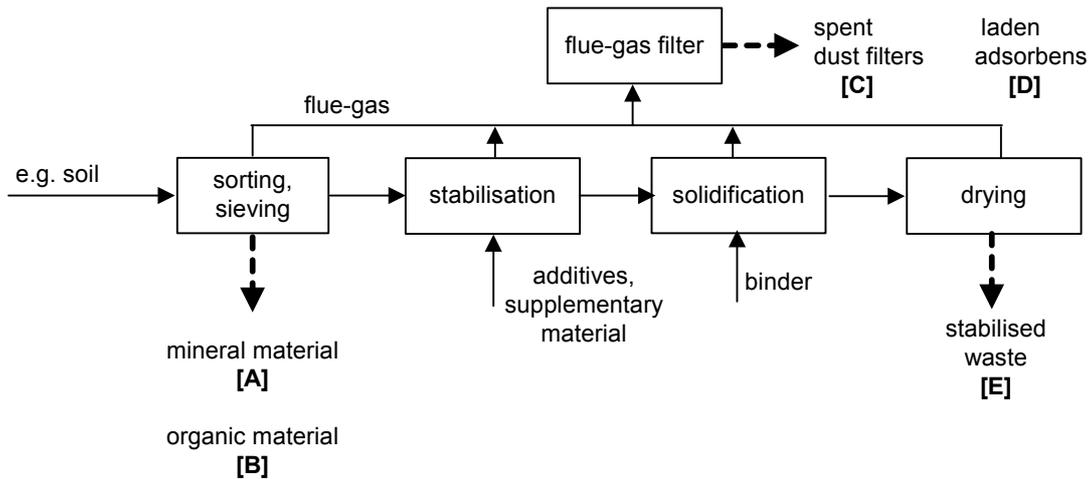


Fig 1: Chemical stabilisation of waste

1.2 Solidification processes

Waste can be solidified by adding binders. The aim is to partly bind mobile hazardous substances in a matrix (immobilisation), to increase the mechanical strength, for example in materials used to fill spaces, or to reduce the water permeability and so improve the leachate behaviour of the stabilised material. The input material is mainly inorganic waste, for example filter dusts or untreated soil. Cement, fly-ash or organic binders are used as binders. In the case of waste with a high organic component, immobilisation and stabilisation can only be achieved using specifically matched binders.

The input material is pre-treated (chopped, sieved, homogenised). Any foreign materials are removed there. Following that, the material together with the binder is mixed while water is added and then hardened.

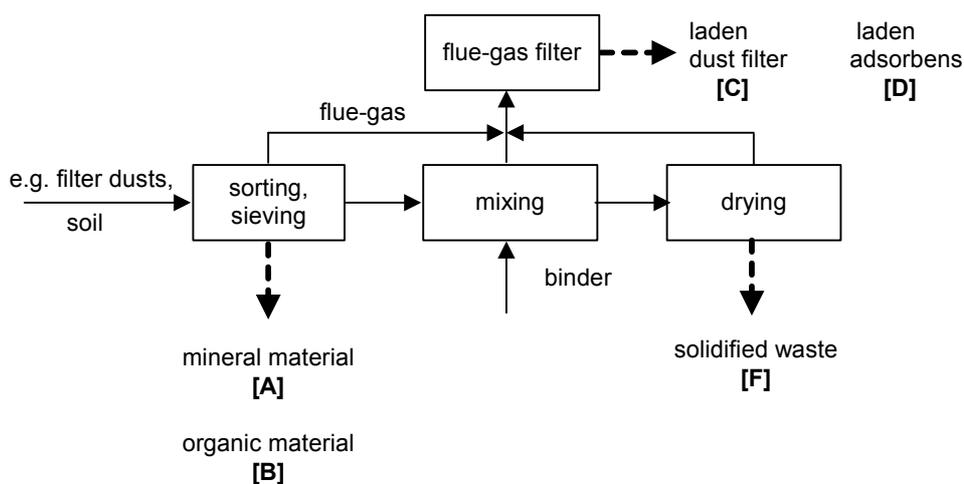


Fig 2: Solidification using binders

2 Wastes

Mineral material from sorting and sieving [A]

During pre-treatment, material which interferes with the mixing or solidification processes or which can be used for other purposes is removed.

Classification of waste in accordance with EWL:

19 12 02	ferrous metal
19 12 03	non-ferrous metal
19 12 05	glass
19 12 09	minerals (for example sand, stones)

Notes on recycling, utilization and disposal :

Using appropriate separation, recycling or utilization (metallurgy, glass recycling, building rubble recovery).

Otherwise, for heavily contaminated fractions, disposal to landfill, as a rule together with municipal waste.

Organic matter from sorting and sieving [B]

During pre-treatment of waste, material which interferes with the mixing or solidification processes or which can be used for other purposes is removed.

Classification of waste in accordance with EWL:

19 12 04	plastic and rubber
19 12 06*	wood containing dangerous substances
19 12 07	wood other than that mentioned in 19 12 06
19 12 10	combustible waste (refuse derived fuel)

Notes on recycling, utilization and disposal:

Incineration, together with municipal waste if it does not contain hazardous substances.

Spent filter materials [C]

For dust separation, especially during chopping and sieving processes, textile filters are used. The plant input material determines which dangerous substances are found in them.

Classification of waste in accordance with EWL:

15 02 02*	absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances
15 02 03	absorbents, filter materials, wiping cloths and protective clothing other than those mentioned in 15 02 02

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

Disposal to landfill, together with municipal waste if it does not contain hazardous substances.

Spent adsorbents [D]

Adsorbents are primarily used to clean extracted shop floor air and to eliminate smells. Activated charcoal is mainly used as an adsorbent but zeolite and polymere may also be employed.

Classification of waste in accordance with EWL:

19 01 10* spent activated carbon from flue-gas treatment

Notes on recycling, utilization and disposal:

As a rule regenerated and re-used.

Otherwise, incineration, as a rule in HWI.

Stabilised waste [E]

The end product of stabilisation processes is stabilised waste.

Classification of waste in accordance with EWL:

19 03 04* wastes marked as hazardous, partly¹ stabilised (*exception*)

19 03 05 stabilised wastes other than those mentioned in 19 03 04 (*rule*)

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes..

Disposal to landfill, together with municipal waste if it does not contain hazardous substances.

Solidified waste [F]

The end product of solidification processes is solidified waste.

Classification of waste in accordance with EWL:

19 03 06* wastes marked as hazardous, solidified (*rule*)

19 03 07 solidified wastes other than those mentioned in 19 03 06 (*exception*)

Notes on recycling, utilization and disposal:

Used in the building material industry and in mining, e.g. if the silicate content is high.

¹ A waste is considered as partly stabilised if, after the stabilisation process, dangerous constituents which have not be changed completely into non-dangerous constituents could be released into the environment in the short, middle or long term.

Otherwise, disposal to landfill, together with municipal waste if it does not contain hazardous substances.

3 Overview of waste Classification - material flow

	Extract from EWL	Material flow	Treatment
19 03	stabilised/solidified wastes²		
19 03 04*	wastes marked as hazardous, partly ³ stabilised	E	HWL
19 03 05	stabilised wastes other than those mentioned in 19 03 04	E	With municipal waste
19 03 06*	wastes marked as hazardous, solidified	F	HWL
19 03 07	solidified wastes other than those mentioned in 19 03 06	F	1.) material use, 2.) with municipal waste

	stabilised/solidified wastes to be classified under other waste categories		
15 02 02*	absorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	C	HWL
15 02 03	absorbents, filter materials, wiping cloths and protective clothing other than those mentioned in 15 02 02	C	With municipal waste
19 01 10*	spent activated carbon from flue-gas treatment	D	1.) regeneration, 2.) incineration, HWI
19 12 02	ferrous metal	A	1.) recycling, 2.) with municipal waste
19 12 03	non-ferrous metal	A	1.) Recycling, 2.) with municipal waste
19 12 04	plastic and rubber	B	1.) recycling, 2.) with municipal waste
19 12 05	glass	A	1.) recycling,

² Stabilisation processes change the dangerousness of the constituents in the waste and thus transform hazardous waste into non-hazardous waste. Solidification processes only change the physical state of the waste (e.g. liquid into solid) by using additives without changing the chemical properties of the waste.

³ A waste is considered as partly stabilised if, after the stabilisation process, dangerous constituents which have not been changed completely into non-dangerous constituents could be released into the environment in the short, middle or long term.

			2.) with municipal waste
19 12 06*	wood containing dangerous substances	B	incineration, HWI
19 12 07	wood other than that mentioned in 19 12 06	B	1.) incineration, 2.) with municipal waste
19 12 09	minerals (for example sand, stones)	A	1.) recycling, 2.) with municipal waste
19 12 10	combustible waste (refuse derived fuel)	B	incineration, HWI

19 04 Vitrified waste and wastes from vitrification

1	PROCESS	1
1.1	Applications and general process description	1
2	WASTE.....	2
3	OVERVIEW OF WASTE CLASSIFICATION – MATERIAL FLOW.....	3

1 Processes

1.1 Applications and general process description

Vitrification can be used to treat problematic waste, particularly waste heavily contaminated with organic substances and heavy metals (e.g. contents of municipal waste landfill, contaminated soil, sewage sludge, fly-ash). The product of this process is a largely inert glass mass which can be used in the building industry or which is at least easier to dispose of. Due to relatively high costs, this process is seldom used. Also, the high temperature required means that this process is not ecologically advantageous.

During vitrification, materials to be treated are smelted at a very high temperature (> 1500 °C). Organic matter in the material is thus completely destroyed. Pyrolysis gases and flue-gases are filtered and further treated by afterburner.

Inorganic contaminants are bound in the silicate matrix which results once the melted materials have cooled. Depending on how quickly the mix cools, a glass or crystalline slag is produced which is resistant to leaching. The slag is considerably smaller in volume than the input material.

If the silicon content of the input material is not sufficient to create a silicate matrix, it is possible for additives (e.g. sand or waste glass) to be added to assist vitrification.

Fig. 1 shows a vitrification process with electrode heating. Other variations include, for example, vitrification in coke bed and in plasma torch. In-situ processes to clean old landfill sites and contaminated soil are currently being tested.

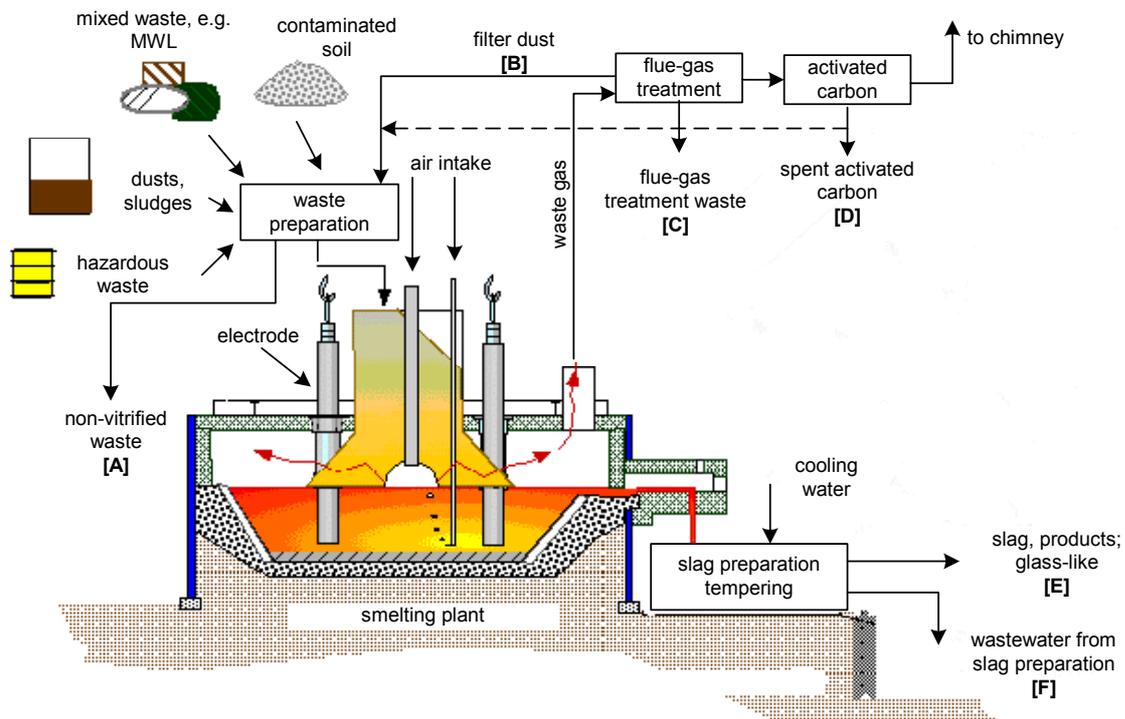


Fig. 1: Vitrification of waste, shown here with electrode heating

2 Waste

Non-vitrified waste [A]

During waste preparation, material that is problematic to the vitrification process is removed. In addition there are materials which are only partly vitrified in the smelting plant.

Classification of waste in accordance with EWL:

19 04 03* non-vitrified solid phase

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

Disposal to HWL, thermal treatment in HWI.

Filter dusts and other waste from flue-gas treatment [B], [C], [D]

Flue-gases are cooled, filtered and in some cases further thermally treated. Activated carbon is often used as a final filtering system.

Classification of waste in accordance with EWL:

19 04 02* fly ash and other flue-gas treatment wastes

Notes on recycling, utilization and disposal:

As a rule, filter dusts and waste from flue-gas treatment are fed back to the vitrification process. Activated carbon can be regenerated and reused.

Otherwise, disposal to landfill, as a rule HWL, UGL.

Slag, glass-like products [E]

In the glass-like slag, dangerous substances are to a large extent inertly bound.

Classification of waste in accordance with EWL:

19 04 01 vitrified waste

Notes on recycling, utilization and disposal:

The slag can be used as building material if suitable.

Otherwise, disposal to landfill, as a rule together with municipal waste.

Wastewater from slag preparation [F]

After leaving the furnace, the slag is quenched with water. The cooling water is normally circulated. Contaminants are normally removed in the form of thin slurry.

Classification of waste in accordance with EWL:

19 04 04 aqueous liquid wastes from vitrified waste tempering

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

Treatment of aqueous waste in CPT plants to separate the water phase, so it can be fed into the sewerage system.

3 Overview of waste classification – material flow

	Extract from EWL	Material flow	Treatment
19 04	vitrified waste and wastes from vitrification		
19 04 01	vitrified waste	E	with municipal waste
19 04 02*	fly ash and other flue-gas treatment wastes	B, C, D	1) internal recycling, 2) HWL
19 04 03*	non-vitrified solid phase	A	HWL, HWI
19 04 04	aqueous liquid wastes from vitrified waste tempering	F	CPT

19 05 Wastes from aerobic treatment of solid wastes

1	Process	1
2	Wastes	3
2.1	<i>Biodegraded municipal waste [A].....</i>	3
2.2	<i>Non-composted fraction from animal and plant waste [B].....</i>	3
2.3	<i>High calorific value fraction [C]</i>	3
2.4	<i>Heavy fraction [D]</i>	4
2.5	<i>Foreign material [E]</i>	4
2.6	<i>Ferrous metal fraction [F].....</i>	4
2.7	<i>Off-specification compost [G].....</i>	5
3	Overview of waste classification – material flow	5

1 Process

In mechanical-biological waste treatment plants, municipal waste is treated using a combination of mechanical and biological processes (see **Fig. 1**). The principal objective is to have landfills that require little aftercare and without costly thermal inert treatment of the waste. By using material-specific pre-treatment, e.g. from household waste, bulky waste and commercial waste similar to household waste, it should be possible to separate out a considerable amount of recyclable parts and thereby achieve a corresponding reduction in the quantity of waste. The mechanical process removes materials which have a material or energy value while in the biological step (aerobic decomposition), native-organic components in the remaining waste are, to a large extent, made inert. In this way emissions from landfills, i.e. landfill gases and highly organic leachate which result from biological decomposition of organic substances, are avoided.

Compost plants (see **Fig. 2**) work on the same basic principle with the input of biodegradable waste (e.g. separately collected bio-waste from household compost bins and green waste from municipal compost collection points).

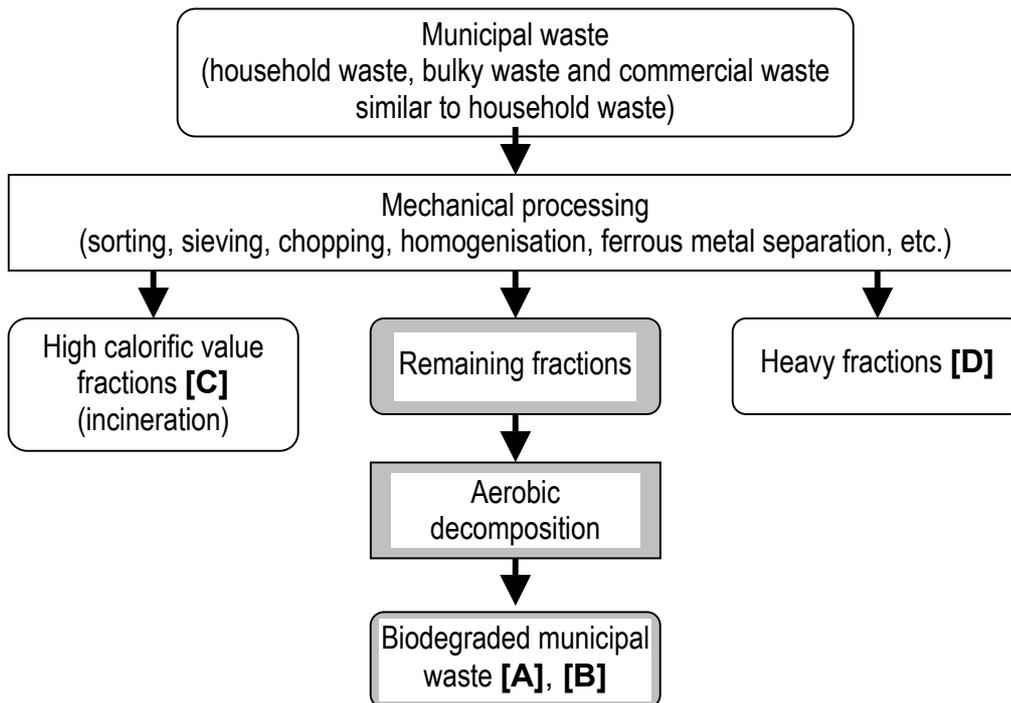


Fig.1: Simplified diagram of mechanical-biological treatment of municipal waste and the resulting wastes

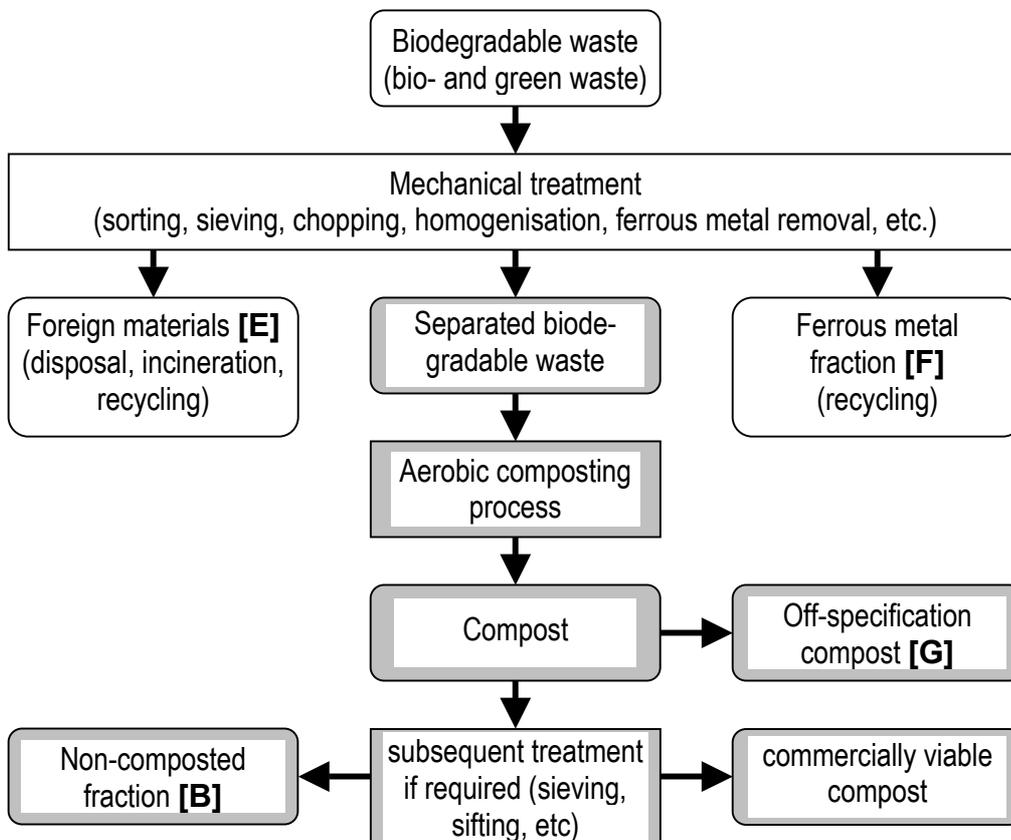


Fig.2: Simplified diagram of mechanical-biological treatment of biodegradable (bio- and green) waste and the resulting wastes

The decomposition of naturally occurring organic materials is primarily carried out by unicellular organisms (micro-organisms). Micro-organisms exist in aerobic and anaerobic systems. The decomposition under consideration here belongs to the aerobic systems where a sufficient supply of oxygen is essential to their existence.

Organic compounds which can be decomposed by microbes are to be found in large quantities in most municipal waste (e.g. waste from food preparation, garden waste, paper and cardboard, natural textile fibres) as well as in industrial waste from the food industry and slaughter houses, in waste from the wood industry, etc. The thing that all these different types of waste have in common is that they are composed of organic and mineral components and water.

The process technology required for biological treatment includes, to a large extent, mechanical processes such as sorting, sieving, chopping and homogenisation, as well as the management of biological processes such as aeration and ventilation as well as watering and drainage during the decomposition processes.

2 Wastes

2.1 *Biodegraded municipal waste [A]*

Biodegraded waste is the residual fraction from municipal and similar waste which cannot be further biologically decomposed by aerobic processes. There is a corresponding reduction in landfill gases and highly organic leachate once it is disposed.

Classification of waste in accordance with EWL:

19 05 01 non-composted fraction of municipal and similar wastes

Notes on recycling, utilization and disposal:

Disposing to landfill together with municipal waste

2.2 *Non-composted fraction from animal and plant waste [B]*

This includes animal and plant organic material, mainly from industrial processes, which decomposes very slowly because of its structure (for example woody plant material) and which arises as non-microbial decomposed fraction following the decomposition or composting process. As a rule, undecomposed fraction from aerobic treatment of municipal waste is not separated from biodegraded municipal waste, but disposed together with it.

Classification of waste in accordance with EWL:

19 05 02 non-composted fraction of animal and vegetable waste

Notes on recycling, utilization and disposal:

Disposing to landfill together with municipal waste.

2.3 *High calorific value fraction [C]*

Larger pieces, mainly comprising plastic sheet, wood and other pieces with a large surface area, most of which have a high calorific value, can be separated by sieving. Thus separation of the bulky fraction results in a rich calorific value material flow.

Classification of waste in accordance with EWL:

- 19 12 04 plastic and rubber
- 19 12 07 wood other than that mentioned in 19 12 06
- 19 12 10 combustible waste (refuse derived fuel)

Notes on recycling, utilization and disposal:

Incineration, as a rule together with municipal waste.

2.4 Heavy fraction [D]

Fraction passed through the sieve is then separated into 'light' and 'heavy' flows using wind separation. Mineral components, glass and metals are concentrated in the 'heavy' fraction.

Classification of waste in accordance with EWL:

- 19 12 02 ferrous metal
- 19 12 03 non-ferrous metal
- 19 12 05 glass
- 19 12 09 minerals (for example sand, stones)
- 19 12 12 other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11

Notes on recycling, utilization and disposal:

Under suitable separation, recycling or utilisation (metallurgical processes, glass recycling, building rubble recycling). If applicable, material recycling of the ferrous metal fraction, as a rule after separation using magnetic separators (see 2.6).

Otherwise, in case of heavy polluted fractions, disposing to landfill together with municipal waste.

2.5 Foreign material [E]

Even with separate collection of biodegradable waste it cannot be avoided that non-compostable waste is present. This is separated from the material flow by sieving, sifting or also manual picking.

Classification of waste in accordance with EWL:

- 19 12 12 other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11

Notes on recycling, utilization and disposal:

Disposing together with municipal waste.

2.6 Ferrous metal fraction [F]

Ferrous metal can be extracted from the material flows D and E using magnetic separators.

Classification of waste in accordance with EWL:

- 19 12 02 ferrous metal

Notes on recycling, utilization and disposal:

Recycling in steel works.

2.7 Off-specification compost [G]

Off-specification compost is the fraction from the composting process of biodegradable (bio- and green) waste which doesn't satisfy quality requirements (e.g. due to insufficient aeration or too much foreign material component).

Classification of waste in accordance with EWL:

19 05 03 off-specification compost

Notes on recycling, utilization and disposal:

As a rule disposing together with municipal waste.

If applicable, incineration of fraction with high calorific value following drying.

3 Overview of waste classification – material flow

Extract from EWL		Material flow	Treatment
19 05	wastes from aerobic treatment of solid wastes		
19 05 01	non-composted fraction of municipal and similar wastes	A	With municipal wastes
19 05 02	non-composted fraction of animal and vegetable waste	B	With municipal wastes
19 05 03	off-specification compost	G	1) With municipal wastes, 2) incineration
19 05 99	wastes not otherwise specified	not normally required	

	wastes from aerobic treatment of solid wastes to be classified under other waste categories		
19 12 02	ferrous metal	D, F	Recycling
19 12 03	non-ferrous metal	D	1) Recycling, 2) with municipal waste
19 12 04	plastic and rubber	C	1) Incineration, 2) with municipal waste
19 12 05	glass	D	1) Recycling, 2) with municipal waste

19 12 07	wood other than that mentioned in 19 12 06	C	1) Incineration, 2) with municipal waste
19 12 09	minerals (for example sand, stones)	D	1) materials recycling, 2) with municipal waste
19 12 10	combustible waste (refuse derived fuel)	C	Incineration
19 12 12	other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11	D, E	With municipal wastes

19 06 Wastes from anaerobic treatment of waste

1	Processes	1
2	Wastes	3
2.1	<i>Liquids from anaerobic treatment [A]</i>	3
2.2	<i>Sludges from anaerobic treatment [B]</i>	3
2.3	<i>Metal and mineral matter from sorting and sieving [C]</i>	4
2.4	<i>Organic material from sorting and sieving [D]</i>	4
2.5	<i>Other material from sorting and sieving [E]</i>	4
2.6	<i>Spent adsorbents [F]</i>	5
3	Overview of waste classification - material flow	5

1 Processes

In the same way as organic waste components (with a supply of oxygen) can be aerobically mineralised in a decomposition process (see subchapter 19 05), anaerobic decomposition is also possible, where oxygen has been excluded, with biogas being produced. Anaerobic biological digestion processes are mainly used in purifying industrial wastewater, in treating sewage and in the treatment of solid organic waste. The purpose of the latter is to decompose bio matter as far as possible in order to reduce biochemical processes taking place in landfill which lead to the production of methane gas and contamination of landfill leachate. This should result in landfill sites which require little attention without operating complicated thermal processes to render waste inert.

Mechanical biological treatment of waste (MBW) is a process for treating waste containing mainly organic matter, e.g. residue waste fraction from households or similar commercial waste. It may include aerobic (see subchapter 19 05, par. 1) or anaerobic processes. In some cases an aerobic process is used in addition to an anaerobic process (see **fig. 1**) in order to further decompose organic matter (e.g. biomass) and to reduce the pressure on landfill as described above by rendering the waste inert. As a rule, MBW is used in waste pretreatment before final disposal. Waste still containing matter that can be biologically decomposed is stabilised using this process.

The input material (e.g. residue waste, sewage sludge) is stored in a bunker. It is then shredded, sieved and homogenised. Problematic material and any energy-rich fraction, e.g. plastic, is separated. Depending on the digestion process being used, the prepared matter is treated in one or more stages of digestion, in some cases with

the addition of water. Thereby, organic substances are largely decomposed to form methane and carbon dioxide (biogas). The quantity of trace gases such as ammonia and hydrogen sulphide is dependent on the nitrogen and sulphur content of the decomposed (e.g. protein-rich) waste. The residue remaining after digestion is microbial biomass and matter that cannot be digested. It is normally sludge or liquid phase. Using its own energy content, the dried digested sludge can in some cases be thermally treated, hydrogenated or disposed to landfill. Flue-gas from these processes is treated in a flue-gas treatment plant (adsorber).

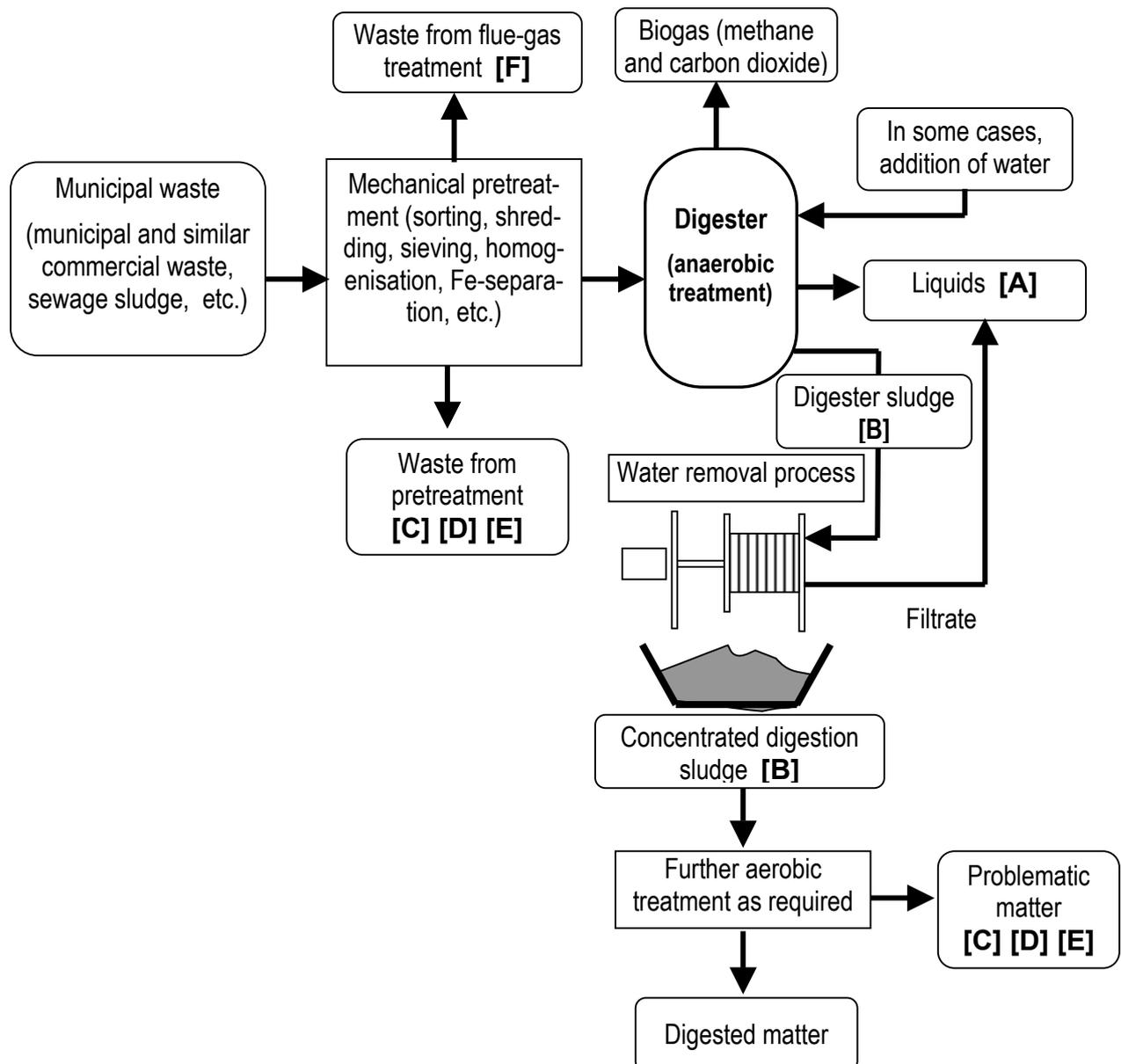


Fig. 1: Simplified diagram of mechanical, biological treatment of waste (anaerobic, with further aerobic treatment)

2 Wastes

2.1 Liquids from anaerobic treatment [A]

The liquid phases from anaerobic digestion processes contain organic (biomass) and mineral components in very dilute form. In some cases they may be contaminated with varying amounts of matter that is difficult to decompose (e.g. polymer suspended particles).

Classification of waste in accordance with EWL:

19 06 03 liquor from anaerobic treatment of municipal waste

19 06 05 liquor from anaerobic treatment of animal and vegetable waste

Notes on recycling, utilization and disposal:

It may be used to moisten organic waste. In this case, an inoculation of anaerobic micro-organisms into the waste to be decomposed takes place at the same time.

Otherwise, chemical physical treatment (CPT) using precipitation/flocculation and filtration processes (see subchapter 19 08, par. 2.5) to separate the water phase for feeding into the sewerage system. In 19 06 03 attention must be paid to an increased heavy metal content, which follows from leaching the residue waste under acidic conditions.

2.2 Sludges from anaerobic treatment [B]

As a rule the sludgy phases from anaerobic digestion contain organic (biomass) and mineral components. They may be contaminated to varying degrees with matter which is difficult to decompose (e.g. metal and plastic).

The dry mass content of the organic fraction depends on the digestion process being used. For example, in the case of solid matter digestion, the dry mass content lies between 25 and 30% as a rule. In the case of wet digestion, sufficient water is added to produce a sludge which can be pumped by conventional means with a dry mass content of 12 to 18%.

Classification of waste in accordance with EWL:

19 06 04 digestate from anaerobic treatment of municipal waste

19 06 06 digestate from anaerobic treatment of animal and vegetable waste

Notes on recycling, utilization and disposal:

Drying to a water content below 15% mass weight (dry "stabilisation"). Following that, in some cases after further aerobic treatment (decomposition), disposal to landfill or incineration, as a rule together with municipal waste.

If it does not contain detrimental substances (e.g. in the case of mainly vegetative waste from green waste collection points), utilization as compost, in some cases following further aerobic treatment (composting).

2.3 Metal and mineral matter from sorting and sieving [C]

During mechanical pretreatment of waste, inorganic matter which is problematic to the digestion process or which can be used in some other way (e.g. metal, glass and mineral material) is taken out.

Classification of waste in accordance with EWL:

- 19 12 02 ferrous metal
- 19 12 03 non-ferrous metal
- 19 12 05 glass
- 19 12 09 minerals (for example sand, stones)

Notes on recycling, utilization and disposal:

Following separation, recycling or utilization (metallurgy, glass recycling, building rubble processing).

Otherwise, if the fraction is heavily contaminated, disposal to landfill, as a rule together with municipal waste.

2.4 Organic material from sorting and sieving [D]

During mechanical pretreatment of waste, organic matter, which cannot be decomposed (e.g. wood waste) or which can be used for its material or energy content (e.g. plastic), is removed.

Classification of waste in accordance with EWL:

- 19 12 04 plastic and rubber
- 19 12 07 wood other than that mentioned in 19 12 06
- 19 12 10 combustible waste (refuse derived fuel)

Notes on recycling, utilization and disposal:

Incineration, as a rule together with municipal waste.

2.5 Other material from sorting and sieving [E]

In addition, during mechanical pretreatment, mixed fraction arises that has to be classified in the appropriate EWL category in accordance with where it originates from and its content. For example, batteries or electronic appliances in household waste lead to a classification as hazardous waste because they contain dangerous substances.

Classification of waste in accordance with EWL:

- 19 12 11* other wastes (including mixtures of materials) from mechanical treatment of waste containing dangerous substances
- 19 12 12 other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

Incineration or disposal to landfill, together with municipal waste if it does not contain dangerous substances.

2.6 Spent adsorbents [F]

Adsorbents are mainly used in cleaning work-place air and removing smells. Activated charcoal is the main adsorbent, but zeolites and polymers may also be used.

Classification of waste in accordance with EWL:

15 02 02* adsorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances

15 02 03 adsorbents, filter materials, wiping cloths and protective clothing other than those mentioned in 15 02 02

Notes on recycling, utilization and disposal:

Regeneration and recycling.

Otherwise, incineration, together with municipal waste if it does not contain dangerous substances.

3 Overview of waste classification - material flow

	Extract from EWC	Material Flow	Treatment
19 06	wastes from anaerobic treatment of waste		
19 06 03	liquor from anaerobic treatment of municipal waste	A	1) recycling, 2) CPT
19 06 04	digestate from anaerobic treatment of municipal waste	B	with municipal waste
19 06 05	liquor from anaerobic treatment of animal and vegetable waste	A	1) recycling, 2) CPT
19 06 06	digestate from anaerobic treatment of animal and vegetable waste	B	1) with municipal waste, 2) material use
19 06 99	wastes not otherwise specified	not normally required	

	wastes from anaerobic treatment of waste to be classified under other waste categories		
15 02 02*	adsorbents, filter materials (including oil filters not otherwise specified), wiping cloths, protective clothing contaminated by dangerous substances	F	1) regeneration, 2) HWL, HWI

15 02 03	absorbents, filter materials, wiping cloths and protective clothing other than those mentioned in 15 02 02	F	1) regeneration, 2) with municipal waste
19 12 02	ferrous metal	C	1) recycling, 2) with municipal waste
19 12 03	non-ferrous metal	C	1) recycling, 2) with municipal waste
19 12 04	plastic and rubber	D	1) incineration, 2) with municipal waste
19 12 05	glass	C	1) recycling, 2) with municipal waste
19 12 07	wood other than that mentioned in 19 12 06	D	1) incineration 2) with municipal waste
19 12 09	minerals (for example sand, stones)	C	1) material use, 2) with municipal waste
19 12 10	combustible waste (refuse derived fuel)	D	1) incineration, 2) with municipal waste
19 12 11*	other wastes (including mixtures of materials) from mechanical treatment of waste containing dangerous substances	E	HWL, HWI
19 12 12	other wastes (including mixtures of materials) from mechanical treatment of wastes other than those mentioned in 19 12 11	E	with municipal waste

19 07 Landfill leachate

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1. Process

1.1 Scheme of a landfill

Fig. 1 shows, in principle, what a landfill looks like today. A plane sloping evenly to a low point is created on the base of the landfill. Landfill base sealing is placed on this slope. On top of this comes a drainage system consisting of drainage pipes laid in straight lines and radiating out to collection chutes outside the body of the landfill. The drainage pipes are perforated or have a punctured wall. They are connected to a flat filter layer consisting of pieces of material of gravel or clinker from power stations. On top of this, waste is piled up and compressed with municipal waste achieving a weight of around 1 t/m³. It is normal practice to have waste mountains of 10 to 20 metres.

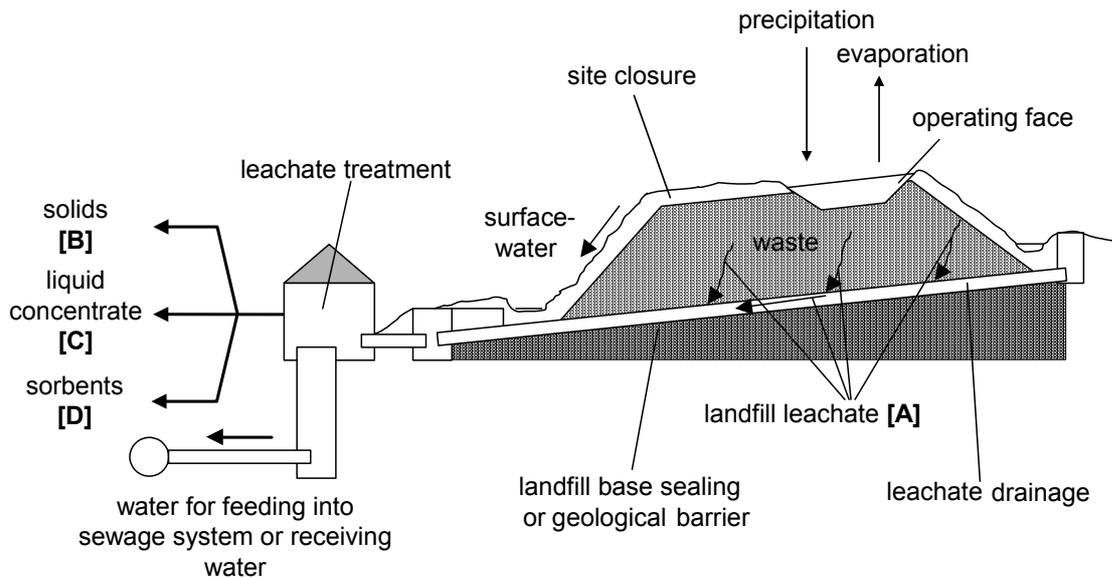


Fig. 1: Diagrammatic representation of landfill with leachate treatment

When the end of the working life of a landfill is reached – this may also apply to a section of landfill - the waste is sealed to prevent rain water penetration and to allow revegetation to take place (**fig. 2**).

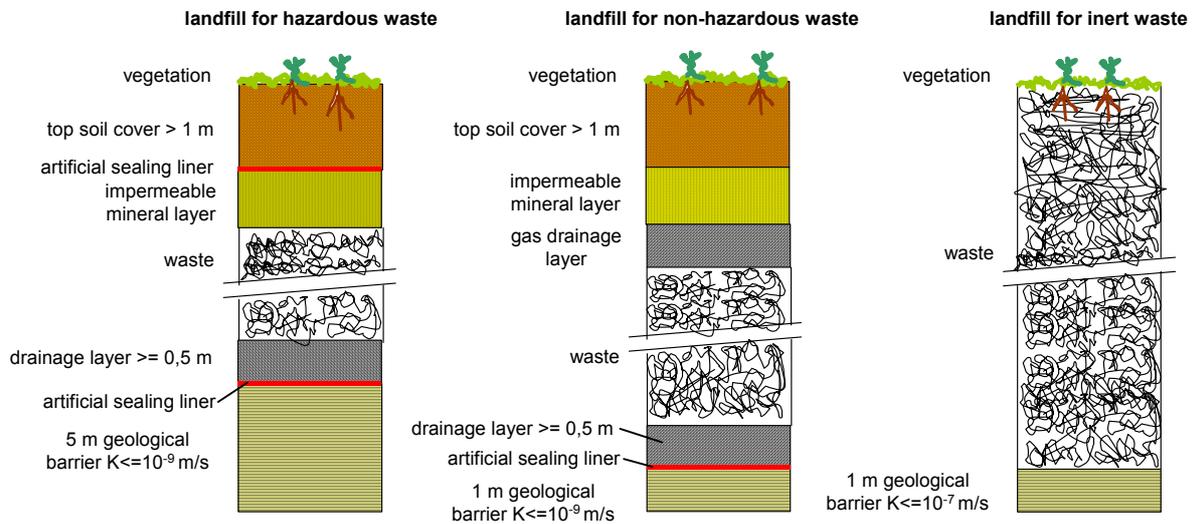


Fig. 2: Comparison between different classes of landfill in terms of sealing

The EU landfill policy 1999/31/EG differentiates between four different categories of landfill:

- landfill for inert waste,
- landfill for non-hazardous waste,
- landfill for hazardous waste and
- underground landfill.

Currently, in Germany, there are sub-categories for inert landfill; earth excavation landfill (landfill class 0) and landfill class 2 in accordance with German technical directive on municipal waste management. In addition to this, there is the possibility of establishing mono-landfill for special industrial waste, eg. for casting sand.

The following descriptions only deal with landfill for non-hazardous waste and landfill for hazardous waste. Inert landfill is less significant in terms of leachate and underground landfill, by definition, generates no leachate.

1.2 Quantity of leachate

Landfill is exposed to rainwater, which runs into the landfill and runs out again as leachate. The following equation represents the total amount of water to be expected:

$$Q = N + W + B - A - V - E + K$$

where:

- Q:** drained leachate,
- N:** rainwater,
- W:** waste water content ,
- B:** the lost or gained quantity of water resulting from biological and chemical decomposition (ie varies +/-)
- A:** surface run-off,
- V:** direct evaporation,
- E:** evaporation through vegetation
- K:** periodic retention and spontaneous run-off collected cascade coefficient (i.e. varies +/-)

The cascade coefficient K is an attempt to describe spontaneous, measurable variations. These variations are caused when water, which is first of all absorbed by the waste, is later released or when impervious layers, which have built up in the landfill, hold back water later allowing it to be spontaneously released when they fail hydraulically. Extensive research has already been carried out to quantify the individual factors. On balance, it can be taken that the quantity of leachate Q is about 25-40 % of rainfall over a long period of time on a yearly average in central Europe. In the final analysis, this amount is heavily dependent on how the landfill is operated. If large areas lie open, the amount of leachate is greater than in partly or completely recultivated landfill.

1.3 Quality of leachate

In waste there are substances which, directly or as intermediate or end products in decomposition processes, dissolve in leachate and are thereby drained from the landfill. Salts are the most significant inorganic substances. Organic waste plays an important role in present generation municipal landfill. Near the surface it is subject to aerobic decomposition whilst towards the centre, mainly anaerobic decomposition. In municipal waste, anaerobic decomposition predominates. First of all organic matter goes through an acidification stage in which large molecular substances form mainly organic acids. There follows methane fermentation in which organic substances are broken down into basic units which cannot be broken down further or which are very difficult to break down. Large quantities of carbonic acid and methane and other gases are released. It takes several decades for decomposition to be completed.

The composition of leachate can vary considerably. As a general rule, leachate from raw waste landfill contains more organic matter and is more difficult to decompose than, for example, domestic waste water. **Tab. 1** shows the range of measured values in leachate from municipal landfill. The EU landfill policy requires a continual reduction in the organic content of landfill waste. Some member states are calling for specific technical pretreatment, eg. incineration. Today's generation of landfill shows a potential figure of around 300 kg organic matter per ton of landfilled waste, although this figure is falling. A considerable amount of this is again biodegradable.

Parameter	Concentration
BOD ₅	up to 40.000 mg/l
COD	up to 100.000 mg/l
TOC	up to 35.000 mg/l
Ammonia-N	up to 4.000 mg/l
AOX	up to 5 mg/l
Salt content pressed out as leachate	up to 25.000 µS per centimeter
Iron	up to 2.000 mg/l

Tab. 1: Range of leachate components from municipal waste landfill

If, in the future, waste with less biological matter – in extreme circumstances incineration ash – is deposited, there will be a respective change in the quality of leachate. **Tab. 2** shows the range for leachate from ash deposits.

Parameter	Analyses results
PH-value	6 to 10
Conductivity	19.000 to 53.000 µS per centimeter
Evaporation residue	15.000 to 34.000 mg/l
Nitrate	From less than 20 to 70 mg/l
Ammonia-N	10 to 140 mg/l
Sulphate	70 to 1.300 mg/l
Chloride	6.500 to 20.000 mg/l
Sodium	2.200 to 8.200 mg/l

Potassium	2.000 to 10.000 mg/l
BOD ₅	from less than 1 mg/l to 350 mg/l
TOC	10 mg/l to 44 mg/l

Tab. 2: Quality of leachate from ash landfill

If the quality criteria for waste in hazardous waste landfill (HWI) as proposed by the commission in June 2002 are followed, it is estimated that hazardous materials as shown in **tab. 3** below will arise. It can be seen that the leachate contains almost no organic components and that inorganic contaminants dominate.

Parameter	Concentration
AOX	approx. 2 mg/l
Ammonia-N	approx. 10 mg/l
Cyanide total	approx. 3 mg/l
TOC	approx. 100 mg/l
Calcium	approx. 2.000 mg/l
Potassium	approx. 2.000 mg/l
Sodium	approx. 5.000 mg/l
Chloride	approx. 10.000 mg/l
Sulphate	approx. 4.000 mg/l

Tab. 3: Quality of leachate from hazardous waste landfill

1.4 Removal of leachate by tanker

Depending on the situation, it may be appropriate to transport the untreated leachate to a treatment plant by tanker.

1.5 Treatment of leachate on-site

In Germany, if leachate is treated on-site in order to be discharged into receiving water or into the sewage system, the limits as laid down in the waste water directive – shown in appendix 51 – have to be met. **Table 4** provides an overview.

Requirements 1-7 have to be met if landfill leachate is to be discharged directly into receiving water. In addition, requirements 8-19 apply before leachate is mixed with waste water from other sources, for example, before being discharged into a public sewage system.

	Parameter	limit:
1	COD	200 mg/L
2	BOD ₅	20 mg/L
3	Nitrogen total ^{1,2}	70 mg/L

¹ for waste water temperature $\geq 12^{\circ}\text{C}$ in output of bioreactor

² N_{total} 100mg/l, if minimization of maximum value N-load in waste water treatment plant > 75 %

4	Phosphorus total	3 mg/L
5	Hydrocarbons ³	10 mg/L
6	Nitrite-nitrogen	2 mg/L
7	Fish test:	Dilution factor 2
8	AOX	0,5 mg/L
9	Hg	0,05 mg/L
10	Cd	0,1 mg/L
11	Cr	0,5 mg/L
12	Cr (VI)	0,1 mg/L
13	Ni	1,0 mg/L
14	Pb	0,5 mg/L
15	Cu	0,5 mg/L
16	Zn	2,0 mg/L
17	As	0,1 mg/L
18	Cyanide, easily released	0,2 mg/L
19	Sulphide	1,0 mg/L

Tab. 4: Limits for treated leachate from above-groundlevel storage of waste to be discharged into the sewage system or receiving water (source: German waste water directive, appendix 51)

Fixed drainage values for leachate treatment plants are set by the authorities as part of the licencing process. The German technical directive on waste management, appendix F, gives an indication of the range of leachate treatment processes (see **tab. 5**). It is mainly concerned with precipitation, separation and concentration processes to separate off the water phase which can then be discharged into the sewage system. In practice, processes are usually combined.

	Process	Advantages/disadvantages
Mechanical processes		
	Sedimentation in sand trap	<ul style="list-style-type: none"> Only suspended matter, i.e. solids, are separated
	Membrane process (reverse osmosis)	<ul style="list-style-type: none"> A variety of emulsions/solutions (eg. organic acids, organic ester, aliphatic alcohol, aromatic particles, formaldehyde, etc) can be separated High disposal costs for the residue
	Adsorption on Activated charcoal	<ul style="list-style-type: none"> Especially suitable for organic halogens, Phenol, Aromatics, org. solvents, Pesticides, Detergents Ammonia, Salts and Metals cannot be adsorbed
	Adsorption on Adsorption resins	<ul style="list-style-type: none"> Especially suitable for halogen-organic compounds and metal ions Water soluble organic matter, solids and high salt content cannot be adsorbed
Thermal processes:		
	Evaporation	<ul style="list-style-type: none"> Volatile chlorinated hydrocarbons

³ not valid for municipal waste

		<ul style="list-style-type: none"> and ammonia must also be removed from the (evaporation) condensate High energy consumption
	Incineration	<ul style="list-style-type: none"> Nearly all organic hazardous materials are destroyed Volatile heavy metals cause heavy flue-gas contamination
Biological processes:		
	Aerobic process	<ul style="list-style-type: none"> Predominantly organic materials can be biologically decomposed Various contaminants (eg. heavy metals) are poisonous to the biological process or inhibit Little process certainty
	Anaerobic process	
Chemical processes:		
	Precipitation	<ul style="list-style-type: none"> Heavy metals can be separated (complexing agent often not) Large quantity of sludge produced
	Flocculation	

Tab. 5: Range of landfill leachate treatment processes
(Source: Following German technical instruction on hazardous waste management, Appendix F)

1.5.1 Separation of solids [B]

Separation of solids from desanding

Solid and suspended matter from landfill leachate sediments out in a settling bath on the bottom of the sand trap and can then be removed. As a rule, it consists of mineral and, occasionally, organic substances (eg. sand containing oil) and is taken to have the water removed.

Precipitation of landfill leachate

The precipitation process converts soluble contaminants, for example, chrome, chrome-VI, nickel, copper, zinc, ammonia, etc. into an insoluble phase (eg. by pH change or conversion to a less soluble compound). Depending on the substance to be precipitated, sodium hydroxide, slaked lime, soda, etc, are used as precipitating agents. Precipitates such as metal hydroxide sludge, i.e. sludges containing ammonia hydroxide, are subsequently removed and the water taken out (CPT plant).

Flocculation of landfill leachate

During flocculation, colloidal (finely dispersed) organic contaminants, such as plant matter, grease, protein, mineral material, surfactants or phosphate are coagulated into larger units by adding a precipitant, eg. calcium hydroxide, aluminium salts, iron(II) salts. These are separated from the water phase by sedimentation (eg. baffle plate thickener) and then water is removed (eg. in a chamber filter press).

Aerobic treatment of landfill leachate

Aerobic biological processes oxidise organic compounds mainly to carbon dioxide and water. Other aerobic processes include, for example, the oxidation of nitrogen to nitrate (nitrification). Aerobic processes result in a sharp increase in bacteria mass. This is continually removed as biomass and surplus organic sludge for anaerobic treatment (rotting process).

Anaerobic treatment of landfill leachate

During anaerobic decomposition of organic substances in waste water, suitable bacteria are used to produce biogas (eg. methane and hydrogen). Other anaerobic processes are, for example, the reduction of sulphate to hydrogen sulphide or anaerobic denitrification. Water is removed from the resulting foul sludge in a CPT plant and the separated water phase is discharged into the sewage system or receiving water.

1.5.2 Separation of dissolved materials [C]

Membrane process (reverse osmosis)

Dissolved components (eg. heavy metals and their compounds) and organic compounds (eg. hydrocarbons) can be removed from landfill leachate using the membrane process. During reverse osmosis, a liquid is pressurised through a semi-permeable membrane against the natural osmotic pressure. The process separates landfill leachate into a larger, relatively pure flow (permeate) and a smaller flow laden with dangerous substances (residue).

Evaporation of landfill leachate

The evaporation of landfill leachate is a thermal separation process based on differing boiling points and used to separate water from dangerous substances. The evaporated water is condensed and discharged into the sewage system or receiving water if it cannot be otherwise used. The landfill leachate concentrate shows high salt content. Substances with a lower boiling point, such as volatile hydrocarbons or compounds containing ammonia exist as gases.

1.5.3 Sorbents [D]

Adsorption of dangerous substances

The main purpose of adsorption of landfill leachate is to remove organic, liquid, water insoluble substances as well as certain groups of substances (eg. humic matters). In principle, adsorption represents a concentration of the contents of liquid and gas phases on a solid surface. Sorbents such as activated charcoal, brown and hard coal coke as well as adsorption resins are mainly used.

Adsorption on activated charcoal

Mainly organic substances such as halogens, phenol, aromatics, organic solvents, pesticides, detergents (surfactant), etc. can be adsorbed by adsorption of landfill leachate on activated charcoal. Activated charcoal is pure carbon, which possesses good adsorption properties due to its porous structure and large inner surface area.

After a certain number of regeneration cycles, laden activated charcoal has to be disposed of as a result of mechanised rubbing and insufficient regeneration potential.

Adsorption on adsorption resins

Adsorption resins are mainly a polymer based matrix with so-called activated groups, which are specially arranged for the adsorption of specific materials or groups of materials, eg. humic matters (part of the biological COD which cannot be decomposed), chlorinated hydrocarbons or metal ions. Laden adsorption resins arise for disposal.

2. Wastes

2.1 Landfill leachate [A]

Landfill leachate may contain dangerous substances such as organic substances (phenol, aromatics, solvents, pesticides, etc.), heavy metals (Pb, Cd, Cr, Cu, Hg etc.), halogenated compounds, ammonia compounds, acids, bases, surfactants, etc. which means it must be classified as hazardous waste.

Classification of waste in accordance with EWL:

- 19 07 02* landfill leachate containing dangerous substances
- 19 07 03 landfill leachate other than those mentioned in 19 07 02

Notes on recycling, utilization and disposal:

At present there are known any viable treatment processes.

Treatment in CPT plants to remove poisons and neutralise. Separation of the water phase for feeding into sewage system or receiving water.

2.2 Solids [B]

Settled material, as a rule mineral in origin, which has been held back in the sand trap normally doesn't contain dangerous substances.

Precipitation or flocculation sludges may contain dangerous substances such as heavy metal, organic substances, as well as phosphate and sulphate.

Surplus organic sludge from biological waste water treatment plants has a high organic content consisting mainly of biomass but also organic non-biodegradable remaining substances.

Classification of waste in accordance with EWL:

- 19 02 05* sludges from physico/chemical treatment containing dangerous substances
- 19 02 06 sludges from physico/chemical treatment other than those mentioned in 19 02 05
- 19 08 02 waste from desanding
- 19 08 11* sludges containing dangerous substances from biological treatment of industrial waste water

19 08 12 sludges from biological treatment of industrial waste water other than those mentioned in 19 08 11

Notes on recycling, utilization and disposal:

For the waste categories named above there are at present known any viable treatment processes.

19 02 05*: Disposal to landfill (HWL, UGL) or thermal treatment (HWI).

19 02 06: Disposal, in some cases with municipal waste.

19 08 02: Disposal, in some cases with municipal waste.

19 08 11*: Thermal treatment (HWI).

19 08 12: As a rule, disposal, if applicable together with municipal waste.
Otherwise, if the limits set for sewage sludge have been met, it can be spread on agricultural or landscape gardening land.

2.3 Liquid concentrate [C]

Depending on the source of treated waste water, landfill leachate concentrate contains high concentrations of heavy metals (Pb, Cd, Cr, Hg, etc.), organic substances, solvents, hydrocarbons (perhaps containing halogens), compounds containing sulphur, ammonia or cyanide, which make it necessary to classify it as hazardous waste.

Classification of waste in accordance with EWL:

19 02 11* other wastes containing dangerous substances

19 08 08* membrane system waste containing heavy metals

Notes on recycling, utilization and disposal:

19 02 11*: At present there are known any viable treatment processes.
As a rule, thermal treatment (HWI)

19 08 08*: At present there are known any viable treatment processes.
As a rule, treatment with CPT processes to neutralise or remove water (eg. precipitation).
Otherwise, thermal treatment (HWI) in the case of high organic content.

2.4 Sorbents [D]

Sorbents such as activated charcoal or adsorbent resins contain, for example, organic halogens, phenol, aromatics, organic solvents, pesticides, etc. and, as a result, must be declared as hazardous waste.

Classification of waste in accordance with EWL:

for activated charcoal:

19 01 10* spent activated carbon from flue-gas treatment

for adsorption resins:

19 08 06* saturated or spent ion exchange resins

Notes on recycling, utilization and disposal:

For the waste categories named above there are at present known any viable treatment processes.

- 19 02 11*: As a rule, incineration (HWI).
 Otherwise disposal to landfill (HWL).
- 19 08 06*: As a rule, thermal treatment in waste incineration plants (HWI).
 Otherwise, disposal to landfill (HWL).

3. Overview of waste classification – material flow

	Extract from EWL	Material flow	Treatment
1907	Landfill leachate		
19 07 02*	landfill leachate containing dangerous substances	A	CPT
19 07 03	landfill leachate other than those mentioned in 19 07 02	A	CPT

	Wastes from landfill leachate to be classified under other waste categories		
19 01 10*	spent activated carbon from flue-gas treatment	D	HWL, HWI
19 02 05*	sludges from physico/chemical treatment containing dangerous substances	B	HWL, HWI, UGL
19 02 06	sludges from physico/chemical treatment other than those mentioned in 19 02 05	B	with municipal waste
19 02 11*	other wastes containing dangerous substances	C	HWI
19 08 02	waste from desanding	B	with municipal waste
19 08 06*	saturated or spent ion exchange resins	D	HWL, HWI
19 08 08*	membrane system waste containing heavy metals	C	CPT, HWI
19 08 11*	sludges containing dangerous substances from biological treatment of industrial waste water	B	HWI
19 08 12	sludges from biological treatment of industrial waste water other than those mentioned in 19 08 11	B	1) Recycling, 2) with municipal waste

19 08	Wastes from wastewater treatment plants not otherwise specified	
1	Municipal wastewater treatment	1
1.1	<i>Process</i>	<i>1</i>
1.2	<i>Wastes</i>	<i>2</i>
2	Wastewater treatment plants for industrial wastewater.....	3
2.1	<i>Biological wastewater treatment plants for industrial wastewater.....</i>	<i>3</i>
2.2	<i>Ion exchangers used in the treatment of industrial wastewater.....</i>	<i>4</i>
2.3	<i>Membrane systems.....</i>	<i>6</i>
2.4	<i>Oil/water separator.....</i>	<i>7</i>
2.5	<i>Other wastewater treatment plants for industrial wastewater</i>	<i>8</i>
3	Overview of waste classification – material flow.....	10

1 Municipal wastewater treatment

1.1 Process

Municipal sewage plants (see **fig. 1**) deal with household, commercial and industrial wastewater as well as rain water which is supplied to them through drainage systems. The plants operate several stages and separate both solid materials and dissolved materials from the wastewater using mechanical, biological and chemical processes.

In the first mechanical cleaning stage, grills first of all hold back large pollutants, e.g. textiles, plastic or cleaning wool. In the following stage, smaller, mainly mineral pollutants are deposited in a sand trap. Other, mainly organic solids are separated out in the primary settling basins. Dissolved materials are either broken down biologically or converted into insoluble materials in a precipitation process and then separated. The resulting sludges are either anaerobically or aerobically stabilised and mechanically drained.

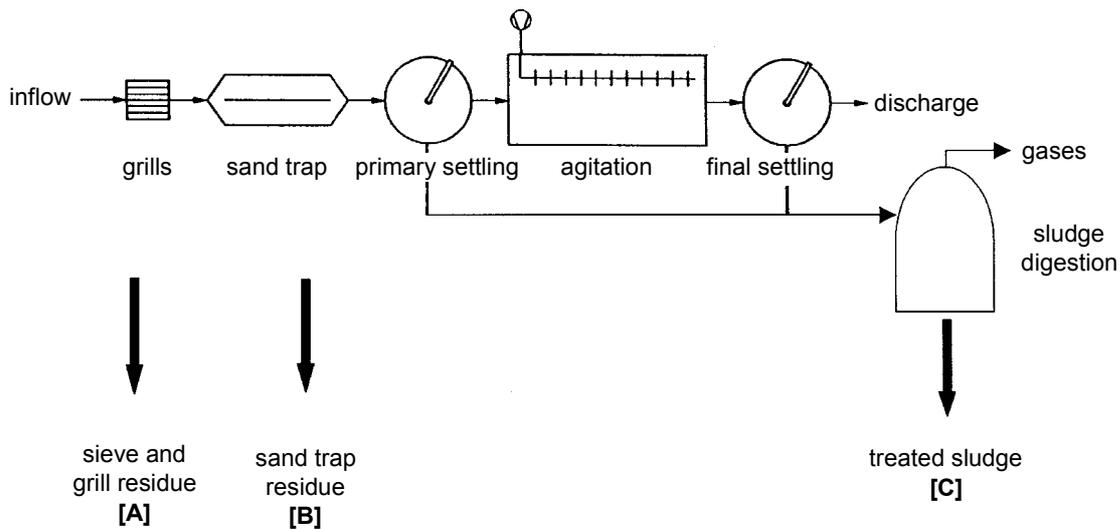


Fig 1: An example representation of a municipal sewage plant and its possible types of waste and emissions

1.2 Wastes

Sieve and grill residue [A]

The grill residue is mainly composed of textiles, plastic particles, paper remains and faeces and a large amount of water. In order to reduce the volume as well as to prevent fermentation of the materials, a mechanical draining process is often included.

Classification of waste in accordance with EWL:

19 08 01 screenings

Notes on recycling, utilization and disposal:

There are at present no viable treatment processes known.

Disposing normally together with municipal waste.

Sand trap residue [B]

Fine, mainly mineral particles accumulate at the bottom of the sand trap through sedimentation. The organic matter still contained in this residue is normally small and can, if required, be reduced to below 5% in a further washing process.

Classification of waste in accordance with EWL:

19 08 02 waste from desanding

Notes on recycling, utilization and disposal:

There are at present no viable treatment processes known.

Disposing normally together with municipal waste.

Treatment sludge [C]

The raw sludge from the mechanical and biological treatment stages have a dry material content of below 5%. In order to avoid future treatment problems (especially odour emissions), the sludges are stabilised either aerobically in thickeners, or anaerobically in digesters. In order to reduce the volume, the sludge is thickened. The stabilised sludge has a dry material content of up to 10% which can be increased to 30% in a further draining system. Treated sludges contain organic and mineral components and can be contaminated with varying amounts of heavy metals and persistent traces of dangerous organic substances.

Classification of waste in accordance with EWL:

19 08 05 sludges from treatment of urban waste water

Notes on recycling, utilization and disposal:

Without dangerous substances possibly using as fertiliser in the agriculture.

Landfilling or incineration, normally together with municipal waste.

2 Wastewater treatment plants for industrial wastewater

Foreword

In terms of origin and composition, there is an overlap between the waste classified under EWL 19 08 described below and similar EWL wastes in other categories. This is especially true of all the codes "sludges from on-site wastewater treatment" indicated in the following chapters and sub-chapters:

- 07 wastes from organic chemical processes
- 10 01 wastes from power stations and other combustion plants (except 19)
- 11 01 wastes from chemical surface treatment and coating of metals and other materials (for example galvanic processes, zinc coating processes, pickling processes, etching, phosphating, alkaline degreasing, anodising)
- 13 05 oil/water separator contents
- 19 02 wastes from physico/chemical treatments of waste (including dechromatation, decyanidation, neutralisation)
- 19 09 wastes from the preparation of water intended for human consumption or water for industrial use.

In accordance with the Waste List classification system, which is structured according to fields of industry, sludges should be classified in the specialist chapter/sub-chapter from which they originate.

2.1 Biological wastewater treatment plants for industrial wastewater

2.1.1 Process

Biological sewage plants for industrial wastewater are similar to municipal sewage plants described in paragraph 1.1 in terms of their method of operation. They are, first and foremost, installed in large companies where a sufficient quantity of wastewater with constant or similar constituents arises. Depending on the specific industrial materials present in the wastewater, treatment plants also use chemical-

physical treatment stages. From this, wastes arise similar to those in municipal sewage plants.

2.1.2 Wastes

Sludges from biological wastewater treatment plants for industrial wastewater [C]

Sludges from biological wastewater treatment plants for industrial wastewater resemble treatment sludges from municipal sewage plants described in paragraph 1.2 in terms of consistency and composition. Depending on the source of this treated wastewater, the sludges could contain dangerous substances in such a quantity as to make it necessary to classify them as dangerous.

Classification of waste in accordance with EWL:

If waste cannot be clearly classified in one of the categories 1 to 17, the following waste categories should be adopted:

- 19 08 11* sludges containing dangerous substances from biological treatment of industrial waste water (*exceptions*)
- 19 08 12 sludges from biological treatment of industrial waste water other than those mentioned in 19 08 11 (*rule*)

Notes on recycling, utilization and disposal:

Landfilling or incineration. Without dangerous substances together with municipal waste.

2.2 Ion exchangers used in the treatment of industrial wastewater

2.2.1 Process

The purpose of an ion exchanger (see **fig. 2**) is to remove dissolved metal ions from process fluids or industrial wastewater by sorption of heavy metals on the structure of a resin. The main purpose, depending on each particular case, is either the necessary treatment of wastewater before it is fed into the sewage system or the recovery of metals.

Once resins used in the ion exchanger reach their maximum load, they lose their effectiveness and must be regenerated. During regeneration, the ions which have been taken up are precipitated out using the appropriate regeneration chemicals. After a number of cycles, ion exchange resins are exhausted and must be disposed of. Among other applications, ion exchangers are used for condensate (condensation) cleaning in power stations.

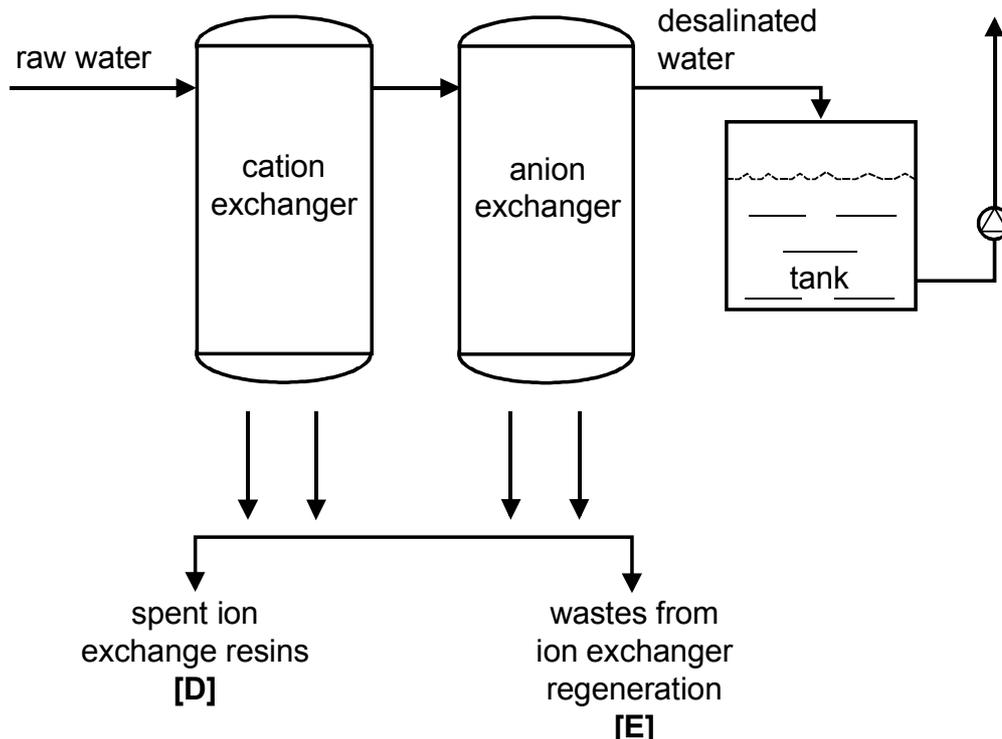


Fig 2: Ion exchanger use as an example for a desalination plant with tanks for desalinated water

2.2.2 Wastes

Spent ion exchanger resins [D]

After a certain period of time ion exchanger resins become useless and must be completely disposed of.

Classification of waste in accordance with EWL:

19 08 06* saturated or spent ion exchange resins

When the origin is from the industrial waste water treatment:

From chemical surface treatment and coating of metals:

11 01 16* saturated or spent ion exchange resins

From the preparation of water intended for human consumption or water for industrial use:

19 09 05 saturated or spent ion exchange resins

Notes on recycling, utilization and disposal:

Incineration.

Without dangerous substances, disposing together with municipal waste.

Regenerate [E]

Regeneration of ion exchanger resins results in the production of regenerate which contains dissolved wastewater components in concentrated form. The regenerate, in

the form of solutions or sludges (following a precipitation stage), contains the precipitated ions 500 times more concentrated than in the original input.

Classification of waste in accordance with EWL:

19 08 07* solutions and sludges from regeneration of ion exchangers

When the origin is from the industrial waste water treatment:

11 01 15* eluate and sludges from membrane systems or ion exchange systems containing dangerous substances

19 09 06 solutions and sludges from regeneration of ion exchangers

Notes on recycling, utilization and disposal:

There are at present no viable treatment processes known.

As a rule chemical-physical treatment (CPT) using precipitation / flocculation and filtration processes (see par. 2.5) to neutralise and precipitate the dissolved metals and separate out the water phase which can then be fed into the sewerage system.

2.3 Membrane systems

2.3.1 Process

Ultrafiltration (UF) and reverse osmosis (RO) are two types of membrane technology relevant to wastewater treatment. Ultrafiltration is a crossflow filtration process to separate complex molecular compounds (see **fig. 3**). Using this process, emulsions, for example, can reach 50% concentration (concentrate). The permeate then contains only simple-molecular dissolved substances.

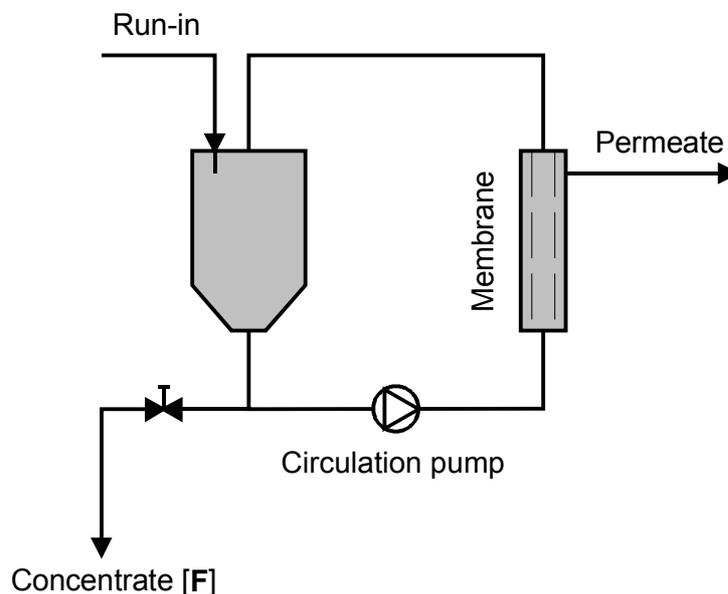


Fig. 3:Principle of ultrafiltration

Reverse osmosis with a 100-fold lower pore size than UF is used to separate simple-molecular dissolved substances.

If applicable, the resulting permeate from this process can be used as process water in on-site circulation systems.

One use of membrane technology is in the treatment of landfill leachate.

2.3.2 Wastes

Concentrate from membrane systems [F]

Concentrates containing heavy metals arise from membrane systems especially during the treatment of landfill leachate.

Classification of waste in accordance with EWL:

19 08 08* membrane system waste containing heavy metals

When the origin is from the industrial waste water treatment:

11 01 15* eluate and sludges from membrane systems or ion exchange systems containing dangerous substances

Notes on recycling, utilization and disposal:

There are at present no viable treatment processes known.

As a rule chemical-physical treatment (CPT) using precipitation / flocculation and filtration processes (see par. 2.5) to neutralise and separate out the water phase which can then be fed into the sewerage system.

2.4 Oil/water separator

2.4.1 Process

Oil/water separators separate water from, for example, oils and grease by exploiting the lower specific weight of these materials compared to water and their insolubility in water (see **fig. 4**).

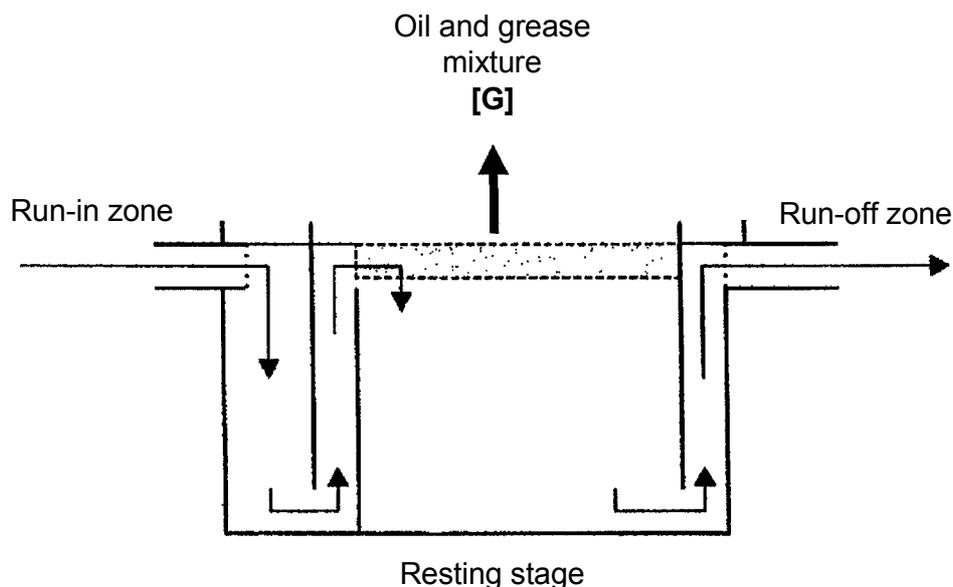


Fig 4: Scheme of an oil/water separator

Typical applications are in the catering industry, for example, pubs, hotels, canteens, and the food processing industry. In addition, oil and grease separators are

sometimes used in municipal sewage works as well as being installed before the biological wastewater treatment plant for industrial wastewater.

2.4.2 Wastes

Oil phase from oil separators [G]

The specific grease and oil components from the preceding production processes, or source of the wastewater, characterise this waste.

Classification of waste in accordance with EWL:

19 08 09 grease and oil mixture from oil/water separation containing only edible oil and fats

When the origin is from municipal or industrial sewage treatment plants and other wastewater treatment plants other than the food industry:

19 08 10* grease and oil mixture from oil/water separation other than those mentioned in 19 08 09

05 01 09* sludges from on-site effluent treatment containing dangerous substances

05 01 10 sludges from on-site effluent treatment other than those mentioned in 05 01 09

11 01 13* degreasing wastes containing dangerous substances

11 01 14 degreasing wastes other than those mentioned in 11 01 13

13 05 06* oil from oil/water separators

13 05 07* oily water from oil/water separators

Notes on recycling, utilization and disposal:

Incineration.

13 05 07*: As a rule chemical-physical treatment (CPT) using flocculation and filtration processes (see par. 2.5) to separate out the water phase which can then be fed into the sewerage system.

Without dangerous substances, disposing together with municipal waste.

2.5 Other wastewater treatment plants for industrial wastewater

2.5.1 Process

Under this heading we include chemical and physical processes which are used in different industrial fields including precipitation, flocculation and filtration (with and without filter agents) (see **fig. 5**).

In the case of precipitation and flocculation, sludge separation can be carried out by sedimentation or flotation, depending on the specific sludge density. Further process steps to thicken the sludges are used. These include chamber filter presses, centrifuges as well as vaporisers.

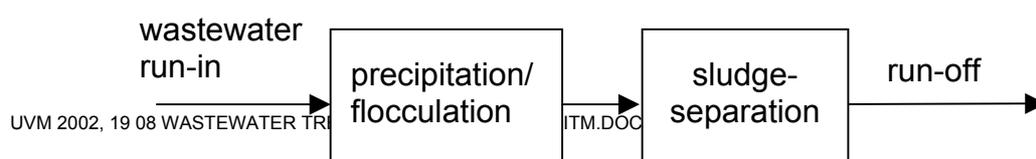


Fig. 5: Scheme of a chemical-physical treatment (CPT)

2.5.2 Wastes

Wastes from other wastewater treatment plants for industrial wastewater [H]

Depending on the origin of the treated wastewater, sludges from other wastewater treatment plants for industrial wastewater vary in terms of their chemical composition, consistency and water content. Depending on the source of the treated wastewater, the sludges considered here may also contain dangerous substances such as heavy metals which would require them to be classified as hazardous waste.

Classification of waste in accordance with EWL:

- 19 08 13* sludges containing dangerous substances from other treatment of industrial waste water
- 19 08 14 sludges from other treatment of industrial waste water other than those mentioned in 19 08 13

When the origin is from industrial waste water treatment plants specified elsewhere in the EWL:

- 10 01 20* sludges from on-site effluent treatment containing dangerous substances
- 10 01 21 sludges from on-site effluent treatment other than those mentioned in 10 01 20
- 11 01 09* sludges and filter cakes containing dangerous substances
- 11 01 10 sludges and filter cakes other than those mentioned in 11 01 09

Notes on recycling, utilization and disposal:

There are at present no viable treatment processes known.

Normally landfilling; without dangerous substances together with municipal waste.

3 Overview of waste classification – material flow

Extract from EWL		Material flow	Treatment
19 08	Wastes from waste water treatment plants not otherwise specified		
19 08 01	screenings	A	with municipal waste
19 08 02	waste from desanding	B	with municipal waste
19 08 05	sludges from treatment of urban waste water	C	1) fertilizer, 2) incineration, 3) with municipal waste
19 08 06*	saturated or spent ion exchange resins	D	incineration
19 08 07*	solutions and sludges from regeneration of ion exchangers	E	CPT
19 08 08*	membrane system waste containing heavy metals	F	CPT
19 08 09	grease and oil mixture from oil/water separation containing only edible oil and fats	G	1) incineration, 2) with municipal waste
19 08 10*	grease and oil mixture from oil/water separation other than those mentioned in 19 08 09	G	Incineration
19 08 11*	sludges containing dangerous substances from biological treatment of industrial waste water	C	incineration, HWL
19 08 12	sludges from biological treatment of industrial waste water other than those mentioned in 19 08 11	C	1) incineration, 2) with municipal waste
19 08 13*	sludges containing dangerous substances from other treatment of industrial waste water	H	HWL
19 08 14	sludges from other treatment of industrial waste water other than those mentioned in 19 08 13	H	with municipal waste
19 08 99	waste not otherwise specified	not normally required	
Wastes from waste water treatment plants, to be classified under other waste categories			
05 01 09*	sludges from on-site effluent treatment containing dangerous substances	G	incineration

05 01 10	sludges from on-site effluent treatment other than those mentioned in 05 01 09	G	1) Incineration, 2) with municipal waste
10 01 20*	sludges from on-site effluent treatment containing dangerous substances	H	HWL
10 01 21	sludges from on-site effluent treatment other than those mentioned in 10 01 20	H	With municipal waste
11 01 09*	sludges and filter cakes containing dangerous substances	H	HWL
11 01 10	sludges and filter cakes other than those mentioned in 11 01 09 fallen	H	With municipal waste
11 01 13*	degreasing wastes containing dangerous substances	G	Incineration
11 01 14	degreasing wastes other than those mentioned in 11 01 13	G	1) Incineration, 2) with municipal waste
11 01 15*	eluate and sludges from membrane systems or ion exchange systems containing dangerous substances	E, F	CPT
11 01 16*	saturated or spent ion exchange resins	D	Incineration
13 05 06*	oil from oil/water separators	G	Incineration
13 05 07*	oily water from oil/water separators	G	CPT
19 09 05	saturated or spent ion exchange resins	D	1) Incineration, 2) with municipal waste
19 09 06	solutions and sludges from regeneration of ion exchangers	E	CPT

19 09 Wastes from the preparation of water intended for human consumption or water for industrial use

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Foreword

The difference between drinking water and water for industrial or domestic use lies in the respective quality requirements.

Drinking water is for human consumption, whether in its original state or following treatment, and is intended for drinking, cooking, food preparation or other domestic activities, thus placing high demands on quality, for example on smell, taste, clouding and absence of germs.

Water for industrial use is mainly used commercially as cooling water, for watering agricultural and forestry land as well as cleaning water. With a few exceptions, water for domestic use is permitted for use in watering gardens, flushing toilets, filling ponds and as cleaning water outside the house.

The main advantage of using water for domestic or industrial use is the preservation of valuable, high quality drinking water reserves and simpler processing.

Because of the different requirements for quality, the respective methods of treating drinking water and water for industrial and domestic use will be described separately. The treatment of industrial and domestic water will be presented together in paragraph 2 because of their similarities.

1. Treatment of drinking water

Drinking water can be obtained from different sources, for example in Germany up to 71% comes from ground and spring water, 12% from enriched ground water, 7% from reservoirs, 6% from riverside filtrate and up to 4% from lakes and rivers.

High demands are made of drinking water as it is for immediate consumption. To avoid any danger to health, water providers must guarantee certain limits regarding salt content, organic substances and germs as well as taste and visual qualities as far as the connection to the house. The limits for the observed chemical parameters

are stated in the annex I, Part B, Council Directive 98/83/EC of 3. November 1998 on the quality of water intended for human consumption (see **table 1**).

Substance	Limit [mg/L]
Arsenic	0,01
Lead	0,01
Cadmium	0,005
Chrome	0,05
Cyanide	0,05
Fluoride	1,5
Nickel	0,02
Nitrate	50
Nitrite	0,5
Mercury	0,001
Polycyclic aromatic hydrocarbons	total 0,0001
Pesticide	total 0,0005
Antimony	0,005
Selenium	0,01

Table. 1: Extract from drinking water limits
(Annex I, Part B, Directive 98/83/EC on the quality of water intended for human consumption)

A large number of processes and combinations of processes are used in treating drinking water with the three objectives being:

- the removal of solid and dissolved impurities,
- stabilisation of the water so that it does not alter during its distribution or consumption and causes no corrosion to water pipes and
- removing unwanted germs from the water to make it hygienic.

1.1 Process

Depending on the properties of the raw water and the type of constituents present, the following processes are used in drinking water treatment (see **fig. 1**).

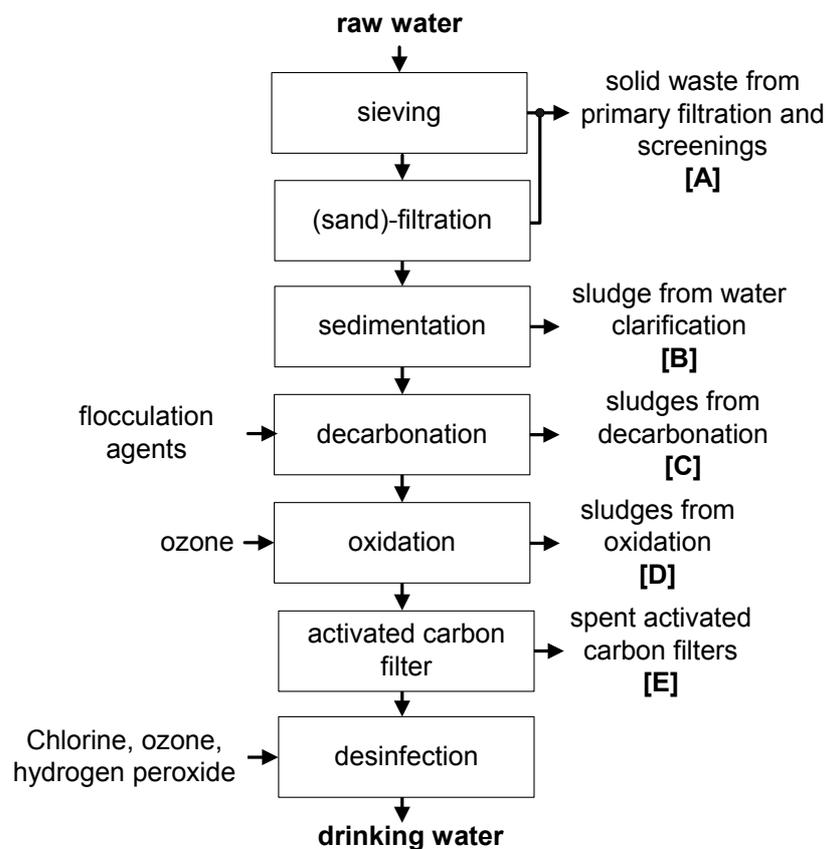


Fig. 1: Diagrammatic representation of the processes used in the treatment of drinking water

Sieving or (sand) filtration

In the first cleaning stage, solids are held back in sieves (drum sieves) and/or other filters (usually sand filters). The held-back solids are composed of mineral and plant matter and have to be disposed of as **waste from primary filtration and screenings [A]**.

Sedimentation

Water passes slowly through a settling tank where solids settle and create **sludges from water clarification [B]**. They are composed, to a greater extent, of mineral substances.

Decarbonation

In some cases water is softened or decarbonised in a drinking water treatment plant. As a rule, this process is carried out in a sedimentation tank. A precipitating agent is continually added to the water to bind hardeners such as calcium. The **sludges from decarbonation [C]** (CaCO_3) are then filtered and the water is removed.

Oxidation

The oxidation of dangerous substances in water is one of the most important stages in drinking water treatment. Ozone, hydrogen peroxide or potassium permanganate

are used, or oxygen is added using an aerating system. These substances react with organic or inorganic substances in the water which then settle as **sludges from oxidation [D]**.

Activated carbon adsorption

Activated carbon is pure carbon which possesses good adsorption properties due to its porous structure and large internal surface. Activated carbon adsorbs, in particular, organic impurities which would otherwise cause taste or smell problems or a clouding of the water. In addition, activated carbon filters germs and residual solid particles from the water. From time to time, the saturated **activated carbon [E]** has to be exchanged.

Desinfection

Desinfection is carried out using ozonisation or chlorination, whereby pathogens, such as bacteria, virus, spores, are killed, sometimes with the additional use of UV light (256nm) radiation.

1.2 Waste

Solid waste from primary filtration and screenings [A]

Solid waste from primary filtration and screenings mostly consists of mineral solids resembling soil and plant matter which as a rule do not contain dangerous substances.

Classification of waste in accordance with EWL:

19 09 01 solid waste from primary filtration and screenings

Notes on recycling, utilization and disposal:

As a rule, spread on agricultural or horticultural land.

Otherwise, disposal to landfill, as a rule together with municipal waste.

Sludges from water clarification [B]

Sludges from the settling tanks consist of finely-grained mineral particles and as a rule, do not contain dangerous substances.

Classification of waste in accordance with EWL:

19 09 02 sludges from water clarification

Notes on recycling, utilization and disposal:

As a rule, spread on agricultural or horticultural land.

Otherwise, disposal to landfill, as a rule together with municipal waste.

Sludges from decarbonation [C]

Sludges from decarbonation consist of CaCO_3 and do not contain dangerous substances.

Classification of waste in accordance with EWL:

19 09 03 sludges from decarbonation

Notes on recycling, utilization and disposal:

Used as an input material for rendering for the building industry and as an input material for acetylene manufacture in the chemical industry.

Otherwise, disposal to landfill, as a rule together with municipal waste.

Spent activated carbon [D]

During its working life, spent activated carbon adsorbs organic substances, germs and particles which as a rule are not dangerous substances.

Classification of waste in accordance with EWL:

19 09 04 spent activated carbon

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

As a rule, incineration in waste incinerators.

Otherwise, disposal to landfill, as a rule together with municipal waste.

Sludges from oxidation [E]

Sludges from oxidation consist of inorganic iron, manganese or ammonia oxides. As a rule, these sludges do not contain dangerous substances.

Classification of waste in accordance with EWL:

19 09 02 sludges from water clarification

Notes on recycling, utilization and disposal:

As a rule, spread on agricultural or horticultural land.

Otherwise, disposal to landfill, in some cases together with municipal waste.

2. Treatment of water for industrial use

Compared to drinking water, water for industrial purposes has different requirements because it is used for technical processes, e.g. cooling water or for cleaning. Approximately 70% of water for industrial processes is used as cooling water. As a rule, important specifications have to be observed in the treatment of water for industrial use (see **fig. 2**), in particular reduced water hardness or complete salt removal (deionized water).

2.1 Process

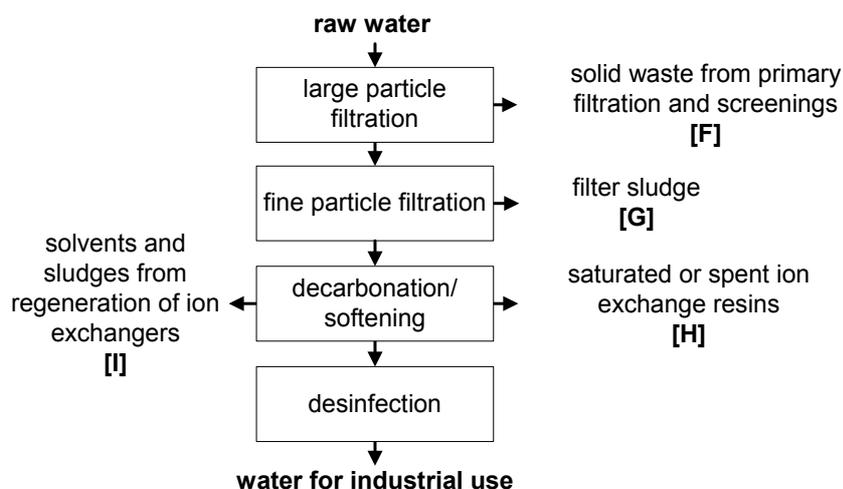


Fig. 2: Diagrammatic representation of the processes used in treating water for industrial use

Large particle filtration

In large particle filtration, solids are held back by sieves or other filters. These solids consist of mineral or plant matter and have to be disposed of as **solid waste from primary filtration and screenings [F]**.

Small particle filtration

Various filter agents, e.g. diatomite, cellulose or other fine-pore materials, are used in small particle filtration. Diatomites are fossilised single-celled “Diatoms” of silicon dioxide. The most important property of diatom is their porosity. The filter material builds a finely porous layer which can hold back solid particles $> 0,1 \mu\text{m}$. The solid particles consist of mineral or plant matter. If diatomite is too heavily laden, together with their load they create **filter sludge [G]**.

Softening

Softening means decalcification of water, in which the substances which cause water hardening are removed as calcium and magnesium ions. Two processes are used to achieve this: the addition of precipitating agents (as described in paragraph 1.1 decarbonation) or the use of ion exchangers. Ion exchangers are preferred in water treatment plants for industrial water because of the fact that they require less room and are easier to use.

Ion exchangers exchange freed ions, e.g. calcium or magnesium ions, by adsorption on the resin structure (see **fig. 3**) and replace them with sodium ions.

Once they have reached complete saturation, the resins used in the ion exchanger become ineffective and have to be regenerated. Here, the absorbed ions are removed from the resins using regeneration chemicals creating **solutions and sludges from the regeneration of ion exchangers [I]**.

After a number of regeneration cycles, **ion exchange resins [H]** are spent and have to be replaced.

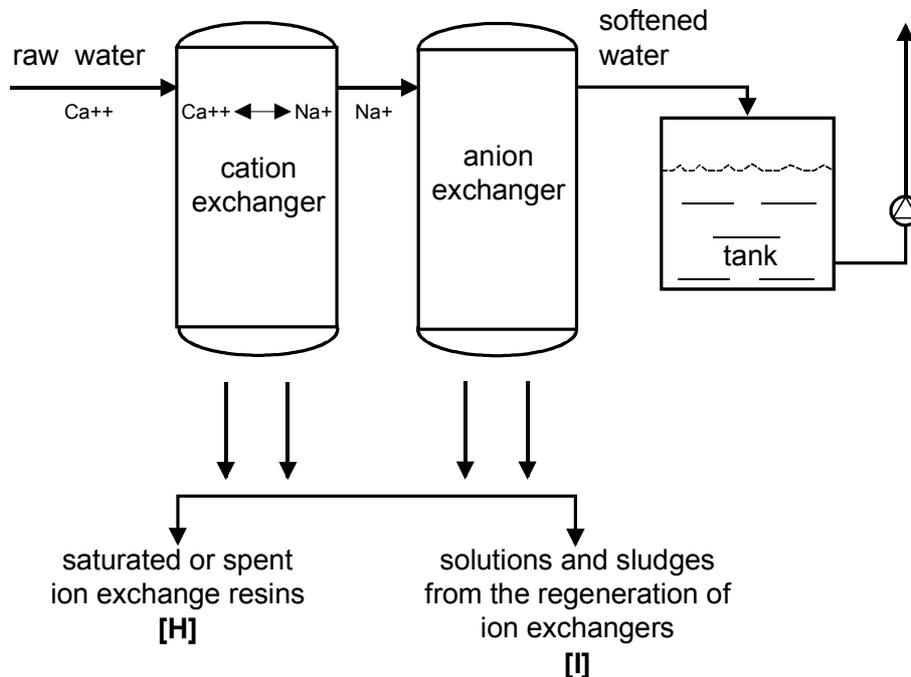


Fig. 3: Diagrammatic representation of water decalcification using ion exchangers

2.2 Waste

Solid waste from primary filtration and screenings [F]

Solid waste from primary filtration and screenings mostly consists of mineral solids resembling soil and plant matter which as a rule do not contain dangerous substances.

Classification of waste in accordance with EWL:

19 09 01 solid waste from primary filtration and screenings

Notes on recycling, utilization and disposal:

As a rule, spread on agricultural or horticultural land.

Otherwise, disposal to landfill, as a rule together with municipal waste.

Filter sludges [G]

Filter sludges consist of solids and diatomite (only dangerous when present as a powder), which, as a rule, do not contain dangerous substances.

Classification of waste in accordance with EWL:

19 09 02 sludges from water clarification

Notes on recycling, utilization and disposal:

As a rule, spread on agricultural or horticultural land.
Otherwise, disposal to landfill, as a rule together with municipal waste.

Saturated or spent ion exchange resins [H]

After a certain time, ion exchange resins become ineffective and have to be completely disposed of.

Classification of waste in accordance with EWL:

19 09 05 saturated or spent ion exchange resins

Notes on recycling, utilization and disposal:

Regeneration.

Otherwise, disposal to landfill, in some cases together with municipal waste.

Solutions and sludges from the regeneration of ion exchangers [I]

During regeneration of ion exchange resins, regenerant which contains the freed water components in concentrated form, is produced. The separated ions in the regenerant, which is present as a solution or as a sludge following precipitation, are 500 times more concentrated than in the original input.

Classification of waste in accordance with EWL:

19 09 06 solutions and sludges from regeneration of ion exchangers

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

As a rule, chemical physical treatment using precipitation/flocculation and filtration processes to neutralise and precipitate the separated metals as well as separate the water phase so it can be fed into the sewerage system.

3. Overview of waste classification – material flow

	Extract from EWL	Material Flow	Treatment
1909	wastes from the preparation of water intended for human consumption or water for industrial use		
19 09 01	solid waste from primary filtration and screenings	A, F	1) recycling, 2) with municipal waste
19 09 02	sludges from water clarification	B, D, G	1) recycling, 2) with municipal waste
19 09 03	sludges from decarbonation	C	1) recycling, 2) with municipal waste
19 09 04	spent activated carbon	E	with municipal waste
19 09 05	saturated or spent ion exchange resins	H	1) regenerating, 2) with municipal waste
19 09 06	solutions and sludges from regeneration of ion exchangers	I	CPT
19 09 99	wastes not otherwise specified	not normally required	

19 10 Wastes from shredding of metal-containing wastes

1	Process	1
2	Waste	2
2.1	<i>Ferrous metal fraction [A]</i>	2
2.2	<i>Non-ferrous metal fraction [B]</i>	3
2.3	<i>Shredder fluff-light fraction [C]</i>	3
2.4	<i>Dusts from shredder plants [D]</i>	3
2.5	<i>Miscellaneous shredder fraction [E]</i>	4
2.6	<i>Wastes from dry storage of car wrecks [F], [G]</i>	4
3	Overview of waste classification – material flow	6

1 Process

End-of-life vehicles ELV's (car wrecks), electrical equipment (e.g. white goods) as well as metal components from dismantled industrial plant cannot be used directly as scrap by the steel industry. In order to obtain a more manageable ferrous fraction and also to separate out non-ferrous metals and other fractions, the scrap is initially treated in a shredder plant (see **fig. 1**).

In terms of input, there are two main groups of fraction to be distinguished between:

- End-of-life vehicles (ELV's)
- Collected scrap (household electrical equipment such as washing machines, cookers, refrigerators, etc., industrial steel and sheet metal from old plant, material from scrap collections, etc.)

While collected scrap is normally taken straight to the shredder plant, old cars are normally, first of all, dry-stored, i.e. environmentally significant industrial fluids (e.g. fuel, oil, brake and cooling fluids and coolants) are drained. At the same time, some valuable components (eg. engine and tyres) are dismantled.

After shredding, normally carried out in a hammer mill, into particles of < 100mm a fluff-light fraction (SLF) (plastic, foam, cardboard, rubber, glass, etc) is separated from the material mixture using air classification. This portion comprises about 20% weight of end-of-life vehicles.

The remaining heavy fraction, with approx. 70% ferrous metal fraction, is separated using magnet separators. After magnetic separation, the non-ferrous metal fraction (approx. 6-7%) is separated in additional sorting equipment, e.g. eddy current separator, or sometimes by hand separation (e.g. to extract electrical motors, pieces of cable) from the resulting material flow. The remainder (broken glass, heavy composite material, ceramic, etc.) comprising approx. 2%, is of little significance.

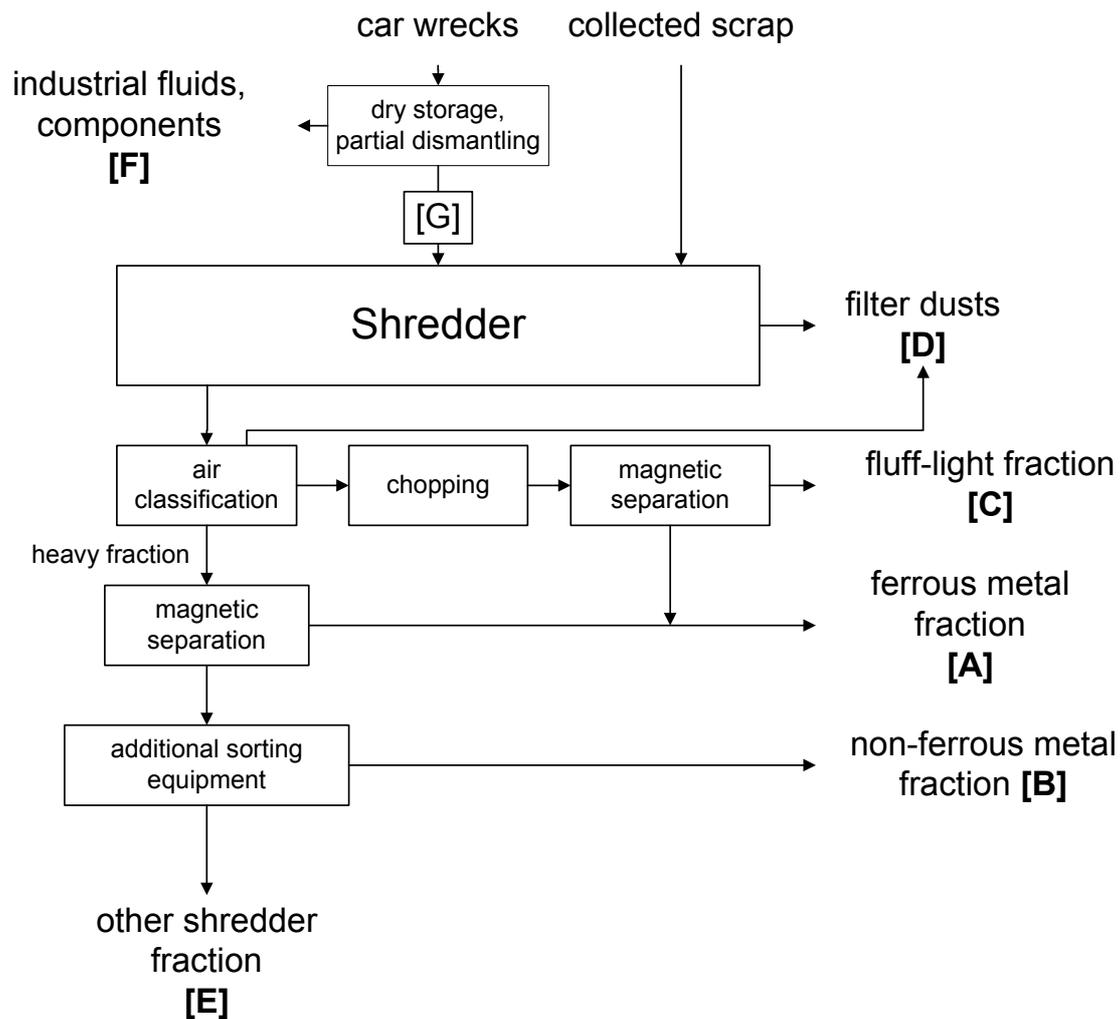


Fig 1: Flow-diagram of the process in a shredder plant

2 Waste

The resulting waste material flow from the individual process steps in a shredder plant, as seen in **fig. 1**, is specified in more detail below. The quantity and composition depends principally on the type of scrap being processed (input). Individual shredder plants have specialised in processing specific types of waste (e.g. only end-of-life vehicles), and by doing so succeed in obtaining purer separated fractions.

2.1 Ferrous metal fraction [A]

All magnetic metals, irrespective of their metallurgical composition, are separated in magnetic separators that are installed following the shredding and air classification processes. The degree of foreign substances is very low, so that the ferrous metal fraction can be recycled directly in steel mills.

Classification of waste in accordance with EWL:

19 10 01 iron and steel waste

Notes on recycling, utilization and disposal:

Recycling in secondary metallurgy, mostly steel mills.

2.2 Non-ferrous metal fraction [B]

The non-ferrous metals remaining in the heavy fraction following magnetic separation (Al, Cu, Mg, brass) are separated, as far as possible, using various separating processes. Although 6 – 7% is not a large quantity, this separation step is of high value. In order to achieve better market potential, different metal fractions are separated and utilized in various plants for non-ferrous secondary metallurgy.

Classification of waste in accordance with EWL:

19 10 02 non-ferrous metal-waste

Notes on recycling, utilization and disposal:

Recycling in secondary non ferrous metallurgy.

2.3 Shredder fluff-light fraction [C]

The so-called fluff-light fraction is separated out in the first process step after shredding usually using the air classification process. In ELV's processing, after ferrous metal, this represents the most valuable part in terms of quantity with just under 20%. The largest components are plastics, foam, and covers from the interior as well as spoilers and other accessories. Other parts worth noting include, for example, rust particles, flaking paint, glass, pieces of cable, thin non-ferrous parts and, in some cases, wood. It is not possible to separate this complete mixture economically using known processes. Traditional disposal is in landfills. Because of the large surface area and absorbency, hazardous substances (PCB, oil) may be present, especially from operation liquids which has leaked out. Heat energy lies by approx. 20 MJ/kg, so energy processing is being investigated.

Classification of waste in accordance with EWL:

19 10 03* fluff-light fraction and dust containing dangerous substances

19 10 04 fluff-light fraction and dust other than those mentioned in 19 10 03

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

Disposal to landfill or incineration. If it does not contain dangerous substances, together with municipal waste.

2.4 Dusts from shredder plants [D]

Dusts which arise in shredder processing as well as from air classification are separated in the filters of extraction plants. The composition resembles that of the fluff-light fraction (rust, paint and glass particles, brake pad particles, dirt, fabric particles, etc.). The hazardous substance content tends to be higher. Therefore an addition to the shredder fluff-light fraction is not to be recommended. Disposal is normally in landfills.

Classification of waste in accordance with EWL:

- 19 10 03* fluff-light fraction and dust containing dangerous substances (rule)
- 19 10 04 fluff-light fraction and dust other than those mentioned in 19 10 03 (exception)

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

Disposal to landfill or incineration, if it does not contain dangerous substances, together with municipal waste.

2.5 Miscellaneous shredder fraction [E]

Following the various separation processes, the remaining fraction from the heavy fraction that cannot be economically treated remains. This contains, for example, glass fragments, dirt (e.g. oily sand) and heavy metals (fine Cu and Pb parts from cables and electrical components), and, therefore, the most significant parts containing hazardous substances. Disposal is normally in landfills.

Classification of waste in accordance with EWL:

- 19 10 05* other fractions containing dangerous substances (rule)
- 19 10 06 other fractions other than those mentioned in 19 10 05 (exception)

For separately collected glass

- 16 01 20 glass

Notes on recycling, utilization and disposal:

- 19 10 05*/
19 10 06: At present there are no known viable treatment processes.
Disposal to landfill. If it does not contain dangerous substances, together with municipal waste.
- 16 01 20: Pure fraction, recycling for the manufacture of glass.
Otherwise disposal to landfill, normally together with municipal waste.

2.6 Wastes from dry storage of car wrecks [F], [G]

In order to reduce the hazardous substance content but also on safety grounds (small explosions), end-of-life vehicles are dry-stored. This means that operation liquids and fuel are drained and, for example, starter batteries are dismantled. As a rule, the fuel is collected and disposed of separately.

If this has already happened before transportation to the shredder plant the shredder input can be classified as “16 01 06 end-of-life vehicles, containing neither liquids nor other hazardous components” or in the case of other non hazardous shredder input or after dismantling hazardous material as “16 02 14 discarded equipment other than those mentioned in 16 02 09 to 16 02 13”.

Appropriate EWL categories are only to be found in other sub-categories, especially 13 07 and 16 01.

Classification of waste in accordance with EWL:

- 13 02 05* mineral-based non-chlorinated engine, gear and lubricating oils
- 13 07 01* fuel oil and diesel
- 13 07 02* petrol
- 16 01 13* brake fluids
- 16 01 14* antifreeze fluids containing dangerous substances
- 16 01 15 antifreeze fluids other than those mentioned in 16 01 14
- 16 06 01* lead batteries

Notes on recycling, utilization and disposal:

- 13 02 05*: reprocessing as base oil according to waste oil directive. Otherwise incineration.
- 13 07 01*: Incineration, normally as heating oil.
- 13 07 02*: Reprocessing as fuel in oil refineries.
- 16 01 13*: Reprocessing in recycling facilities. Otherwise incineration, normally in HWI.
- 16 01 14*: Reprocessing for the manufacture of glycol. Otherwise thermal treatment, normally in HWI.
- 16 01 15: Reprocessing for the manufacture of glycol. Otherwise thermal treatment, possibly together with municipal waste.
- 16 06 01*: Separation of acid and reprocessing of lead.

Overview of waste classification – material flow

Extract from EWL		Material flow	Treatment
19 10	wastes from shredding of metal-containing wastes		
19 10 01	iron and steel waste	A	Recycling
19 10 02	non-ferrous [metal]-waste	B	Recycling
19 10 03*	fluff-light fraction and dust containing dangerous substances	C, D	HWL, HWI
19 10 04	fluff-light fraction and dust other than those mentioned in 19 10 03	C, D	With municipal waste
19 10 05*	other fractions containing dangerous substances	E	HWL
19 10 06	other fractions other than those mentioned in 19 10 05	E	With municipal waste

	wastes from shredding of metal-containing wastes to be classified under other waste categories		
13 02 05*	mineral-based non-chlorinated engine, gear and lubricating oils	F	1) recycling, 2) incineration
13 07 01*	fuel oil and diesel	F	1) recycling, 2) incineration
13 07 02*	petrol	F	1) recycling, 2) incineration
16 01 13*	brake fluids	F	1) recycling, 2) HWI
16 01 14*	antifreeze fluids containing dangerous substances	F	1) recycling, 2) HWI
16 01 15	antifreeze fluids other than those mentioned in 16 01 14	F	1) recycling, 2) with municipal waste
16 01 20	glass	E	1) recycling, 2) with municipal waste
16 06 01*	lead batteries	F	Recycling

in the case of off-site pretreatment: wastes from pretraetment before shredding (shredder input)			
16 01 06	end-of-life vehicles, containing neither liquids nor other hazardous components	G	1) dismantling, 2) shredding
16 02 14	discarded equipment other than those mentioned in 16 02 09 to 16 02 13	G	1) dismantling, 2) shredding

19 11 wastes from oil regeneration

1	FOREWORD	1
2	PROCESS	1
2.1	General.....	1
2.2	Sulphuric acid/clay treatment contact process	2
2	WASTES	3
3	OVERVIEW OF WASTE CLASSIFICATION - MATERIAL FLOW	5

1 Foreword

The directive 75/439/EWG (waste oil disposal) gives priority to the reprocessing of waste oil to base oil as long as there are no technical, economic or organizational practical constraints preventing it.

Waste oil arises primarily during car and machine maintenance and also as spent lubricating coolants and hydraulic oil. These waste oils are recovered by substance in various processes or used as a fuel. In this paper, the reprocessing processes – these are processes to manufacture base oil – will be described.

2 Process

2.1 General

Waste oil is principally regenerated by distillation. The regenerated product is base oil which can be used in the manufacture of oil and lubricants as well as flux oil which is used as a heavy heating oil. As a rule, three different base oil fractions are produced – gas oil, neutral oil and ground oil. These fractions differ considerably in terms of their differing boiling points and viscosity.

After the initial removal of water and volatile components (petrol, solvents, etc.) by distillation, residue additives and their components, unstable mineral compounds changed by oxidation and mechanical shearing as well as metal dust, soot and other solid foreign matter are removed.

Base oil and flux oil are produced from waste oil during several stages of thermal processing. Worldwide, about 10 different processes are used. The most significant are:

- Sulphuric acid/clay treating process,
- Thin-film evaporation,
- Film evaporation in cyclone,
- Treatment with hydrogen (hydrogenation) and
- ENTRA-tubular reactor process

The processes differ, sometimes considerably, in terms of the yield and the specific amount of waste. The processes are fairly similar in terms of the waste produced. Because of this, only the most widely used sulphuric acid/clay treatment contact process (fig 1) will be dealt with in detail here.

2.2 Sulphuric acid/clay treatment contact process

Waste oil for reprocessing is usually delivered by tanker and temporarily stored in storage tanks. In rare cases, waste oil may be delivered in barrels or small containers.

Reprocessing begins with filtering out dirt particles from the waste oil. Then it is dried in a dehydration column at a temperature of 160°C under normal pressure whereby volatile components and water are removed. The oil from which water has been removed (dry oil) is then taken to a thermal cracking plant where it is passed over a directly heated tube furnace at a temperature of 320 °C in a vacuum at a residual pressure of 200 mbar. This pre-treatment thermally changes most of the additives so that the consumption of sulphuric acid and clay in the subsequent processes can be considerably reduced. In simultaneously operated cracking processes, about 30% of the dry oil passes out as gas oil/spindle oils distillate. Decomposed products containing sulphur and nitrogen from the additives arise in the distillate and residue. The „overhead product“ and part of the bottom product are thoroughly mixed in a reactor with around 10% concentrated sulphuric acid (around 96%). The rest of the bottom product is taken off as flux oil. The sulphuric acid reacts with the additive residue, additive components, unstable components, metal dust and aromatic compounds to form a dark syrupy mass (acid tars or acid resins). Acid resin contains, in addition to about 50% oil, resin and asphalt, up to about 30% free sulphuric acid and is insoluble in mineral oil. Because of its higher density it can be tapped off after being allowed to settle.

Once the acid resin has been separated, the acid oil is mixed with activated clay (aluminum hydro silicate). This mixture is passed over a warmer in an evaporator in which approx. 40% of the input products evaporate at a temperature of 280 °C in a vacuum under 200 mbar pressure. With this heat contact, the clay performs more functions: It neutralizes the acidic components in the oil fraction, binds polar, colloidal and coloring substances (e.g. resins, bitumen, soot, oxidation products, etc.) and thereby bleaches the raffinate.

The vapor phase is condensed in a fractionating column. The resulting fractions are neutral oil and gas oil. Heavy ground oil is obtained from the vaporizer bottom phase following pressure filtration to separate out the spent clay and then filtration in paper filter presses. Neutral oil together with heavier ground oil is used in the production of base oil for lubricants to the respective ISO viscosity classification. Gas oil can be used for heating.

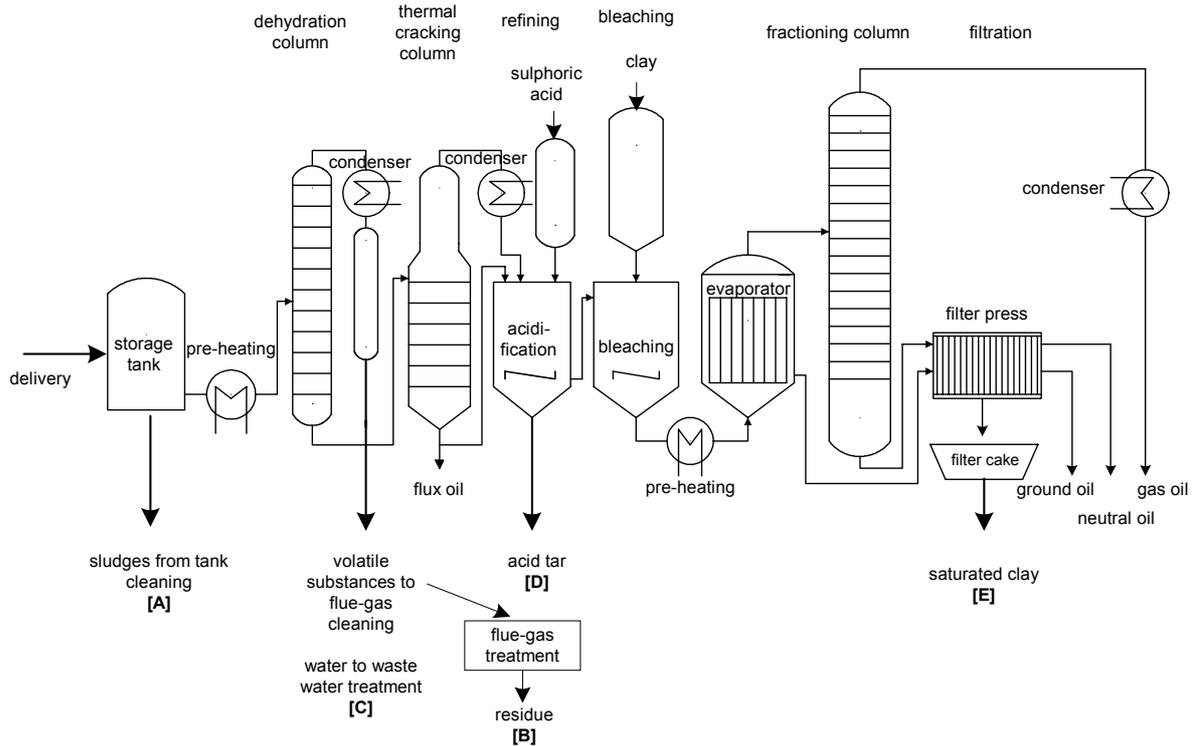


Fig. 1: Reprocessing of waste oil using the acid/clay contact process

2 Wastes

Sludges from tank cleaning [A]

There are particles (dirt and metal dust) present in waste oil which settle on the bottom of the oil tanks. Bottom sludges arise during regular periodic cleaning of the tanks.

Classification of waste in accordance with EWL:

05 01 03* tank bottom sludges

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes .

Incineration, as a rule in HWI.

Incineration of volatile substances, waste from flue-gas treatment [B]

During drying, gaseous emissions, mainly volatile hydrocarbons, are created. These must be thermally/catalytically treated in accordance with 17. BImSchV or EU directive 2000/76/EG. A wide variety of waste is produced in flue-gas treatment depending on the process (filter dusts, spent catalysts, activated charcoal, filter cake, etc.).

Classification of waste in accordance with EWL:

19 11 07* wastes from flue-gas cleaning

Notes on recycling, utilization and disposal:

Spent activated charcoal can be regenerated and re-used. For other wastes from flue-gas treatment (e.g. filter dusts), there are no known viable treatment processes at present.

Disposal to landfill (HWL, UGL), incineration of spent activated charcoal, as a rule, HWI.

Contaminated water [C]

The dehydration of waste oil results in contaminated water which undergoes chemical physical or, in some cases, biological wastewater treatment.

Classification of waste in accordance with EWL:

- 19 11 03* aqueous liquid wastes
- 19 11 05* sludges from on-site effluent treatment containing dangerous substances
- 19 11 06 sludges from on-site effluent treatment other than those mentioned in 19 11 05

Notes on recycling, utilization and disposal:

- 19 11 03* Chemical physical treatment (CPT) using precipitation, flocculation and filtration processes and separation of water phase for feeding into the sewerage system.

For sludges, there are no known viable treatment processes at present.

If there is a high organic content, incineration (HWI), otherwise, disposal to landfill, as a rule HWL; if it does not contain dangerous substances, together with municipal waste.

Acid tar [D]

Acid tars contain resins, bitumen, additive components and about 30% sulphuric acid. In addition to oils with a high boiling point.

Classification of waste in accordance with EWL:

- 19 11 02* acid tars

Notes on recycling, utilization and disposal:

Reprocessing in sulphuric acid manufacture, used as a reducing agent in ore works and in the steel industry.

Otherwise, incineration, as a rule HWI.

Spent clay [E]

The clay (Aluminium silicate) is laden with resins, bitumen, soot and oxidation products.

Classification of waste in accordance with EWL:

19 11 01* spent filter clays

Notes on recycling, utilization and disposal:

Utilization in the cement industry.

Otherwise, incineration, as a rule, HWI.

3 Overview of waste classification - material flow

EWL	Extract from EWL	Material flow	Treatment
19 11	wastes from oil regeneration		
19 11 01*	spent filter clays	E	1) material use, 2) incineration
19 11 02*	acid tars	D	1) material use, 2) incineration
19 11 03*	aqueous liquid wastes	C	CPT
19 11 04*	wastes from cleaning of fuel with bases	-	In Germany there are no known processes where bases are used.
19 11 05*	sludges from on-site effluent treatment containing dangerous substances	C	1) HWI, 2) HWL
19 11 06	sludges from on-site effluent treatment other than those mentioned in 19 11 05	C	1) incineration 2) with municipal waste
19 11 07*	wastes from flue-gas cleaning	B	1) regeneration, 2) HWL, HWI
19 11 99	wastes not otherwise specified	not normally required	

	wastes from oil regeneration to be classified under other waste categories		
05 01 03*	tank bottom sludges	A	1) incineration, 2) HWI

19 12 Wastes from the mechanical treatment of waste (for example sorting, crushing, compacting, pelletising) not otherwise specified

1	Processes	1
1.1	<i>Crushing process.....</i>	<i>2</i>
1.2	<i>Sorting process.....</i>	<i>2</i>
1.3	<i>Screening processes.....</i>	<i>2</i>
1.4	<i>Metal separation.....</i>	<i>2</i>
1.5	<i>Heavy and light fraction separation using air separation</i>	<i>3</i>
1.6	<i>Heavy/light fraction separation using swim-float plants.....</i>	<i>3</i>
1.7	<i>Compacting and pelletising</i>	<i>3</i>
2	Waste	3
2.1	<i>Waste from dust removal [A].....</i>	<i>3</i>
2.2	<i>Target materials [Z] and problematic materials [B].....</i>	<i>4</i>
3	Overview of waste classification – material flow.....	6

Foreword

In the European Waste List, which is branch-oriented, sub-chapter 19 12 has a special place because it deals with an industrial branch which uses waste instead of raw materials. Instead of products, secondary raw materials or waste for the recycling market are produced. Correspondingly, waste code 19 12 XX can refer to target products (secondary raw materials or waste for recovery) or equally to unwanted problematic materials (waste for disposal).

1 Processes

It can be assumed that the process steps described below apply to heterogeneous waste. The processes can be modified and combined depending on the situation and the requirements of the recycling industry. A typical process configuration is shown in Fig. 1.

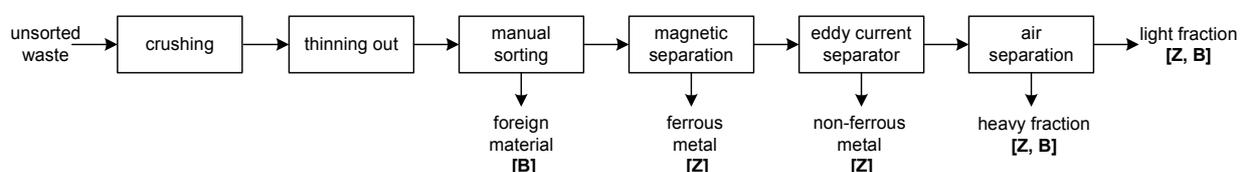


Fig. 1: Theoretical process configuration

1.1 Crushing process

Bulky waste and waste of different materials are crushed before sorting to make them easier to handle and to release the individual components. Crushing plants include crushers, e.g. for stone, rolling mills to produce a specific spectrum of grain size or impact crushing machines, e.g. hammer mills. The only waste produced in the crushing process is dust which is separated in textile filters (material flow [A]).

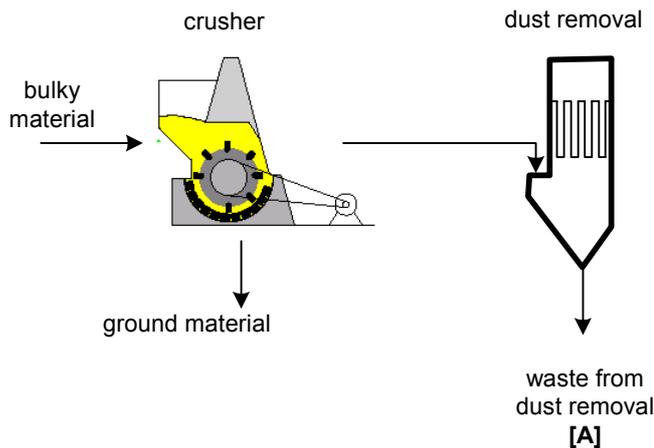


Fig. 2: Crushing process with a crusher as example.

1.2 Sorting process

Unsorted waste, e.g. mixed plastic waste or waste paper, is placed on conveyor belts and, for example, by the belt branching it is thinned out and manually separated. In addition to this manual sorting, sensor controlled sorting is increasingly used. For example, it is used to separate mixed plastic components (often packaging material) into individual types of plastic or to sort differently coloured plastics or glass fragments according to colour. This facilitates the extraction of valuable material and reduces the number of unhealthy working places.

1.3 Screening processes

Screening processes involve the separation of material according to grain size. The most important processes are sieving processes whereby grains of between 200 mm (grilles) to 0.5 mm (thin layer sieving) can be separated. During sieving, target materials [Z] and problematic materials [B] are separated.

1.4 Metal separation

The separation of magnetic ferrous metals as target material [Z] is carried out with magnets of various forms. The most common is the overhead magnet. For non-magnetic metal, the eddy current process is now used. By creating a magnetic field, non-ferrous metals can be temporarily magnetised and therefore separated as target materials [Z].

1.5 Heavy and light fraction separation using air separation

The waste mix is brought into an airstream whereby light materials are carried in the airstream to be later separated again in a cyclone or settling area, while heavy components fall to the bottom from where they can be removed.

1.6 Heavy/light fraction separation using swim-float plants

Swim-float plants exploit the difference in density to separate different materials. To accomplish this, the material mix is placed in a liquid (water - ferro-silicon) whose density is so adjusted that material with certain characteristics is separated by swimming or sinking. Plants may have several stages, whereby the liquid is adjusted to have different densities. This technology is used in particular for heavy shredder fraction. Two valuable fractions, light metals (aluminium, magnesium) and heavy metals (copper, zinc, brass) are obtained in this way.

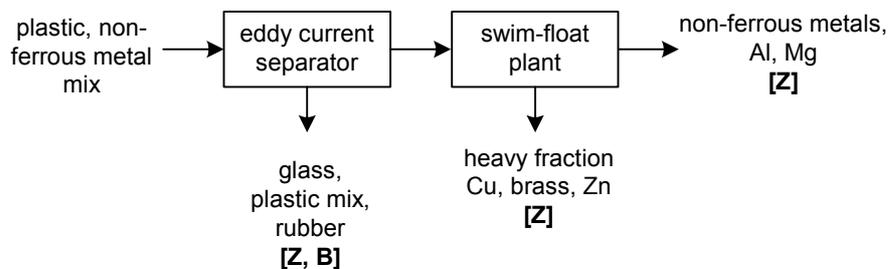


Fig. 2: Principle of a swim-float plant

1.7 Compacting and pelletising

Sorted and prepared waste can be compacted or turned into briquettes or pellets to make handling and transport easier. Compacting means reducing the volume of the output material using mechanical pressure, e.g. squashing drinks cans. With briquetting and pelletising, loose material is given a defined geometric shape under pressure and in some cases with the addition of binders.

2 Waste

2.1 Waste from dust removal [A]

In nearly all the processes described above, dusts are created which are then separated in textile filters. Possible dangerous substances vary according to the composition of the input material.

Classification of waste in accordance with EWL:

19 12 11* other wastes (including mixtures of materials) from mechanical treatment of waste containing dangerous substances

19 12 12 other wastes (including mixtures of materials) from mechanical treatment of waste other than those mentioned in 19 12 11

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

Disposal to HWL, UGL; if it does not contain dangerous substances, together with municipal waste.

2.2 Target materials [Z] and problematic materials [B]

Several processes result in target materials [Z] for which the process is adapted, and problematic materials [B] which are removed from the process and disposed of. Each of these material flows can be classified under different waste categories and some waste categories can also refer to each of these material flows.

Possible dangerous substances vary according to the composition of the input material.

Material flow [Z]

Classification of waste in accordance with EWL:

- 19 12 01 paper and cardboard
- 19 12 02 ferrous metal
- 19 12 03 non-ferrous metal
- 19 12 04 plastic and rubber
- 19 12 05 glass
- 19 12 07 wood other than those mentioned in 19 12 06
- 19 12 08 textiles
- 19 12 09 minerals (with restrictions)
- 19 12 10 combustible waste (refuse derived fuel)

Notes on recycling, utilization and disposal:

- 19 12 01/07/08: Paper, wood and textiles: material use, e.g. cellulose extraction or use as a fuel. Otherwise, incineration, as a rule together with municipal waste.
- 19 12 02/03: Recycling in secondary metallurgical plants.
- 19 12 04: Sheer, sorted plastic fractions can as a rule be used as fuel and to some extent for material use. Otherwise, incineration ; if it does not contain dangerous substances, together with municipal waste.
- 19 12 05: Glass can be recycled or used for material use, in some cases following further separation steps.
- 19 12 09: Depending on the market situation, minerals can be used as recycled building material.

Otherwise, disposal to landfill; if it does not contain dangerous substances, together with municipal waste.

Material flow [B]

Classification of waste in accordance with EWL:

- 19 12 06* wood containing dangerous substances
- 19 12 09 minerals (as far as recycling is not applicable)
- 19 12 11* other wastes (including mixtures of materials) from mechanical treatment of waste containing dangerous substances
- 19 12 12 other wastes (including mixtures of materials) from mechanical treatment of waste other than those mentioned in 19 12 11

Notes on recycling, utilization and disposal:

With restrictions for waste code 19 12 09, minerals: At present there are no known viable treatment processes.

Incineration, HWL or disposal to HWL, UGL; if it does not contain dangerous substances, together with municipal waste.

3 Overview of waste classification – material flow

	Extract from EWL	Material flow	Treatment
19 12	wastes from the mechanical treatment of waste (for example sorting, crushing, compacting, pelletising) not otherwise specified		
19 12 01	paper and cardboard	Z	1) material use, 2) incineration
19 12 02	ferrous metal	Z	recycling
19 12 03	non-ferrous metal	Z	1) recycling, 2) with municipal waste
19 12 04	plastic and rubber	Z, B	1) material use, 2) incineration, 3) with municipal waste
19 12 05	glass	Z, B	1) recycling, 2) with municipal waste
19 12 06*	wood containing dangerous substances	B	1) incineration, 2) HWI
19 12 07	wood other than those mentioned in 19 12 06	Z, B	1) material use, 2) incineration, 3) with municipal waste
19 12 08	textiles	Z, B	1) material use, 2) with municipal waste
19 12 09	minerals (for example sand, stones)	B, Z	1) with municipal waste, 2) material use
19 12 10	combustible waste (refuse derived fuel)	Z	use as a fuel
19 12 11*	other wastes (including mixtures of materials) from mechanical treatment of waste containing dangerous substances	A, B	HWL, HWI UGL
19 12 12	other wastes (including mixtures of materials) from mechanical treatment of waste other than those mentioned in 19 12 11	A, B	with municipal waste

19 13 Wastes from soil and groundwater remediation

1. PROCESS	1
1.1 Soil washing	1
1.2 Thermal soil treatment	2
1.3 Biological soil treatment	2
1.4 Soil gas removal in soil and groundwater treatment (in situ – without excavating)	3
1.5 Hydraulic process (in situ without excavating)	3
2 WASTES	4
3 OVERVIEW OF WASTE CLASSIFICATION - MATERIAL FLOW	9

1. Process

The processes for soil and groundwater remediation outlined below are often implemented together, for example, it is common to combine hydraulic and pneumatic processes. The processes are described separately here to provide a better overview. Processes 1.1 – 1.2 are used for soil remediation while processes 1.3 – 1.5 can also be used for groundwater remediation.

1.1 Soil washing

In soil washing, foreign materials such as pieces from road construction, building rubble and foreign bodies (e.g. metal containers) are first of all sorted out. Then, the soil is separated according to particle size (classifying). Coarse material (particle size > 2mm) is separated off and washed. The remaining soil fractions are homogenised by intensive mixing with water. In some cases detergents may be added to the water to improve cleaning. After washing, the cleaned sand fraction (grain size between 0.063 mm and 2 mm) is phased out and the water removed. Hazardous materials from the soil settle in the remaining suspension of finely grained material (coarse clay, grain size < 0.063 mm). This suspension is thickened in a hydrocyclone, flocculated and concentrated to about 55 to 65% dry mass in a sieve or chamber press. The water is to a large extent recycled. The withdrawn water is treated in a water treatment plant.

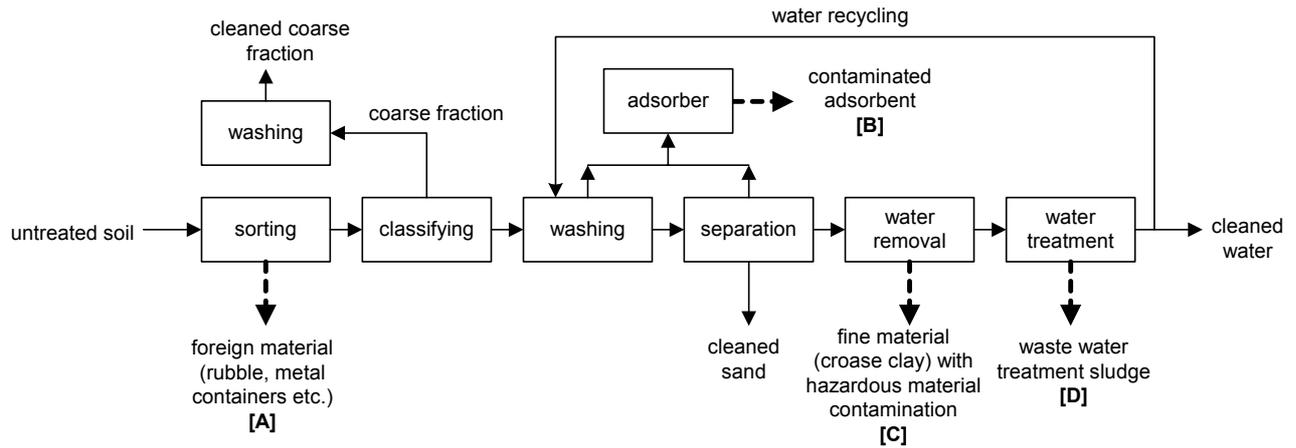


Fig. 1: Flow diagram of soil washing

1.2 Thermal soil treatment

First of all the untreated soil is sorted and foreign material such as material from road construction, rubble and foreign bodies (e.g. metal containers) are removed. The coarse fraction (stones and gravel) is crushed before treatment.

Hazardous materials in the soil are removed by incineration or evaporation as well as by pyrolytic change. The process technology used includes directly heated rotary kiln (at temperatures of 600 °C to 1.200 °C), fluidised bed and pyrolysis. Flue-gas treatment must be carried out. To this end aggregates such as those used in power stations and incinerators are used. An alternative low temperature process has recently been introduced in which organic hazardous materials are removed and then incinerated in the gas phase. Here, regulations in accordance with clean air acts must be observed as well.

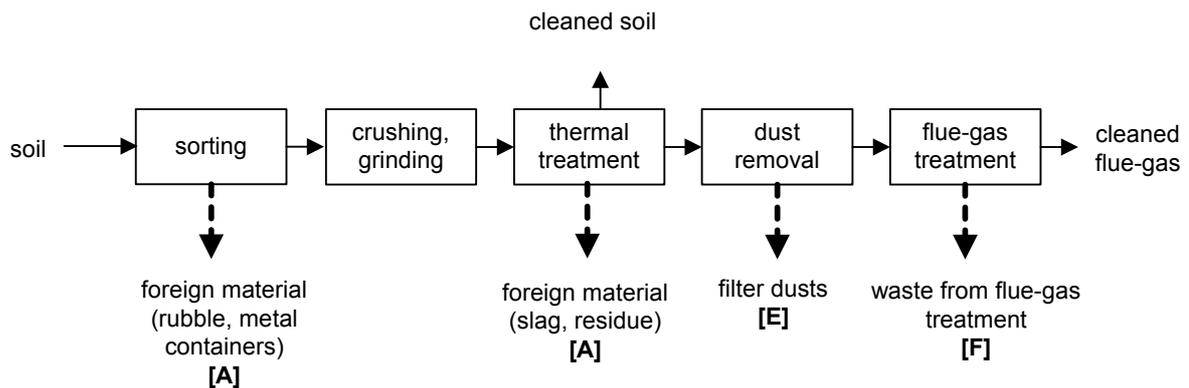


Fig. 2: Flow diagram of thermal soil remediation

1.3 Biological soil treatment

During biological soil treatment, micro-organisms decompose organic hazardous substances to CO₂. Treatment can take place in situ, on-site or off-site. In the case of on-site and off-site treatment, in other words with excavating, first of all foreign materials such as material from road construction, rubble and foreign bodies (e.g. metal containers) are removed. Suitable micro-organisms and nutrients as well as water -

to replace water which has been lost - are added to the untreated soil. In the case of on-site/off-site treatment, organic additives such as compost, bark and straw are added to accelerate decomposition and to decompact material. The gas produced is cleaned (normally with activated carbon) in order to avoid smells and hazardous emissions.

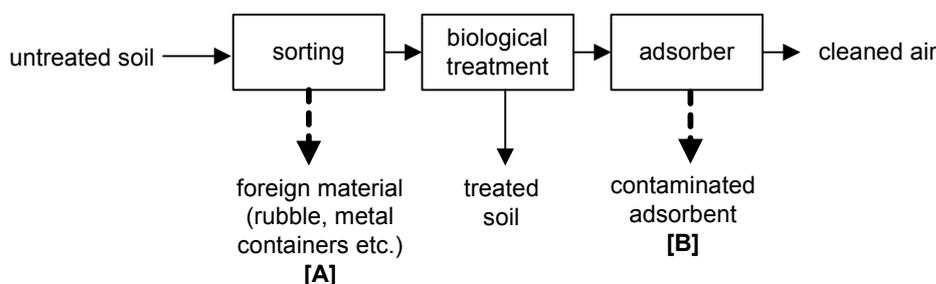


Fig. 3: Flow diagram of biological soil treatment

1.4 Soil gas removal in soil and groundwater treatment (in situ – without excavating)

When soil gas removal is used to treat contaminated soil, volatile hazardous substances are drawn out from the unsaturated ground. When this process is used to remove contaminants in the treatment of groundwater, air is blown into the groundwater channels thus forcing hazardous substances out (stripping). Hazardous substances removed in this air are usually removed by a process of adsorption on activated carbon. If the air is carrying higher concentrations of contaminants, thermal incineration, catalytic oxidation and biological flue-gas treatment are used to convert the contaminants.

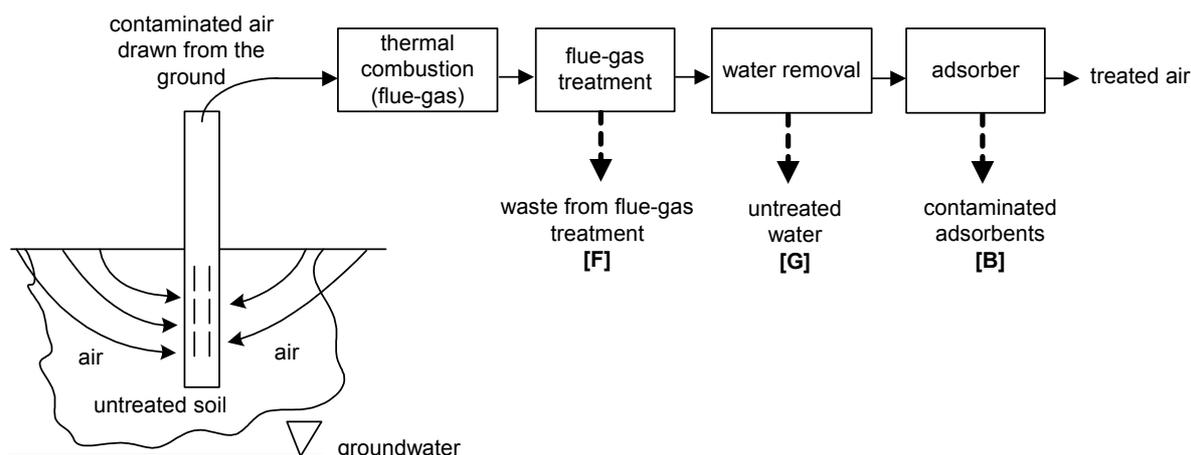


Fig. 4: Flow diagram of soil gas removal

1.5 Hydraulic process (in situ without excavating)

When the hydraulic process is used to remove dissolved or emulsified hazardous substances, contaminated groundwater is passed through wells and treated. Floating or sinking hazardous substances (insoluble hazardous substances that are heavier than water) are drawn out of the untreated phase and subsequently treated. Stripp

processes, chemical-physical processes and the adsorption of contaminants using activated carbon are used in the treatment of untreated water.

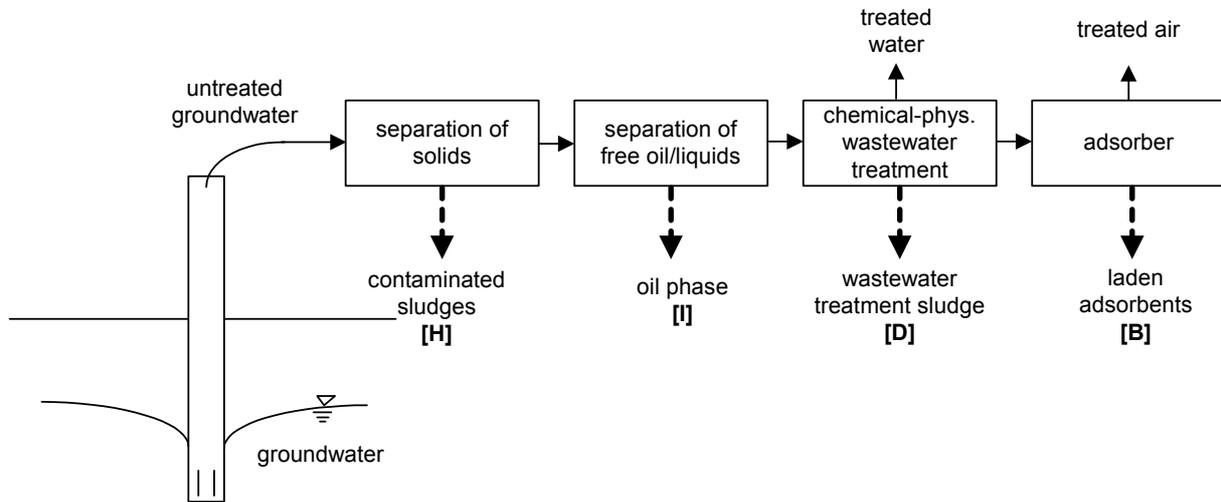


Fig. 5: Flow diagram of groundwater treatment

2 Wastes

Foreign material [A]

While processing soil, foreign material is sorted out before treatment. This material is of varying composition, for example, material from road construction, rubble and metal and plastic containers.

Classification of waste in accordance with EWL:

- 19 13 01* solid wastes from soil remediation containing dangerous substances
- 19 13 02 solid wastes from soil remediation other than those mentioned in 19 13 01

If it is clear that the isolated waste should be classified in other specific categories, these categories should be used.

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

As a rule disposal to landfill or incineration, if it does not contain hazardous substances, together with municipal waste.

Laden adsorbents [B]

Adsorbents are used in the cleaning of waste air from the workshop floor and to remove smells in fixed soil treatment plants (soil washing, biological, hydraulic and pneumatic processes). Adsorbents are mainly activated carbon but zeolite and poly-

mere are also used. In thermal treatment the adsorber is the final stage in flue-gas treatment.

Classification of waste in accordance with EWL:

19 01 10* spent activated carbon from flue-gas treatment

Notes on recycling, utilization and disposal:

Regeneration and reuse..

Otherwise, incineration, as a rule HWI.

Fine material, coarse clay [C]

During soil treatment, hazardous substances become concentrated in the fine material (coarse clay). Depending on the degree of contamination of the soil, this waste contains heavy metals and organic contaminants (oil, CHC, PAH, etc.).

Classification of waste in accordance with EWL:

19 13 03* sludges from soil remediation containing dangerous substances (*rule*)

19 13 04 sludges from soil remediation other than those mentioned in 19 13 03 (*exception*)

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

In the case of mainly inorganic contamination, disposal to landfill.

Otherwise, incineration, as a rule in HWI.

Wastewater treatment sludge [D]

In the treatment of wastewater from the treatment of soil with mainly inorganic components and contaminants, sodium hydroxide and calcium hydroxide are used as precipitants in the separation of heavy metals. Alternatively, metal sulphides may be used. The resulting sludge is normally filtered and pressed in chamber filter presses. (see chapter 1902, par. 2.1)

The resulting filter cake has a watertight consistency with a solids content of 30 – 40 %. Occasionally, a subsequent process is used to thermally dry to a solid content of 70%. The composition of the sludge depends on the one hand on the input and on the other on the treatment chemicals used. Significant constituents are different metal hydroxides or sulphides as well as calcium compounds (hydroxide, sulphate, phosphate, silicate, fluoride) that are difficult to dissolve.

Organic constituents that cannot be separated using mechanical/physical processes can be split off using chemical processes. The chemicals used for this (e.g. acids, salts, precipitants) make it possible to largely separate organic constituents from the water phase by reducing the pH value, by precipitation and flocculation. Sludges from which the water has been removed either by flotation or in chamber filter presses u-

usually have a high organic content (10 – 50%). The separated phase is liquid when organic chemicals are used.

Classification of waste in accordance with EWL:

- 19 02 05* sludges from physico/chemical treatment containing dangerous substances (*rule*)
19 02 06 sludges from physico/chemical treatment other than those mentioned in 19 02 05 (*exception*)

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

Disposal to landfill, incineration if there is a high organic content, as a rule, HWI; if it does not contain hazardous substances, together with municipal waste.

Fly ash [E]

Fly ash arises as a solid during dust separation in cyclonic or electro filters. These dusts contain hazardous substances such as salts, sulphur, heavy metals and dioxine.

Classification of waste in accordance with EWL:

- 19 01 13* fly ash containing dangerous substances
19 01 14 fly ash other than those mentioned in 19 01 13

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

Deposited on landfill (HWL, UGL), if it does not contain hazardous substances, together with municipal waste.

Wastes from flue-gas treatment [F]

In fixed plants, flue-gas treatment is normally installed with fly ash separation, high temperature incineration and dry absorption (HCl, SO₂ separation). In mobile plants, which are as a rule operated on-site, thermal combustion is usually sufficient, depending on the degree of soil contamination. As a rule, an activated carbon filter is used.

Using dry absorption processes (Ca(OH)₂), acidic gases can be absorbed and converted into solid salt compounds. In the wet wash, acidic gases are bound to chalk by spraying lime water.

Liquid wastes are treated in chemical/physical processes, see [D].

Classification of waste in accordance with EWL:

- 19 01 05* filter cake from gas treatment
19 01 06* aqueous liquid wastes from gas treatment and other aqueous liquid wastes

- 19 01 07* solid wastes from gas treatment
19 01 10* spent activated carbon from flue-gas treatment

Notes on recycling, utilization and disposal:

- 19 01 05* Waste containing calcium can be used in the building materials industry (plaster).
19 01 06* Treatment in CPT plants to neutralise waste and to feed the water phase into the sewage system.
19 01 07* At present there are no known viable treatment processes.
19 01 10* Activated carbon filters can be regenerated and reused.

Otherwise, HWL, activated carbon filters HWI.

Untreated water [G]

Contaminated water can arise at various points in the soil and groundwater treatment process. One reason is that during in situ/on site processes, wastewater treatment is carried out externally so that the wastewater has to be transported. However, this is more often an exception than the rule as transportation of large quantities of water is very costly.

Contaminated water also arises in water separators, which are used before adsorbents, in order to reduce their load. As a rule, this water is treated in wastewater treatment plants on site and only in exceptional cases treated externally.

Aqueous concentrate results when untreated groundwater is evaporated on site.

Classification of waste in accordance with EWL:

- 19 13 07* aqueous liquid wastes and aqueous concentrates from groundwater remediation containing dangerous substances
19 13 08 aqueous liquid wastes and aqueous concentrates from groundwater remediation other than those mentioned in 19 13 07

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

As a rule, treatment in CPT plants to neutralise waste and to feed the water phase into the sewage system.

Contaminated sludges [H]

In the case of hydraulic processes, solids (e.g. sand, fine soil particles) contained in the water are usually separated out in the first stage of the process using simple sedimentation or filtration processes. This waste is predominantly inorganic but may contain organic substances such as mineral oil depending on the type of soil/groundwater contamination.

Classification of waste in accordance with EWL:

- 19 13 05* sludges from groundwater remediation containing dangerous substances (*rule*)

19 13 06 sludges from groundwater remediation other than those mentioned in
19 13 05 (*exception*)

Notes on recycling, utilization and disposal:

At present there are no known viable treatment processes.

If mainly inorganic contamination, disposal to landfill. In the case of a larger organic component, incineration and if it does not contain dangerous substances, then together with municipal waste.

Oil from liquid separation [I]

By exploiting the difference in viscosity, free, i.e. non-emulsified or dissolved, oil is separated off as oil phase using coagulation or flotation equipment.

Classification of waste in accordance with EWL:

19 02 07* oil and concentrates from separation

Notes on recycling, utilization and disposal:

Reprocessing or used as a fuel in accordance with waste oil regulations.

Otherwise, incineration, as a rule, HWI.

3 Overview of waste classification - material flow

Extract from EWL		Material flow	Treatment
19 13	wastes from soil and groundwater remediation		
19 13 01*	solid wastes from soil remediation containing dangerous substances	A	1) HWL, 2) HWI
19 13 02	solid wastes from soil remediation other than those mentioned in 19 13 01	A	with municipal waste
19 13 03*	sludges from soil remediation containing dangerous substances	C	1) HWL, 2) HWI
19 13 04	sludges from soil remediation other than those mentioned in 19 13 03	C	with municipal waste
19 13 05*	sludges from groundwater remediation containing dangerous substances	H	1) HWL, 2) HWI
19 13 06	sludges from groundwater remediation other than those mentioned in 19 13 05	H	with municipal waste
19 13 07*	aqueous liquid wastes and aqueous concentrates from groundwater remediation containing dangerous substances	G	CPT
19 13 08	aqueous liquid wastes and aqueous concentrates from groundwater remediation other than those mentioned in 19 13 07	G	CPT

wastes from soil and groundwater remediation to be classified under other waste categories			
19 01 05*	filter cake from gas treatment	F	1) material use 2) HWL
19 01 06*	aqueous liquid wastes from gas treatment and other aqueous liquid wastes	F	CPT
19 01 07*	solid wastes from gas treatment	F	HWL
19 01 10*	spent activated carbon from flue-gas treatment	B, F	1) regeneration 2) HWI
19 01 13*	fly ash containing dangerous substances	E	1) HWL, 2) UGL
19 01 14	fly ash other than those mentioned in 19 01 13	E	1) UGL, 2) with municipal waste
19 02 05*	sludges from physico/chemical treatment containing dangerous substances	D	1) HWL, 2) HWI

19 02 06	sludges from physico/chemical treatment other than those mentioned in 19 02 05	D	with municipal waste
19 02 07*	oil and concentrates from separation	I	1) oil regeneration, 2) incineration, 3) HWI