ZDHC

ZDHC Sludge Reference Document

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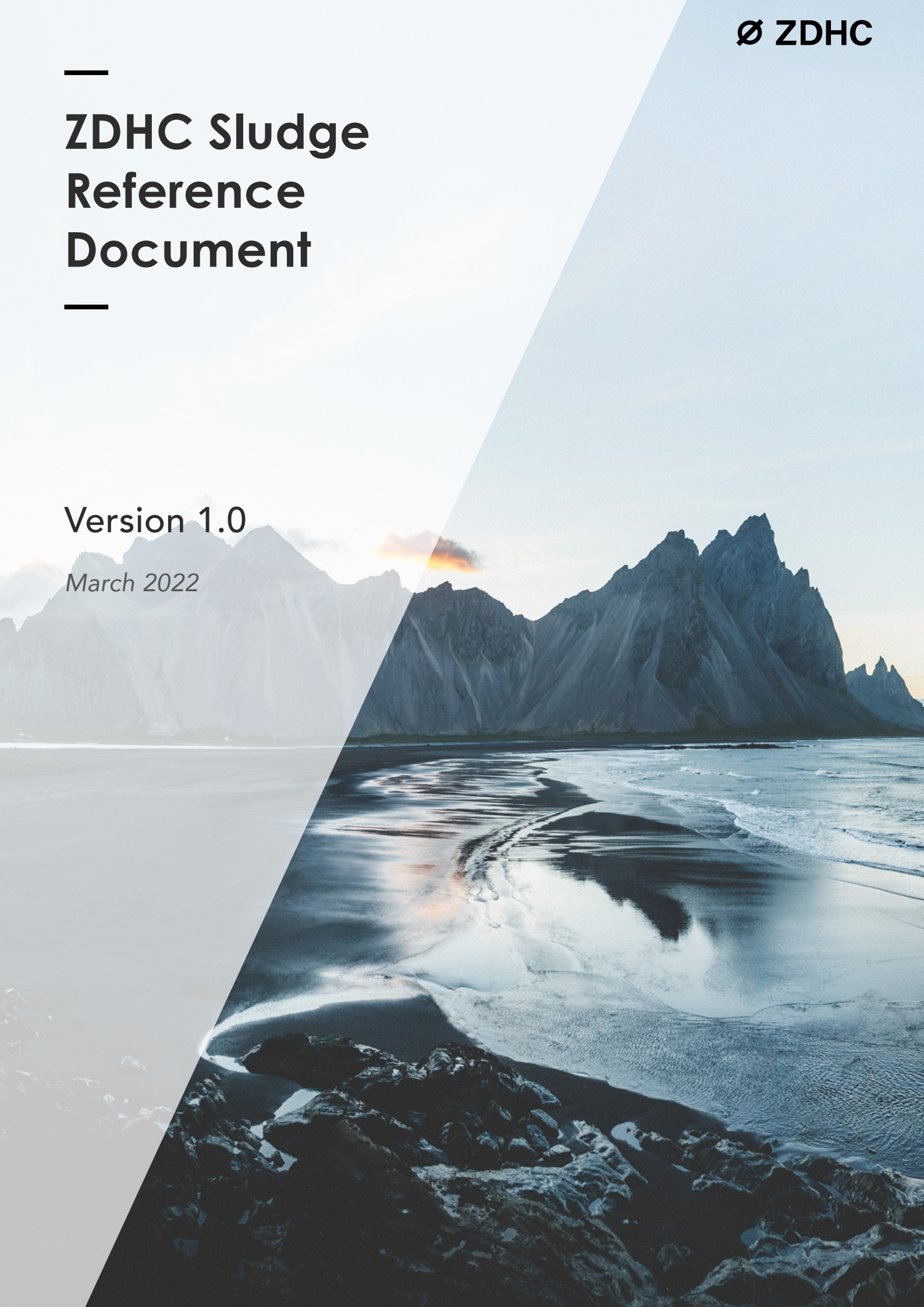

Notes

The ZDHC Sludge Reference Document does not guarantee the following:

a. Compliance with, or take the place of, legal or regulatory requirements. Examples might include[1]: stricter legal, local or regional wastewater and sludge limits, or other requirements relating to the handling and disposal of sludges shall supersede any requirements outlined in this ZDHC Sludge Reference Document.
b. Compliance with, or conformance to, any national or international environmental or workplace safety requirements including, but not limited to, relevant regulations and/or standards.
c. Nor does this document replace any national or international environmental or workplace safety requirements, including, but not limited to, regulations and/or standards.

It is not the intent of, nor shall the ZDHC Foundation act as an agency reporting wastewater and sludge discharge data to governments or authorities having jurisdiction. It is expected that manufacturing facilities are accountable for reporting on their wastewater and sludge discharges in accordance with applicable laws and regulatory permits at all times. This ZDHC Sludge Reference Document is not intended nor can be used as a statement of legal requirements.

Disclaimers

ZDHC has made every reasonable effort to make sure that the content and information contained in the ZDHC Sludge Reference Document[2] is as accurate and correct as possible at the time of publication. ZDHC makes no claims, promises, or guarantees about the accuracy, completeness, or adequacy of the contents of this document.

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a. By errors or omissions, whether such errors or omissions result from negligence, accident, or any other cause and/or;
b. From any use, decision made, or action taken or any other kind of reliance on the ZDHC Sludge Reference Document[2] by a reader or user of it and/or;
c. For any results obtained or not obtained from the use of the ZDHC Sludge Reference Document[2].

[1] This is non-exhaustive list.
[2] For the avoidance of doubt this Disclaimer applies to all related documents produced by ZDHC, specifically: ZDHC Sludge Reference Document, ZDHC Wastewater Guidelines, ZDHC Wastewater Implementation Approach, and ZDHC Wastewater and Sludge Laboratory Sampling and Analysis Plan (SAP) etc.

Introduction

Wastewater treatment sludge (referred to as “sludge”) is a necessary and inevitable by-product of the proper treatment of wastewater. Regulations regarding the handling and disposal of sludge vary widely worldwide, as does the infrastructure available for further treatment and final disposal of sludge. Examples of poor sludge management and disposal, resulting in negative impacts on human health and the environment, can, unfortunately, be seen around the world. To date, there are no global guidelines or requirements that apply to sludge generated by facilities in the textiles, leather, apparel, and footwear value chain.

The purpose of the ZDHC Wastewater Guidelines (hereafter referred to as “WW Guidelines”) is to support changes in practices at facilities worldwide by setting a worldwide process with consistent requirements for sludge handling and disposal that minimise the negative impact of sludge on human health and the environment.The Sludge Reference Document supports the understanding and implementation of the sludge portion in the WW Guidelines.

What can be Found in the ZDHC Wastewater Guidelines and Sludge Reference Document?

The WW Guideline defines ZDHC Disposal Pathways for sludge and provides a methodology for facilities to determine the pathways used for sludge disposal. The ZDHC Disposal Pathways cover the current handling and disposal methods used globally for sludge. Additionally, the WW Guidelines also define the testing requirements of MRSL parameters (which have a propensity to partition to the sludge in wastewater) and other parameters, including metals.

This Sludge Reference Document provides further explanation and background on each ZDHC Disposal Pathway and contains information supporting and further explaining the WW Guidelines. The Sludge Reference document is arranged according to the sludge generation, handling, and disposal. The following sections are contained in this document:

- In Scope/Out of Scope Sludge
- Onsite Sludge Volume Reduction
- Sampling, Storage, and Handling of Sludge
- ZDHC Disposal Pathways and Documentation Requirements
- Interpretation of Sludge Analysis Results
- Root Cause Analysis and Corrective Action Plan guidance

Each section contains background information to answer common questions and providing a consistent basis for discussing sludge issues.

The Sludge Reference Document also specifies documentation and management practices needed to properly manage and account for sludge generation, handling, testing, and disposal. Documentation is crucial to provide transparency and traceability for sludge, from generation to final disposal.

Contents

Definitions of Terms

Visit the ZDHC Glossary to search for explanations on terminology used across this document and the ZDHC Foundation.

Related Work

This document is part of a set of guidelines and solutions provided by ZDHC. All stakeholders (Suppliers, manufacturing facilities, brands and retailers, and laboratories) are expected to follow the most current guidance documents and practical tools given below:

- ZDHC Wastewater Guidelines
- ZDHC Wastewater and Sludge Laboratory Sampling and Analysis Plan
- ZDHC Wastewater Industry Implementation Approach
- ZDHC Root Cause Analysis and Corrective Action Plan Template found in the Supplier Platform.
- ZDHC List of Accepted Laboratories for ZDHC Wastewater Guidelines Testing
- ZDHC Gateway
- ZDHC Manufacturing Restricted Substances List (ZDHC MRSL)

Acknowledgements

We warmly thank the ZDHC contributors who provided their expertise, practical input, critical feedback, and constructive suggestions in the creation of this document, in particular the members of the Sludge Task Team.

What is Sludge and Why is it Essential to Test?

Sludge is the residual solid, semisolid, or slurry material produced as a by-product of wastewater treatment processes, including septic / sewage and Zero Liquid Discharge (ZLD) systems. It is commonly generated from chemical precipitation, sedimentation, biomass and other biological treatment processes. Sludge can be generated from primary, secondary, and tertiary treatment stages of wastewater treatment processes. Any other sludge or solid waste mixed into this sludge before sludge treatment or disposal shall be considered commingled and fall under the definition of sludge.

Sludge testing is an important part of the WW Guidelines for the following reasons:

1. Certain organic ZDHC Manufacturing Restricted Substance List (ZDHC MRSL) parameters have a propensity by their chemical nature to partition to the sludge phase. Testing the sludge from wastewater treatment systems is important to assess whether those organic ZDHC MRSL parameters are in use at the facility, in addition to testing the wastewater.

2. Metals are normally found in wastewater treatment plant influents and can come from dyes and chemicals, piping, cotton, and other sources. As a normal function of wastewater treatment systems, metals partition to the sludge to some extent.

3. Provides qualitative data for certain parameters that also protects human health and the environment, including solids content, pH, and the presence or absence of pathogens.

Hence the ZDHC WW Guidelines specify the testing of these parameters in the sludge. Detailed sampling and analysis protocols and procedures can be found in the ZDHC Wastewater and Sludge Laboratory Sampling and Analysis Plan (SAP).

Methodology used to Develop the WW Guidelines and Sludge Reference Document

In developing the WW Guidelines and the Sludge Reference Document, the ZDHC Sludge Task Team considered the best available knowledge, practices, and regulatory approaches at the time regarding sludge generation, handling, and disposal from countries around the world. The team reviewed and considered a range of regulations and requirements relating to sludge, including the most stringent, risk-based regulatory developments and implementation approaches related to sludge regulations and limitations. The Task Team also reviewed and considered a report entitled "Proposal for defining sludge limit values for inclusion into the ZDHC Wastewater Guidelines", which was produced for ZDHC by the University of Stuttgart[4].

The WW Guidelines and the Sludge Reference Document were reviewed by industry peers and the ZDHC Wastewater Council. ZDHC will continue to review developments and additional information regarding sludge handling and disposal, and needed updates will be incorporated into future versions of the WW Guidelines and the Sludge Reference Document.

What is not Considered in the Methodology?

The WW Guidelines and the Sludge Reference Document do not cover other pollutants that are not specifically listed in the Guideline, and does not consider issues such as[5]:

- bioaccumulation, and;
- disposal facility design considerations (other than the general definitions that are included in the Guideline), and;
- toxicological considerations of the sludge and compounds in the sludge, or
- other legal, regulatory, and human health issues related to sludge handling and disposal.

Each facility using the WW Guidelines and Sludge Reference Document accepts and acknowledges that it is the facility management's responsibility to know and understand the local legal requirements applicable to sludge handling, storage, and disposal. It is the facility management's responsibility to comply with applicable legal requirements. Nothing in the WW Guidelines and Sludge Reference Document should be interpreted as relieving facility management of these responsibilities. Further, it is also facility management's responsibility to know and consider and prepare for potential future liabilities and issues related to sludge handling, storage, and disposal. As in the ZDHC Disclaimers, ZDHC will not accept nor is responsible for any current or future liability related to sludge handling, storage, and disposal. The methodology used to Develop the WW Guidelines and Sludge Reference Document.

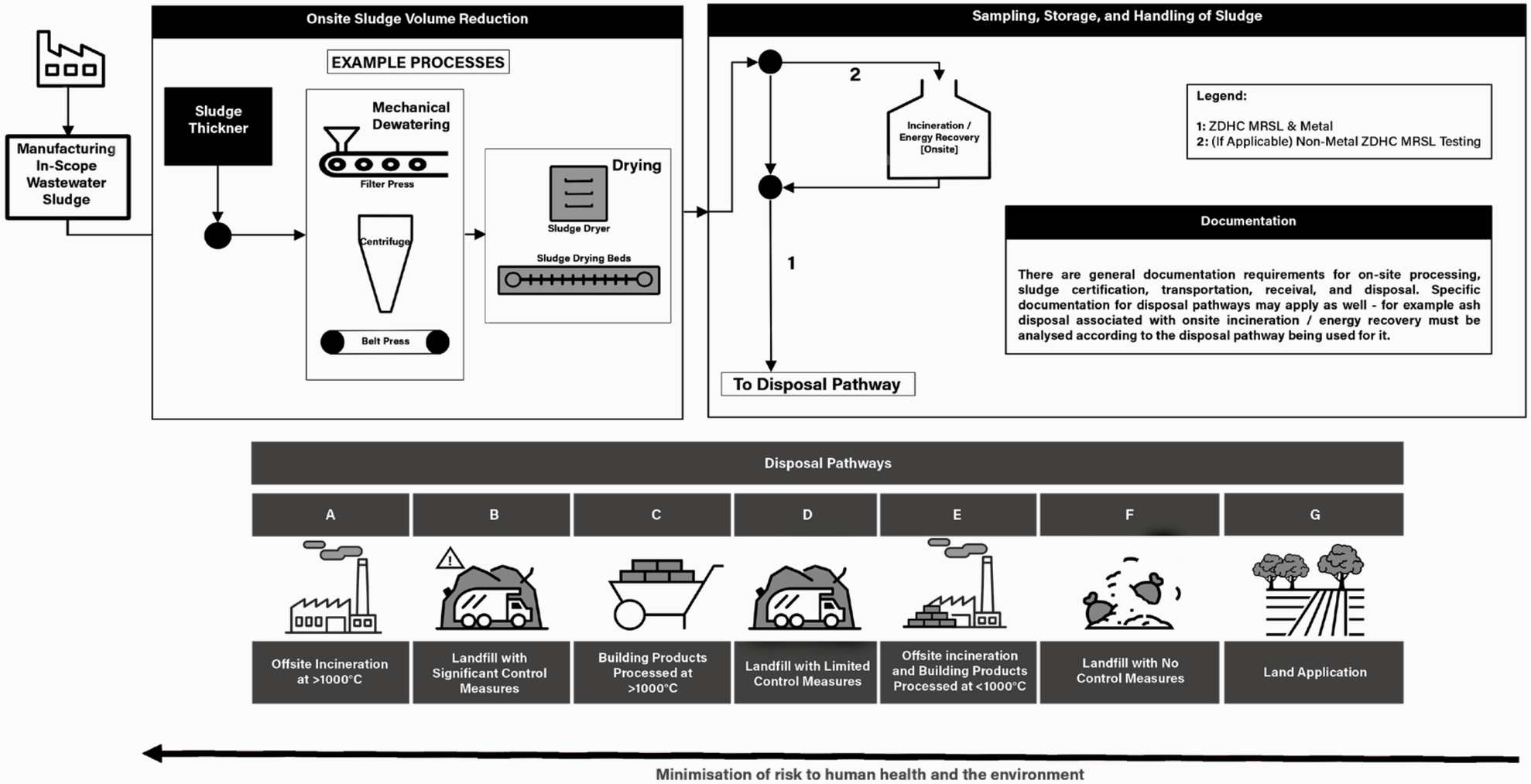
[4] Universität Stuttgart. Proposal for defining sludge limit values for inclusion into the ZDHC Wastewater Guidelines. January 2018, Stuttgart, Germany.
[5] This is a non-exhaustive list.

How to use the Wastewater Guidelines and Sludge Reference Document?

Suppliers should take the following steps in accordance with the WW Guidelines and this Sludge Reference Document, to:

1. Determine which sludges are "In Scope" at the facility, see next chapter;
2. Suppliers must complete their Gateway profiles to determine the ZDHC Disposal Pathway being used for disposal of the sludge;
3. Ensure that proper documentation, handling, and storage practices are being followed for sludge;
4. In accordance with SAP, composite samples of sludge to be collected and tested by laboratories, following a testing cycle as specified in the WW Guidelines;
5. ClearStream Report provides a list of approved ZDHC Disposal Pathways for the sludge, based on results compared to the WW Guidelines, and;
6. If the sludge is not approved for the ZDHC Disposal Pathway currently being used, conduct Root Cause Analysis and submit a Corrective Action Plan.

Figure 1: ZDHC Sludge Lifecycle



Scope of Sludge Guidelines

Wastewater treatment systems consist of many different processes resulting in many kinds of sludge. The following table provides a comprehensive list and characteristics of different types of sludges, defining which are In-Scope or Out of Scope for the applicability of the WW Guidelines. Common sludges and wastes generated at manufacturing facilities that are out of the scope of the WW Guidelines are also included in this section.

In Scope[6]

Figure 2: Sludge In Scope

Type of Sludge	Processes that Generate this Type of Sludge	Additional Process Information	Sludge Characteritics
Anaerobically digested secondary sludge	▪ Anaerobic contact reactor (ACR) ▪ Anaerobic sequencing batch reactor (ASBR) ▪ Up-flow anaerobic sludge blanket (UASB) etc.	This is a secondary (biological) treatment process involving microorganisms in the absence of oxygen. The digestion step takes place in a sludge digester and is a process used to reduce the organic loading and volume of the sludge.	Dark brown to black in colour and can contain an exceptionally large quantity of gas. When thoroughly digested, they are not offensive, the odour being relatively faint and like that of hot tar, burnt rubber or sealing wax.
Aerobically Digested Secondary Sludge	▪ Aerated lagoons, oxidation ponds, or aeration basins.	Sludge generated via secondary (biological) treatment processes involves microorganisms in the presence of oxygen. Digestion steps take place in a sludge digester and are used to reduce organic load and volume of sludge.	Brown to dark brown and have a flocculent appearance. Odour is not offensive; it is often characterised as musty. Well-digested aerobic sludge dewaters easily.
Primary Treatment Sludge	▪ Primary settling tank or primary clarifier ▪ Consists of coagulation, flocculation, sedimentation and clarification processes. ▪ This treatment step frequently involves the addition of chemicals to aid in coagulation and flocculation, including inorganic chemicals and organic polymers.	Substantial quantities of gas may be given off and the sludge density increased by long residence times in storage.	Sludge from primary settling tanks is usually grey and slimy and, in most cases, has an extremely offensive odour. • Sludge from chemical precipitation with metal salts is usually dark in colour, though its surface may be red if it contains much iron. • Lime sludge is greyish-brown. • While chemical sludge is somewhat slimy, the hydrate of iron or aluminium in it makes it gelatinous.
Biomass or secondary treatment and tertiary treatment sludge	▪ Rotating biological contactors (RBCs) ▪ Membrane bio reactors (MBRs) ▪ Moving bed biofilm reactor (MBBR) ▪ Submerged aerated filter (SAF) ▪ Activated sludge processes and secondary clarifiers ▪ Processes which involve microorganism or bacteria in presence of oxygen ▪ Trickling filters	Secondary / tertiary treatment may be used to remove organic compounds, nitrogen, phosphorus, additional suspended solids, heavy metals, and dissolved solids.	Generally has a brown flocculent appearance. Tertiary sludge may be light brown in colour and less odorous. • If the colour is dark, the sludge may be approaching a septic condition. • If the colour is lighter than usual, the sludge may have been under aeration with a tendency for the solids to settle slowly. • Sludge in good condition has an inoffensive "earthy odour". • When sludge contains many worms, it may become inoffensive quickly. Trickling-filter sludge digests readily.

[6] This is non-exhaustive list.

Figure 2: Sludge In Scope

Type of Sludge	Processes that Generate this Type of Sludge	Additional Process Information	Sludge Characteritics
Biomass or secondary treatment and tertiary treatment sludge (continued)	Tertiary treatment processes including: ▪ Chemical precipitation and separation in a clarifier ▪ Fenton process ▪ Ozonation ▪ Reverse osmosis ▪ Nanofiltration ▪ Ultrafiltration ▪ Microfiltration		
Mechanically dewatered sludge "cake"	▪ Floatation ▪ Gravity belt filter press ▪ Thickening drum ▪ Screw drum ▪ Centrifuge ▪ Plate and frame press	Sludge dewatering is the separation of solid and liquid phase in order to create a solid called sludge "cake".	Dewatered sludge cake contains moisture in the range of 65% - 85%. This type of sludge may be brown and have an offensive odour.
Dried sludge or ash	▪ Sludge drying beds ▪ Sludge dryer ▪ Mechanical evaporation ▪ Thermal drying ▪ Thermal evaporator ▪ Ash from onsite incineration	Sludge drying is the process of further reducing moisture content of sludge in order to reduce volume and transportation costs. Onsite incineration of sludge (with or without energy recovery) is considered to be a treatment step, and the ash must be collected and disposed of properly.	Sludge drying processes are used to produce sludge with water content of less than 10 to 20 weight percent moisture.
Adsorption or filtration system waste	▪ Various filtration processes using media like sand, activated carbon, resins, and similar materials.	Media used to remove organic compounds (including MRSL compounds) or media used to remove metals in wastewater must be changed out periodically.	Appearance can vary depending on the media being used.

Out of Scope[7]

Figure 3: Sludge Out Scope

Type of Waste	Description of the Type of Waste	Processes that Generate this Type of Waste
Screening Waste	Screening waste includes all types of organic and inorganic materials large enough to be removed by large mechanical screens (bar racks), lint screens, or other screens. The organic content varies, depending on the nature of the system.	Screening waste generated by mechanical pretreatment process (mechanical screening). Screening is done manually or automatically using screens with different mesh sizes.
Grit Waste	Grit is usually made up of the heavier inorganic solids (including sand) that settle with relatively high velocities. Depending on the operating conditions, grit may also contain significant amounts of organic matter, especially fats and grease.	Generated by hydro-mechanical process.
Scum/Grease Waste	Scum consists of the floatable materials skimmed from the surface of primary and secondary settling tanks and from grit chambers and chlorine contact tanks, if so equipped. Scum may contain grease, vegetable and mineral oils, animal fats, waxes, soaps, paper, plastic materials, grit particles, and similar materials.	Scum is collected by skimming processes. Grease may come from machinery or from kitchen/cafeteria areas and may also be removed by skimming processes.
Chemical Cleaning Waste	Machine cleaning chemicals are used for cleaning knitting or weaving machines, dyeing machines, sewing machines, etc. Floor cleaning chemicals are used for cleaning floors.	Any waste generated due to cleaning of chemical containers and drums.
Print Paste Waste	Waste generated from print paste residues, screen making, screen cleaning or other activities related to printing.	May be generated in the manufacturing facility or in a separate area.

[7] This is non-exhaustive list.

Figure 3: Sludge Out Scope

Type of Waste	Description of the Type of Waste	Processes that Generate this Type of Waste
Other waste not specifically listed in the "In Scope" section	All other waste generated in the manufacturing facility or the wastewater treatment system that is not comingled with In Scope sludge is considered to be Out of Scope.	Refer to the list of In Scope wastes above. Comingling means the mixing of wastes together prior to disposal.

Onsite Sludge Volume Reduction

An important step in handling sludge at manufacturing facilities is the reduction in the volume and weight of the sludge. Sludge may also be stabilised or "digested" to reduce organic content. These steps can be accomplished using several types of processes as described below. It is important to note that volume reduction, moisture content reduction, organic content reduction, and weight reduction of sludge are not disposal techniques. Instead, they are intermediate steps to reduce the amount of sludge disposed of via one of the ZDHC Disposal Pathways.

Seven Onsite Sludge Volume Reduction Operations

Factories with onsite wastewater treatment systems may have one or more processes to reduce the volume, organic content, moisture content, or weight of sludge. Reduction of sludge volume and moisture content can help a facility minimise the cost of sludge handling and disposal. Many of these processes are described below and have been organised into seveb groups:

1. **Sludge Thickening**: is a process in which the solids' concentration increases and the total sludge volume correspondingly decreases. Thickening sludge is required to minimise the loading on downstream processes such as digestion and dewatering. Different types of thickening include co-settling thickening, gravity thickening, flotation thickening, gravity belt thickening, and rotary drum thickening.

2. **Sludge Stabilisation**: also called digestion, reduces the organic content of sludge and is performed to reduce the problems associated with two unfavourable characteristics of sludge: odour and the presence of pathogenic organisms. Sludge may be stabilised by the use of lime, by aerobic digestion, or by anaerobic digestion. Methane gas may be collected from the anaerobic digestion of sludge.

3. **Sludge Conditioning**: is a process whereby sludge solids are treated with chemicals or various other means to prepare the sludge for dewatering processes, in other words, to improve the dewatering characteristics of the sludge. Usually, it is completed through a coagulation and flocculation process.

4. **Sludge Mechanical Dewatering**: is a physical unit operation used to separate the solid matter from wastewater in the sludge, resulting in a higher solids content stream (sometimes called "cake") and a liquid stream. Water content and volume of sludge are reduced by mechanical processes such as centrifuges, plate-and-frame filter press, belt filter press, screw press, and rotary press.

5. **Sludge Drying**: can be accomplished using the sun and air via drying beds or solar pans. Sludge can also be dried using heat from direct or indirect sources to evaporate water.

6. **Sludge Onsite Incineration (with or without energy recovery)**: Incineration is defined as a waste treatment process that involves the combustion of organic substances contained in waste materials. Incineration of sludge converts the sludge into ash, flue gas and heat (that may or may not be used to recover energy). When this is performed onsite at a manufacturing facility, it is considered a volume reduction activity. Note that the ash from onsite sludge incineration must be managed according to one of the Disposal Pathways, and that air emissions from onsite sludge incineration are subject to ZDHC Air Emissions Position Paper[8]. If there is onsite incineration of sludge, laboratories must indicate this in the ZDHC Gateway. Records establishing amounts of sludge incinerated and documentation of proper operational temperatures and air pollution controls must be maintained.

7. **In systems such as Zero Liquid Discharge (ZLD) systems,** evaporators of various designs are used to evaporate liquid content and create dried sludge.

Sampling, Storage, and Handling of Sludge

Sludge Onsite Incineration (with or without energy recovery): Incineration is defined as a waste treatment process that involves the combustion of organic substances contained in waste materials. Incineration of sludge converts the sludge into ash, flue gas and heat (that may or may not be used to recover energy). When this is performed onsite at a manufacturing facility, it is considered a volume reduction activity. Note that the ash from onsite sludge incineration must be managed according to one of the Disposal Pathways. Air emissions from onsite sludge incineration are subject to ZDHC Air Emissions Position Paper8. If there is onsite sludge incineration, facilities must indicate this in the Supplier Profile in the ZDHC Gateway. Records establishing amounts of sludge incinerated, proper operational temperatures, and air pollution controls must be maintained.

[8] For more information refer to the ZDHC Air Emissions Position Paper found on the Roadmap to Zero website.

Sludge should be stored in an adequate storage area having at least 50% higher capacity than the average annual sludge generation quantity. The storage area should be designed to withstand the load of material stored and must be well ventilated. The surface of the sludge storage area should be impermeable and inert in nature. The sludge storage area should be enclosed or covered and protected from weather (precipitation or wind). Any seepage of liquid from the stored sludge should be sent back to the influent of the wastewater treatment plant, as should any other water or precipitation that comes into contact with the sludge. (Note: Facilities with reverse osmosis systems must be cautious concerning the impact of seepage containing Iron on the reverse osmosis membranes. Iron can cause irreversible fouling of reverse osmosis membranes).

Secondary containment should be provided for the sludge storage area through the use of berms and curbing to contain the sludge inside the storage area. Dry sludge should be managed so that dried sludge is not blown from the area to the surrounding environment.

ZDHC Disposal Pathways and Documentation Requirements

Sludge disposal means the final placement or incorporation of sludge (and ash from the incineration of sludge) into a permanent storage location or state, such that the sludge poses no or very low risk to human health and the environment. Disposal also includes the incorporation of sludge and ash into building products, or in the case of sludge going to land application, the safe and beneficial incorporation of sludge into an acceptable land area.

The ZDHC Sludge Reference Document sets forth seven ZDHC Disposal Pathways that encompass acceptable disposal practices for sludge, they are as follows:

- **Pathway A - Offsite Incineration at >1000 °C**
- **Pathway B - Landfill with Significant Control Measures**
- **Pathway C - Building Products Processed at >1000 °C**
- **Pathway D - Landfill with Limited Control Measures**
- **Pathway E - Offsite Incineration and Building Products Processed at <1000 °C**
- **Pathway F - Landfills with No Control Measures**
- **Pathway G - Land Application**

Each of the ZDHC Disposal Pathways is fully explained in the following sections, and Suppliers should categorise their sludge according to one of the ZDHC Disposal Pathways.

Sludge Documentation

To protect human health and the environment, records must be maintained that document the quantity, quality, and method of disposal of all sludge generated. For all ZDHC Disposal Pathways, the following documentation must be maintained by the facility and must be available for audit[9] all documentation should be maintained for a minimum of 3 years:

1. Sludge inventory and mass balance must include all sludge generated and the sludge disposal method.

2. Test results from sludge sampling under the WW Guidelines and the SAP. Also, test results from other sludge testing that local laws and regulations might require.

3. Manifests or similar documentation of sludge handling, transportation, processing, and disposal, accounting for all sludge generated at the facility.

4. Documentation regarding the facilities and entities involved in the transportation and disposal of the sludge, including technical and engineering information on the processing and disposal practices utilised and documents showing that the facilities are properly permitted and licensed to handle and process the sludge. The information collected should support the ZDHC Disposal Pathway indicated by the facility.

5. For each shipment, a waste manifest or a similar local transport document that contains the following information:
    - » Shipper (the facility generating the sludge);
    - » Mass or volume of net shipment;
    - » Transporter name;
    - » Driver's signature;
    - » Disposal or processing facility that the sludge was shipped to, and;
    - » Signature of personnel at the disposal or processing facility certifying acceptance of the sludge.

    Specific information regarding documentation required for each ZDHC Disposal Pathway is included in the individual sections below.

6. Facility personnel should show an 'in good faith' effort to obtain the documentation listed in the requirement sections below. If the receiving facility refuses to provide the documentation, the generating facility must be able to show a verifier their 'in good faith' effort to obtain the documentation. In this case, the generating facility should be able to show the verifier the local regulatory approvals of the receiving facility, as well as the regulatory requirements that clearly show that the facility meets the minimum requirements of the ZDHC Disposal Pathway by virtue of the local regulatory approval and the regulatory requirements.

[9] Audits are part of the Supplier to Zero Programme.

ZDHC Disposal Pathways

ZDHC Disposal Pathway A: Offsite Incineration at >1000 °C

Description

Incineration is a waste treatment process that involves the combustion of organic substances contained in waste materials. Offsite incineration occurs at facilities not owned or operated by the Supplier. Incineration and other high-temperature waste treatment systems are described as "thermal treatment". Incineration of waste materials converts the waste into ash, flue gas and heat. This ZDHC Disposal Pathway is for sludge sent to offsite incineration operated at temperatures greater than or equal to 1000°C. The ash generated by the incineration process must be disposed of using one of the other ZDHC Disposal Pathways.

Documentation Requirements

The following documentation must be maintained by the facility and must be available for audit:

1. Offsite incineration facility documentation demonstrating the facility is properly permitted and authorised to accept the sludge.
2. Technical information regarding the offsite incineration process that outlines:
    - » Incineration temperature, dwell time, percentage of total incinerator throughput represented by the Supplier's sludge;
    - » Flue gas treatment steps;
    - » Use of the heat generated by the incineration process, and;
    - » Disposal Pathway utilised for the ash from the incineration process.

ZDHC Disposal Pathway B: Landfill with Significant Control Measures

Description of General Landfill

Landfills are engineered facilities used to manage the disposal of solid waste to facilitate the storage and slow degradation of material in a manner that is safe to the surrounding environment. Many types of landfills exist depending on the type of waste the landfills are designated to receive. Some landfill types include municipal solid waste, industrial waste, construction and demolition debris, ash and coal-burning residuals, toxic and harmful substances.

The primary pollutants produced by the degradation of material are gas and leachate. Leachate is a liquid produced by the percolation of water through waste and has a high concentration of potentially harmful pollutants. Gas is generated by the decomposition process and can be potentially explosive/flammable, odorous, and can contain harmful greenhouse gases if not controlled. Additional safeguards implemented in modern landfills prevent leachate and gas from harming the environment, human health, and safety. These additional safeguards must meet stringent legal requirements for operation. Landfills can be lined and sealed with natural clay and soils and synthetic membranes. The goal is to prevent chemicals in the waste from polluting the surrounding environment, including groundwater. The type of landfill determines the type and thickness of lining (natural and/or synthetic) needed to prevent exposure to the environment. Once landfills are filled with the appropriate waste, they are sealed off. The exception to this is open landfills.

Description of Landfill with Significant Control Measures

Landfills with Significant Control Measures are landfills that control both leachate and gas produced from the materials placed in the landfill and are engineered to store waste in a manner that is safe to the surrounding environment. For purposes of the WW Guideline, significant control measures are defined as:

- Lined landfill such that the permeability of no more than 1 x 10^{-7} cm/sec is achieved. This is most often achieved using a synthetic composite liner on top of a packed natural clay liner but can also be achieved through two synthetic liners.
- Leachate is collected above the liner and removed for proper treatment and disposal. Leak detection and collection is implemented beneath the primary liner and above the secondary liner.
- Gas produced from aerobic and anaerobic decomposition is collected and safely used or disposed of. This gas is primarily carbon dioxide or methane but can include sulphurous compounds. Depending on the content of the gas, carbon dioxide can be vented directly to the atmosphere or collected, filtered, and used beneficially.
- Monitoring and documentation are maintained for the life of the landfill.

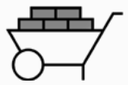
Documentation Requirements

The following documentation must be maintained by the facility and must be available for audit:

1. Landfill facility documentation demonstrating the facility is properly permitted and authorised to accept the sludge.
2. Technical information regarding the landfill facility that outlines:
    - » Liner thickness, permeability, and materials of construction;
    - » Description of leachate collection, treatment, and disposal practices;
    - » Description of the leak detection system installed;
    - » Description of the gas collection system and the disposition of collected gas, and;
    - » Description of the monitoring and documentation process for landfill operation.

ZDHC Disposal Pathway C:

Building Products Processed at >1000 °C



Description

The use of sludge in the manufacturing process of building and construction materials includes manufacturing concrete, concrete aggregates, ceramics, brick, mortar, stucco, grout, and more. These manufacturing processes occur at high temperatures (>400°C) over a long period, efficiently oxidising and destroying most organic compounds. Fly ash, a by-product from incineration processes, may also be blended into the building product manufacturing processes. In some cases, ash can be added up to 20% by volume into the standard recipe to create cement products such as cement blocks without compromising final products' strength criteria.

Sludge limits associated with building products are separated into two distinct categories based on the temperature the sludge is exposed to during the production of the building product. When temperatures in sintering production processes reach >1000°C with a dwell time of eight minutes, metals are stabilised in crystalline structures such as quartz, hematite, calcinates, and aluminosilicates within the final product. This process significantly reduces the leaching potential of heavy metals such as zinc, copper, lead, aluminium, and chromium in the final product. This is critical to mitigating the potential leaching and migration of heavy metals into the environment. When building product manufacturing processes utilise sludge and are operated below 1000°C, metals are less stable and can leach from the finished building products. Therefore, two distinct Disposal Pathways are included in the WW Guidelines based on the building product processing temperature. This Disposal Pathway is for building product processing temperatures of 1000°C and above.

Documentation Requirements

The following documentation must be maintained by the facility and must be available for audit:

1. Proper permits for manufacturing building products that prove the facility is appropriately permitted and authorised to accept sludge.
2. Technical information regarding the building products manufacturing facility that outlines:
    - » Operating temperature and dwell time for the manufacturing process of the building products where sludge is used;
    - » Description of the building products being manufactured;
    - » Use of the building products being manufactured;
    - » Percentage of total process mass inputs from the building product, and;
    - » Description of the flue gas treatment steps for the process.

ZDHC Disposal Pathway D:

Landfill with Limited Control Measures

Description

Landfills with Limited Control Measures are landfill types that do not meet the description requirements specified in the Landfill with Significant Control Measures section. The permeability, leachate and gas control, and documentation are generally less restrictive. Leachate control may be non-existent or consist of simple collection and drain to local sewer lines. Gases may be vented versus stored, treated and used. Monitoring requirements for these types of landfills are less stringent – requiring less frequent sampling, inspections, and records for a shorter time depending on the local laws and regulations.

Documentation Requirements

The following documentation must be maintained by the facility and must be available for audit:

1. Landfill facility documentation demonstrating the facility is properly permitted and authorised to accept the sludge.
2. Technical information regarding the landfill facility that outlines:
    - » Liner thickness, permeability, and materials of construction;
    - » Description of leachate collection, treatment, and disposal practices;
    - » Description of the leak detection system installed;
    - » Description of the gas collection system and the disposition of collected gas, and;
    - » Description of the monitoring and documentation process for landfill operation.

ZDHC Disposal Pathway E:

Offsite Incineration and/or Building Products Processed at <1000 °C

Description

This ZDHC Disposal Pathway is for sludge sent to offsite incineration operated at temperatures below 1000°C, and sludge utilised in building product manufacturing processes with temperatures below 1000°C. The ash generated by the incineration process must be disposed of using one of the other ZDHC Disposal Pathways. See the description sections of ZDHC Disposal Pathways A and C for more information regarding this Pathway.

Documentation Requirements

The following documentation must be maintained by the facility and must be available for audit:

1. Offsite incineration facility documents or the facility documents for the manufacturing facility demonstrating the facility is properly permitted and authorised to accept the sludge.
2. Technical information document regarding the building products manufacturing facility that further outlines:
    - » Operating temperature and dwell time for the building products; the manufacturing process in which the sludge is used;
    - » Description of the building products being manufactured;
    - » Use of the building products being manufactured;
    - » Percentage of total process mass inputs from the building product represented by the supplier's sludge, and;
    - » Description of the flue gas treatment steps for the process.
3. Technical information regarding the offsite incineration process that outlines:
    - » Incineration temperature, dwell time, percentage of total incinerator throughput represented by the Supplier's sludge;
    - » Flue gas treatment steps;
    - » Use of the heat generated by the incineration process, and;
    - » ZDHC Disposal Pathway utilised for the ash from the incineration process.

ZDHC Disposal Pathway F: Landfills with No Control Measures

Description

This ZDHC Disposal Pathway is for sludge disposed of in landfills constructed with no control measures. Any landfill that has not been designed to contain waste, limit percolation, or control leachates from exposure or entering the environment is considered a landfill with no control measure. This includes dump piles and holes with no lining or packing to limit waste exposure to the ground and/or groundwater. There may be few or no monitoring requirements for these types of landfills. In many cases, these types of landfills are constructed by simply digging a hole and then filling the hole with waste, or it may consist of filling a naturally occurring depression with waste.

Documentation Requirements

The following documentation must be maintained by the facility and must be available for audit:

1. Landfill facility documentation demonstrating the facility is properly permitted and authorised to accept the sludge.

2. Technical information regarding the landfill facility that outlines:
    - » Description of the construction method and design characteristics of the landfill, and;
    - » Description of the monitoring and documentation process for landfill operation.

ZDHC Disposal Pathway G: Land Application

Description

Land application is defined as the application of sludge to approved land areas. The sludge must be of quality determined to benefit the area soil and harmless to public health and the environment. This can be done through spreading, spraying, injection, mixing, etc., on or below the land surface. Sunlight, soil microorganisms, and desiccation assist in destroying remaining pathogens and organic substances. Trace metals existing in the soil matrix and nutrients can benefit plants. The presence of organic matter can improve the biological diversity in the soils and enhance the availability of nutrients to plants. Designated land sites include pasture, forests, reclamation sites, agricultural land, and public parks, street median strips, golf courses, lawns, and home gardens. Since exposure to the environment is guaranteed and the probability of human contact for this sludge management method is high, sludge used for this purpose must meet strict quality, metal, pathogen, and odour standards.

Documentation Requirements

The following documentation must be maintained by the facility and must be available for audit:

1. Documentation for each land application site demonstrating that the site is properly permitted and authorised to accept the sludge
2. The following technical information regarding the land application sites:
    - » Test data and documentation showing that the sites benefit from the application of the sludge;
    - » Documentation showing the approved and actual rate of sludge application;
    - » Description of buffer zones around the land application sites;
    - » Description of the monitoring and documentation process for land application sites, including soil and groundwater monitoring and data;
    - » Description of the use of the sites on which the land application occurs.