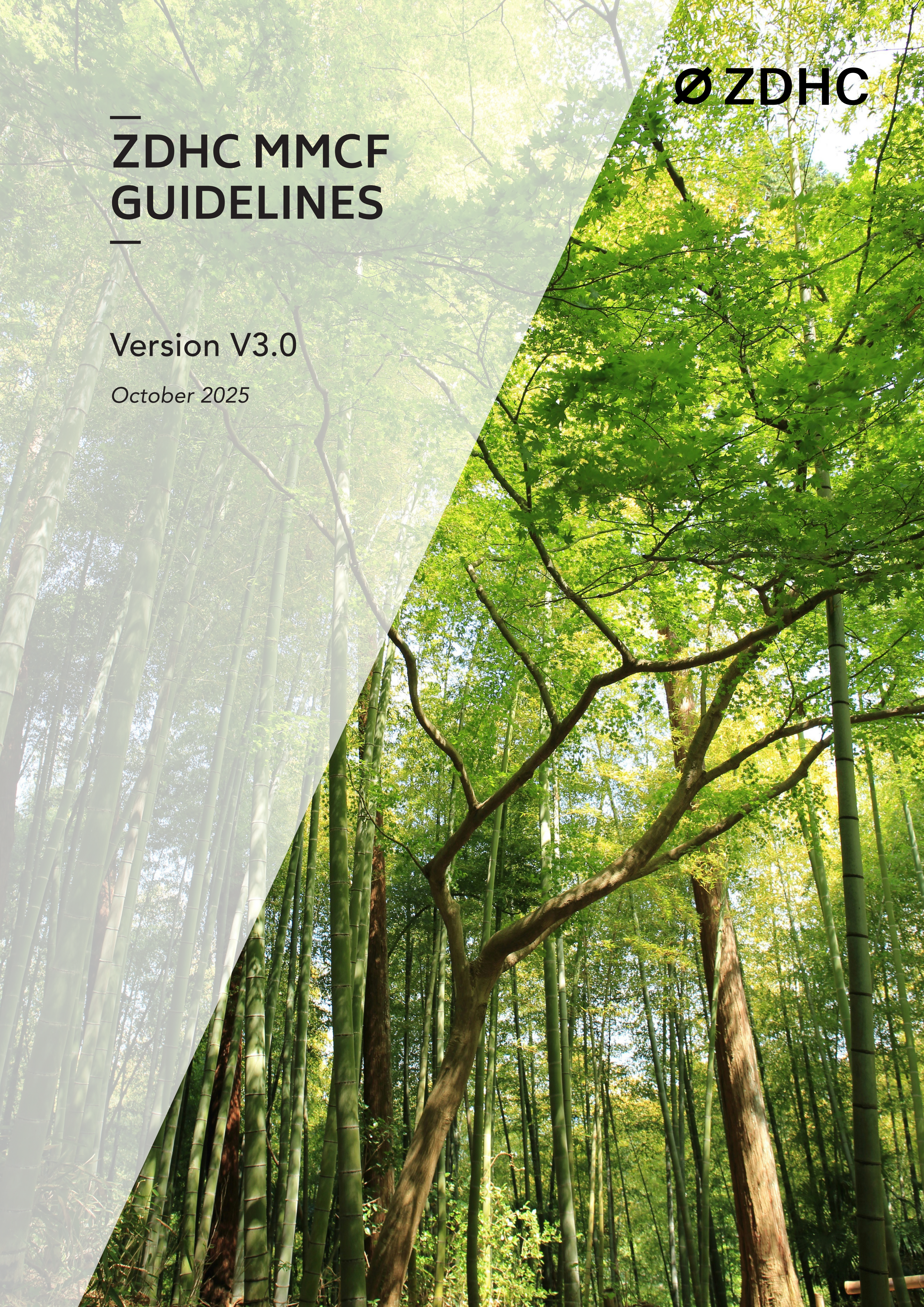

ZDHC

ZDHC MMCF GUIDELINES

Version V3.0

October 2025

NOTES

Any mentions of innovations and/or innovative practices within this document are provided as examples and shouldn't be construed as the only ones available. Organisations are responsible to conduct their own research into all possible solutions to determine the best one for them.

DISCLAIMERS

The ZDHC Foundation (hereinafter "ZDHC") MMCF Guidelines V3.0 is not intended to replace brand-specific requirements for chemical management/waste/wastewater, but to be supportive or complimentary to such requirements.

The information in this ZDHC MMCF Guidelines V3.0 is provided for information only and does not guarantee the following:

a. Compliance with, or take the place of, legal or regulatory requirements. Examples might include: stricter legal, local or regional regulatory requirements on the use, storage and transport of chemical products; or other requirements relating to the handling and disposal of chemical products, which shall supersede any requirements as set forth in this document.

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Revision history

Version Number	Changes	Time of Publication
Version 3.0	**Guidelines Restructuring** Restructuring of guidelines content into three chapters: Input, Process and Output Management to align with the structural approach used across other ZDHC guidelines. ▪ The original Chapter 1: ZDHC MMCF Responsible Fibre Production from V2.2 has been divided between the Input and Process Management chapters. ▪ The content from Chapter 2: ZDHC MMCF Wastewater Guidelines V2.2 and Chapter 3: ZDHC MMCF Air Emissions Guidelines V2.2 has been consolidated under Output Management. ▪ Addition of VSF and Modal as an integrated facility type. **Input Management** ▪ Introduction of requirements for input feedstock. ▪ Integration of best practices for chemical use quantities as requirements at F/P/A levels. **Process management** ▪ Revision of sodium sulphate recovery limits at P/A levels for VSF. ▪ Revision of sodium sulphate recovery limits at F/P/A levels for VFY.	**October 2025**
	Output management ▪ Update in the wastewater parameters table titles from conventional, additional and specific parameters related to MMCF production to a. Conventional and anion b. Heavy metals ▪ CS_2 and APEO parameters removed. ▪ Absolute temperature (in case temperature difference measurement is not possible) and persistent foam included as conventional wastewater parameters. ▪ Aspirational limit for BOD (5-day concentration) updated. ▪ Limit for oil and grease revised across Foundational, Progressive and Aspirational (F/P/A) Levels. ▪ Limit for total phenol / phenol index updated at Aspirational Level. ▪ Sulphate added as a conventional parameter for sample and report only. ▪ Cadmium, chromium (VI), and mercury removed from the list of heavy metals. ▪ Limit for nickel revised. ▪ Sulphate (SO_4^{2-}) also added as load-based wastewater parameter. ▪ Requirement added to report the major sludge disposal pathway. ▪ Requirement added to conduct sludge testing. ▪ Sulphur (S) air emission limits revised. ▪ Introduction of GHG Scope 1 and Scope 2 emissions reporting requirement. ▪ Calculation added for Channelised Sulphur Emission.	

Version 2.2	▪ Revision to the progressive limit value for copper and ammonia recovery for cupro fibre. ▪ Revision to the raw material consumption value for acetone for acetate fibre. ▪ Alignment of wastewater test methods for some parameters to the ZDHC Wastewater Guidelines V2.1. ▪ APEO wastewater limit value changed from Foundational/Progressive/Aspirational categories into a single category of 5 µg/litre. ▪ Removal of the 'Sum of Hydrocarbon' parameter. ▪ Requirements for sludge changed to: MMCF manufacturing facilities should meet local legal regulations. If no such regulation exists, facilities to refer and implement ZDHC requirements for sludge disposal and testing, as mentioned under ZDHC Wastewater Guidelines V2.1 and ZDHC Sludge Reference Document V1.0. ▪ Addition of wastewater discharge types, sample locations and test parameters for MMCF facilities.	**August 2023**
	▪ Addition of acetone air emissions limit values at Foundational/Progressive/Aspirational Level for acetate fibre manufacture. ▪ Revision of ambient air emissions limit value for CS_2, H_2S and NH_3 from foundational/ progressive/ aspirational to a single limit. ▪ Separate tables have been added for air emissions by mass balance calculation and ambient air emissions by direct testing. ▪ CS_2 & H_2S ambient air emissions limits are referred to from the World Health Organisation's Air quality guidelines for Europe, 2nd Edition, 2000, and a reference has been added.	

Version 2.1	▪ Revision in the copper and ammonia recovery (cupro fibre) calculation.	**February 2023**
	▪ Correction in test method for Zn, sulphide, CS_2 (specific parameter) due to a typographical error.	
Version 2.0	▪ Scope expansion to include viscose filament yarn (VFY), lyocell, cuprammonium rayon (cupro) and cellulose acetate (acetate).	**January 2023**
	▪ Guidelines and requirements defined for chemical recovery, wastewater and sludge discharge and air emissions discharge for the fibres included in the expanded scope.	
	▪ Testing of the toxicity of wastewater (which was optional in MMCF Wastewater Guidelines V1.0 for viscose and modal staple fibres) is deleted from the requirements in MMCF Wastewater Guidelines V2.0 for viscose staple fibre and modal staple fibres.	

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List of terms (Abbreviations)

CAP	Corrective Action Plan
CEMS	Continuous Emission Monitoring System
CETP	Central Effluent Treatment Plant
cupro	Cuprammonium rayon
ETP	Effluent treatment plant
GB	Guojia Biaozhun (Chinese required national standard)
GB/T	Guojia Biaozhun/Tuījiàn (Chinese recommended national standard)
GHG	Greenhouse Gas Protocol
HJ/T	Chinese recommended environmental protection standard (Chinese industry standard)
IPE	Institute of Public and Environmental Affairs (Chinese non-governmental organisation)
ISO	International Organization for Standardization
LC	Liquid chromatography
MMCF	Man-made cellulosic fibres
N/A	Not available or not applicable
NMMO	N-methyl-morpholine-n-oxide
RCA	Root Cause Analysis
RL	Reporting limit

SCM	Sustainable Chemical Management
TDS	Total Dissolved Solids
TSS	Total Suspended Solids
VSF	Viscose staple fibre
VFY	Viscose filament yarn
WHO	World Health Organization
WWTP	Wastewater treatment plant
ZLD	Zero liquid discharge

Collaborative process and acknowledgements

The fundamental principle of collaboration at ZDHC was followed in the development of this document. The ZDHC Fibres and Materials Competence Centre and Roadmap to Zero (RtZ) Delivery teams reached out to the former ZDHC MMCF Focus Group, formed in 2018, consisting of Signatory Brands, collaboration organisations and other industry affiliates. Through a series of calls and e-mails with this focus group, ZDHC gathered and collated inputs on the updates from August 2023 until May 2025. A draft of the guidelines document was prepared by the Fibres and Materials Competence Centre and reviewed by the focus group members and the ZDHC internal team. Their comments and suggestions were incorporated into the draft, which was sent to all ZDHC Signatories for an additional review period of three weeks.

We acknowledge and thank the contribution of the focus group members for their assistance in the development of this document. For a full list of acknowledgements, please see the end of this document.

Introduction

Background

ZDHC is a global multi-stakeholder organisation/initiative that oversees the implementation of its Roadmap to Zero Programme with a Signatory Community of over 380 organisations from the textile, apparel, leather and footwear industry.

Our vision is to create a world where better chemistry leads to the protection of life, land, air and water, and our Signatories are vital in driving collective progress.

The Roadmap to Zero Programme, by ZDHC, leads the fashion industry to eliminate harmful chemicals from its global value chain by building the foundation for more sustainable manufacturing to protect workers, consumers and our planet's ecosystems.

To address the use and discharge of hazardous chemicals in man-made cellulosic fibre (MMCF) manufacturing, ZDHC published the ZDHC MMCF Guidelines V1.0 in April 2020. These guidelines were focused on the viscose staple fibre manufacturing sector. In version 2.2, the scope of these guidelines was expanded to other fibre categories in the MMCF sector, such as lyocell, viscose filament yarn (VFY), cuprammonium rayon (cupro) and cellulose acetate (acetate). A collaborative and aligned approach to these fibres would generate cleaner outputs from production while including a circular approach to their processes.

The ZDHC MMCF Guidelines V3.0 have been restructured to align with the ZDHC framework of input, process and output management, bringing consistency across sectors. One of the key updates includes the revision of sulphur (S) air emission limits to align with the EU Best Available Techniques (BAT) requirements. The guidelines now also require sludge testing and reporting of disposal pathways. Wastewater parameters have been revised to better align with the general ZDHC Wastewater and Sludge Guidelines for textile, leather and footwear sectors. Additionally, now facilities are expected to report Scope 1 and Scope 2 GHG, promoting greater environmental transparency and accountability.

Objective

The ZDHC MMCF Guidelines V3.0 addresses integrated expectations for feedstock sourcing, input chemical management, chemical recovery, discharged wastewater, sludge disposal and air quality for manufacturing facilities producing man-made cellulosic fibres. The guidelines cover:

1. Input management (Chapter 1)
2. Process management (Chapter 2)
3. Output management (Chapter 3)

The three sections (above) of the ZDHC MMCF Guidelines V3.0 provide guidance for an aligned industry approach, and should be implemented as one. Outputs from the production process of fibres cannot be seen as a stand-alone, and these three chapters provide guidance for an aligned industry approach. With this content, ZDHC expects to support the transition of MMCF production towards a safer, more circular and transparent system by proposing input feedstock and input chemical management, recovery of key chemicals such as sulphur, sodium sulphate, NMMO, ammonia, copper and acetone and output management where ZDHC appeals to its Committed Community and the entire MMCF industry to improve the quality of discharged industrial wastewater and production-related air emissions.

ZDHC hopes to define milestones through a roadmap for fibre manufacturing facilities advancing towards the production described in the EU BAT BREF Reference Document on Best Available Techniques for the Production of Polymers (EU BREF POL) and Best Available Techniques (BAT) Reference Document for Common Waste Gas Management and Treatment Systems in the Chemical Sector (**BAT WGC – BREF 2023**). Aiming to prevent and control pollution arising from production, which will lead to a high level of environmental protection.[a]

This document does not cover requirements for the processes of converting wood into dissolving pulp for MMCF fibres, as this is addressed separately in the ZDHC Dissolved Pulp Guidelines V1.0.

a (European Commission – IPPC Bureau 2007) https://ec.europa.eu/commission/presscorner/detail/fr/MEMO_07_441

As manufacturing facilities are not identical in terms of capabilities, knowledge, strategic priorities, or resources, this document provides a three-level approach for the requirements of the proposed parameters. The levels get more stringent to promote continuous improvement as they move from Foundational to Progressive to Aspirational. We encourage suppliers to continuously improve their impact on the environment and human health. Manufacturing facilities shall proactively develop and manage a data-driven, continuous improvement plan to achieve the requirements of each level.

To learn more about the continuous improvement roadmap, see ZDHC MMCF Guidelines Implementation Approach V3.0.

Scope

These guidelines apply to the production of man-made cellulosic fibres (MMCF) using dissolved pulp as the input material. Specifically, they cover the following fibre types:

- Viscose staple fibres (VSF)
- Modal staple fibres
- Viscose filament yarn (VFY)
- Lyocell
- Cuprammonium rayon (cupro)
- Cellulose acetate (acetate)

The requirements outlined in this document apply to facilities directly engaged in MMCF production, regardless of their scale or geographic location. Facilities solely involved in the upstream conversion of wood to dissolved pulp are **not** covered under these guidelines and should refer to the **ZDHC Dissolved Pulp Guidelines V1.0** for applicable requirements.

Note: *Dissolved Pulp is also referred in the industry as Dissolving Grade (DG) Pulp*

Connectivity

The ZDHC MMCF Guidelines V3.0 are part of a series of guidelines and solutions from ZDHC to drive positive change in the industry towards sustainable chemical management. MMCF and filament manufacturing facilities are expected to comply with the solutions applicable to them, considering the type of processes conducted in the facility.

This guidelines document should be read in connection with the following:

- ZDHC Dissolved Pulp Guidelines V1.0
- ZDHC Wastewater and Sludge Laboratory Sampling and Analysis Plan (SAP) V3.0
- ZDHC Air Emissions Guidelines V1
- Suppliers Roadmap to Zero - Wastewater and Sludge Chapter V2

Table 1: Summary of requirements in the MMCF Guidelines V3.0

Chapter	Fibres	Requirements
Input management	All MMCF fibres	**Input feedstock management** ▪ Integrate the ZDHC Dissolved Pulp Guidelines V1.0 into the policy for sourcing feedstock from pulp suppliers*. ▪ Initiate communication with dissolved pulp suppliers to raise awareness about the guidelines and encourage them to participate in the ZDHC Dissolved Pulp Module on the Supplier Platform. ▪ Conduct a Canopy-style audit and show preference for FSC/PEFC certified inputs. **Input chemical management** ▪ Monitor and record the monthly average chemical consumption per unit of fibre. ▪ Chemicals consumption for MMCF per tonne of fibre or filament is within recommended ranges.
Process management	VSF/ VSF & modal	Sulphur recovery (%) Sodium sulphate recovery (%)
	VFY	Sodium sulphate recovery (%)
	Lyocell	NMMO recovery (%)
	Cupro	Copper, ammonia recovery (%)
	Acetate	Acetone recovery (%)

Output management	All MMCF fibres	**Wastewater discharge** ▪ Test wastewater for conventional parameters and heavy metals twice a year (April and October cycles). ▪ Undertake a Root Cause Analysis (RCA) for any non-conformities detected and implement a Corrective Action Plan (CAP). ▪ Calculate and report load-based wastewater parameters.
	All MMCF fibres	**Sludge testing and disposal** ▪ Report the major sludge disposal pathway utilised by filling out the ZDHC sludge documentation template. ▪ Maintain information and records of the major sludge disposal pathway. ▪ Confirm that requirements for the major disposal pathway are met through detection of metals and other applicable conventional parameters.
		Air emissions
	VSF/ VSF & modal	▪ Calculate and report sulphur air emissions through mass balance calculation. ▪ Test and report ambient air emission for CS_2 and H_2S through an appropriate ISO 17025 certified lab, or report using air dispersion modelling. ▪ Report GHG Scope 1 & Scope 2 emissions.
	Lyocell	▪ Report GHG Scope 1 & Scope 2 emissions.
	VFY	▪ Test and report ambient air emission for CS_2 and H_2S through an appropriate ISO 17025 certified lab, or report using air dispersion modelling. ▪ Report GHG Scope 1 & Scope 2 emissions.

	Cupro	▪ Test and report ambient air emission for NH_3 through an appropriate ISO 17025 certified lab, or report using air dispersion modelling. ▪ Report GHG Scope 1 & Scope 2 emissions.
	Acetate	▪ Calculate and report acetone air emissions through mass balance calculation. ▪ Report GHG Scope 1 & Scope 2 emissions.

Note*: VSF/ VSF & modal: Here, VSF indicates a standalone VSF facility, and VSF & modal indicate a combined facility producing viscose and modal staple fibre.*

Chapter 1: Input management

Input management focuses on the responsible sourcing and management of feedstock and the input chemicals used to manufacture MMCF.

This document focuses on two input management areas:

- **Input feedstock management**
  - Use of responsibly manufactured dissolved pulp
  - Best practices for input feedstock consumption
  - Feedstock traceability
- **Input chemicals management**
  - Best practices for input chemical consumption

1.1 Input feedstock management

The selection of feedstock for the production of MMCF can have a great impact on the environment. The growth in market share of these fibres shows the need to establish clear policies related to the input feedstock. The following subsections contain the requirements that organisations should implement.

Requirements for input feedstock management

- Integrate the ZDHC Dissolved Pulp Guidelines V1.0 into the policy for sourcing feedstock from pulp suppliers.
- Initiate communication with dissolved pulp suppliers to raise awareness about the guidelines and encourage them to participate in the ZDHC Dissolved Pulp Module on the Supplier Platform.
- Conduct a Canopy-style audit and show preference for FSC/PEFC certified inputs.

Note*: The above requirements do not apply to cupro manufacturers as they use cotton linters as a feedstock.*

1.1.1 Responsible sourcing of raw material*

Organisations shall have a responsible raw material sourcing policy mentioning that sourcing wood, dissolved pulp and/or cellulose fibre is not from ancient and endangered forests, endangered species habitats and other controversial sources. To promote responsible chemical management and transparency throughout the MMCF supply chain, MMCF manufacturing facilities are expected to strengthen their dissolved pulp sourcing practices in alignment with the ZDHC Dissolved Pulp Guidelines (Version V1.0).

1. To support this policy, organisations should:
   A. Engage with dissolved pulp suppliers to raise awareness about the ZDHC Dissolved Pulp Guidelines and encourage them to implement the guidelines and to participate in the ZDHC Dissolved Pulp Module on the ZDHC Supplier Platform.
   B. Conduct a Canopy-style verification audit to assess the risk of sourcing from ancient and endangered forests and other controversial sources. And include a preference for Forest Stewardship Council (FSC) or Programme for the Endorsement of Forest Certification (PEFC) certified inputs.

*This does not apply to cupro manufacturers as they use cotton linters as a feedstock.

2. To ensure transparency throughout the value chain, organisations should have a proper chain of custody system that includes, but is not limited to, blockchain-based traceability or use of Unique Trace.

1.1.2 Circularity and recycled feedstock

To reduce the environmental impact of MMCF production, it is imperative to incentivise new developments that lead to the creation of a product fit for purpose within a circular economy.

Brands and manufacturing facilities should work to reduce the input of virgin raw materials by increasing the amount of alternative fibre feedstock. This includes, but is not limited to, pre- and post-consumer fibre waste and agricultural waste.

A. Organisations should have a sourcing strategy that includes commitments to increase the percentage of raw material originating from next-generation feedstock.[a] This strategy should clearly define the feedstock used, as well as appropriate targets and timelines for adopting materials originating from next-generation feedstock.

B. To support the use of recycled feedstock, organisations should take part in a certification programme that includes but is not limited to, Textile Exchange's RCS (Recycled Claim Standard) or GRS (Global Recycled Standard) or their latest standard, ISCC (International Sustainability & Carbon Certification) etc.

1.1.3 Best practices for dissolved pulp consumption

Monitor and record the monthly average pulp consumption per unit of fibre and compare it with the reference ranges in Table 2.

a ZDHC refers to next-generation feedstock as one that originates from alternatives and recycled feedstock.

Table 2: Recommended feedstock consumption for MMCF per tonne of fibre or filament

Parameter	Unit	Recommended Consumption				
		VSF/ VSF & Modal	VFY	Lyocell	Cupro	Acetate
Dissolved pulp/pulp	t/tonne of fibre or filament	1.010 – 1.065	1 – 1.2	1.01 – 1.065	1 – 1.1	1.01 – 1.065

1.2 Input chemicals management

Requirements for Input chemicals management

Manufacturing facilities should calculate their annual consumption of input chemicals based on the average of fibre production per site. The minimum average accepted is no shorter than one month.

Table 3: Requirements for input chemical management

Levels	Requirement	Focus
Foundational	Monitor and record average chemical consumption per unit of fibre.	Establishing a baseline for chemical consumption
Progressive	Continue monitoring of average chemical consumption per unit of fibre, calculate annual chemical consumption and compare it with the reference ranges in Table 4.	Progressing towards data tracking
Aspirational	Monitor, record, and continuously optimise chemical consumption per unit of fibre. Annual chemical consumption stays within the recommended reference ranges in Table 4.	Continuous optimisation to be within recommended ranges

1.2.1 Recommended input chemical consumption

The parameters listed below are defined as the amount of input chemicals required to produce one tonne of fibre or filament. To understand more about the production process and efficiency, it is essential to have a complete overview of the input chemicals' average consumption. Facilities shall monitor and continually optimise their chemical consumption to uphold process efficiency, minimise environmental impact and demonstrate the implementation of sustainable chemical management practices.

Table 4: Recommended chemical consumption for MMCF per tonne of fibre or filament

Parameter	Unit	Recommended Consumption				
		VSF/ VSF & Modal[a]	VFY[c]	Lyocell	Cupro[d]	Acetate
CS_2	kg/tonne of fibre or filament	80 – 100	250 – 300	N/A	N/A	N/A
NMMO (100%)		N/A	N/A	12 – 30	N/A	N/A
Ammonia		N/A	N/A	N/A	250 – 500	N/A
Copper sulphide		N/A	N/A	N/A	5 – 30	N/A
Zn		2 – 10	10 – 20	N/A	N/A	N/A
Spin finish		3 – 5.3	10 – 25	3 – 5.3	12 – 25	3 – 5.3
NaOCl[b]		0 – 70	0 – 50	0 – 90	5 – 40	N/A
Acetone		N/A	N/A	N/A	N/A	2 – 3
Acetic acid	t/tonne of fibre or filament	N/A	N/A	N/A	N/A	1 – 4
Acetic anhydride		N/A	N/A	N/A	N/A	0.5 – 3
Caustic		0.45 – 0.60	0.60 – 0.80	N/A	0.25 – 0.50	N/A
H_2SO_4		0.65 – 1.03	0.9 –1.1	N/A	1.5 – 2.0	0.03 – 0.09

a The applicability of this table for modal staple fibre production shall only be for sites with mixed production of viscose and modal fibres. This table does not apply to facilities with production of modal without viscose production. While ZDHC recognises the importance of energy and water consumption during the production process, the inclusion of these parameters in this document will require further data collection and analysis.

b NaOCl consumption is reported normalised to available chlorine (AvCl2 -15%).

c CS_2 consumption figures are based on the weighted average of different technologies and are limited to standalone VFY sites.

d Consumption calculations for cupro include the linter purification process up to the spinning process.

Chapter 2: Process management

This section sets requirements for MMCF manufacturing facilities to ensure that chemicals used in manufacturing are managed responsibly by recycling.

Requirements for chemical recovery

MMCF facilities should implement chemical recovery processes and initiate the following actions under process management.

- Maintain a detailed record of chemical recovery activities and calculations based on the type of MMCF fibre.
- Meet the chemical recovery requirement, as applicable from Tables 5-10.
- Report chemical recovery data as a yearly average of the calendar year (from 1 January to 31 December) on a ZDHC platform to evaluate against the limit values specified below.

2.1 Viscose and modal (staple fibres) - chemical recovery

During the viscose and modal (staple fibre) production process, sulphur compounds from the spin bath and by-products, sodium sulphate, should be recovered and either returned to the on-site production processes or sold as by-products. Control technologies and recovery treatments should be applied to achieve the recommended recovery percentage of these chemicals (sulphur and sodium sulphate) as listed in this document.

Sulphur recovery – treatment methods and control technologies

The sulphur recovery treatment methods mainly include:

- CS_2 recovery from spinning off-gases by a condensation route.
- CS_2 recovery by activated carbon adsorption from exhaust gases of spinning and spin bath, coupled with either of the following upstream processes to remove H_2S:

  a) Recovery as sulphur by a catalytic redox process.

  b) Recovery as $NaHS+Na_2S$ is produced by caustic scrubbing.
- Conversion of both CS_2 & H_2S to sulphuric acid by a catalytic process.

There are various sulphur recovery technologies available within viscose and modal production. The control technology applied at the point of fibre production depends on many conditions, including:

- Year of establishment of the plant and the technology used
- National regulations
- Best available technologies

Recovery technologies within viscose and modal (staple fibres) production are specified in the Best Available Techniques for Polymer Production applicable to viscose and modal staple fibres (EU BAT BREF POL). In addition, there are several other technologies that have been applied in viscose processes in recent years to improve their natural resource efficiency.

2.1.1 Sulphur recovery rates

Table 5: Correlation of sulphur air emissions (kg/tonne of fibre) and the corresponding % sulphur recovery rates calculated based on the CS_2 charged in feed

ZDHC Levels	Sulphur Air Emissions (Kg/Tonne Of Fibre)[a,c]	Corresponding % Sulphur Recovery[b, c]
Foundational	20	85%
Progressive	12	92%
Aspirational	09	95%

a Same limit values are mentioned under Section 3.3 Air Emissions of this guidelines document, Table 19: Air emissions (calculated using mass balance).

b Based on mass balance calculation explained under Appendix B, Table 21 - Mass balance of sulphur or acetone flows.

c Sulphur air emissions (kg/tonne of fibre) and corresponding % sulphur recovery values mentioned in the table are calculated considering CS_2 addition per unit product of 280kg/tonne by using sulphur mass balance method.

Note: *The aspirational target of 9 kg/tonne of sulphur should be met either through mass balance calculation or by measuring channelled emissions (the sum of H_2S and CS_2, expressed as total sulphur).*

Note: *CS_2 charged in the feed for viscose production is recovered either as CS_2 or other sulphur-containing chemicals by various technologies (O1-O6). Therefore, to simplify the mass balance recovery calculation, both CS_2 added and CS_2 recovered are converted into sulphur, and therefore chemical recovery is reported as % sulphur recovery and not as CS_2 recovery.*

2.1.2 Sodium sulphate recovery rates

During viscose staple fibre and viscose filament yarn production, sodium sulphate is recovered as a by-product from the spin bath.

Table 6: Sodium sulphate recovery rates (VSF)

ZDHC Levels	Sodium Sulphate Recovery (%)
Foundational	50
Progressive	55
Aspirational[d]	60

Calculation of sodium sulphate recovery[e]

$$\text{Sodium sulphate recovery (\%)} = \frac{\text{quantity of sodium sulphate produced as by-product (tonne)}}{\text{viscose or modal fibres produced (tonne)}} \times 100$$

d A higher rate of recovery for Aspirational Level is theoretically achievable, but such higher levels will require increased input of energy and steam, which can lead to increased GHG emissions, creating additional environmental pollution.

e To support the reporting of this parameter, facilities should provide information about by-products produced including, but not limited to, sodium sulphate, H_2SO_4, barium sulphate, etc. on MMCF Module (ZDHC Supplier Platform).

2.2 Viscose filament yarn (VFY) - chemical recovery

There is no proven technology for CS_2 recovery from waste gases generated in viscose filament yarn manufacturing, either in spool spun yarn (SSY), continuous spun yarn (CSY) or pot spun yarn (PSY). Theoretically, recovery is feasible in SSY via technical treatment and some facilities are equipped with related equipment, but the proportion of CS_2 generated is not high. This means that all CS_2 inputs need to be treated or discharged rather than recycled in VFY production.

Table 7: Sodium sulphate recovery rates (VFY)

ZDHC Levels	Sodium Sulphate Recovery (%)
Foundational	50
Progressive	55
Aspirational	60

Note: *In the case of VFY, CSY (continuous spinning yarn) production will be exempted from SS recovery requirements, in accordance with the Indian regulatory notification dated 30 January 2024.*

Calculation of sodium sulphate recovery[e]

$$\text{Sodium sulphate recovery (\%)} = \frac{\text{quantity of sodium sulphate produced as by-product (tonne)}}{\text{VFY produced (tonne)}} \times 100$$

e To support the reporting of this parameter, facilities should provide information about by-products produced, including, but not limited to, sodium sulphate, H_2SO_4, barium sulphate, etc. on MMCF Module (ZDHC Supplier Platform).

2.3. Lyocell - chemical recovery

The core part of the lyocell process is the direct dissolution of cellulose through NMMO (N-methyl-morpholine-n-oxide). The solvent, NMMO, is able to dissolve cellulose physically without any chemical pretreatment. The important environmental issue in lyocell production is the recovery of NMMO. During the production of lyocell, after washing out residual NMMO, spin finish is applied, and the fibre is dried and packed.

NMMO recovery – treatment methods and control technologies

NMMO is recovered through a multi-stage cleaning process, including filtration, purification (ionic exchange) and evaporation.

NMMO (in certain concentrations) can be recovered at a very high recovery rate. Meanwhile, water that is regained during the evaporation step is recycled back into the washing section of the fibre line.

Table 8: NMMO recovery rates

ZDHC Levels	NMMO Recovery (%)
Foundational	99.5
Progressive	99.7
Aspirational	99.8

Calculation of NMMO recovery

Recovery rate of NMMO (%) = [1- (NMMO loss / NMMO consumption)] x100

NMMO loss = NMMO in wastewater to WWTP + NMMO remaining on product + NMMO remaining on waste

NMMO consumption = NMMO fresh input + NMMO recovered and recycled

Alternatively, this could also be calculated through mass balance:

Recovery rate of NMMO = (1- (NMMO net input / NMMO consumption)) %

Because in the process NMMO is present in different concentrations, for the calculation, all concentrations must be converted to 100%.

2.4. Cupro - chemical recovery

During cupro production, copper and ammonia are used as cellulose solvents and are recovered by a closed-loop process. Copper and ammonia discharged in wastewater are recovered using various wastewater treatment technologies. In addition, some ammonia escapes into the atmosphere as a gas and is recovered by scrubbing techniques and then transferred to the wastewater.

Copper and ammonia recovery – treatment methods and control technologies

During the production of cupro, copper and ammonia in the wastewater are recovered by a multi-stage process.

- Copper is recovered mainly by sedimentation separation and ion exchange.
- Ammonia is recovered mainly by distillation and ion exchange.

Ammonia gas that escapes is captured by a wet scrubber, and the captured ammonia is recovered through the wastewater treatment process described above.

The recovered chemicals are reused in the spinning dope production process.

Table 9: Copper and ammonia recovery rates

ZDHC Levels	Ammonia Recovery (%)	Copper Recovery (%)
Foundational	40	98.0
Progressive	42	99.0
Aspirational	44	99.5

Calculation of ammonia and copper recovery is done as mentioned below.

$$\text{Ammonia recovery (\%)} = \frac{\text{ammonia recovered \& recycled}}{\text{ammonia recovered \& recycled + ammonia fresh input}} \times 100$$

$$\text{Copper recovery (\%)} = \frac{\text{total copper used - copper fresh input}}{\text{total copper used}} \times 100$$

Note: *Since ammonia is recovered as an aqueous solution, the total amount of ammonia recovered can be directly determined. Copper, on the other hand, is recovered as slurry, making it difficult to directly determine the total amount of copper recovered. However, the total used copper can be determined from the total amount of produced spinning dope and its concentration. Therefore, the recovered copper can be determined by subtracting fresh input from the total used copper.*

2.5. Acetate - chemical recovery

During the production of acetate fibre, acetone solvent (which is non-toxic but can cause serious eye irritation, drowsiness and dizziness) is recovered by a closed-loop process. Scrubbers can be used to recover acetone during all the production processes even though acetone is a very highly volatile solvent and easily escapes to the environment.

Acetone recovery – treatment methods and control technologies

- The distillation process of acetone-water mixture and the re-use of the regenerated solvent in the process.
- Capturing any possible escaped acetone vapours through charcoal filters and recycling and regenerating them back into the system.

Table 10: Acetone recovery rates

ZDHC Levels	Acetone Recovery (%)
Foundational	93
Progressive	95
Aspirational	98

Calculation of acetone recovery is done by mass balance.[f]

$$\text{Where fresh acetone input} = \text{(opening stock as per inventory + purchase) - closing stock}$$

$$\text{Recovery (\%) of acetone} = \frac{\text{(total acetone used) - (fresh acetone input)}}{\text{(total acetone used)}} \times 100$$

f Acetone recovery is based on mass balance calculation explained under Section 3.3 Air Emissions of this guidelines Appendix B-Table 21 Mass balance of sulphur or acetone flows).

Chapter 3: Output management

Output management focuses on ensuring that the environmental impacts of the MMCF manufacturing processes are monitored and continuously improved. It includes wastewater, sludge and air emissions management that ensures the effective identification, monitoring and control of pollutants throughout MMCF production processes.

It contributes to cleaner water systems, reduces environmental impact and supports the transition to more sustainable and responsible manufacturing.

Output management covers:

1. **Wastewater discharge**
2. **Sludge testing and disposal**
3. **Air emissions**

3.1 Wastewater discharge

Requirements for wastewater discharge

Suppliers should meet the following requirements:

1. Facilities are expected to meet local regulations for wastewater parameters mandated by local legal authorities to ensure that their wastewater discharged to the receiving environment does not compromise the quality of the receiving environment.
2. Perform wastewater testing twice a year, i.e. during the October and April cycles.
3. Generate a ClearStream Report for every wastewater testing cycle.
4. Wastewater testing
    a. Direct discharge:
        - Meet, at a minimum, wastewater foundational limits for all conventional parameters and anions (Table 11) for direct discharge facilities.
        - Meet, at a minimum, wastewater foundational limits for all heavy metals (Table 12) for direct discharge facilities.
        - Calculate load-based wastewater parameters mentioned in Table 15 and report to the ZDHC platform along with the reference data used for calculation. The reported value should be the yearly average.

    b. Indirect discharge:
        - Sample and report heavy metals mentioned in Table 12.

    c. ZLD
        - No wastewater testing.
5. In case of non-conformities in the ClearStream Report, suppliers should perform an RCA and upload a CAP in their ZDHC Gateway supplier account.

Note: *Wastewater testing and conformance requirements for MMCF facilities do not depend on the volume of wastewater generated. Even if generated wastewater is less than 15m^3 per day, all parameters mentioned under Tables 11 and 12 are applicable for a MMCF facility.*

Note: *Wastewater discharge types and sample locations are described under Appendix A.*

3.1.1 ZDHC conventional parameters and anions for wastewater

Conventional parameters have traditionally been used by global legislation to describe and regulate wastewater quality.

ZDHC has created a three-level approach to the limits for conventional parameters to promote continuous improvement. The limits become more stringent as they move from Foundational, Progressive to Aspirational Levels.

We encourage suppliers to strive for continuous improvement in their impact on the environment and human health. This can be achieved by proactively developing and managing data-driven, continuous improvement plans addressing chemicals management systems and output control.

These guidelines recommend methods for analysis and testing based on internationally recognised standard water and wastewater testing methodologies, as well as government-recognised testing requirements in the European Union, the United States of America, China and India. Equivalent methods can be used if approved by ZDHC.

Table 11: ZDHC conventional parameters and anions for wastewater

Substance/ Parameter	Unit	VSF/ VSF & Modal			VSF/Lyocell			Lyocell			VFY			Cupro			Acetate			Test Method
		Limit Value			Limit Value			Limit Value			Limit Value			Limit Value			Limit Value			
		Foundational	Progressive	Aspirational	Foundational	Progressive	Aspirational	Foundational	Progressive	Aspirational	Foundational	Progressive	Aspirational	Foundational	Progressive	Aspirational	Foundational	Progressive	Aspirational	
pH	pH	6-9			6-9			6-9			6-9			6-9			6-9			ISO 10523 USEPA 150.1 SM 4500-H+ HJ1147 IS 3025 (Part 11) Electrometric method only
Temperature difference*	°C	Δ+15	Δ+10	Δ+5	Δ+15	Δ+10	Δ+5	Δ+15	Δ+10	Δ+5	Δ+15	Δ+10	Δ+5	Δ+15	Δ+10	Δ+5	Δ+15	Δ+10	Δ+5	DIN 38 404-4 USEPA 170.1 SM 2550 GB/T 13195 IS 3025 (Part 9)
Absolute temperature	°C	40°C	37°C	35°C	40°C	37°C	35°C	40°C	37°C	35°C	40°C	37°C	35°C	40°C	37°C	35°C	40°C	37°C	35°C	DIN 38 404-4 USEPA 170.1 SM 2550 GB/T 13195 IS 3025 (Part 9)
Colour (436nm; 525nm; 620nm)	m-1	7;5;3	5;3;2	4;2;1	7;5;3	5;3;2	4;2;1	7;5;3	5;3;2	4;2;1	7;5;3	5;3;2	4;2;1	7;5;3	5;3;2	4;2;1	7;5;3	5;3;2	4;2;1	ISO 7887-B
Persistent foam	Absent / present	No indication of persistent foam in receiving water																		NA
Ammonium-Nitrogen	mg/L	5	3	1	5	3	1	5	3	1	5	3	1	75	65	15	5	3	1	ISO 11732 ISO 7150 USEPA 350.1 USEPA 350.3 SM 4500 NH3 - D, E, F, G, or H HJ 535 IS 3025 (Part 34) phenate or ammonia selective
AOX	mg/L	5.0	2.0	0.2	5.0	2.0	0.2	5.0	2.0	0.2	5.0	2.0	0.2	5.0	2.0	0.2	5.0	2.0	0.2	ISO 9562 US EPA 1650 HJ/T 83-2001
BOD 5-day concentration	mg/L	30	15	8	30	15	8	30	15	8	60	40	30	30	15	8	30	15	8	ISO 5815-1 USEPA 405.1 SM 5210-B HJ 505 IS 3035 (Part 44) seeded dilution water (BOD5)
COD discharge to sea	mg/L	150	100	60	150	100	60	300	200	120	200	150	100	150	100	60	150	100	60	ISO 6060 ISO 15705 USEPA 410.4 SM 5220-D HJ 828 GB/T 11914e IS 3025 (Part 58)e
COD discharge to other bodies of water	mg/L	120	100	60	120	100	60	240	200	120	120	100	80	120	100	60	120	100	60	ISO 6060 ISO 15705 USEPA 410.4 SM 5220-D HJ 828 GB/T 11914e IS 3025 (Part 58)e
Oil and grease	mg/L	10	2	0.5	10	2	0.5	10	2	0.5	10	2	0.5	10	2	0.5	10	2	0.5	ISO 9377-2 SM 5520-B/C USEPA 1664-revision B HJ 637 (total oil and grease) IS 3025 (Part 39) partition gravimetric or partition Infra-red

Substance/ Parameter	Unit	VSF/ VSF & Modal			VSF/Lyocell			Lyocell			VFY			Cupro			Acetate			Test Method
		Limit Value			Limit Value			Limit Value			Limit Value			Limit Value			Limit Value			
		Foundational	Progressive	Aspirational	Foundational	Progressive	Aspirational	Foundational	Progressive	Aspirational	Foundational	Progressive	Aspirational	Foundational	Progressive	Aspirational	Foundational	Progressive	Aspirational	
Total Phenol/ Phenol Index	mg/L	1.0	0.5	0.001	1.0	0.5	0.001	1.0	0.5	0.001	1.0	0.5	0.001	1.0	0.5	0.001	1.0	0.5	0.001	ISO 6439 SM 5530-B/C HJ 503 must meet required reporting limit IS 3025 (Part 43)
Total Nitrogen	mg/L	30	25	20	30	25	20	30	25	20	30	25	20	80	70	20	30	25	20	ISO 11905 - Part 1 ISO 29441 USEPA 351.2 SM 4500P-J SM 4500N-B SM 4500N-C HJ 636 IS 3025 (Part 34) measure and total all forms of nitrogen (ammonia,nitrate, nitrite, organic)
Total Phosphorus	mg/L	3.0	1.0	0.5	3.0	1.0	0.5	3.0	1.0	0.5	3.0	1.0	0.5	3.0	1.0	0.5	3.0	1.0	0.5	ISO 17294 ISO 11885 ISO 6878 USEPA 365.4 SM 4500P-J USEPA 200.7 USEPA 200.8 USEPA 6010C USEPA 6020A GB/T 11893 IS 3025 (Part 31) IS 3025 (Part 65)
Total Suspended Solids (TSS)	mg/L	70	50	30	70	50	30	70	50	30	70	50	30	70	50	30	70	50	30	ISO 11923 USEPA 160.2 SM 2540D GB/T 11901 IS 3025 (Part 17) 103°C to 105°C
Sulphate	mg/L	Sample and Report only			Sample and Report only			Sample and Report only			Sample and Report only			Sample and Report only			Sample and Report only			ISO 10304-1 ISO 15923-1 SM 4500 SO4, E, F, G SM 4100 B, C USEPA 300 USEPA 9038 IS 3025 (Part 24) HJ 84-2016
Sulphide	mg/L	2.0	1.0	0.5	2.0	1.0	0.5	NA	NA	NA	5.0	3.0	2.0	NA	NA	NA	NA	NA	NA	ISO 10530 SM 4500-S2-D, E,G,or I HJ 1226-2021 IS 3025 (Part 29) Methylene blue only

Footnote for Temperature Difference and Absolute Temperature: Take the temperature of the discharged wastewater and the receiving body of water upstream. The temperature of the receiving body is subtracted from the temperature of the discharged wastewater to give the delta temperature difference, which can be a positive or a negative value. The discharge limits only refer to a positive value, which produces an overall increase in the temperature of the receiving body of water.
This parameter is measured on-site by the sampler and is applicable only for direct discharge.
There may be situations where the sampler is not able to measure the temperature of the receiving body. These situations may include:

- The receiving body may be several kilometres away from the point of discharge, and the facility is discharging the effluent into the receiving body through a pipeline.
- Accessing the location of the receiving body to measure its temperature can be risky in terms of injury to the sampler or damage to equipment.
- The effluent is discharged directly into the ground.

In all such cases where access to the receiving body is not possible or unsafe, the laboratory should report this parameter as "Not Applicable" and then proceed to check Absolute Temperature.

Footnote for Persistent foam: Foam is a naturally occurring phenomenon in aeration basins in which biological wastewater treatment occurs. Samplers should include photographs of the foam they witnessed in the final lab report, along with the time and date of taking such photos. The foam colour should be similar to the liquid in the aeration basin, should dissipate quickly and should be contained within the aeration basin. For direct discharge facilities, samplers should check for persistent foam on the surface of receiving waters at the point of discharge, and the presence or absence of foam should be noted. This should be checked at the same location used for sampling the temperature difference.
This test is to be done on-site by the sampler.
In case the receiving body is not accessible or risky to access for the sampler, a visual estimation of the foam in the aeration basin should be done. If the foam is higher than 45 centimetres in height (by visual estimation), then it could result in permanent foam being discharged onto the surface of receiving waters and should be reported as 'fail' for the foam parameter.

Footnote for COD: The COD discharge destination—whether to the sea or to other water bodies—must be clearly specified and reported by the sampler/ Laboratory. This distinction should be confirmed during the wastewater sampling, and limits apply accordingly based on the discharge location.

3.1.2 ZDHC heavy metals wastewater parameters

ZDHC has created a three-level approach to the limits for heavy metals to promote continuous improvement. The limits become more stringent as they move from Foundational and Progressive, to Aspirational Levels.

We encourage suppliers to strive for continuous improvement in their impact on the environment and human health.

Test Methods

These guidelines recommend methods for analysis and testing based on internationally recognised standard water and wastewater testing methodologies, as well as government-recognised testing requirements in the European Union, the United States of America, China and India. Equivalent methods can be used only if approved by ZDHC.

Table 12: ZDHC heavy metals wastewater parameters

		VSF/ VSF & Modal			VSF/Lyocell			Lyocell			VFY			Cupro			Acetate			
Substance/ Parameter	Unit	Limit Value			Limit Value			Limit Value			Limit Value			Limit Value			Limit Value			Test Method
		Foundational	Progressive	Aspirational	Foundational	Progressive	Aspirational	Foundational	v	Aspirational	Foundational	Progressive	Aspirational	Foundational	Progressive	Aspirational	Foundational	Progressive	Aspirational	
Chromium total	mg/L	0.2	0.1	0.05	0.2	0.1	0.05	0.2	0.1	0.05	0.2	0.1	0.05	0.2	0.1	0.05	0.2	0.1	0.05	ISO 17294 USEPA 200.8 USEPA 6010C USEPA 6020A IS 3025 (Part 65) HJ 700
Copper	mg/L	1.0	0.5	0.25	1.0	0.5	0.25	1.0	0.5	0.25	1.0	0.5	0.25	1.0	0.5	0.25	1.0	0.5	0.25	ISO 17294 USEPA 200.8 USEPA 6010C USEPA 6020A IS 3025 (Part 65) HJ 700 GB 7475 IS 3025 (Part 42) AAS Instrumental Method
Nickel (Ni)	mg/L	0.2	0.1	0.05	0.2	0.1	0.05	0.2	0.1	0.05	0.2	0.1	0.05	0.2	0.1	0.05	0.2	0.1	0.05	ISO 17294 USEPA 200.8 USEPA 6010C USEPA 6020A IS 3025 (Part 65) HJ 700 GB 11912 IS 3025 (Part 54) AAS Instrumental Method
Lead (Pb)	mg/L	0.1	0.05	0.01	0.1	0.05	0.01	0.1	0.05	0.01	0.1	0.05	0.01	0.1	0.05	0.01	0.1	0.05	0.01	ISO 17294 USEPA 200.8 USEPA 6010C USEPA 6020A IS 3025 (Part 65) HJ 700 GB 7475 IS 3025 (Part 47) AAS Instrumental Method
Zinc (Zn)	mg/L	2.5	1	0.5	2.5	1	0.5	NA	NA	NA	5	3	2	NA	NA	NA	2.5	1	0.5	ISO 17294 USEPA 200.8 USEPA 6010C USEPA 6020A GB 7472 GB7475 HJ 700 IS 3025 (Part 65) IS 3025 (Part 49) AAS Instrumental Method

Note: *For indirect discharge facilities, the above metals should be "sample and report" only, and the limits at Foundational, Progressive and Aspirational Levels are not applicable.*

3.1.3 Load-based wastewater parameters (load per tonne of fibre or filament)

To understand the environmental impact and efficiency of water usage in the production of viscose or modal staple fibres or filament, lyocell and acetate, it is necessary to measure the wastewater parameters listed below in terms of load-based values (g/tonne of fibre produced) rather than only concentration-based (mg/L of discharged wastewater). This requires measuring the amount of discharged wastewater from the fibre or filament production process, and calculating the load per tonne of fibre or filament by linking the pollutant concentration with the wastewater flow rate.

Parameters shall be calculated using the sampled average across one month of water flow from the fibre or filament production process considered for the calculation. The concentration (mg/L) used for this calculation shall be taken from the wastewater reporting cycles (April/October). The selected month used to create the sampled average water flow shall be the same as the sampling month of the wastewater testing.

The lower the load, the more progressive the facility is.

Table 13: Calculation of the parameter to be reported in load per tonne of fibre or filament

Parameter Load (A)	=	Concentration in mg/L (B)	X	Water Flow per Day in m^3 /tonne(C)
A = Any of the parameters from Table 11 below.		B = Concentration of the parameter obtained from the testing result done for the ZDHC MMCF Guidelines V3.0.		C= Sampled average water flow across the month when the sample for the wastewater testing of the concentration parameter was collected.

Table 14: Example of sampled average load per tonne of fibre or filament

Reporting Cycle and Year	Para-meter	Sampling Month for Reporting ZDHC MMCF Guidelines V3.0	Test Result (Concen-tration Value)	Water Flow Volume – Sampled Average	Load Per Tonne of Fibre or Filament (g/tonne of fibre)
1 – 2026	COD – sea	January 2026	150 mg/L	January 2026 = 60 m^3 / tonne	150 x 60 = 9,000
2 – 2026	COD – sea	June 2026	130 mg/L	June 2026 = 60 m^3 /tonne	130 x 60 = 7,800

Table 15: Wastewater parameters to be assessed in load per tonne of fibre or filament (sampled average)

Wastewater parameters – load per tonne of fibre or filament																
	Unit	VSF/ VSF & Modal			VSF/Lyocell			Lyocell			Acetate			VFY		
		Limit Value			Limit Value			Limit Value			Limit Value			Limit Value		
		Foundational	Progressive	Aspirational	Foundational	Progressive	Aspirational	Foundational	Progressive	Aspirational	Foundational	Progressive	Aspirational	Foundational	Progressive	Aspirational
COD# – to sea	Load* in g/tonne of fibre/filament	9000	6000	3600	9000	6000	3600	9000	6000	3600	9000	6000	3600	24000	18000	12000
COD# – to other bodies of water		7200	6000	3600	7200	6000	3600	7200	6000	3600	7200	6000	3600	14400	12000	9600
BOD – 5 day		1800	900	300	1800	900	300	1800	900	300	1800	900	300	7200	4800	2400
Zn		150	60	30	150	60	30	NA	NA	NA	150	60	30	600	360	240
Sulphate (SO_4^{2-})	Load* in kg/tonne of fibre/filament	200–300			200–300			NA			NA			200–1000		

* Load calculated for a $60m^3$ per tonne water flow average.

For any MMCF facility, COD values will either be for discharge to sea or discharge to other water bodies.

Note*: For COD, BOD and Zn parameters, facilities are required to meet either load-based or concentration-based wastewater limits. For sulphate (SO_4^{2-}), it is mandatory to meet load-based ranges.*

Note*: load per tonne has been excluded for cupro. Since cupro is an integrated production process from linter purification to spinning, the BOD and COD load per tonne of fibre significantly exceed the limit values listed here.*

To support the reporting of this document, facilities should provide the following information:

- Fibre production of the month in which wastewater sampling is done by a ZDHC Approved Wastewater Laboratory.
- Wastewater test results, from a ZDHC Approved Wastewater Laboratory, of the required parameters within the corresponding testing cycle.
- Wastewater flow rate during the month when sampling for the testing of the above parameters is conducted.

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3.1.4 Implementation of wastewater testing

Wastewater testing of MMCF, done through sampling and testing of the wastewater at a facility, should occur twice a year through a ZDHC Approved Wastewater Laboratory.

- Suppliers should find a ZDHC Approved Wastewater Laboratory using Find your Expert.
- Initiate sampling and testing.
- Sampling before 30 April and before 31 October every year to meet the cycle timelines.
- There should be at least a three-month gap between the two sampling and testing cycles.
- The wastewater test reports for the two cycles must be uploaded to the supplier's ZDHC Gateway account by the ZDHC Approved Wastewater Laboratory, completing the sampling and testing.

MMCF manufacturing facilities should sample and test wastewater and sludge according to the following table.

Table 16: Testing requirements and sampling location for an MMCF facility

Test Parameters and Sample Locations/ Discharge Types	ZDHC Conventional Parameters Testing And Reporting In Discharged Wastewater (Table no. 11)	ZDHC Heavy Metals Testing And Reporting In Discharged Wastewater (Table no. 12)	ZDHC Sludge Sample Sludge & Test (Table no. 17, 18)
Direct	✓	✓	✓ Sample and test against the major ZDHC sludge disposal pathway.
Indirect with pretreatment (with sludge)	✗	✓ Sample and report (copper, lead, nickel, zinc, total chromium).	✓ Sample and test against the major ZDHC sludge disposal pathway.
Indirect with pretreatment (without sludge)	✗	✓ Sample and report (copper, lead, nickel, zinc, total chromium).	✗
Indirect without pretreatment	✗	✓ Sample and report (copper, lead, nickel, zinc, total chromium).	✗
Zero liquid discharge (ZLD)	✗	✗	✓ Sample and test against the major ZDHC sludge disposal pathway.

Note: *Pretreatment can be defined as any sort of treatment (flow equalisation, pH adjustment, screening, grit removal, primary treatment such as, but not limited to, coagulation and flocculation, and secondary treatment such as, but not limited to anaerobic and aerobic treatment) done before discharging to a central effluent treatment facility (CETP) to align with local legal and/or CETP regulations and limit values. Pretreatment processes may or may not generate sludge.*

Without pretreatment, effluent goes directly to the CETP unaffected by the facility.

Untreated wastewater ('raw wastewater'): Wastewater that is collected prior to any treatment.

Discharged wastewater (effluent): Treated wastewater that is discharged to the environment or partially treated or untreated wastewater that is discharged to a central effluent treatment plant (CETP) for further treatment. (This is not applicable to indirect discharge without pretreatment as well as to zero liquid discharge facilities.)

3.1.5 Determining conformance to this document

Sampling, testing and reporting processes are the same for manufacturing facilities, whether they discharge wastewater directly, indirectly or have zero liquid discharge (ZLD). The only difference is what the resulting concentration data is compared to in order to determine conformance with this document.

a. Manufacturing facilities with direct discharge are expected to have:
   - Achieved at least foundational limit values for conventional and anions wastewater parameters as per Table 11.
   - Achieved at least foundational limit values for heavy metals as per Table 12.
   - Achieved at least foundational limit values for load-based wastewater parameters as per Table 15.

Note: *For COD, BOD and Zn parameters, facilities are required to meet either load-based or concentration-based wastewater limits. For sulphate (SO_4^{2-}), it is mandatory to meet load-based ranges.*

b. Manufacturing facilities with indirect discharge with pretreatment (with sludge) are expected to have:
   - All conventional parameters in compliance with their agreements with the receiving centralised effluent treatment plant (CETP).
   - Sample and report five heavy metals (copper, lead, nickel, zinc and total chromium) in discharged wastewater.

c. Manufacturing facilities with indirect discharge with pretreatment (without sludge) are expected to have:
   - All conventional parameters in compliance with their agreements with the receiving centralised effluent treatment plant (CETP).
   - Sample and report five heavy metals (copper, lead, nickel, zinc and total chromium) in discharged wastewater.

d. Manufacturing facilities with indirect discharge without pretreatment are expected to have:
   - All conventional parameters in compliance with their agreements with the receiving centralised effluent treatment plant (CETP).

   - Sample and report five heavy metals (copper, lead, nickel, zinc and total chromium) in untreated wastewater.

e. Manufacturing facilities with ZLD are not required to test the wastewater

Note*: For indirect discharge facilities, in case of detection of the heavy metals metals, the supplier is expected to do a root cause analysis and corrective action.*

Manufacturing facilities should proactively develop and manage a data-driven plan to continuously meet foundational limit values and achieve progressive and aspirational limit values in the wastewater parameters wherever applicable.

3.1.6 Resolution of non-conformances

A) Definition of non-conformance

Non-conformance for wastewater is defined through conventional, anions and heavy metal parameters for the MMCF production process. This is when test results either:

- For direct discharge facilities: Exceed the foundational limit values in this document (Tables 11, 12 and 15).
- For indirect discharge with pretreatment with sludge facilities: Exceed the limit values of the receiving CETPs' requirements. Any of the five heavy metals (copper, lead, nickel, zinc and total chromium) is detected.
- For indirect discharge with pretreatment without sludge facilities: Exceed the limit values of the receiving CETPs' requirements, any of the five heavy metals (copper, lead, nickel, zinc and total chromium) is detected.
- For indirect discharge without pretreatment facilities: Exceed the limit values of the receiving CETPs' requirements. Any of the five heavy metals (copper, lead, nickel, zinc and total chromium) is detected.
- For ZLD facilities: Does not apply.

B) Actions by manufacturing facilities with non-conformance(s)

If a test report indicates non-conformance as defined above, the supplier is expected to develop a root cause analysis (RCA) and corrective action plan (CAP) with a defined completion date. Upload a CAP within defined completion date on the ZDHC Gateway – Wastewater Module.

3.2 Sludge disposal and testing

Wastewater treatment sludge (referred to as "sludge") is a necessary and inevitable by-product of proper wastewater treatment. Poor sludge disposal can result in negative impacts on human health and the environment.

Sludge sampling and testing requirements depend on the disposal pathway. The purpose of sampling and testing of sludge is to confirm that the requirements for the major disposal pathway are met through the detection of metals and other applicable conventional parameters.

Requirements for sludge testing and disposal

Facilities shall:

- Comply with the existing local legal regulations for the treatment, handling, and disposal of sludge generated in their facility.
- Report the major sludge disposal pathway used on the ZDHC platform using ZDHC sludge documentation template.
- Maintain information and records of their major sludge disposal pathway.
- Conduct sludge testing from ZDHC Approved Labs and maintain records on the sludge testing for metals and other applicable conventional parameters.
- Ensure that requirements for the major disposal pathway are met through the detection of metals and conventional parameters.

3.2.1 ZDHC sludge disposal pathways

There are seven sludge disposal pathways as mentioned below. Please refer to the Annexure D for details of each disposal pathway.

If the pathway is unknown, the facility should assume Disposal Pathway F.

1. Pathway A – On-site or off-site incineration at >1000 °C
2. Pathway B – Landfill with significant control measures

3. Pathway C – Building products processed at >1000 °C
4. Pathway D – Landfill with limited control measures
5. Pathway E – Building products processed at <1000 °C
6. Pathway F – Landfills with no control measures
7. Pathway G – Land application for a specific purpose in approved areas

3.2.2 Sludge documentation required to demonstrate applicable disposal pathway

Suppliers should identify their sludge disposal pathway and are expected to maintain information on and records of their major sludge disposal pathway, along with the sludge manifest required for legal purposes. In cases where sludge is disposed of via authorised third-party waste contractors, suppliers should make an effort to get all relevant information on the disposal pathway from the waste contractor.

Suppliers should use the declaration templates to enter information for each disposal pathway, which also includes declaration templates that suppliers should use to enter information for each disposal pathway. After inputting the information relevant to the supplier's major disposal pathway, the supplier should sign and give details of the signing authority and date in the declaration.

These declarations will be collected by samplers during the sludge sample collection and submitted to their lab.

This will help the laboratory determine the applicable testing and reporting requirements for the sludge sample.

Download the sludge disposal pathway declaration template

3.2.3 Sludge testing: Parameters and limits

Sludge sampling and testing requirements depend on the disposal pathway.

The purpose of sampling and testing of sludge is to confirm requirements for the major disposal pathway are met through detection of metals and other applicable conventional parameters.

The flow chart below outlines testing requirements for sludge samples:

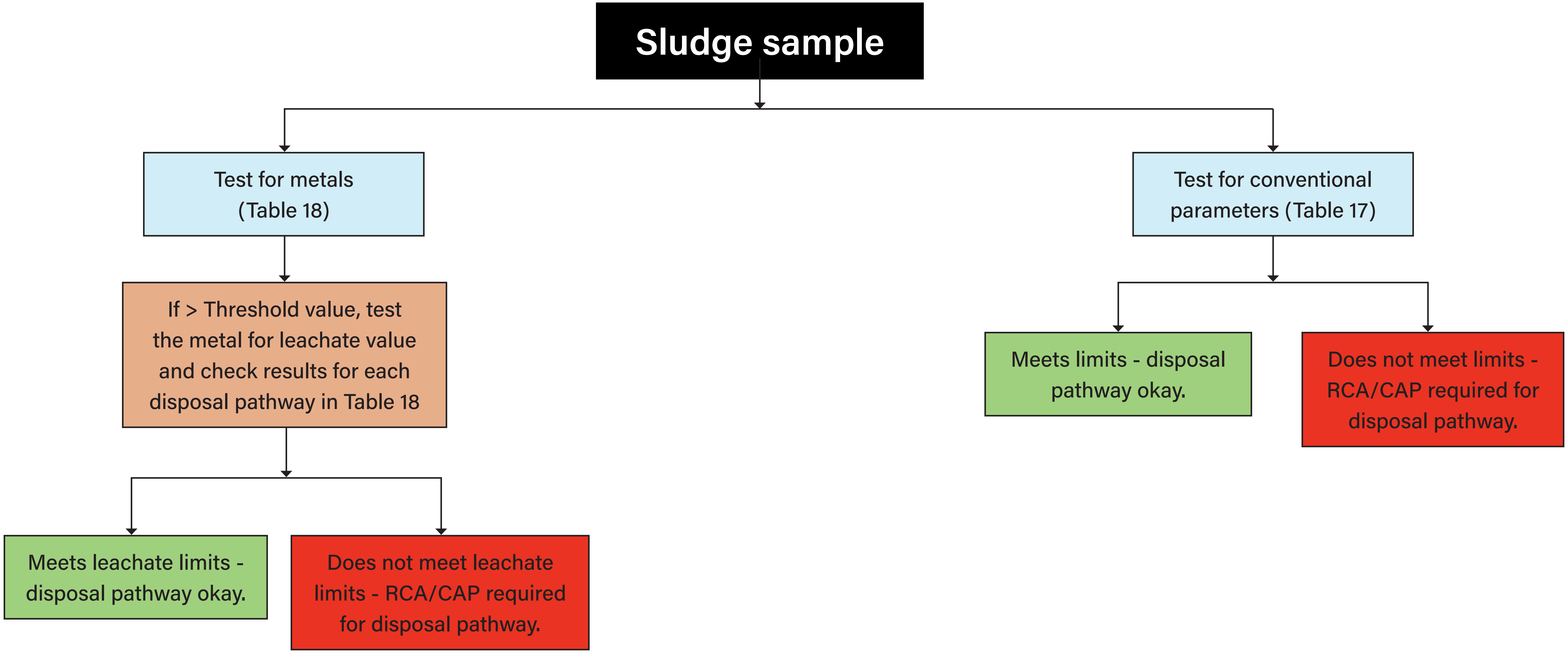

Fig 1: Flow chart for testing of the sludge sample

For MMCF facilities, sludge testing must be done for the following parameter:

A. Conventional parameters

- For Sludge Disposal Pathway A, B, and C only test % solids on a "sample and report" basis.
- For Disposal Pathways D-G, the sludge sample should additionally be tested for conventional parameters (pH, faecal coliform, % solids and paint filter test).
- Non-conformance with the limit values should trigger immediate action to stop the use of the disposal pathway until the requirements are met. Suppliers should also explore a possible move to Disposal Pathways A, B or C.

Table 17: Conventional parameters and limit values for each sludge disposal pathway

Substance/ Parameter	Disposal Pathway A	Disposal Pathway B	Disposal Pathway C	Disposal Pathway D	Disposal Pathway E	Disposal Pathway F	Disposal Pathway G	Test Method
pH	NA	NA	NA	5-11 s.u.	5-11 s.u.	6.5-9 s.u.	6.5-9 s.u.	Preparation: Suspension with Water Analysis: ISE Preparation and analysis: EPA SW 9045D or HJ962 HJ 962
Fecal coliform	NA	NA	NA	NA	NA	<1000 MPN/g	<1000 MPN/g	Preparation: Blended suspension Analysis: Multiple Tube Fermentation Analysis: EPA 1681
% solids	Sample and report %	Sample and report %	Sample and report %	Sample and report %	Sample and report %	Sample and report %	Sample and report %	Analysis: Dry at 105°C Analysis: EPA 160.3, HJ613 at 105°C HJ 613 drying at 105°C
Paint filter test	NA	NA	NA	Pass	Pass	Pass	Pass	Analysis: EPA SW-846 or EPA 9095B

Note*: The purpose of the **% solid test** is to measure the amount of solids (or % moisture) present in the sludge. Any detection which is up to or less than 5% is an indicator that there is high moisture in the sludge. In such scenarios, the suppliers are expected to undertake suitable sludge drying or suitable dewatering techniques, which reduce the moisture content in the sludge (except for those locations where it is legally mandated or allowed by the local regulation that liquid sludge can be safely transported to external agencies for safe treatment and disposal without impacting the environment).*

*The purpose of the **paint filter test** is to assess the suitability of sludge for transportation and management, including incineration, landfill and land application.*

B. Metals and leachate metals:

- For Sludge Disposal Pathways A, B, and C, testing of metals and leachate is “not applicable”.
- For pathways D-G, the listed metals are tested to check if they exceed the threshold limit values.
- In case a listed metal(s) exceeds the threshold value, leachate testing of the metal(s) is done to check for conformance to the permissible limit values for leachates in Disposal Pathways D-G.
- Non-conformance to these requirements should motivate a Root Cause Analysis (RCA) and corrective actions to meet the threshold limit metal values. In addition, immediate action must be taken to stop the use of the disposal pathway until the requirements are met. Alternatively, suppliers should explore a possible move to Disposal Pathways A, B or C.

Table 18: Threshold Metal Values, Leachate Testing Limit Values for Each Sludge Disposal Pathway

Substance/ Parameter			Disposal pathway								Test Method		
	Reporting limit	Threashold value	Disposal Pathway A	Disposal Pathway B	Disposal Pathway C	Disposal Pathway D	Disposal Pathway E	Disposal Pathway F	Disposal Pathway G	Disposal Pathway G			
	Sludge (mg/kg) dry weight	Sludge (mg/kg) dry weight	Leachate Result (mg/L)	Leachate Result (mg/L)	Leachate Result (mg/L)	Leachate Result (mg/L)	Leachate Result (mg/L)	Leachate Result (mg/L)	Leachate Result (mg/L)	Maximum Total Metals Limits in Sludge (mg/ kg) dry weight			
Copper	50	200	NA	NA	NA	17.5 mg/l	10 mg/l	10 mg/l	10 mg/l	1500 mg/kg	Preparation: Acid/Peroxide digestion Analysis: ICP/OES or ICP/MS (For Leachate) Extraction: Toxicity Leachate Extraction Procedure followed by Acid Digestion Analysis: ICP/ OES, or ICP/ MS	Preparation: EPA 3050 Analysis: EPA 6010D, or EPA 6020B	Leachate Extraction: EPA 1311 followed by Acid Digestion EPA 3051A Analysis: USEPA 200.7 USEPA 200.8 USEPA 6010c USEPA 6020a HJ 803
Lead	5	10	NA	NA	NA	2.75 mg/l	0.5 mg/l	0.5 mg/l	0.5 mg/l	400 mg/kg	Preparation: Acid/Peroxide digestion Analysis: ICP/OES or ICP/MS (For Leachate) Extraction: Toxicity Leachate Extraction Procedure followed by Acid Digestion Analysis: ICP/ OES, or ICP/ MS	Preparation: EPA 3050 Analysis: EPA 6010D, or EPA 6020B	Leachate Extraction: EPA 1311 followed by Acid Digestion EPA 3051A Analysis: USEPA 200.7 USEPA 200.8 USEPA 6010c USEPA 6020a HJ 803
Nickel	20	70	NA	NA	NA	11.75 mg/l	3.5 mg/l	3.5 mg/l	3.5 mg/l	420 mg/kg	Preparation: Acid/Peroxide digestion Analysis: ICP/OES or ICP/MS (For Leachate) Extraction: Toxicity Leachate Extraction Procedure followed by Acid Digestion Analysis: ICP/ OES, or ICP/ MS	Preparation: EPA 3050 Analysis: EPA 6010D, or EPA 6020B	Leachate Extraction: EPA 1311 followed by Acid Digestion EPA 3051A Analysis: USEPA 200.7 USEPA 200.8 USEPA 6010c USEPA 6020a HJ 803
Zinc	400	1000	NA	NA	NA	50 mg/l	50 mg/l	50 mg/l	50 mg/l	2800 mg/kg	Preparation: Acid/Peroxide digestion Analysis: ICP/OES or ICP/MS (For Leachate) Extraction: Toxicity Leachate Extraction Procedure followed by Acid Digestion Analysis: ICP/ OES, or ICP/ MS	Preparation: EPA 3050 Analysis: EPA 6010D, or EPA 6020B	Leachate Extraction: EPA 1311 followed by Acid Digestion EPA 3051A Analysis: USEPA 200.7 USEPA 200.8 USEPA 6010c USEPA 6020a HJ 803
Total Chromium	50	100	NA	NA	NA	5 mg/l	5 mg/l	5 mg/l	5 mg/l	1200 mg/kg	Preparation: Acid/Peroxide digestion Analysis: ICP/OES or ICP/MS (For Leachate) Extraction: Toxicity Leachate Extraction Procedure followed by Acid Digestion Analysis: ICP/ OES, or ICP/ MS	Preparation: EPA 3050 Analysis: EPA 6010D, or EPA 6020B	Leachate Extraction: EPA 1311 followed by Acid Digestion EPA 3051A Analysis: USEPA 200.7 USEPA 200.8 USEPA 6010c USEPA 6020a HJ 803

Footnote: Reference link for Pathway G: https://extension.uga.edu/publications/detail.html?number=B1353

Note: *Threshold values are used to define if leachate testing is required. Leachate testing should be done only if the threshold value for a metal is exceeded in the sludge sample testing.*

3.2.4 Requirements for approval of sludge disposal pathways

Requirements for Disposal Pathway A, B, C

There are no testing requirements for approval of these pathways except % solids test as sample and report only. Sludge documentation confirmation is required to demonstrate that these disposal pathways are used by the supplier.

Requirements for Disposal Pathway D and E

Testing of metals

The sludge sample is tested for all metals as listed in Table 18.

If the test result for any metal exceeds the threshold limit values, leachate testing should be conducted by the laboratory, for those metals only, to approve this disposal pathway.

Testing of conventional parameters

The sludge sample is tested for conventional parameters (pH, % solids, paint filter test) as given in Table 17 and meets the requirement for approval of this disposal pathway.

Requirements for Disposal Pathway F and G

Testing of metals

The sludge sample is tested for all metals as listed in Table 18.

If the test result for any metal exceeds the threshold limit values, the laboratory should only conduct leachate testing for those metals to confirm this disposal pathway.

Note: *Additionally, for Disposal Pathway G, the maximum limit value for total metals (in mg/kg) as given in Table 18 should also not exceed. If the limit value is exceeded, the disposal pathway is not approved.*

Testing of conventional parameters

The sludge sample is tested for conventional parameters (pH, % solids, paint filter test) as given in Table 17 and meets the requirement for approval of this disposal pathway.

3.2.5 RCA/CAP for sludge

If the disposal pathway requirements are not approved, immediate and long-term responses must be included in the CAP. The facility must immediately determine whether other options that are approved for sludge disposal are available, and take steps to move the sludge generated from the facility to the approved disposal pathway. This is the case even as additional CAP activities are developed. Longer-term CAP measures should include improving the quality of the sludge so that it is approved and appropriate for the original disposal pathway via source reduction, treatment modifications, and other actions. Wherever possible, Disposal Pathways A, B and C should be preferred.

3.3 Air emissions

This section addresses the integrated expectations of the air emissions related to the priority hazardous chemicals used during production processes of man-made cellulosic fibre (MMCF) and applies to process-related air emissions associated with the production of man-made cellulosic fibres and filaments from different feedstock sources, such as, but not limited to, wood and bamboo.

This document specifies a unified set of parameters and limit values related to the production of man-made cellulosic fibres and filaments. It also includes the analytical test methods and sampling procedures, with the ultimate objective of allowing brands and manufacturing facilities to share their testing results in a systematic and efficient manner.

The expected outcomes of using this document are to:

- Address air emissions from MMCF fibre or filament production and minimise any adverse impact on the environment and surrounding communities.

- Provide a unified approach to monitoring and testing for manufacturing facilities, so that they can systematically and efficiently share emission data with brands they work with and other interested parties.
- Increase operational efficiencies by defining a standard cadence for air emissions monitoring and reporting requirements that is applicable to all brands and manufacturing facilities adopting this document.

As a minimum requirement, facilities are expected to

- Quantify and track emissions of all parameters, consistent with standards and best practices of measurement and transparency.
- Follow generally accepted process engineering best practices for air emissions to minimise environmental impact.

This document will focus on the following:

1. Sulphur air emissions for viscose and modal staple fibres and acetone air emissions for acetate fibre by mass balance.
2. Ambient air outside the facility for viscose and modal staple fibres, viscose filament yarn and cupro.
3. GHG Scope 1 and Scope 2 emission reporting.

Requirements for air emissions

MMCF manufacturers must implement plans to reduce or avoid fugitive emissions. Any fugitive emissions must be controlled and avoided using state-of-the-art technologies. For air emissions, the approach taken to monitor the selected parameters includes indirect and direct measurement methods.

The indirect method of mass balance calculation is to be used for sulphur air emissions (viscose and modal fibre) and acetone air emissions (acetate fibre).

The direct testing method of ambient air emissions of CS_2 and H_2S (viscose and modal staple fibre, viscose filament yarn) and ammonia (cupro) should be conducted to corroborate that these substances are not present above the given concentration.

To ensure accurate reporting, it is important that either a measurement system or a

continuous sampling or testing procedure is established to measure all necessary parameters.

For air emissions, facilities shall:

a. **Ensure compliance with local regulations:**
   - Have a valid licence to operate.
   - Quantify, track and report emissions of all parameters, consistent with applicable local regulations.

Note*: It is not the intent of ZDHC to act as an agency reporting air emissions to governments or authorities with jurisdiction. It is expected that suppliers are accountable for reporting their air emissions in accordance with applicable laws.*

b. **Calculate and report air emissions by mass balance calculation**

Viscose facilities shall calculate sulphur air emissions, and acetate facilities shall calculate acetone air emissions using mass balance calculations (mentioned under Table 21) and meet the limits mentioned under Table 19.

c. **Test and report ambient air testing**

Viscose, modal, and VFY facilities shall test the ambient air concentration for the CS_2 and H_2S, cupro facility shall test the ambient air concentration for the NH_3 at least once a year or shall use air dispersion modelling data (yearly average) outside the facility to prove that the ambient air emissions do not exceed reporting limit values set out in Table 20.

d. **Report GHG Scope 1 and Scope 2 emissions**

All MMCF shall use any existing GHG (Scope 1 and Scope 2 emissions) calculation platforms that are recognised and align with GHG Protocol standards.

Note*: Air emissions by mass balance or ambient air emissions is not applicable to lyocell because NMMO is easily dissolved in water and is not volatile, air emissions in the lyocell process is minimal. The waste air out of the spinning process contains a small amount of NMMO, which can be recovered by scrubbers at the vent.*

Note*: MMCF facilities should report mass balance data as a yearly average of the calendar year (from 1 January to 31 December) on a ZDHC platform to evaluate against the limit values specified under Table 19.*

Note*: Manufacturing facilities are expected to understand that any dilution of air emissions from exhaust systems to purposefully minimise the concentration of pollutants is prohibited.*

3.3.1 Air emissions by mass balance calculation

The viscose/acetate industry uses several technologies to control the emission of sulphur/acetone to the air during the manufacturing process. The major technologies used in the industry are listed in Appendix B, Table 21, with the mass balance calculations.

When establishing a methodology with corresponding limit values for these substances, it is important that the selected methodology is internationally accepted and implemented. The methodology requires an integrated balance of all incoming and outgoing material flows. In principle, it is recommended to follow the Directive 2010/75/EU of the European Parliament on industrial emissions – integrated pollution prevention and control (EU, 2010).

3.3.1.1 Sulphur air emissions for VSF

The effectiveness of the emission control of sulphur release to the air can be calculated by applying a mass balance. Any methods used should include the total mass of sulphur removed from the exhaust gases. Depending on the outputs, it can be either in solid or liquid form. Those recovered chemicals can either be reused as part of the process or sold as a product. Some remaining sulphur can be trapped in the sludge or liquid streams. For detailed S air emissions calculations, refer to Appendix B, Table 21.

3.3.1.2 Acetone air emissions for acetate

During acetate fibre production, acetone is easily regenerated by the distillation process of the acetone-water mixture, and the regenerated solvent is reused for the process. Any possible escaped solvent vapours are captured through charcoal filters and are recycled and regenerated back into the system. This reduces the loss of acetone solvent to the environment during the whole production process, even though acetone is a highly volatile solvent and may easily escape to the environment. For detailed acetone air emissions calculations, refer to Appendix B, Table 21.

3.3.1.3 Air emissions parameters and limit values

Air emissions parameters and their limit values are defined in Table 19.

Table 19: Air emissions parameters and limits (calculated using mass balance)

Air Emissions	Units	Foundational	Progressive	Aspirational
Sulphur air emissions for VSF	kg/ton of fibre (annual basis)	20[a]	12[a]	09[b]
Acetone air emissions for acetate fibre	% (annual basis)	7[c]	5[c]	2[c]

a EU BREF POL 2007 & recommendation.

b BAT WGC – BREF 2023

c % of acetone not recovered as per mass balance calculation is considered as air emissions for acetone (acetate fibre).

Note: *The aspirational target of 9 kg/tonne of sulphur should be met either through mass balance calculation or by measuring channelled emissions (the sum of H_2S and CS_2, expressed as total sulphur).*

Note: *The air emission using mass balance is calculated based on the yearly average of the calendar year.*

3.3.1.4 Testing frequency

The reporting frequency for the mass balance calculation is based on an annual verification. The reporting cycles run from 1 January to 31 December within the same calendar year. The data is reported in the MMCF Module (on the ZDHC Supplier Platform).

3.3.2. Ambient air emissions

Manufacturing facilities shall test the ambient air concentration outside the facility for the key substances involved in viscose, modal and VFY production (CS_2 and H_2S), as well as key substances involved in the cupro production (NH_3), to prove that the ambient air emissions do not exceed reporting limit values set out in this document.

The intention of air sampling and corresponding analytical testing is to identify harmful substances related to the manufacturing process in the ambient air and whether the concentration of these substances is within or above given limit values.

ZDHC proposes one standardised approach for the measurement of the ambient air in the surrounding area of the production facility as per Appendix C.

3.3.2.1 Ambient air emissions testing or monitoring

The ambient air emissions measurement in the surrounding area of the production facility could be done through direct monitoring (sampling and testing by an ISO 17025 accredited laboratory shall be done at least once a year) or air dispersion modelling data (yearly average).

Standardised test methods shall be used where specific testing is required:

- Standard test methods shall be chosen for the manufacturing region.
- In the absence of local or regional test methods, internationally recognised test methods, often recommended by governmental organisations, shall be used, such as the ISO, EPA or GB.
- Where a test shows that a supplier does not meet the requirements of this document, manufacturing facilities shall identify the root cause, resolve the issue and retest the ambient air as often as necessary to ensure the issue has been resolved.

3.3.2.2 Ambient air emissions parameters and limit values

Table 20 indicates limit values for CS_2 and H_2S in ambient air related to viscose and modal staple fibre and viscose filament production, and NH_3 in ambient air is related to cupro fibre production.

Table 20: Ambient air[d] emissions parameters and limits (in the surrounding environment outside the facility)

Ambient Air Emissions Parameters	Cs_2 (Ambient Air Concentration Outside The Facility) Reporting Limit Value for VSF/ modal and VFY	H_2S (Ambient Air Concentration Outside The Facility) Reporting Limit Value For VSF/modal and VFY	NH_3 (Ambient Air Outside The Facility) Reporting Limit Value For Cupro
Unit	mg/m^3	mg/m^3	ppm
Limits	0.10[e, f]	0.10[e, f]	2[g]

d Ambient air limits values refer to the levels of air quality with an adequate margin of safety, to protect public health.

e Based on WHO recommended ambient air quality norms for (Ref: World Health Organization, Air quality guidelines for Europe. 2nd Edition, 2000).

f Ministry of Environment, Forest and Climate Change of India from 17 January 2018. Notification 17 January 2018 - G.S.R. 35(E).

g Under Japanese offensive odour control law (https://www.env.go.jp/en/air/odor/regulation.html).

WHO recommended ambient air quality norms

CS_2: The lowest concentration of carbon disulphide for which an adverse effect was observed in occupational exposure was about 10 mg/m^3, which may be equivalent to a concentration in the general environment of 1 mg/m^3. In selecting the size of the protection (safety) factor, the expected variability in the susceptibility of the general population was taken into account, and a protection factor of 10 was considered appropriate. This leads to the recommendation of a guideline value of 100 ug/m^3, with an averaging time of 24 hours. It is believed that below this value, adverse health effects of environmental exposure to carbon disulphide (outdoor or indoor) are not likely to occur (Ref: WHO Air Quality Guidelines, Year 2000, Pg No. 73).

H_2S: The lowest-adverse-effect level of hydrogen sulphide is 15 mg/m^3, when eye irritation is caused. In view of the steep rise in the dose-effect curve implied by reports of serious eye damage at 70 mg/m^3, a relatively high protection (safety) factor of 100 is recommended, leading to a guideline value of 0.15 mg/m^3 with an averaging time of 24 hours. A single report of changes in haem synthesis at a hydrogen sulphide concentration of 1.5 mg/m^3 should be borne in mind (Ref: WHO Air Quality Guidelines, Year 2000, Pg No. 147).

3.3.2.3 Testing frequency

- The testing frequency for the mass balance calculation is based on an annual verification. The testing cycles run from 1 January to 31 December within the same calendar year. The data is reported in the MMCF Module (on the ZDHC Supplier Platform).

- The testing cycle for direct monitoring of ambient air emissions (sampling and testing by an ISO 17025 accredited laboratory shall be done at least once a year) or air dispersion modelling data (yearly average) runs from 1 January to 31 December within the same calendar year. The data is reported in the MMCF Module (on the ZDHC Supplier Platform).

3.3.3. GHG Scope 1 and Scope 2 emissions

MMCF facilities may utilise existing platforms for calculating absolute GHG Scope 1 and Scope 2 emissions, which are recognised and aligned with GHG Protocol standards, and report the emissions data and reduction targets in the MMCF Module.

This requirement applies to all MMCF facilities.

Appendix A

Wastewater discharge types and sample locations

There are five ZDHC supplier types under wastewater, as listed below and illustrated in figures 2a-e:

- Direct discharge
- Indirect discharge with pretreatment[a] (with sludge)
- Indirect discharge with pretreatment (without sludge)
- Indirect discharge without pretreatment
- Zero liquid discharge (ZLD)[b]

Additionally, there are three possible sampling locations. These are listed below and illustrated in Figures 2a-2e.

- **Untreated wastewater** (‘raw wastewater’) - wastewater that is collected prior to any treatment.
- **Discharged wastewater** - treated wastewater that is discharged to the environment, or partially treated or untreated wastewater that is discharged to a central effluent treatment plant (CETP) for further treatment. (This is not applicable to indirect discharge without pretreatment, as well as to zero liquid discharge facilities)
- **Sludge** - the residual solid, semisolid, or slurry material generated as a by-product of wastewater treatment processes, including primary, secondary and tertiary (ZLD) treatments.

a Any process or operation carried out to treat the wastewater prior to discharge to the CETP.
b For suppliers to be classified as a zero liquid discharge (ZLD) treatment system, they must meet ZDHC’s definition of ZLD.

Direct discharge

Direct discharge is a process in which the wastewater treated and generated by a supplier through its own and operated effluent treatment plant is discharged directly to the land, municipal sewers, or water bodies, such as streams, lakes, and oceans.

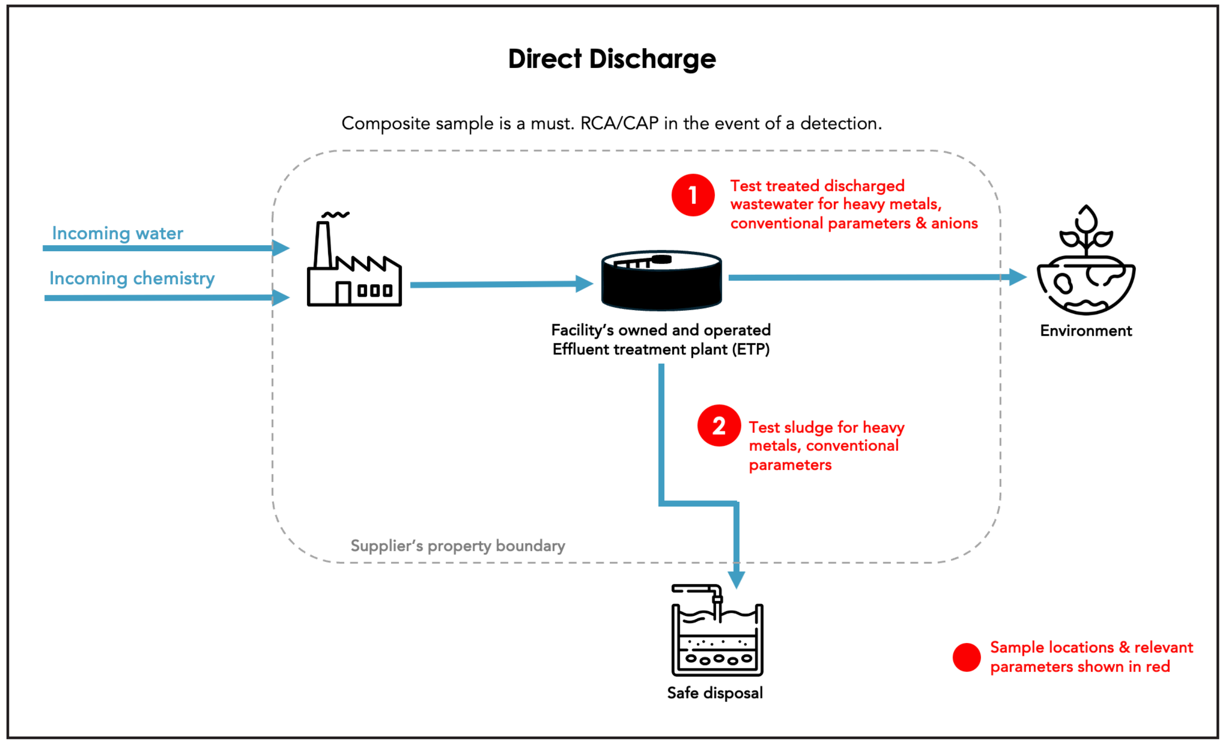

Figure 2a: Schematic illustration of the sample locations for a direct discharge supplier. Sampling locations: discharged wastewater, sludge

Indirect discharge

The discharge of wastewater through an industrial wastewater sewer system to a central effluent treatment plant (CETP) that is not owned or operated by the supplier discharging the wastewater. CETP is also referred to as off-site wastewater treatment. There are two main models of Indirect discharge:

1. Indirect discharge with pretreatment
2. Indirect discharge without pretreatment

Indirect discharge with pretreatment is further categorised into two subparts:

1. Indirect with pretreatment (with sludge) as referred to in Figure 2b.
2. Indirect with pretreatment (without sludge) as referred to in Figure 2c.

Indirect discharge with pretreatment (with sludge)

Where wastewater is collected, mixed and then subjected to a primary treatment process, which can generate sludge, prior to discharge to a CETP.

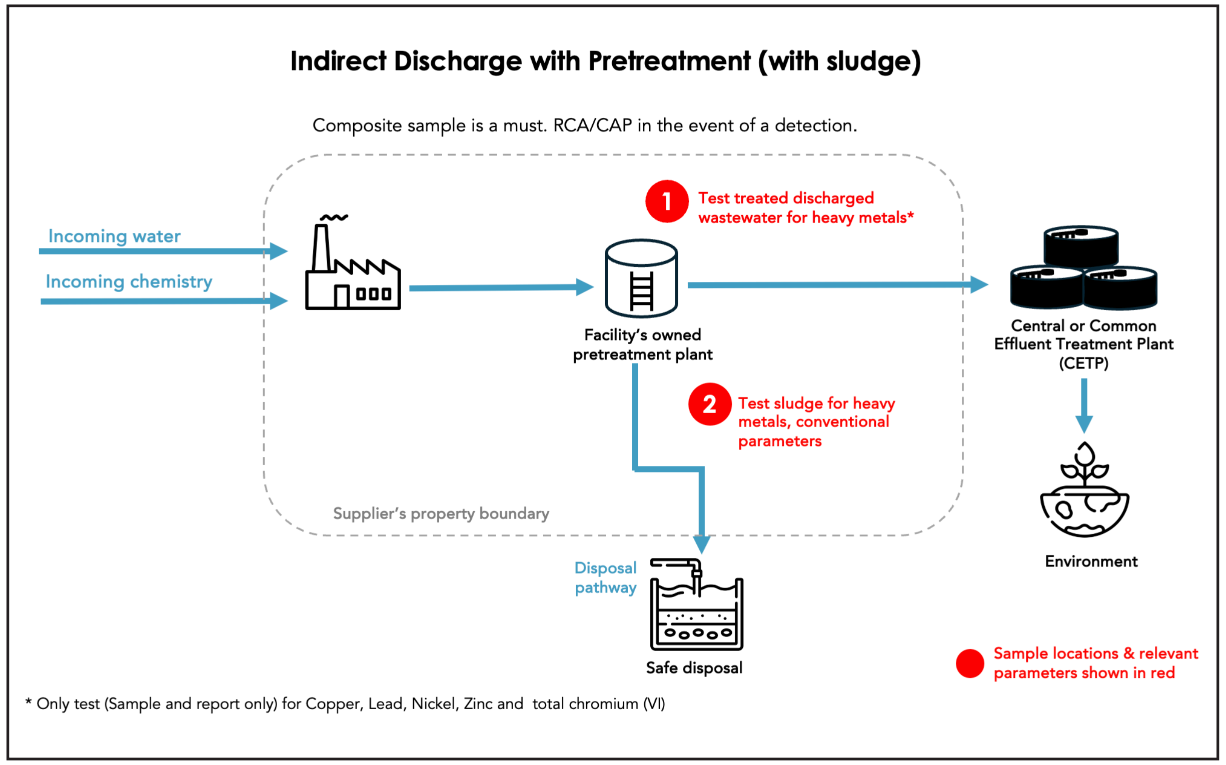

Figure 2b: Schematic illustration of the sample locations for an indirect discharge, with pretreatment (with sludge) supplier. Sampling locations: discharged wastewater, sludge

Indirect with pretreatment (without sludge)

Where wastewater is collected, mixed and then treated using simple physical processes that do not generate sludge, prior to discharge to CETP.

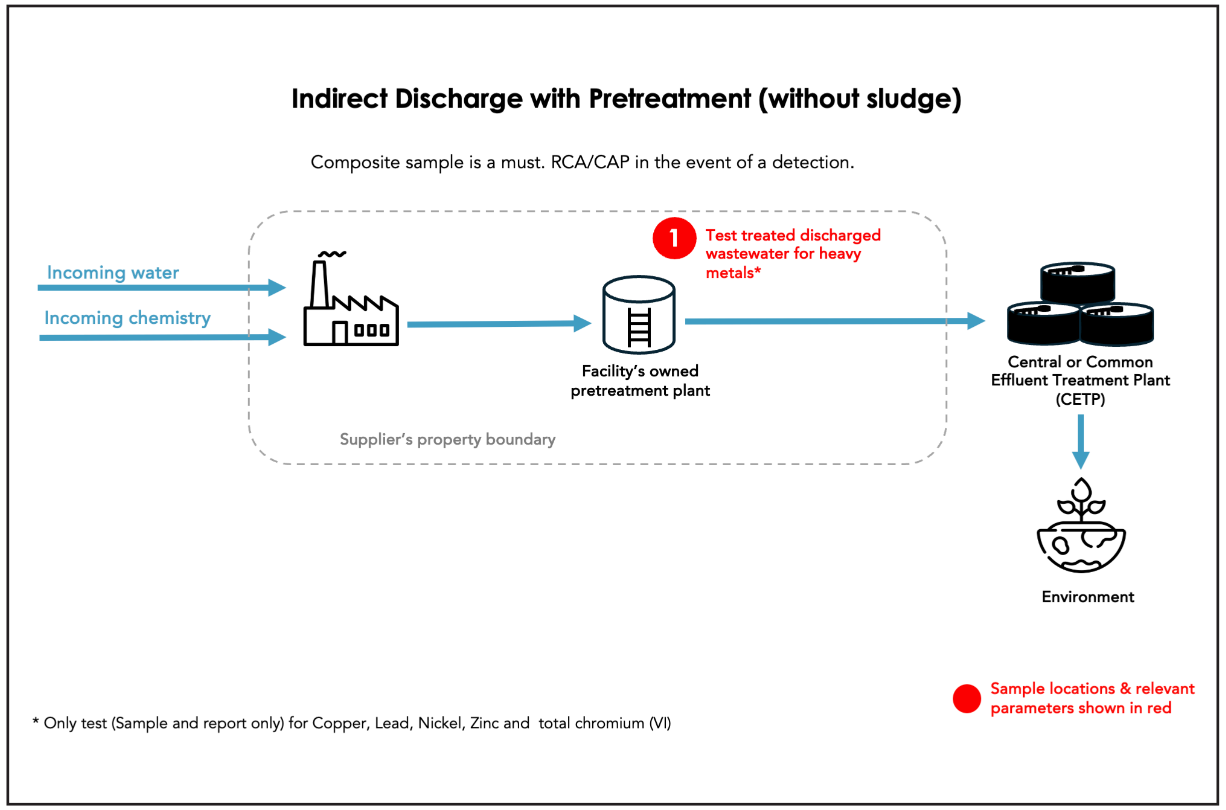

Figure 2c: Schematic illustration of the sample locations for an indirect discharge, with pretreatment (without sludge) supplier. Sampling locations: discharged wastewater

Indirect discharge without pretreatment

Where wastewater is discharged directly from the facility to the CETP without any kind of treatment within the facility.

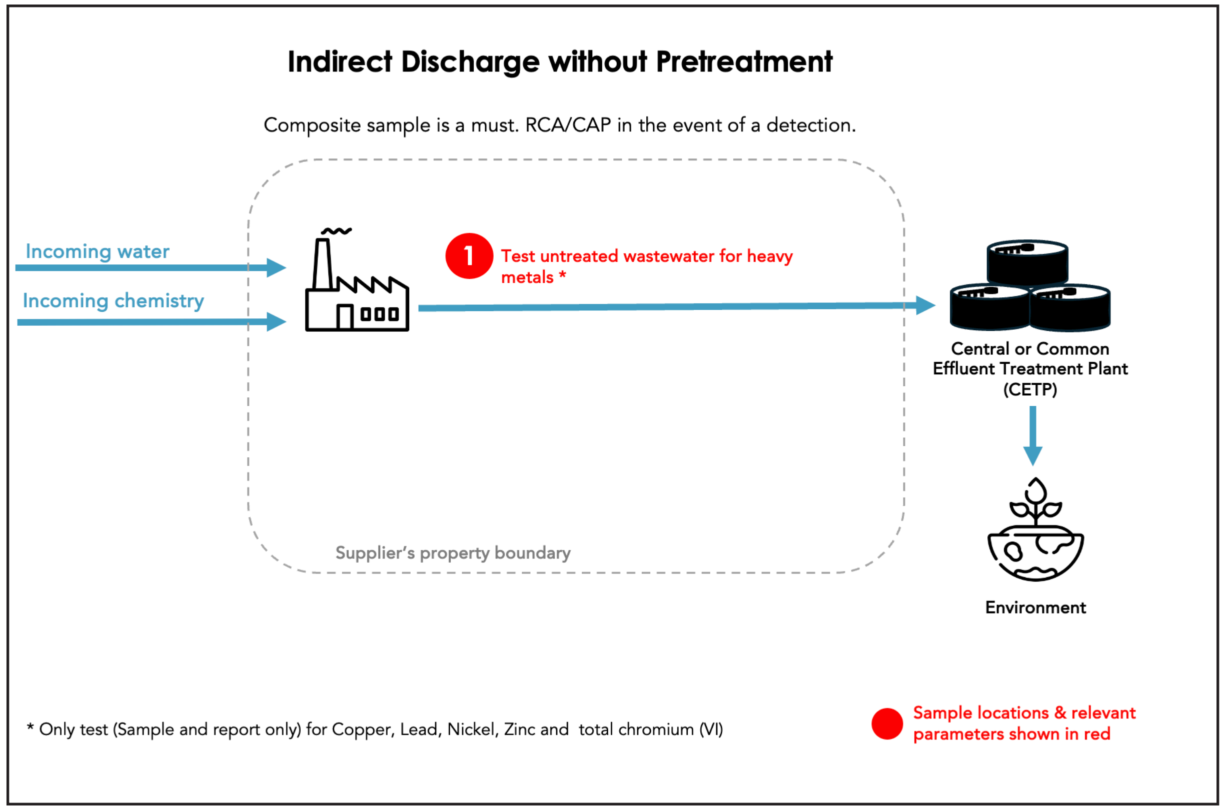

Figure 2d: Schematic illustration of the sample locations for an indirect discharge, without pretreatment supplier. Sampling locations: untreated wastewater (discharged wastewater)

Zero Liquid Discharge (ZLD)

Under ZLD, no industrial wastewater is discharged from a supplier's site in liquid form to the environment. An on-site ZLD treatment system treats and recovers almost all wastewater, such that the only water lost is through evaporation or as moisture in the sludge from treatment plant operations. A supplier is not considered to have a ZLD treatment system if there is any industrial liquid discharge to the environment (including the use of recycled wastewater for gardening purposes).

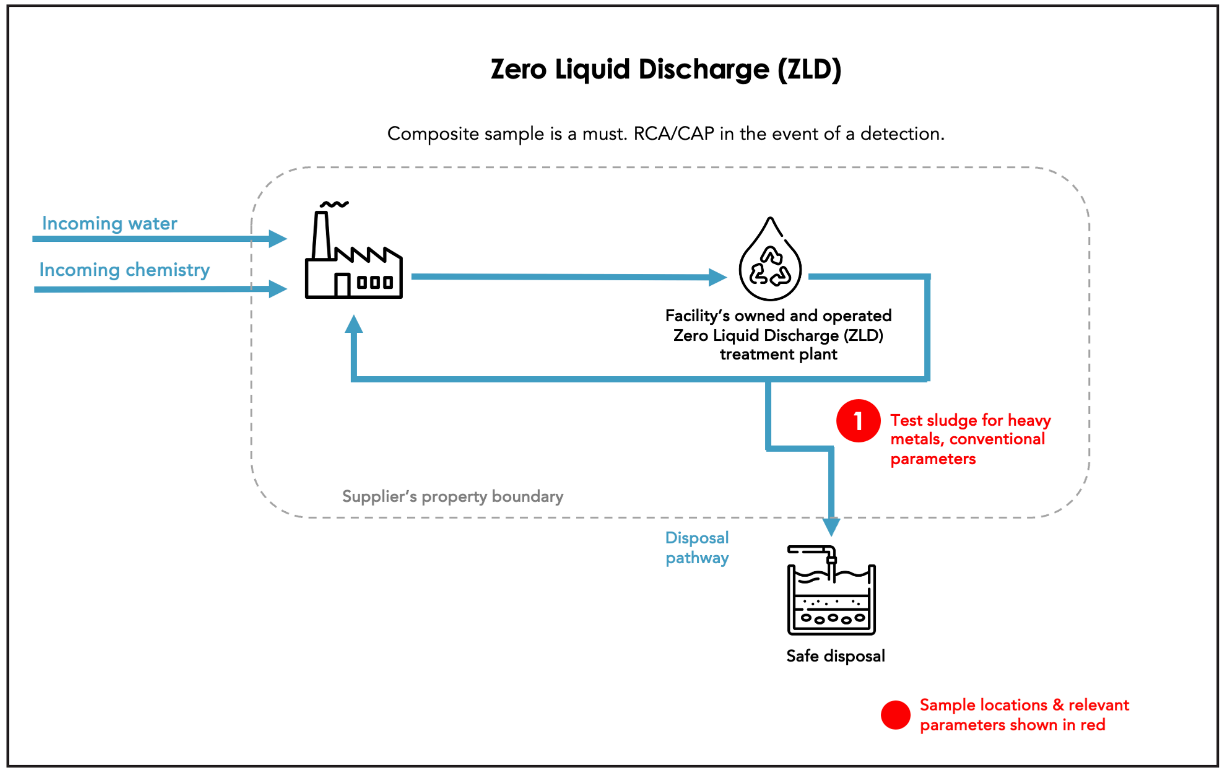

Figure 2e: Schematic illustration of the sample locations for Zero Liquid Discharge (ZLD) suppliers, sampling locations: sludge

Sampling procedure of wastewater and sludge at the facility

The ZDHC Approved Wastewater Laboratory will request a 10-day (including weekends, but excluding public holidays) production window from the facility. Upon receiving this request, the facility is required to specify the specific days within that window during which production activities will occur at their peak. This timeframe will then be designated as the sampling window.

During the sampling window, the laboratory reserves the right to perform sampling on any production day through the sampler from a ZDHC Approved Wastewater Laboratory, without specifying the exact date in advance. This process follows a semi-announced sampling approach, ensuring both operational feasibility and the integrity of the sampling process are maintained.

The facility will be notified that a sampler from a ZDHC Approved Wastewater Laboratory may visit at any point during the declared production days, and should be prepared to accommodate and to extend fullest co-operation to the sampler for sampling purpose.

This sampling procedure will apply once laboratories are approved under the new ZDHC Wastewater and Sludge Guidelines V2.

Appendix B

Mass balance of sulphur or acetone flows

Formula for mass balance

Sulphur air emissions = I1 - (O1 + O2 + O3 + O4 + O5 + O6)

Acetone air emissions = I1 - (O1 + O2)

Table 21 Mass balance of sulphur or acetone flows

Inputs		Notes	L/S/G	Test method
I1	CS_2 addition to reactor, including fresh input and CS_2 recovered from the process (condensation and CAP) Acetone addition to reactor, including fresh input and acetone recovered from the process		Liquid	As per flowmeter/tank level difference
Recovery / recycle / outputs				
O1	CS_2 recycled by condensation Acetone recycled by distillation		Liquid	As per flowmeter/tank level difference
O2	CS_2 recycled by activated carbon adsorption Acetone recycled through charcoal filters		Liquid	As per flowmeter/tank level difference
O3	Removal of H_2S as NaHS or Na_2S by alkaline wash and spray	Effluent / by-product	Liquid / solid	Method 1: Product of inlet gas flow by flowmeter and difference in concentration of CS_2 / H_2S at inlet and outlet of the reactor or wet scrubber Method 2: Product of quantity as per tank level difference and concentration as per lab or density meter. Estimate equivalent sulphur by calculation
O4	Converted H_2S and CS_2 into H_2SO_4 by oxidation using wet sulphuric acid process (WSA)	Wet sulphuric acid (WSA) technology	Liquid	Product of quantity (as per flowmeter or tank level difference) and concentration as per lab or density meter. Estimate equivalent sulphur by calculation. Deduct the supplementary sulphur (if any).
O5*	Converted H_2S and CS_2 into SOx by exhaust gas incineration/boiler, followed by scrubbing of flue gases by lime to produce gypsum	Flue gas desulphurisation	Solid	Calculation given below
O6	Converted H_2S, CS_2 or both to sulphur by biological or catalytic processes or redox process		Solid /liquid	Method 1: Inlet gas flow by flowmeter and difference in concentration of CS_2 / H_2S at inlet and outlet of the reactor or wet scrubber Method 2: Product of quantity as per tank level difference and concentration as per lab or density meter. Estimate equivalent sulphur by calculation

*Calculation method for O5 (gypsum)**

Incineration in a coal-fired boiler

Sulphur is fed into the boiler from the viscose process and is present in the coal itself. Both get converted to SOx in the boiler or incinerator. The SOx is scrubbed by lime to make gypsum. The flue gas from the boiler contains some remaining unscrubbed sulphur as SOx. The purity of gypsum varies depending on the flue gas desulphurisation process applied.

Explanation about gypsum on scrubbing of flue gases from CPP boilers (O5)

O5: (A+B) - (C+D)

Sulphur in: (A + B) where

A: exhaust flow rate from VSF in m^3/hr x equivalent sulphur mg/m^3 (from CS_2 and H_2S)

B: % sulphur in coal + quantity of coal (burnt in boilers in MT[a])

Sulphur out: (C+D)

C: (SO_2 in CPP boiler stack flue gas flow rate Nm^3/hr x SO_2 mg/Nm^3)x 32/64

D: (gypsum produced MT) x (32/120)

Reactions:

Dry scrubbing

$CaCO_{3(s)} + SO_{2(g)} \rightarrow CaSO_{3(s)} + CO_{2(g)}$

Wet Scrubbing

$Ca(OH)_{2(s)} + SO_{2(g)} \rightarrow CaSO_{3(s)} + H_2O_{(l)}$

a MT: metric tonne

Calculation for channelised sulphur emission

Facilities can calculate channelised sulphur emissions using the following formula:

Step 1 — equivalent sulphur concentration (mg/Nm^3)

$$c = \left(a \times \frac{64}{76}\right) + \left(b \times \frac{32}{34}\right)$$

Step 2 — sulphur emission to air (kg/tonne fibre):

$$\text{Sulphur to air} = \frac{Y \times c \times 24}{1{,}000{,}000 \times X}$$

- X = Fibre production (tonne/day)
- Y = Flowrate for each stack (Nm^3/h)
- a = CS_2 concentration (mg/Nm^3) (from CEMS/3rd party analysis)
- b = H_2S concentration (mg/Nm^3) (from CEMS/3rd party analysis)

Note: *When multiple stacks are involved, calculate the emissions (kg/day) for each stack individually. Then, sum the emissions (kgs/day) from all stacks and divide the total by the overall fibre production.*

Monitoring frequency:

CS_2: Continuous, meaning daily average, calculated with averaging hourly or half-hourly averages over a period of one day.

H_2S: Continuous, meaning daily average, calculated with averaging hourly or half-hourly averages over a period of one day.

Analysis and reporting are expressed as:

Values of concentration, expressed as mass of emitted substance per volume of waste gas under standard conditions (dry gas at a temperature of 273.15 K, and a pressure of 101.3 kPa) and expressed in the unit mg/Nm^3.

Appendix C

Measurement of ambient air in the surroundings of the production facility

The ambient air emissions measurement in the surrounding area of the production facility could be from direct monitoring (sampling and testing by an ISO 17025 accredited laboratory) or from air dispersion modelling. In both cases, the reported value is the estimated yearly average of the calendar year.

The definition of the assessment area must enable the proper assessment of the concentration of H_2S and CS_2 for VSF/modal, VFY and NH_3 for cupro and the possible impact on the surrounding environment.

It is proposed that the assessment area begins at the fence and is completely within a circumference around the centre of the emission within a radius of one kilometre or less from the source.

A. Ambient air emissions data from direct testing

Sampling and testing by an ISO 17025 accredited laboratory shall be done at least once a calendar year, considering:

1. That production is running AND
2. The direction of the wind and potential areas are covered. It is imperative that an air sampling protocol contains all relevant and important information applicable to the air sampling procedure.

B. Ambient air emissions data from air dispersion modelling

Assessment of the ambient air emissions of H_2S, CS_2, NH_3 and the possible impact on the surrounding environment can also be reported by air dispersion modelling, which is estimated for the yearly average of the calendar year.

Air dispersion modelling uses mathematical formulations to characterise the

atmospheric processes that disperse a pollutant emitted by a source. Based on emissions and meteorological inputs, a dispersion model can be used to predict concentrations at selected downwind receptor locations.[a]

Appendix D

Description of sludge disposal pathways

Pathway A – On-site or off-site incineration at >1000

This ZDHC disposal pathway is for sludge sent to on-site as well as off-site 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.

- Incineration is a waste treatment process that involves the combustion of organic substances contained in waste materials.
- Off-site 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.
- Facilities based in the EU region must comply with the Directive 2000/76/EC of the European Parliament and of the Council of 4 December 2000 on the incineration of waste (https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32000L0076) for conforming with this sludge disposal pathway.

a Air Quality Dispersion Modelling, United States Environmental Protection Agency, https://www.epa.gov/scram/air-quality-dispersion-modeling

Pathway B – Landfill with Significant Control Measures

This ZDHC disposal pathway is for sludge sent to landfill sites with significant control measures.

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.

Additional safeguards implemented in modern landfills prevent leachate and gas from harming the environment and human health and safety. These additional safeguards must meet stringent legal requirements for operation.

Landfills can be lined and sealed with natural clay, soil 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.

Significant control measures

- 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 are 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.

Leachate: A liquid produced by the percolation of water through waste and has a high concentration of potentially harmful pollutants.

Gas: Generated by the decomposition process and can be potentially explosive/flammable, odorous, and can contain harmful greenhouse gases if not controlled.

Pathway C – Building products processed at >1000

This ZDHC disposal pathway is for sludge made into building products, which are processed at >1000°C.

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 building products 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 the final products' strength.

Sludge limits associated with building products are separated into two distinct categories based on the temperature 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 estabilised 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.

Sintering: A manufacturing process in which powdered materials are compacted and then heated to a temperature below their melting point, causing the particles to bond and form a solid mass without fully liquefying. This process increases the strength, durability, and density of the final product by reducing porosity, and it can be applied to metals, ceramics, plastics, and more

Pathway D – Landfill with Limited Control Measures

This ZDHC disposal pathway is for sludge sent to landfill sites with limited control measures.

These are landfill types that do not meet the description requirements specified in the landfill with significant control measures disposal pathway.

- 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.

Pathway E – Building Products Processed at <1000 °C

This sludge disposal pathway is for sludge utilised in building products manufacturing processes with temperatures below 1000°C .

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 Wastewater and Sludge Guidelines based on the building product processing temperature.

Pathway F – Building products processed at <1000 °C

This sludge disposal pathway is for sludge utilised in building products manufacturing processes with temperatures below 1000°C .

.Pathway G – Land application for a specific purpose in approved areas

Land application is defined as the application of sludge to approved land areas. The sludge must be of a quality determined to benefit the area soil and be 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 landsites 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.

Relevant organisations and contributions

- Canopy click here
- The Collaboration for Sustainable Development of Viscose (CV) click here
- Textile Exchange Recycled Claim Standard click here

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6. Japanese offensive odour control law

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