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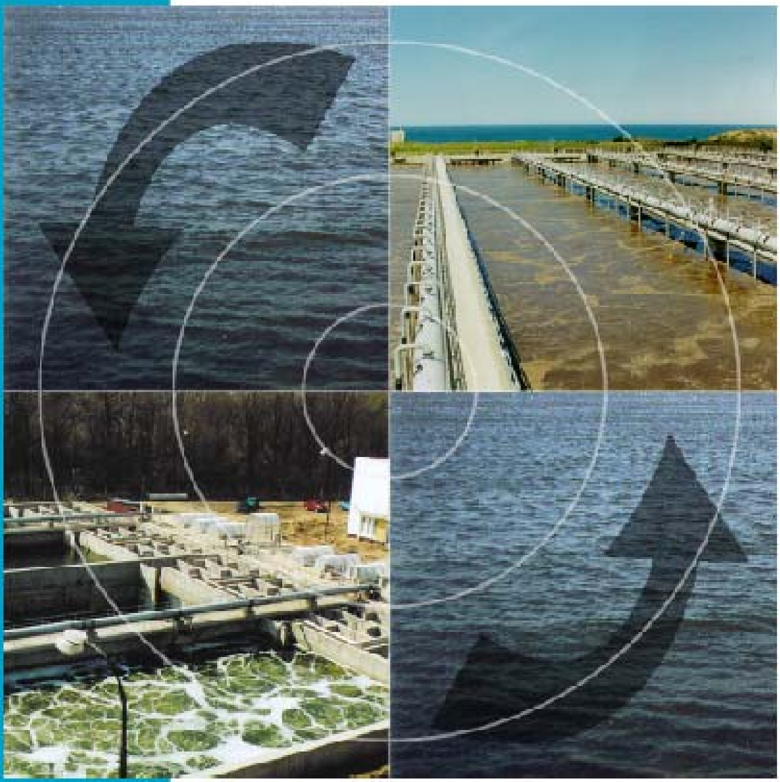
C-TECH



CYCLIC ACTIVATED SLUDGE TECHNOLOGY

Standard Waste Water Treatment Plants

CONTENTS

1 GENERAL DESCRIPTION

The use of the C-TECH System will simplify the operation of the total wastewater treatment plant and provides a more economical footprint.

The benefits of operation of the C-TECH System over SBR (sequencing batch reactor) and other conventional systems are listed hereinafter.

The design matches the design technique of conventional wastewater treatment plants. The differences in process etc. are relatively minor but equipment requirements and capital costs are significant.

This document describes the standard wastewater treatment facility and presents relevant information on the C-TECH process technology.

The technology is state-of-the-art.

Grundfos reserves the right for technical improvements. The given standard sizes, and capacities shall be refined and modified in case of significant deviations from standard domestic sewage compositions and in case of placing an order Grundfos shall be asked for the customer tailored design values.

All given equipment types and manufacturers are to be regarded as a reference (“or equal”) and might be subject to changes during detail design.

2 TREATMENT LEVELS

Two different treatment levels can be offered:

"Treatment level 1" achieves carbon removal only whereas "treatment level 2" deals with nitrification / denitrification and simultaneous sludge stabilization.

Treatment Level 1	removes organic matters (BOD = biological oxygen demand and COD = chemical oxygen demand) as well as suspended solids (SS) according to EU directives. Max. allowed effluent values: BOD<25 mg/l, COD<125 mg/l and SS<35 mg/l
Treatment Level 2	removes BOD, COD, SS and nitrogen (TN plus NH4-N) according to EU directives with simultaneous stabilization of the activated sludge. This option offers the possibility to store the sludge without any further treatment for several months in an underground storage tank. The sludge consequently can then be transported to a sludge deposit facility by truck or being used for agricultural purposes (depending on local requirements).

3 FACILITY DESIGN

The C-TECH system can be offered customer-tailored as follows:

- Inlet pumping station
- Fine screen
- Sand / grease trap
- Distribution to C-TECH basins
- C-TECH basin as biological treatment
- Sludge storage tank (below operation building)
- Sludge dewatering centrifuge
- Operation building for distribution panel, automation system, blower station
- An effluent reuse system comprising a compact filtration unit and a chlorination system can be added if required.

4 DESIGN DATA

4.1 Design Flow Ranges

All design figures refer to people equivalent (PE) which are in terms of loads hereinafter defined as follows:

BOD	g/PE	60
COD	g/PE	120
SS	g/PE	55
TN	g/PE	11
TP	g/PE	2.0

Flow rates are used as litre per PE for the daily design flow.

C-TECH facilities are designed for daily influents ranging from 100 to 400 l/p.e.

The following flow rates and loadings are derived:

PE [-]	**1,000**	**2,500**	**5,000**	**7,500**	**10,000**
Qd [m^3/d]	100-400	250-1000	500-2000	750-3000	1000-4000
Q max [m^3/h] = Q/12	8-33	21-83	42-167	63-250	83-333

Above numbers are regarded as 85% iles.

5 PROCESS DESCRIPTION OF BIOLOGICAL TREATMENT

The biological treatment processing is based on the use of the C-TECH System methodology.

Biological oxidation and reduction of organic and inorganic pollutants is carried out by micro-organisms.

These micro-organisms are typically referred to as *activated sludge*.

During the treatment process activated sludge is generated. Such sludge is odourless, non-harmful and does not impose any health risk to the operators or the environment when handled according to standard regulations and operation instructions which are defined hereinafter.

By comparison with other conventional or sequencing batch reactors (SBR), the use of the C-TECH System offers significant economies in capital cost, including mechanical and electrical costs, operation and maintenance costs and land area requirements.

Apart from these, there are further advantages which ultimately result in the technology referred to as the "C-TECH System".

In comparison to other conventional and generic sequencing batch reactor the C-TECH System includes:

- Elimination of the need for secondary clarifiers and thus a very compact floor print and an aesthetically pleasing facility.
- In case of requiring denitrification, the system can operate **without** mixing equipment !
- In case of requiring P-elimination, phosphorus can be removed to a large extent without chemical addition by using the BIO-P effect in the system.
- All operations take place within a single basin which provides for easy extension through modular construction.

- Automatic containment of growth of most of the filamentous sludge bulking micro-organisms. A fast settling coarse granulated activated sludge which dewaters readily is produced.
- Tolerance to shock loading by organic and/or hydraulic load fluctuations.
- Operation without solids washout.
- Removal of treated effluent at a constant rate, free of scum and **without** complex valving arrangements.
- Operates with minimal internal recycle flows.
- Good references of existing plants.
- Least odour potential technology.

5.1 C-Tech System

The C-TECH System specifically refers to the use of a special world wide patent protected process where amongst other features the combination of a biological selector in combination with a fed-batch reactor mode is protected.

The biological selector allows to accommodate the system to different types of waste waters and to build it smaller and more cost effective without reducing operational safeties.

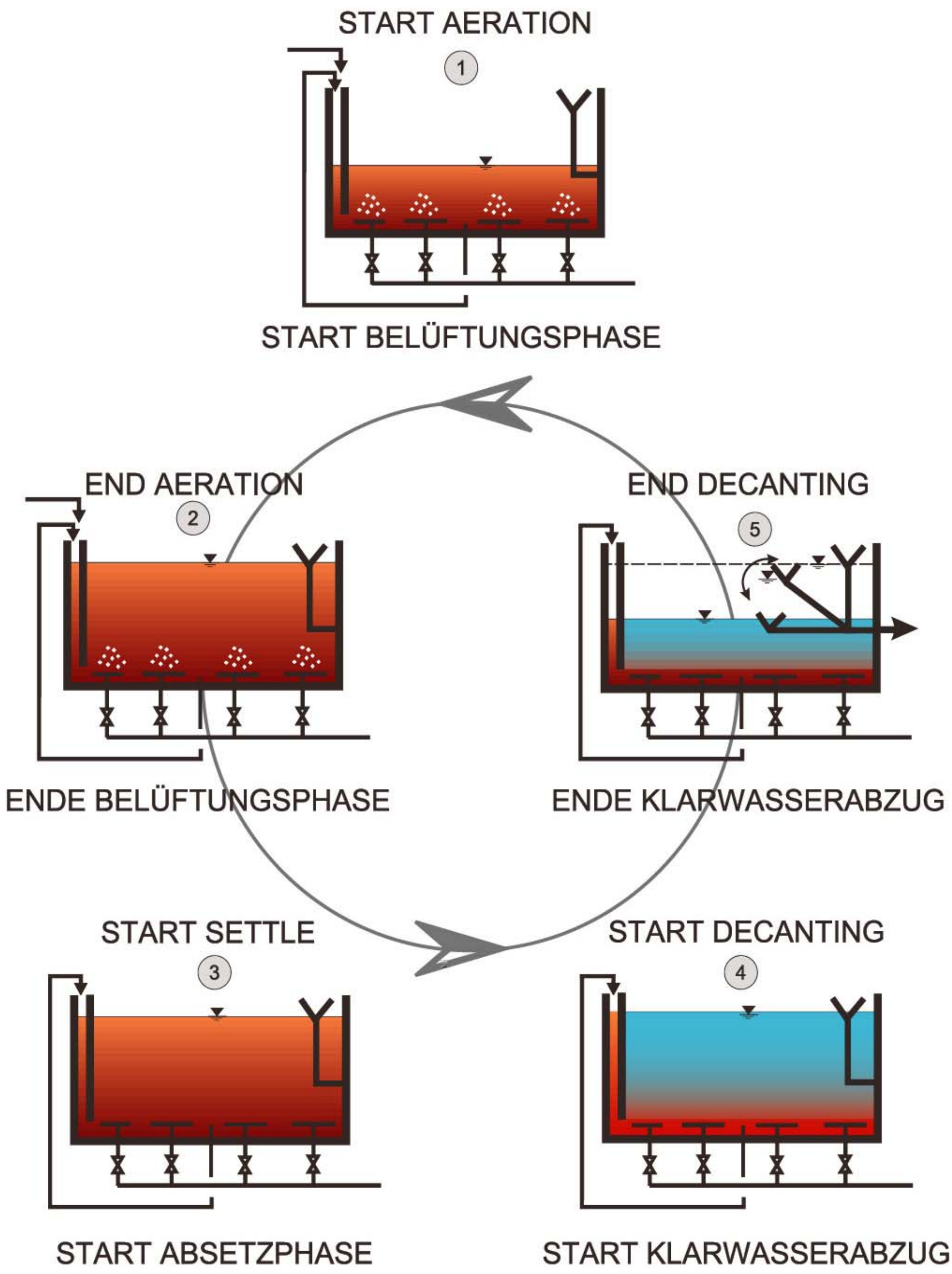
5.2 Cycle Operations

A basic cycle comprises:

- **F**ill-aeration, **A**eration (**F**/**A**)
- **S**ettlement (**S**)
- **D**ecanting (**D**)

Completion of the sequences described above constitute a cycle which is then repeated. During the period of a cycle, the liquid volume inside the vessel increases from a set minimum operating bottom water level in response to a varying influent flow rate.

Aeration and mixing ceases at a predetermined period of the cycle to allow the biomass to flocculate and settle under quiescent conditions. After a specific **settling** period the treated supernatant is removed (**decanted**), using a moving weir decanter. The liquid level in the vessel is so returned to the bottom water level after which the cycle is repeated. Aeration is provided to complete the biological reactions. Solids are wasted from the tanks as required to maintain the biomass at manageable levels.


START AERATION
1
START BELÜFTUNGSPHASE
END AERATION
2
ENDE BELÜFTUNGSPHASE
END DECANTING
5
ENDE KLARWASSERABZUG
START SETTLE
3
START ABSETZPHASE
START DECANTING
4
START KLARWASSERABZUG

5.3 Biorate Control

BIORATE control uses dissolved oxygen measuring sensors and the complete-mix basin configuration to provide a full scale process respirometer.

In this way, the metabolic activity of the biomass is measured within the actual process basin and is subsequently used as a control to the process.

A minimum of 15 % energy saving is realized through the BIORATE operation as the process oxygen delivery is specifically regulated to operate under a less than 1 mg/L in-basin dissolved oxygen concentration for most of the aeration sequence.

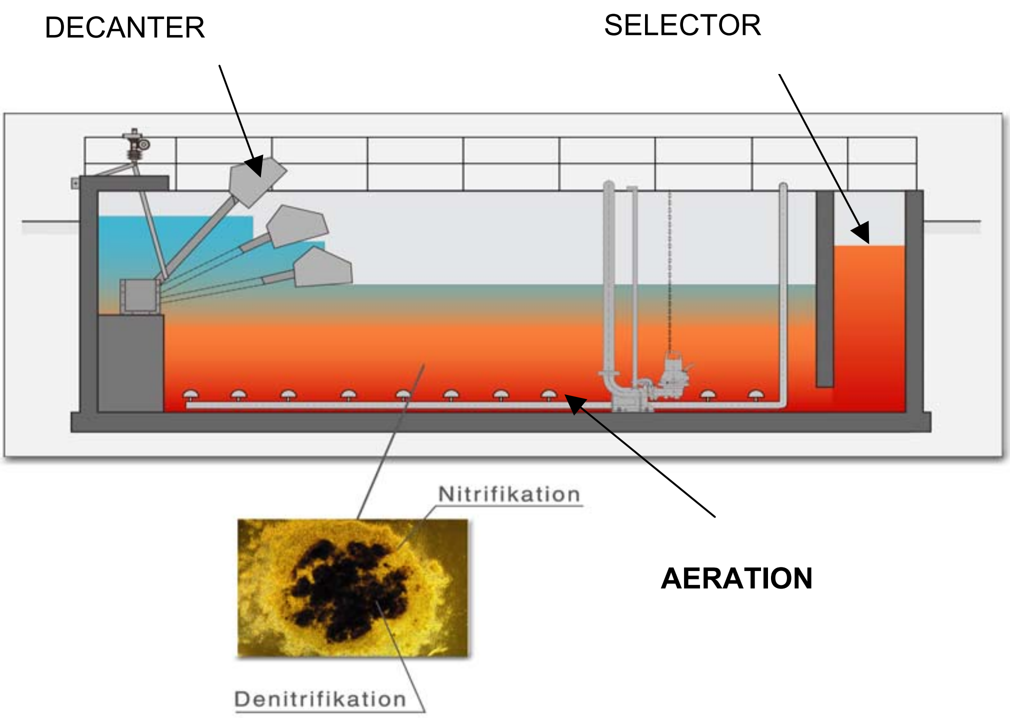


Fig. 4 Schematic drawing of a C-TECH basin

5.4 Biological Selector Zone

The incorporation of a configured biological selector within the variable volume reactor basin differentiates the C-TECH System from other generic SBRs'.

This feature of the process dispenses with the need to operate with FILL AND FILL-ANOXIC-MIX sequencing and replaces it with simple FILL-AERATE sequencing and therefore simplifies the operation of the process.

It also ensures biological selection of predominantly floc-forming micro-organisms, increases the operational safety, reduces the effluent concentrations and allows the facility to be built more cost effective.

The biological selector assists with the selection of poly P micro-organisms and in the process of removing phosphorus biologically without chemical addition.

5.5 Operational Simplicity

The plant control is essentially automatic which is a major factor in reducing operating costs.

The cycling of each batch process and the regulation of each sequence interval is governed by a Programmable Logic Control (PLC). Control for the operation of each sludge pump, each decanter etc. is also included.

The automatic basin air distribution system also regulated by the PLC. This means that optimum operation and performance are synonymous; management of high and low load circumstances is easily maintained providing for steady state performance.

6 DESIGN OF TREATMENT STEPS

6.1 Arriving of Flows

It is assumed that raw sewage arrives by gravity flows underground suitable to pass through the fine screen unit and the sand/grit removal by gravity.

6.2 Fine Screen Unit

A fine screen system HUBER Rotomat or equal is foreseen for screening the raw sewage. This unit to be installed indoors, outdoor installation require technical modifications.

Screenings will be compacted automatically and discharged into a container.

Details concerning scopes, options and sizes to be given in a separate offer.

6.3 Sand and Grit Removal

A circular sand and grit removal system is installed . The smaller sizes can be manufactured in stainless steel, larger sizes to be constructed in concrete locally. The sand shall be discharged via a sand pump into a sand hopper, a small blower provides air for flotation of grease. Grease removal to be carried out manually on a weekly basis. If high fat content in the waste water must be expected an additional grease removal system in the C-Tech selectors can be offered optionally.

6.4 Intermediate Pumping Station and Flow Distribution

After the sand/grit removal the intermediate pumping station lifts the raw sewage and distributes it to the C-Tech basins. The intermediate pumping station also serves as a small flow equalization tank and also allows to dose precipitants in the cases where chemical Phosphorus removal is required. The volume requirements for the pumping station is listed under the following chapter.

6.5 C-Tech Basins

6.5.1 Design cycles

The standard cycle will be designed as follows:

Treatment level	1	2
Normal cycle [h]	**4**	**4**
Aeration time [h]	2	2
Settling phase [h]	1	1
Decant phase [h]	1	1
High flow cycle [h]	**2**	**4**
Aeration time [h]	0.5	2
Settling phase [h]	0.75	1
Decant phase [h]	0.75	1

Following parameters are to be considered as indicative and – in case of placing an order – will have to be modified according to actual project requirements.

6.5.2 Treatment Level 1

PE [-]	1,000	2,500	5,000	7,500	10,000
Number of basins	2	2	2	2	2
Basin surface each [m²]	24	55	104	160	216
Top water level (TWL) [m]	4.0	4.0	4.0	4.0	4.0
*) Bottom water level (BWL) [m]	2.5-3.7	2.5-3.7	2.5-3.7	2.5-3.7	2.5-3.7
Basin depth [m]	4.7	4.7	4.7	4.7	4.7
Total volume at TWL [m³]	190	440	830	1,280	1,630
FM rate [kgBOD/kg.DS.h]	0.09	0.09	0.09	0.09	0.09
*) Hydraulic retention time [h]	11-44	11-44	11-44	11-44	11-44
Total sludge age [d]	10	10	10	10	10
Decanter length [m]	1.0	1.0	2.0	3.0	4.0
*) Max. effluent rate [m³/h]	11-44	28-111	56-222	83-333	111-444
DS at max. water level [g/l]	3.5	3.5	3.5	3.5	3.5
Max. air flow [Nm³/h]	250	650	1,300	1,900	2,500
Standard O_2 demand [kgO_2/h]	14	34	70	105	140
Recirculation volume [m³/h]	10	10	10	20	20
Sludge index SVI [m³/g]	90	90	90	90	90
*) Required volume pump sump [m]³	5-20	10-40	20-80	30-120	40-160
Prethickener l x w x d [m]	1,4 x 1,4 x 3,75	2,2 x 2,2 x 4,95	3,1 x 3,1 x 5,45	3,8 x 3,8 x 5,45	4,4 x 4,4 x 5,45
Max. required sludge storage capacity / month [m³] at 2.5% DS	60	140	260	400	520

*) Mentioned ranges of variation are dependant on possible design requirements of influent raw sewage in the range between 100 – 400 l/pe.d

6.5.3 Treatment Level 2

PE [-]	1,000	2,500	5,000	7,500	10,000
Number of basins	2	2	2	2	2
Basin surface each [m²]	44	102	204	312	406
Top water level (TWL) [m]	4.0	4.0	4.0	4.0	4.0
*) Bottom water level (BWL) [m]	2.5-3.6	2.5-3.6	2.5-3.6	2.5-3.6	2.5-3.6
Basin depth [m]	4.7	4.7	4.7	4.7	4.7
Total volume at TWL [m³]	350	820	1,630	2,500	3.250
FM rate [kgBOD/kg.DS.h]	0.04	0.04	0.04	0.04	0.04
*) Hydraulic retention time [h]	21-84	21-84	21-84	21-84	21-84
Total sludge age [d]	25	25	25	25	25
Decanter length [m]	1.0	1.0	2.0	3.0	4.0
*) Max. effluent rate [m³/h]	13-53	33-133	67-267	100-400	133-533
DS at max. water level [g/l]	4	4	4	4	4
Max. air flow [Nm³/h]	250	450	900	1,300	1,900
Standard O_2 demand [kgO_2/h]	10	24	50	71	95
Recirculation volume [m³/h]	10	10	10	20	20
Sludge index SVI [m³/g]	90	90	90	90	90
*) Required volume pump sump [m]³	5-20	10-40	20-80	30-120	40-160
Prethickener l x w x d [m]	1,3 x 1,3 x 3,25	2,1 x 2,1 x 3,75	2,9 x 2,9 x 4,35	3,6 x 3,6 x 4,75	4,1 x 4,1 x 5,15
Max. required sludge storage capacity / month [m³] at 2.5% DS	60	140	260	400	520

*) Mentioned ranges of variation are dependant on possible design requirements of influent raw sewage in the range between 100 – 400 l/pe.d

6.6 Sludge Thickening

The surplus sludge from the C-Tech basins will be directly discharged to a small gravity thickener in order to reduce sludge storage volume requirements. The thickened sludge will be pumped to an underground sludge storage with a submersible pump. These pumps not operated automatically. Dimension requirements are given within the tables above.

6.7 Sludge storage

Typical sludge concentration after gravity thickening will be about 2,5-3,5% DS.

Volume requirements for storage are given in above tables as “per month”.

If no sludge dewatering facility is chosen even higher storage volumes might be considered in order to best possible use the available transportation volume of road tankers.

If permanent attendance of the plant is available where frequent operation of the dewatering facility is desired much smaller volumes can be designed for.

6.8 Sludge dewatering

Sludge dewatering via centrifuge is a cheep on site solution to reduce transportation, and disposal costs. Depending on raw sewage quality final DS values of 15%-25% are achieved.

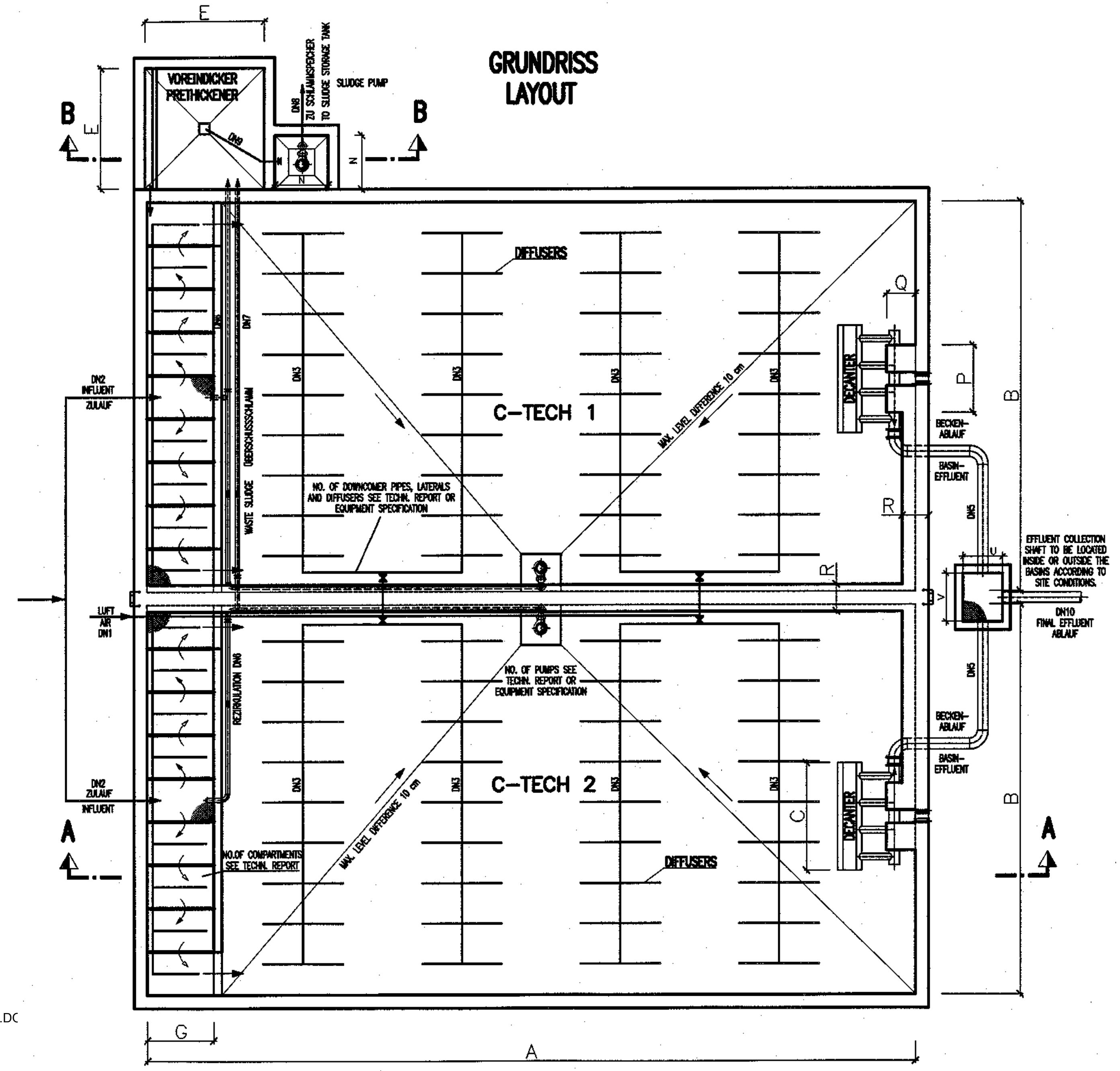
Prior to dewatering polyelectrolytes are dosed. Sediment scrolls transport the sludge cake to sludge hoppers.

6.9 Effluent reuse

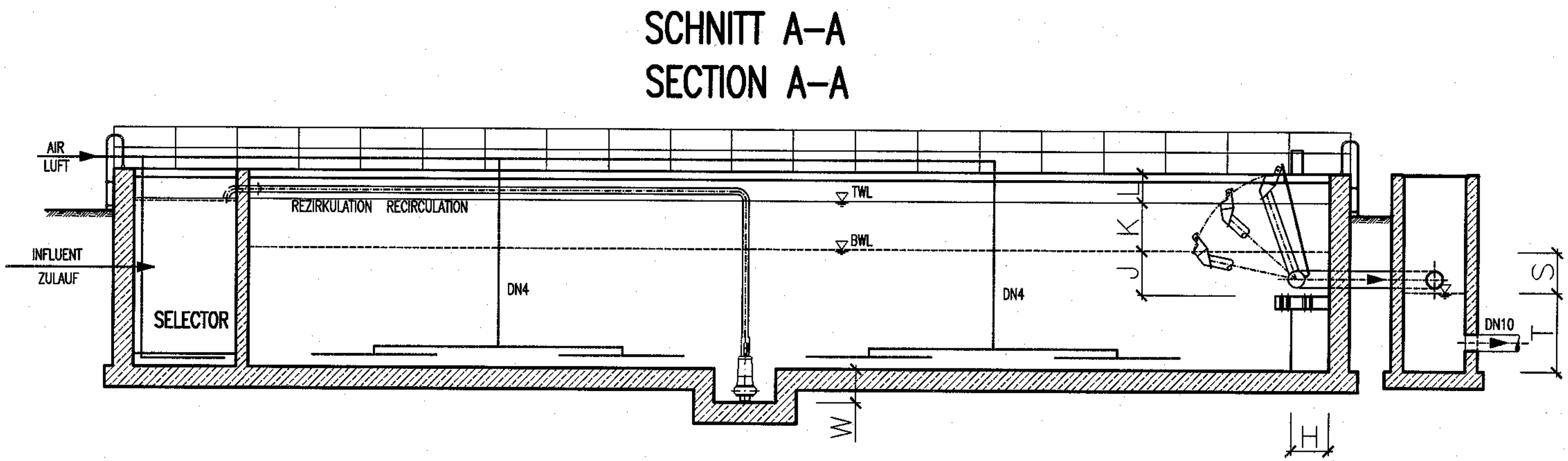
If effluent reuse for irrigation or other purposes is required a reuse system can be added which would comprise the following steps:

- Raw effluent holding tank to equalize the discharge of the C-Tech basins. Submersible pumps to feed the filters.
- Automatic, compact filtration unit with steel vessel filters and 100μm steel cartouche filters. This is only required if suspended solids (SS) concentrations of <5mg/l are required.
- Liquid chlorination unit with chlorine gas. This is only required if disinfection is required.
- Chlorine contact tank and water storage tank to provide a reasonable storage capacity.

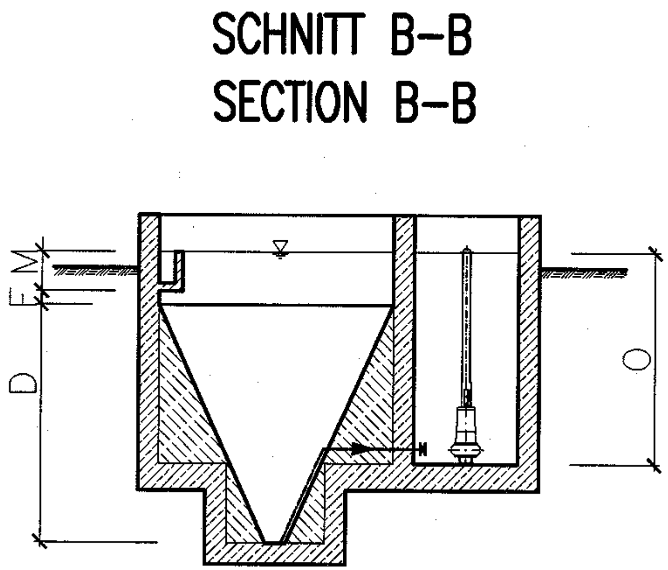
7 EXAMPLE DRAWINGS


GRUNDRISS
LAYOUT
VOREINDICKER
PRETHICKENER
ZU SCHLAMMSPEICHER
TO SLUDGE STORAGE TANK
SLUDGE PUMP
DIFFUSERS
C-TECH 1
C-TECH 2
DECANTER
BECKEN-ABLAUF
BASIN-EFFLUENT
MAX. LEVEL DIFFERENCE 10 cm
NO. OF DOWNCOMER PIPES, LATERALS AND DIFFUSERS SEE TECHN. REPORT OR EQUIPMENT SPECIFICATION
WASTE SLUDGE
ÜBERSCHUSSSCHLAMM
DN2 INFLUENT ZULAUF
LUFT AIR DN1
EFFLUENT COLLECTION SHAFT TO BE LOCATED INSIDE OR OUTSIDE THE BASINS ACCORDING TO SITE CONDITIONS.
DN10 FINAL EFFLUENT ABLAUF
NO. OF PUMPS SEE TECHN. REPORT OR EQUIPMENT SPECIFICATION
REZIRKULATION DN6
NO.OF COMPARTMENTS SEE TECHN. REPORT
DN3
DN5
DN6
DN7
DN8
DN9
A
B
C
E
G
N
P
Q
R
U
V

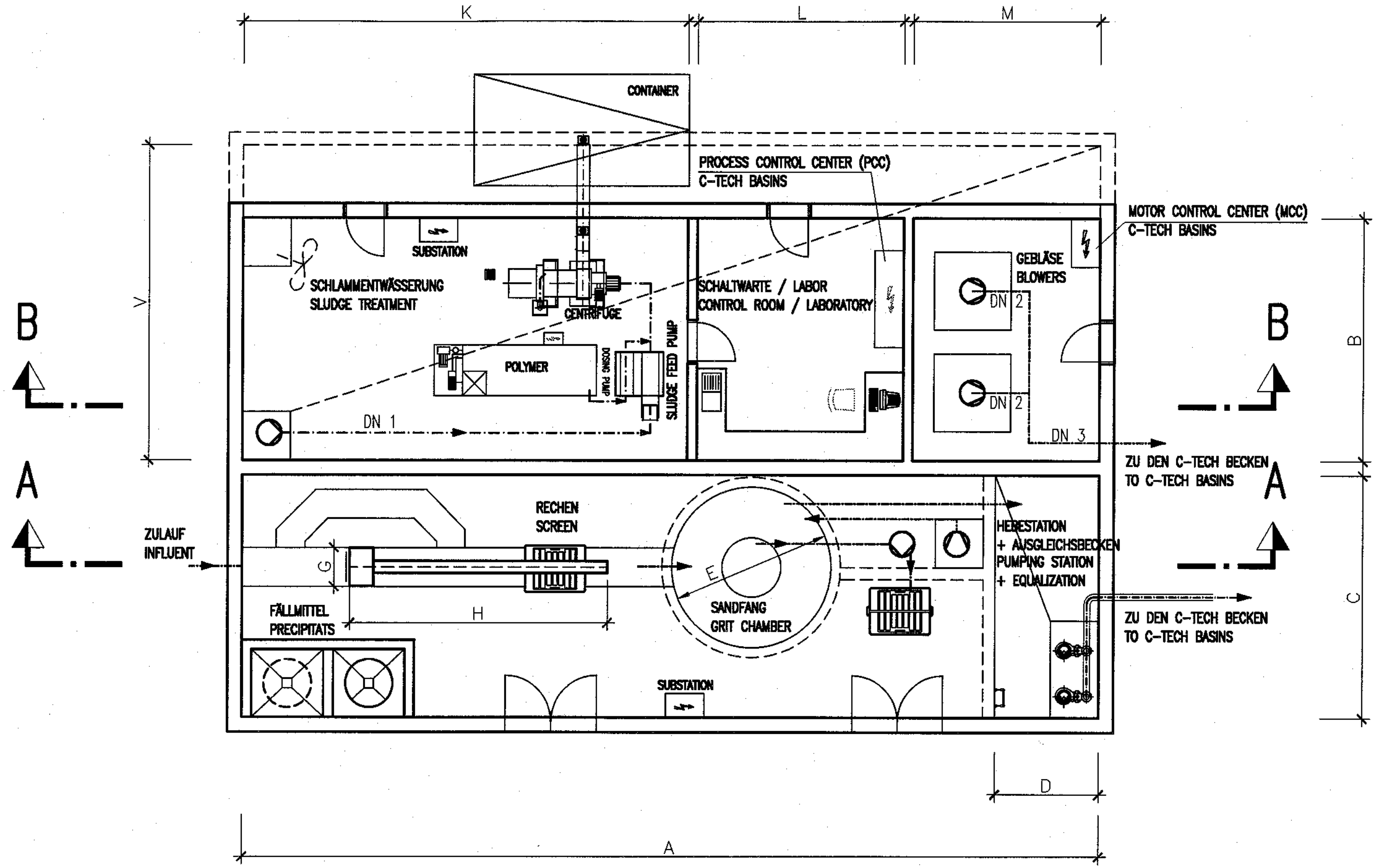
Drawing No. C-TECH 2 (a)



Drawing No. C-TECH 2 (b)



Drawing No. OPERATION 1



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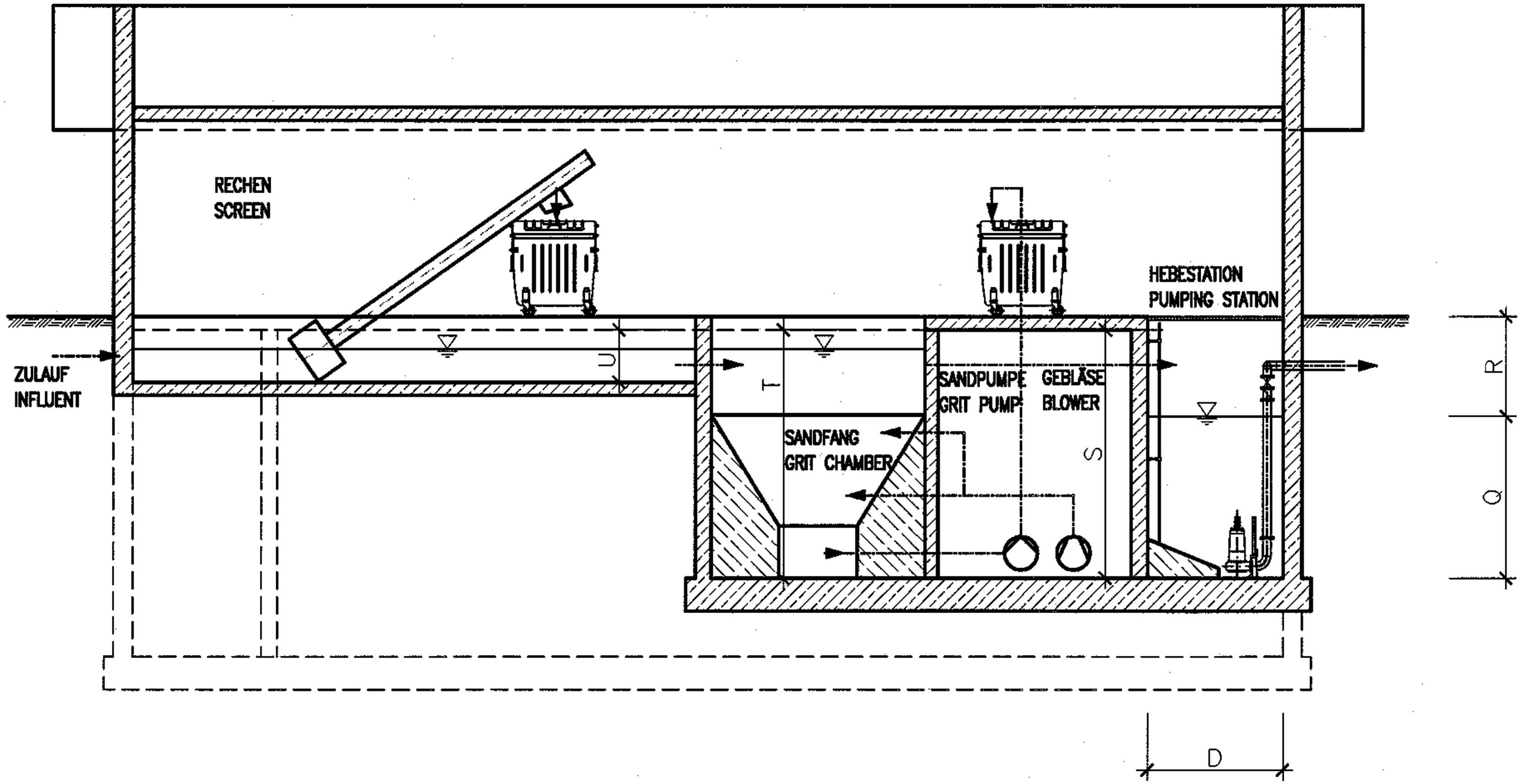
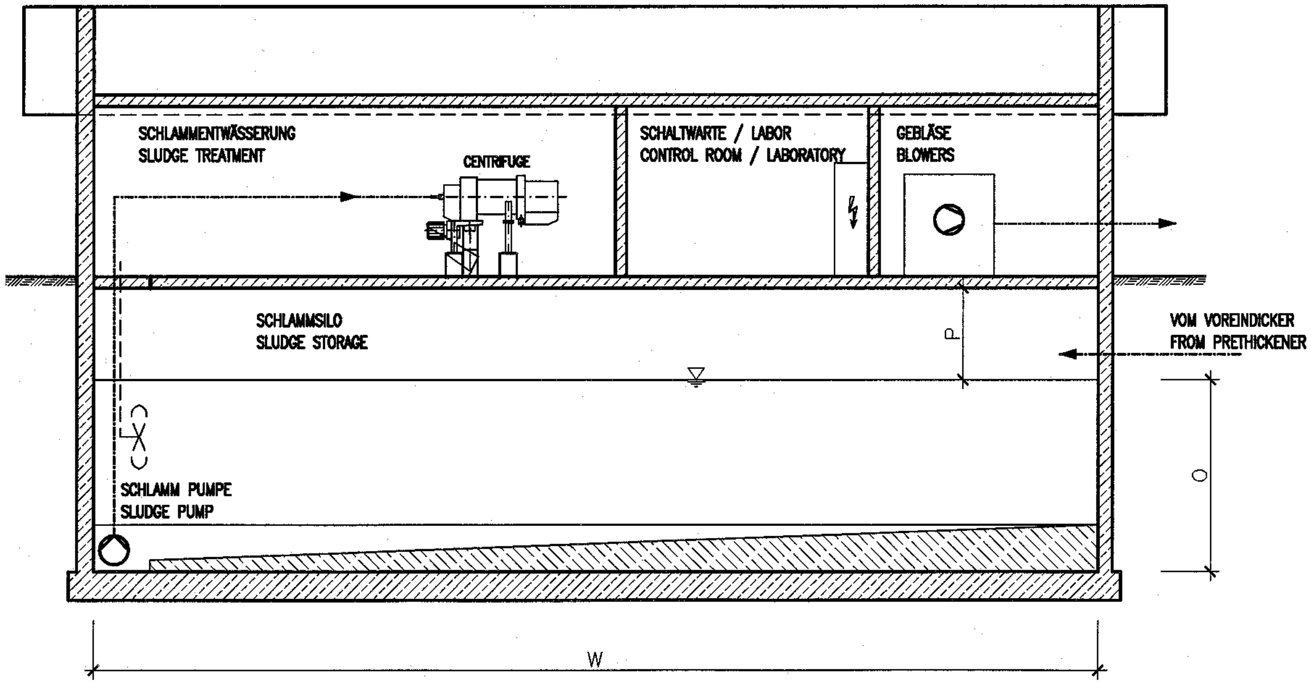
Drawing No. OPERATION 2

SCHNITT A–A
SECTION A–A



Drawing No. OPERATION 3

SCHNITT B–B
SECTION B–B



8 DATA TABLES

8.1 C-TECH Basins Level 1

Index and Data Table for Drawing No. C-TECH 1, C-TECH 2 (a) + (b)

Enclosed figures are for hydraulic estimations and civil structure calculations only.

Not for construction. Detailed figures will be given after a contract coming into force between SFC U and the client

Index	Description	Unit	1.000	2.500	5.000	7.500	10.000
A	Overall internal length C-Tech	cm	690	1050	1450	1800	2080
B	Overall internal width C-Tech	cm	350	530	720	890	1040
BWL	Bottom water level	cm	240	240	240	240	240
C	Decanter trough length	cm	100	100	200	300	300
D	Conical depth of thickener	cm	140	220	310	380	450
E	Length and width of thickener	cm	140	220	310	380	440
F	Vertical spacing in thickener	cm	160	200	160	90	20
G	Selector length from overall length A	%	15	15	15	15	15
H	Foundation sockets for decant arm	cm	110	110	110	110	110
J	Height of foundation socket underneath BWL	cm	45	45	55	60	65
K	Depth between BWL and TWL	cm	160	160	160	160	160
L	Freeboard of C-Tech basin	cm	50	50	50	50	50
M	2nd vertical spacing in thickener	cm	75	75	75	75	75
N	Dimension of sludge pumping shaft	cm	100	100	100	100	100
O	Water level in Sludge pumping shaft	cm	400	400	400	400	400
P	Length of walkway around decant arm	cm	250	250	250	250	250
Q	Width of walkway around decant arm	cm	110	110	110	110	110
R	General width of walkways on basin	cm	100	100	100	100	100

S	Max. allowed water level in effluent collection shaft underneath BWL	cm	45	45	55	60	65
T	Max water depth in effluent collection shaft	cm	to be defined later				
U/V	Length/width of effluent collection shaft	cm	100	100	100	100	100
W	Depth of RAS/SAS pumping pit in C-Tech basins	cm	50	50	50	50	50
DN 1	Main air feeder	mm	100	150	200	250	300
DN 2	Inlet waste water pipe	mm	100	150	200	250	300
DN 3	Lateral air pipe	mm	100	100	100	125	150
DN 4	Downcomer pipe	mm	75	100	150	200	200
DN 5	Basin effluent pipe	mm	250	250	350	400	450
DN 6	Return activated sludge (RAS) pipe	mm	100	100	100	100	100
DN 7	Surplus activated sludge (SAS) pipe	mm	100	100	100	100	100
DN 8	Pipe to sludge storage tank	mm	100	100	100	100	100
DN 9	Gravity thickener sludge pipe	mm	100	100	100	100	100
DN 10	Final effluent pipe	mm	250	250	350	400	450

8.2 C-TECH Basins Level 2

Index and Data Table for Drawing No. C-TECH 1, C-TECH 2 (a) + (b)

Enclosed figures are for hydraulic estimations and civil structure calculations only.

Not for construction. Detailed figures will be given after a contract coming into force between SFC U and the client

Index	Description	Unit	1.000	2.500	5.000	7.500	10.000
A	Overall internal length C-Tech	cm	940	1430	2020	2500	2850
B	Overall internal width C-Tech	cm	470	720	1010	1250	1430
BWL	Bottom water level	cm	240	240	240	240	240
C	Decanter trough length	cm	100	100	200	300	400
D	Conical depth of thickener	cm	130	210	300	360	420
E	Length and width of thickener	cm	130	210	290	360	410
F	Vertical spacing in thickener	cm	120	90	60	40	20
G	Selector length from overall length A	%	15	15	15	15	15
H	Foundation sockets for decant arm	cm	110	110	110	110	110
J	Height of foundation socket underneath BWL	cm	45	45	55	60	65
K	Depth between BWL and TWL	cm	160	160	160	160	160
L	Freeboard of C-Tech basin	cm	50	50	50	50	50
M	2^{nd} vertical spacing in thickener	cm	75	75	75	75	75
N	Dimension of sludge pumping shaft	cm	100	100	100	100	100
O	Water level in Sludge pumping shaft	cm	400	400	400	400	400
P	Length of walkway around decant arm	cm	250	250	250	250	250
Q	Width of walkway around decant arm	cm	110	110	110	110	110
R	General width of walkways on basin	cm	100	100	100	100	100

S	Max. allowed water level in effluent collection shaft underneath BWL	cm	45	45	55	60	65
T	Max water depth in effluent collection shaft	cm	to be defined later				
U/V	Length/width of effluent collection shaft	cm	100	100	100	100	100
W	Depth of RAS/SAS pumping pit in C-Tech basins	cm	50	50	50	50	50
DN 1	Main air feeder	mm	100	150	200	200	250
DN 2	Inlet waste water pipe	mm	100	150	200	250	300
DN 3	Lateral air pipe	mm	100	100	100	100	125
DN 4	Downcomer pipe	mm	50	80	125	150	200
DN 5	Basin effluent pipe	mm	250	250	350	400	450
DN 6	Return activated sludge (RAS) pipe	mm	100	100	100	100	100
DN 7	Surplus activated sludge (SAS) pipe	mm	100	100	100	100	100
DN 8	Pipe to sludge storage tank	mm	100	100	100	100	100
DN 9	Gravity thickener sludge pipe	mm	100	100	100	100	100
DN 10	Final effluent pipe	mm	250	250	350	400	450

8.3 Operation Building

Index and Data Table for Drawing No. Operation 1
Operation 2
Operation 3

Index	Description	Units	1.000	2.500	5.000	7.500	10.000
A	Overall internal length	cm	1800	1800	1800	1800	1800
B	Width of rooms1	cm	500	500	500	500	500
C	Width of rooms 2	cm	500	500	500	500	500
D	Width of intermediate pumping station	cm	120	280	560	830	1100
E	Diameter of sand and grit chamber	cm	126	178	252	281	332
F							
G	Screen drum diameter	cm	30	40	60	78	78
H	Screen drum length	cm	510	510	540	540	540
J							
K	Length of centrifuge room	cm	750	750	750	750	750
L	Length of control room/laboratory	cm	530	530	530	530	530
M	Length of blower room	cm	520	520	520	520	520
N		cm					
O	Max. sludge depth of sludge storage tank	cm	350	350	350	350	350
P	Freeboard in sludge storage tank	cm	50	50	50	50	50
Q	Max. operational water level in intermediate pumping station	cm	300	300	300	300	300
R	Freeboard of intermediate pumping station	cm	50	50	50	50	50

S	Depth of operation room for sand and grit chamber	cm	350	350	350	350	350
T	Depth of sand and grit chamber	cm	350	350	350	350	350
U	Channel depth of inlet channel	cm	80	80	80	80	80
V	Width of underground sludge storage tank	cm	500	500	500	630	825
W	Length of underground sludge storage	cm	340	800	1480	1800	1800
DN 1	Feed pipe for sludge treatment	mm	100	100	100	100	100
DN 2	Air blower pipe	mm	65	100	125	150	
DN 3	Main air pipe to C-Tech basins	mm	100	150	200	250	300

9 LITERATURE

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