Lecture 13 and 14

Preliminary Treatment
-
Mechanical Wastewater Treatment

Part 13: Screen, Sieve

Mechanical wastewater treatment

1. Removal of gruff material, fibrous material and synthetic material devices:
   Screen, sieves

2. Removal of sand device:
   Grit chamber

3. Removal of floating material and fats (not necessary in every sewage plant) devices:
   Grease separator, flotation

4. Removal of material that can sediment (not existent in every wastewater plant) device:
   Primary settlement tank

Types of screens

Differ in technical criteria and/or function:

- Dimension of the screen clefts
- Type of screen
- Cleaning process
- Character of immersion of diving gear

Recommendations for the design and use of screens

- To avoid the deposition of sand the speed of water should not be slower than **0.6 m/s** in front of the screen.
  It should not be higher than **1.5 m/s**, so that the screenings are not forced through.

- In certain cases it is reasonable to use a double-step screening plant, consisting of a coarse screen and a fine screen unit.

- To increase the occupational safety, a **multi-road plant** is recommended.

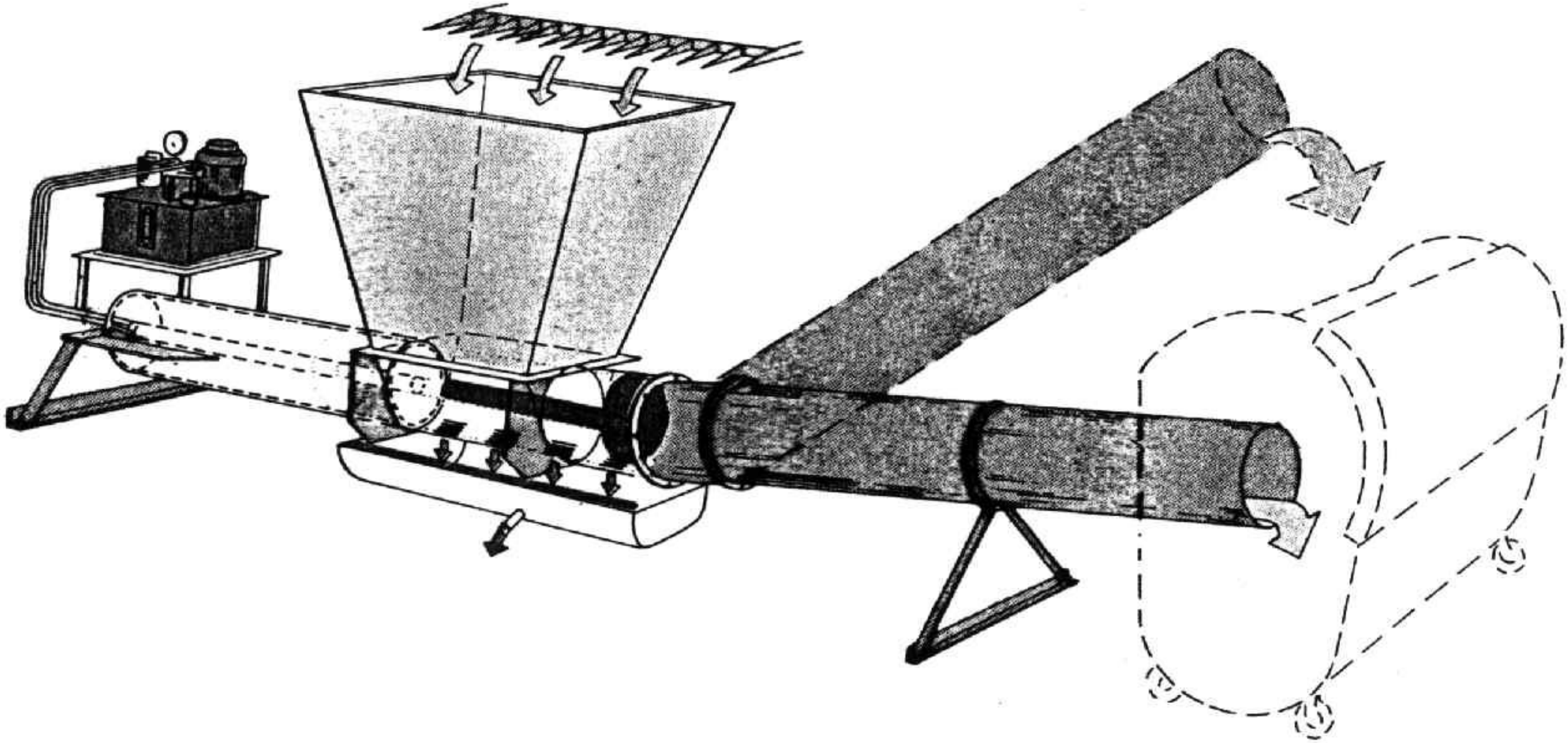
Recommendations for the design and use of screens

- The screens should have a security bypass *(Sicherheitsumlauf)*, that is activated in the case of blockage. This security bypass should have a coarse screen.

- **Screening plant and screening container** should be housed for hygienic reasons, because of the emissions and to protect them from the weather.

- The requirements concerning Ex-protection and aeration should be followed.

Screening press



Passage width for screens and sieves

Screens:

According to DIN 19554: 10 to 100 mm,

Differentiated between:

- Fine screen units: 10 to 25 mm
- Coarse screens : 25 to 100 mm

Sieves:

- In the mechanical process of pre-cleaning between 0.5 and 5.0 mm (usually 1.5 mm).
- For the treatment of drinking water and the last step of sewage purification micro sieve with 10µm are used.

Advantages of sieves in comparison to screens

1. **They hold back fibrous material.** Those can become long plaits due to the water eddies *(Verzopfung)* and can damage the machines and cause blockage.

2. **They filter small plastic materials** that could deposit and cause blockage in the machines and devices. It could interfere the agricultural sewage sludge application too.

Advantages of sieves in comparison to screens

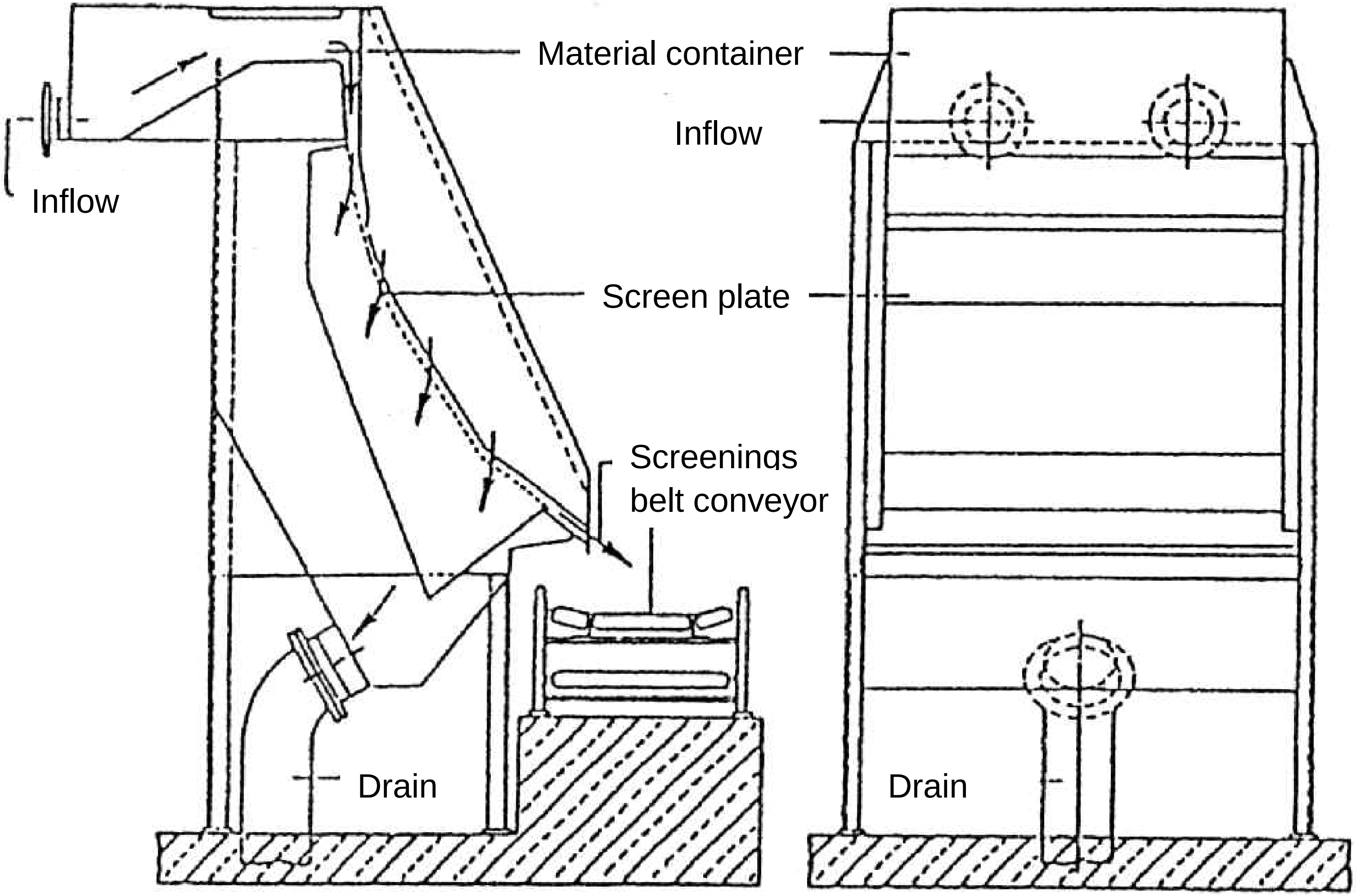
3. Sieves also remove particular organic substances
(e.g. corn grains etc.) and can cause a BOD-reduction up to 10%, but normally this reduction is not considered.

It is not possible to say that by the use of a sieves pre-purification screens are no longer necessary. This happens because screens and sieves strongly differ concerning their deposit of organic material and the disclaimer of pre-purification is mostly based on the need to keep these lightly degradable organic substances.

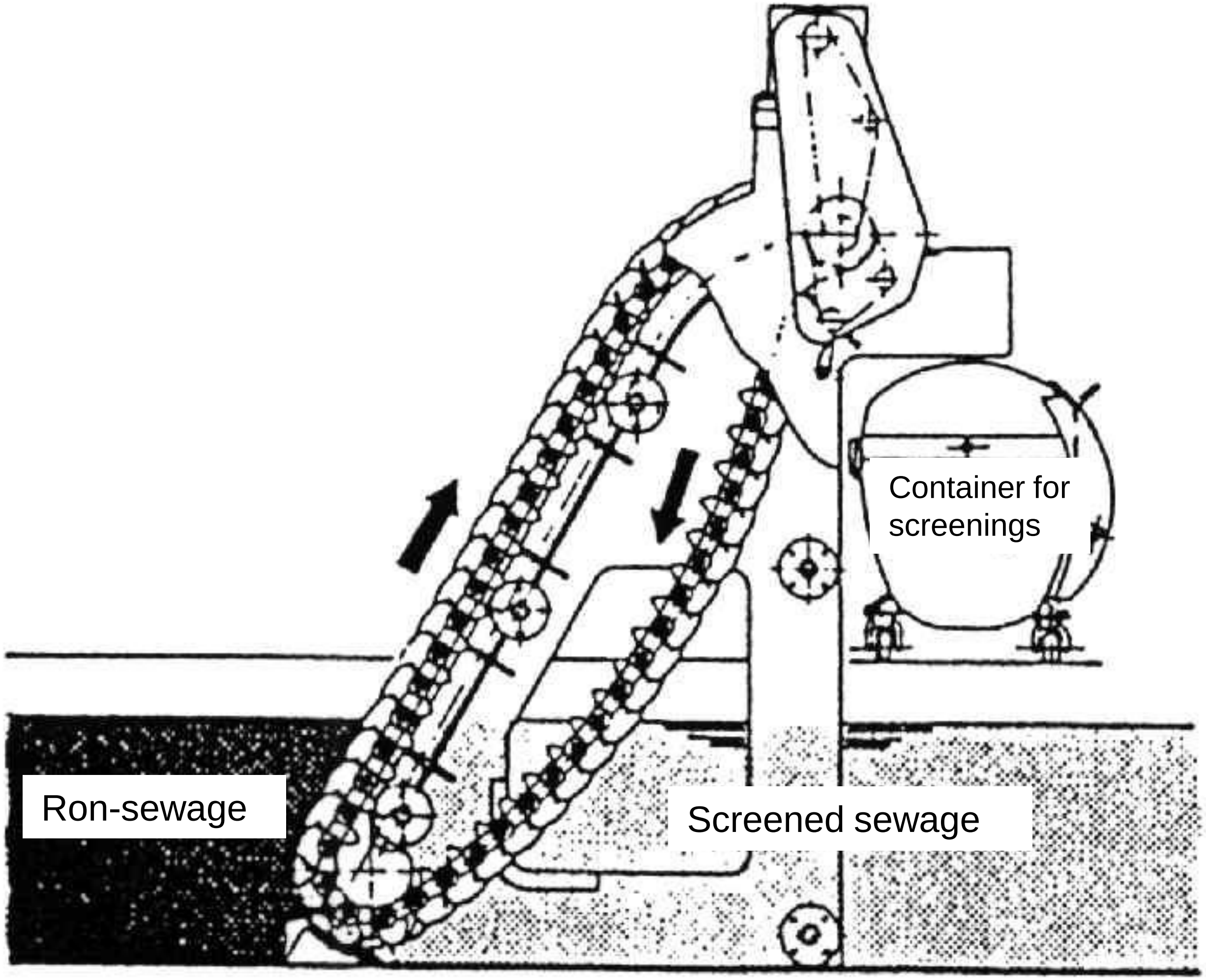
Types of sieves

- Static sieve (e.g. curved screen *(Bogensieb)*)
- Sieve screen (filter screen)
- Rotary sieve
- Helix sieve with integrated compaction unit
- Vibrating sieve or oscillating sieve

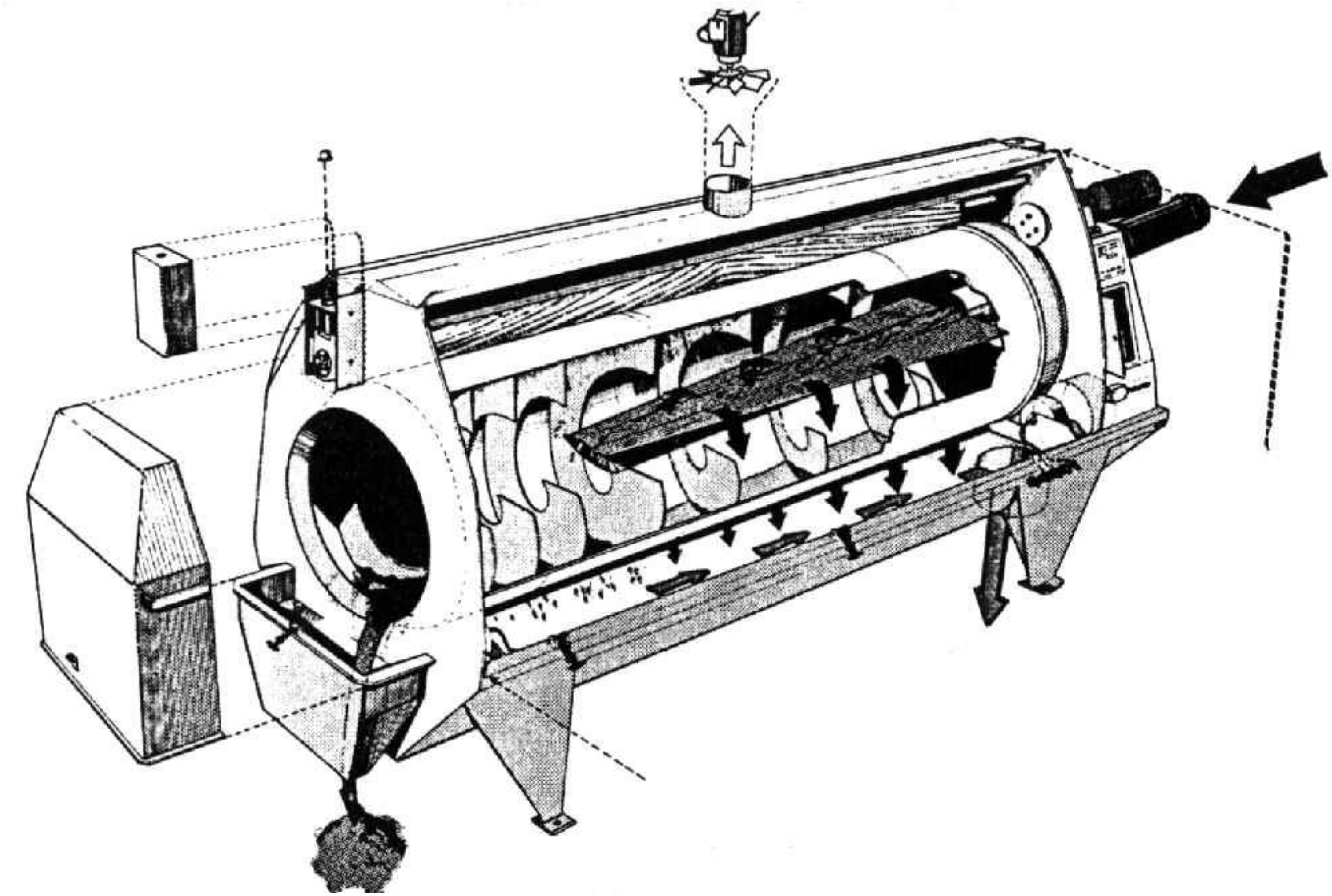
Bend sieve


Material container
Inflow
Inflow
Screen plate
Screenings belt conveyor
Drain
Drain

Sieve screen



Rotary sieve



Specific amount of screenings depending on the passage width

Passage width [mm]	**Specific amount of screenings [l/(I*a)]**	
	Not dewatered	**Mechanical dewatered**
15	11.5	3.9
6	16.7	5.7
3	22.2	7.6
2	26	8.9
1	34.5	11.8
0.5	45.8	15.7

[according to SEYFRIED, C.F. et al. , 1985]

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Preliminary Treatment
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Mechanical Wastewater Treatment

Part 14:
Sedimentation: Grit chamber, primary settlement tank

Sedimentation

Leibniz Universität Hannover

$$v_S = \sqrt{\frac{2g \cdot (\rho_S - \rho) \cdot V}{\lambda_W \cdot \rho \cdot A}}$$

v_s = Settling velocity [cm/s]

g = Gravitational acceleration [981 cm/s²]

ρ_s = Particle density [g/cm³, quartz sand = 2.65 g/cm³]

ρ = Liquid density [g/cm³, water = 1 g/cm³]

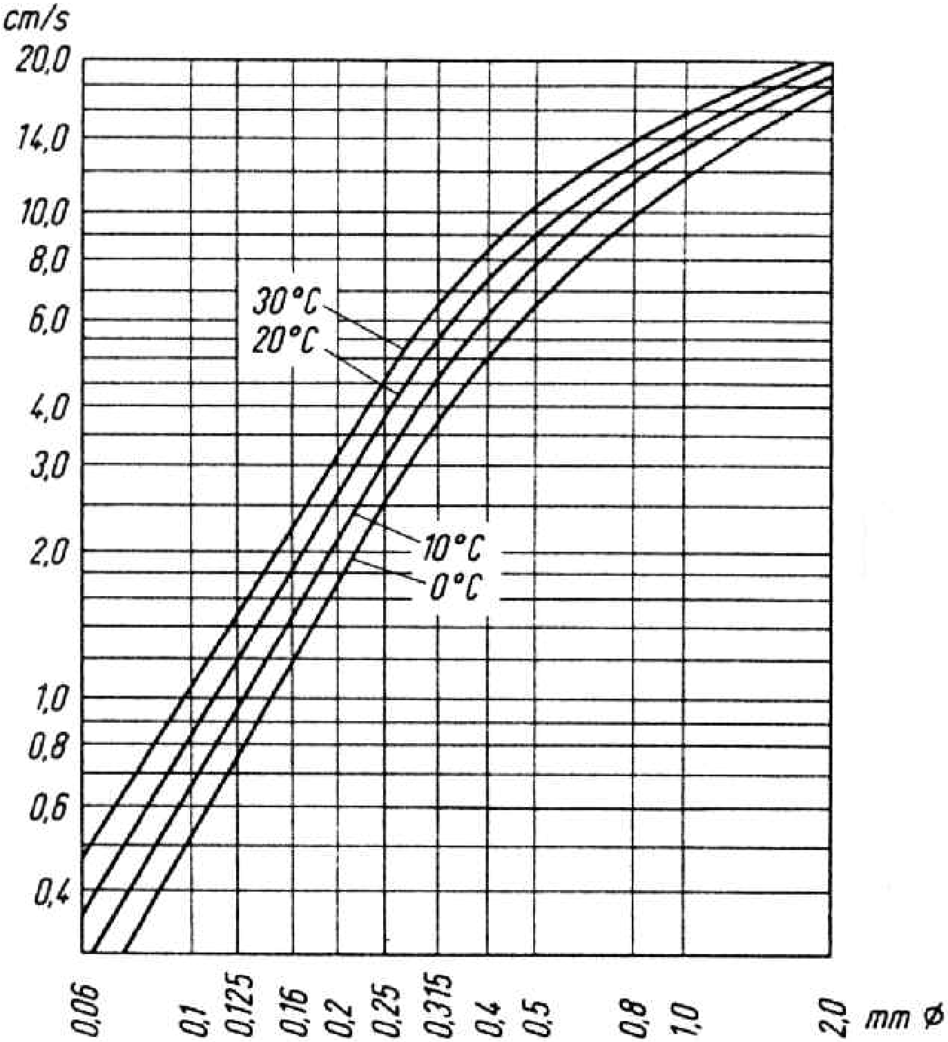
V = Particle volume [cm³]

A = Particle surface orthographic to the direction of movement [cm²]

λ_w = Coefficient of resistance f(Re)

Needed time to sink t_s < Detention time t

Settling velocity for balls (2.65 g/cm³, stagnant water)



Sedimentation

In stagnant water:

Needed time to sink t_s < Detention time t

In laminar flow:

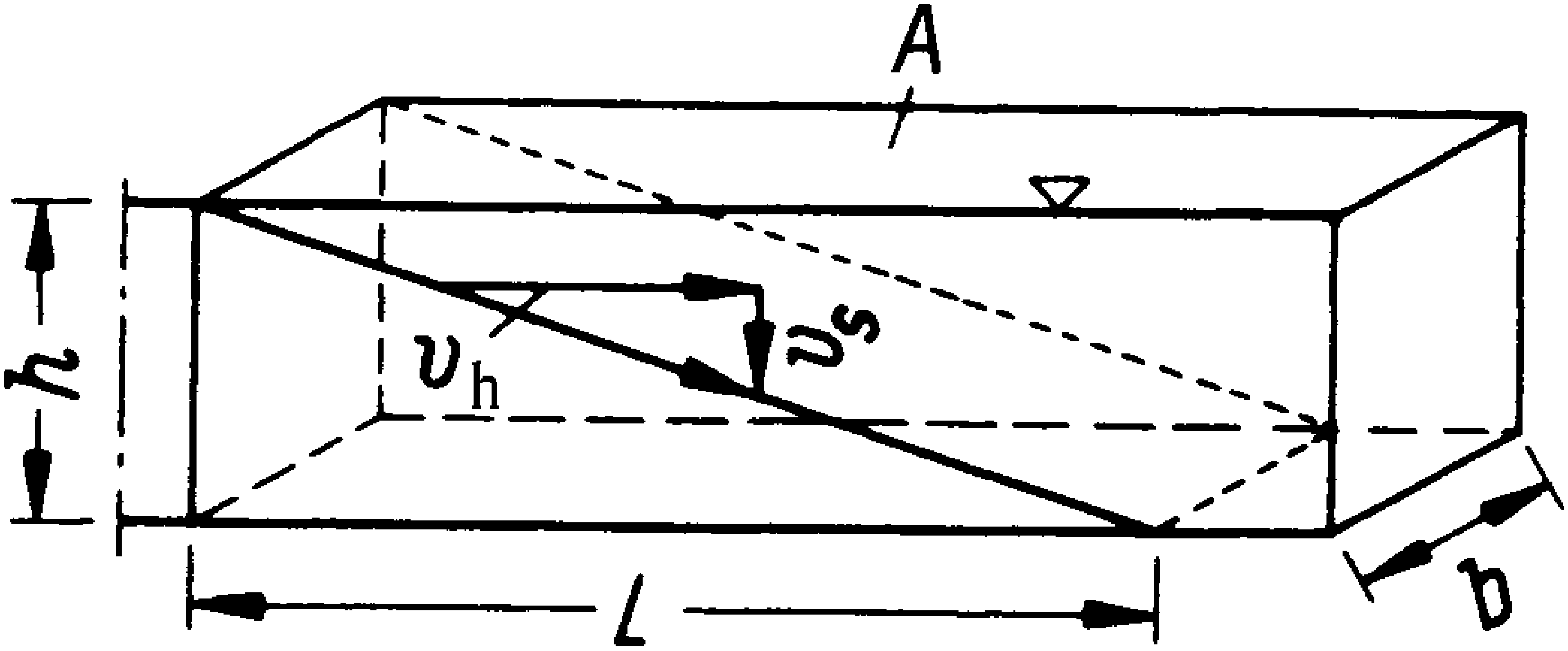
$t = L / v_h$ $t_s = h / v_s$

$v = Q / (b*h)$ $A = b*L$

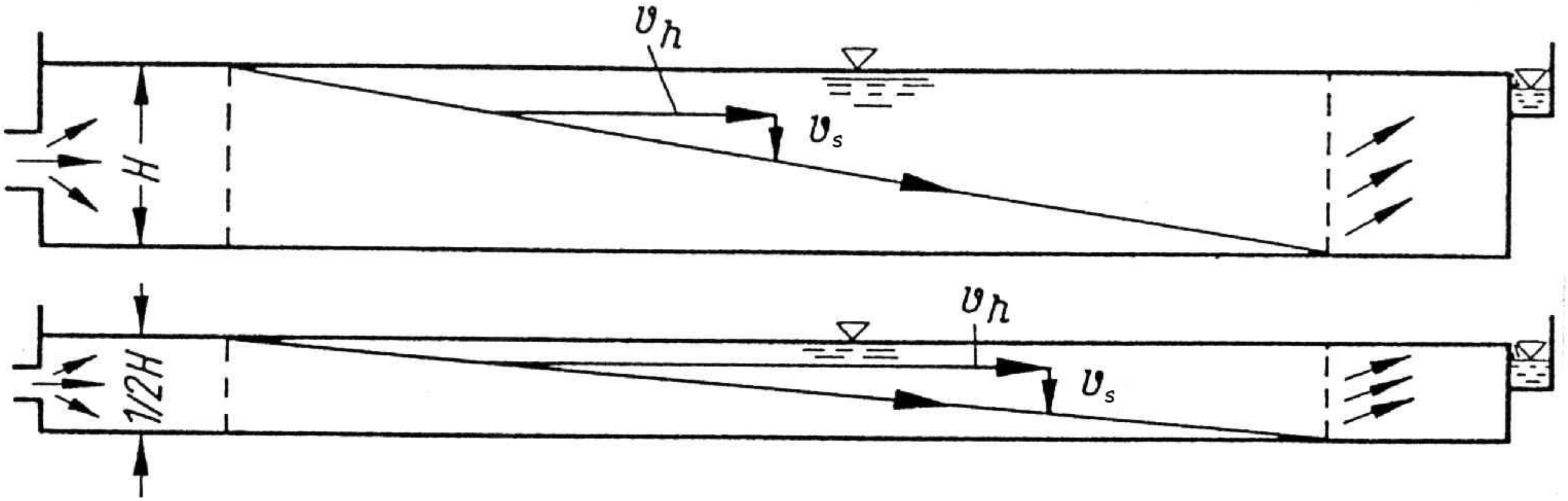
$q_A = Q / A = h / t_s$

Surface loading q_A < Settling velocity v_s

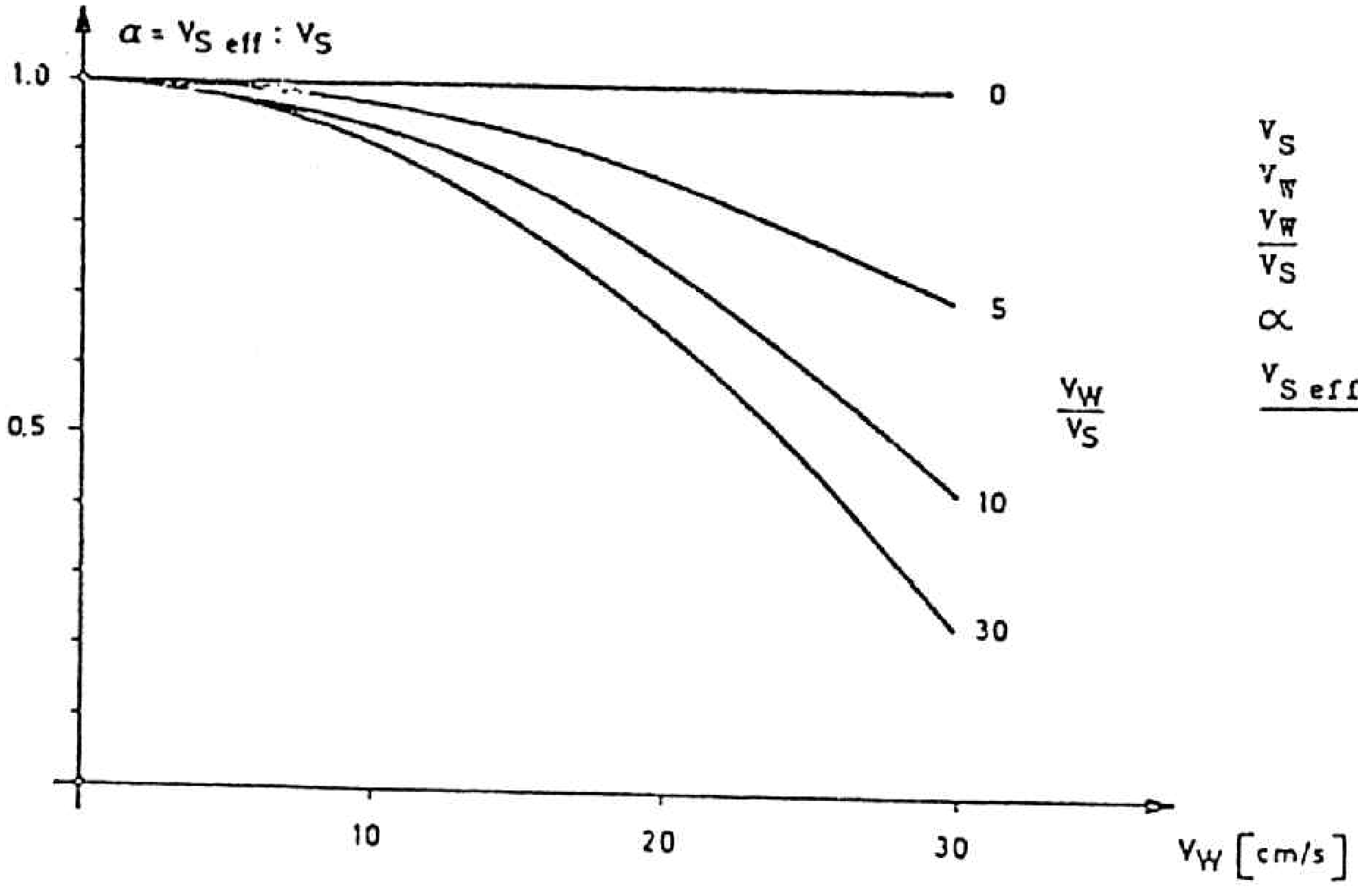
Velocity distribution in laminar flow



Sedimentation in an ideal basin



Reduction ration α

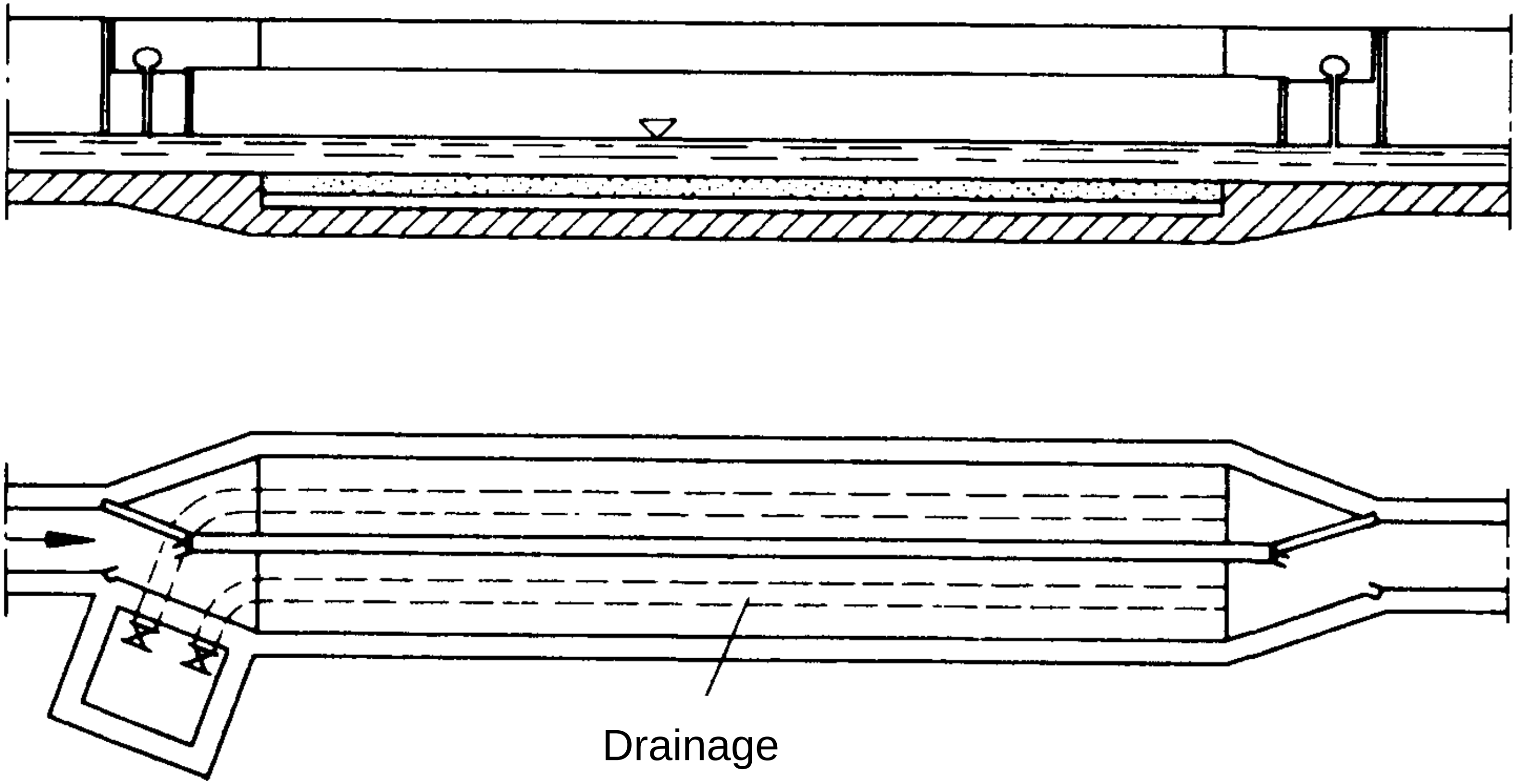


v_S = 1 cm/s
v_W = 30 cm/s
$\frac{v_W}{v_S}$ = 30
α = 0,23
$v_{S\,eff}$ = 0,23 cm/s

Types of grit chambers

- Deep grit chamber
- Long grit chamber
- Round catch pit
- Ventilated long grit chamber
- Ventilated round grit chamber
- Hydro cyclone

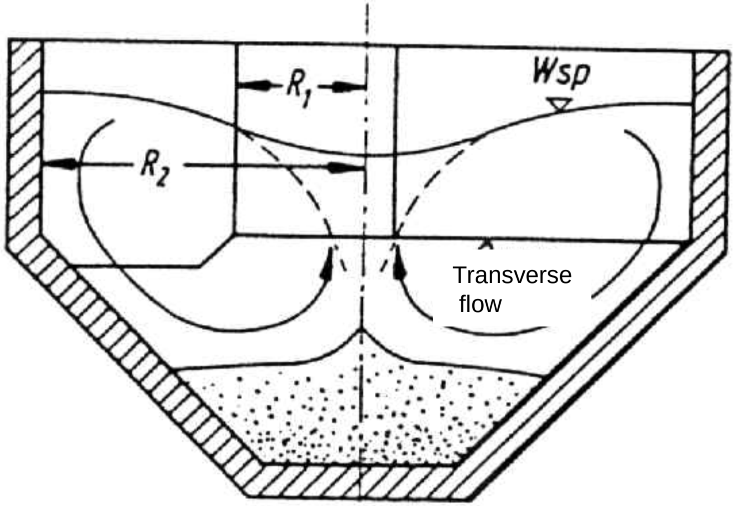
Long grit chamber type Essen

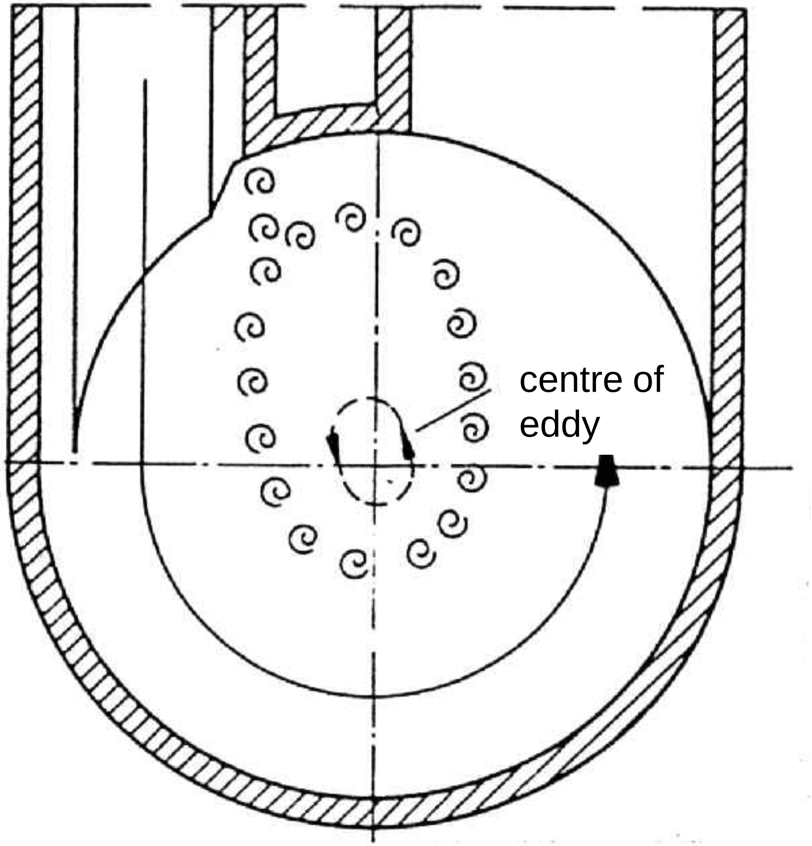


Long grit chamber

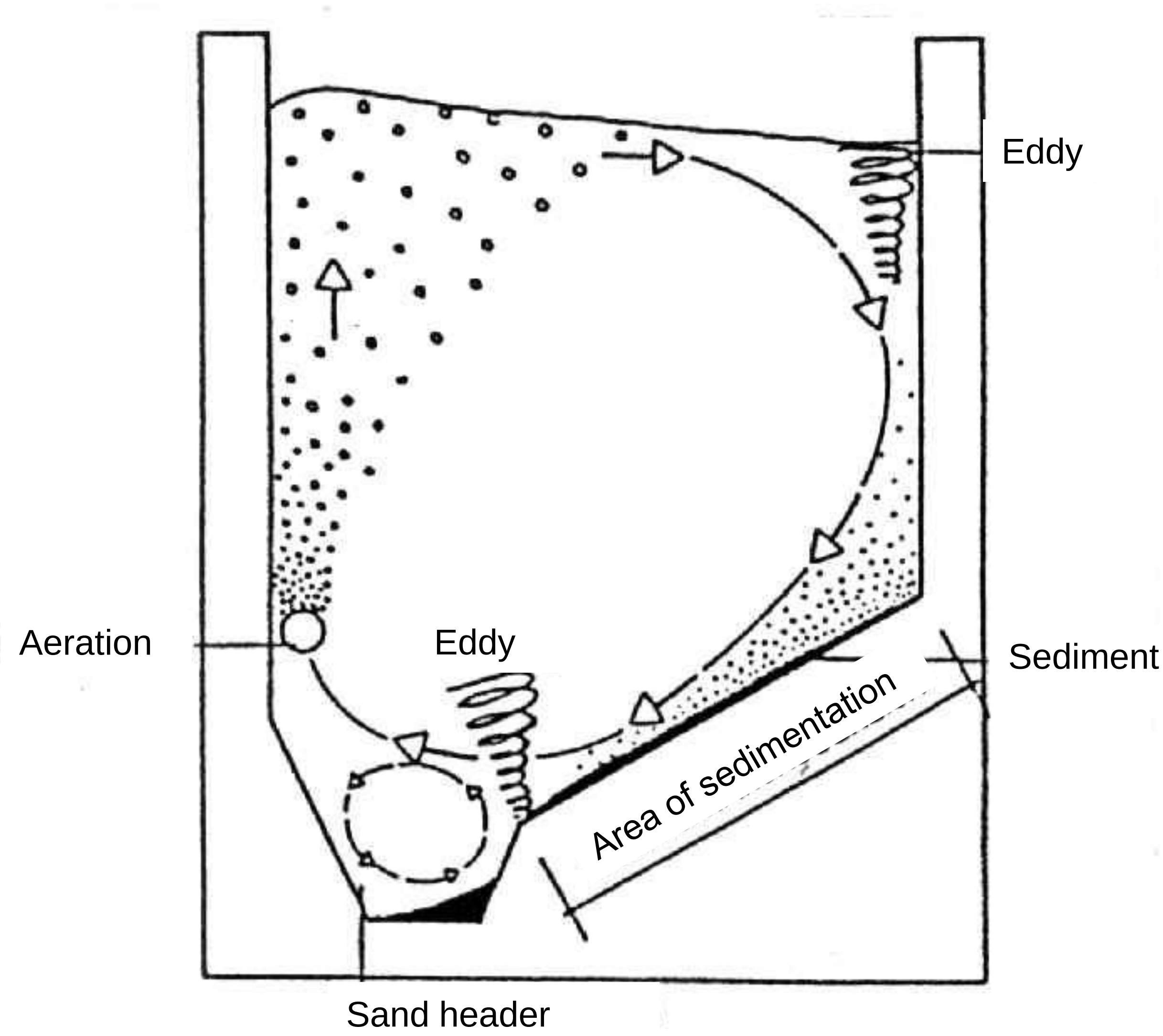
Drainage

Round grit chamber

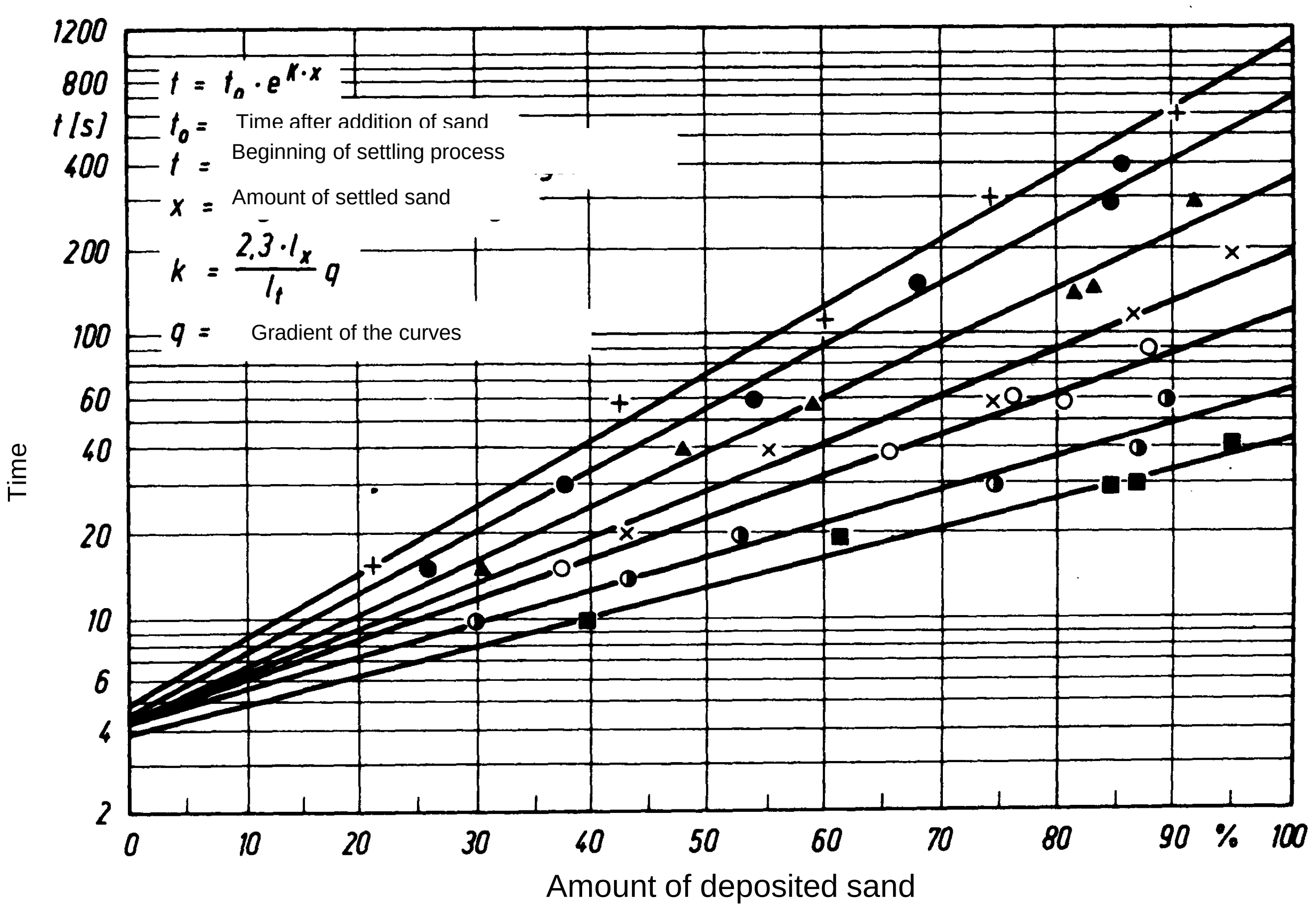




Schematic illustration of a areated grit chamber



Amount of deposited sand in a grit chamber depending on time and grit-diameter



Time s	Granulation mm ∅	
1100	0,125 – 0,16	+
700	0,16 – 0,2	●
366	0,2 – 0,25	▲
200	0,25 – 0,315	×
125	0,315 – 0,4	○
66	0,4 – 0,5	◑
42	0,5 – 0,8	■

Assessment of ventilated grit chambers

Given data for ventilated grit chambers:

Parameter	Proposed range
Horizontal flow rate	< 0.20 m/s
Rate of circulation/revolution	0.30 m/s/minimum 3 revolutions
Proportion of breadth and depth b_{SF}/h_{SF} during dry weather inflow	< 1.0
Proportion of breadth and depth b_{SF}/h_{SF} during rainy weather inflow	> 0.8
Cross-sectional area A (without grease trap)	1 – 15 m²
Length of basin	minimum 10-fold breadth max. 50 m
Flow time for Q_{max} with low demands with high demands on the sand detention	ca. 10 min ca. 5 min ca. 20 min
Crossfall of the base	35 – 45°
Injection depth	30 cm above the top edge of the channel
Space between the aeration pipes	0.6 – 1.0 m
Specific air inlet for the cross-sectional area < 3.0 m² > 3.0 m²	 0.8 m³/(m³·h) 1.3 m³/(m³·h)
Specific air inlet for the following Bio-P or Deni	0.1 – 0.2 m³/(m³·h)
Breadth of the grease traps b_{FF}	0.2 – 0.5 b_{SF}

Dimensioning of ventilated grit chambers

1. Determination of the volume V:

$$V = Q_M \cdot t_{R,Q_M}$$

Choice of selected volume ≥ Calculated volume

2. Determination of the cross sectional area A via longitudinal time

$$A = \frac{Q}{v_L}$$

Selected section A ≥ Calculated A

Dimensioning of ventilated grit chambers

3. Length of the grit chamber L

$$L = \frac{V}{A}$$

If L is bigger than ca. 50 m, A has to be readapted.

4. Verification

Discharge time

- $t_{R,Qt} > 10 - 15$ min
- $t_{R,Qm} > 3 - 5$ min

Longitudinal time

- $v_L \leq 0.20$

Confirmation of the three circulations:

- Calculate the size of U
- Circulate time $t_u = 3 \cdot U / v_U < t_{R,Q}$

Dimensioning of the introducing air for ventilated grit chambers

Specific air input for a cross-sectional area < 3 m²	0.5 – 0.9 $m^3_L/(m^3 \cdot h)$
Specific air input for a cross-sectional area 3 - 5 m²	0.5 – 1.1 $m^3_L/(m^3 \cdot h)$
Specific air input for a cross-sectional area > 5 m²	0.5 – 1.3 $m^3_L/(m^3 \cdot h)$

(nach ATV 1997)

Evaluation of ventilated grit chambers

5. Evaluation of the required amount of air

According to Seyfried (1994) the reached approaches are way too high. An air inlet of 0.2 – 0.5 m³ air/(m³ volume · h) is enough. To avoid a reduction of substrate supply in the following step of denitrification the air inlet has to be limited to

0.1 – 0.2 m³ air/(m³ volume · h)
(altern. water-jet injection (Kaiser, Oldenburg))

and the last 2 - 3 m of the grit chamber have to stay unventilated. The injection depth should be about 0.8 to 0.9 of the height of the grit chamber.

Evaluation of ventilated grit chambers

6. Technical equipment

The air inlet which is required for the circulation can be used in form of **coarse-bubbled ventilation**, because it has the lowest risk of blockage.

7. Grease removal

There are catch cells on both sides of the ventilated grit chamber where floating particles are collected and evacuated, to separate fats and oil from other dispersed material.

Settlement basin

Settlement basins can be differentiated in accordance with its function and its construction:

Function:

- Primary settlement tank
- Final sedimentation basin
- Intermediate sedimentation tank (in double-step plants)

Construction:

- Mainly basins with horizontal water flow (circular or rectangular tanks)
- Sasins with vertical water flow
- Two-storey basins (Emscherbrunnen)

Design of secondary settlement tank (clarifier)

Settling celocity $v_s \cdot SV_{AT}$ = constant = 700 - 750 [l/m²·h]

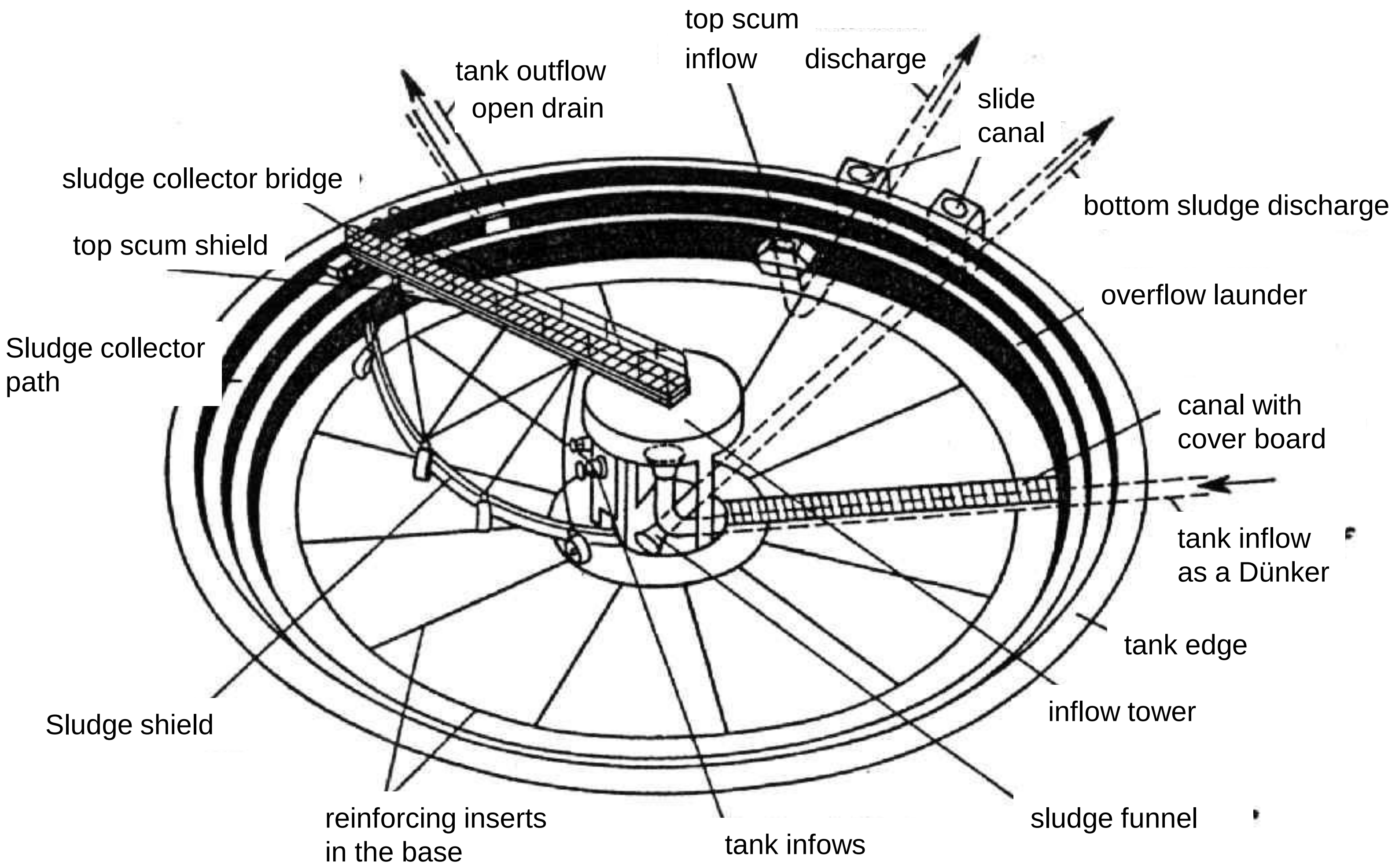
v_S should be ca. $1.5 \cdot q_a$

Consequential : $1.5 \cdot q_a \cdot SV_{AT} = 700 - 750$ [l/m²·h]

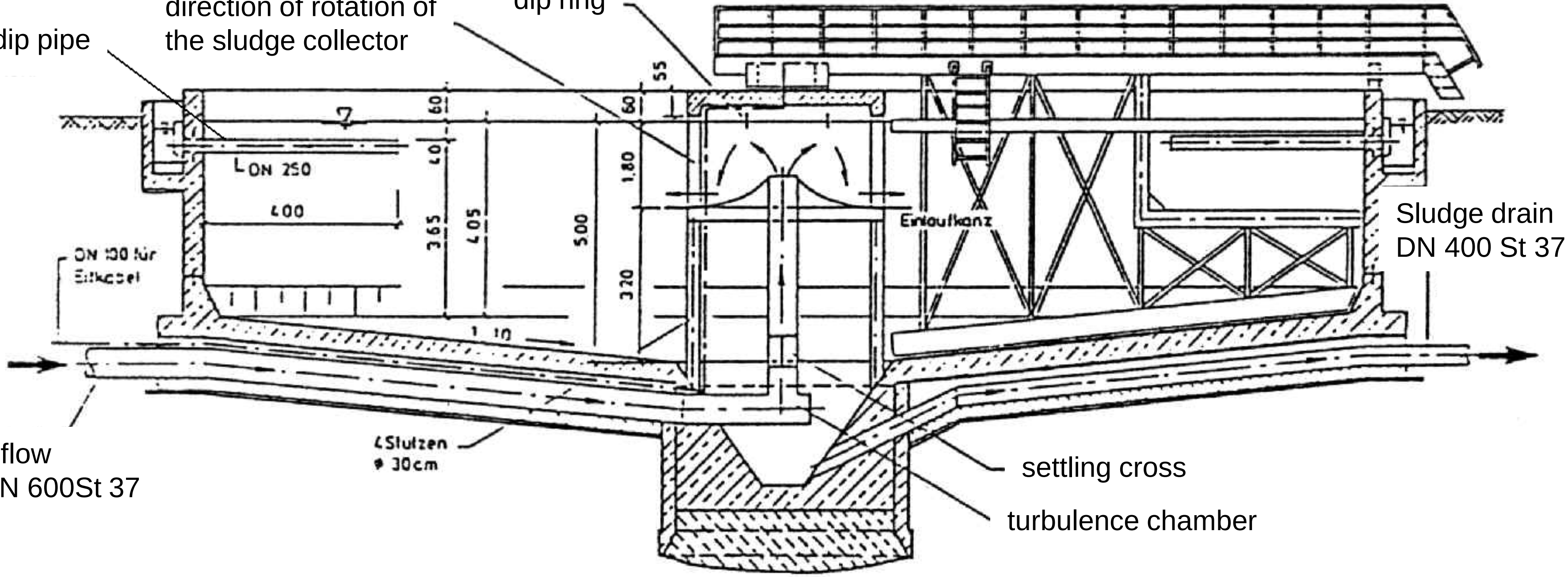
Consequential : $q_{sv} = q_a \cdot SV_{AT} = 500$ [l/m²·h]

with $q_a = Q_M / A_{NB}$ [m/h]

Circular tank with horizontal water flow



Circular tank with horizontal water flow and diving pipes



dip pipe

vertical lamella in the direction of rotation of the sludge collector

dip ring

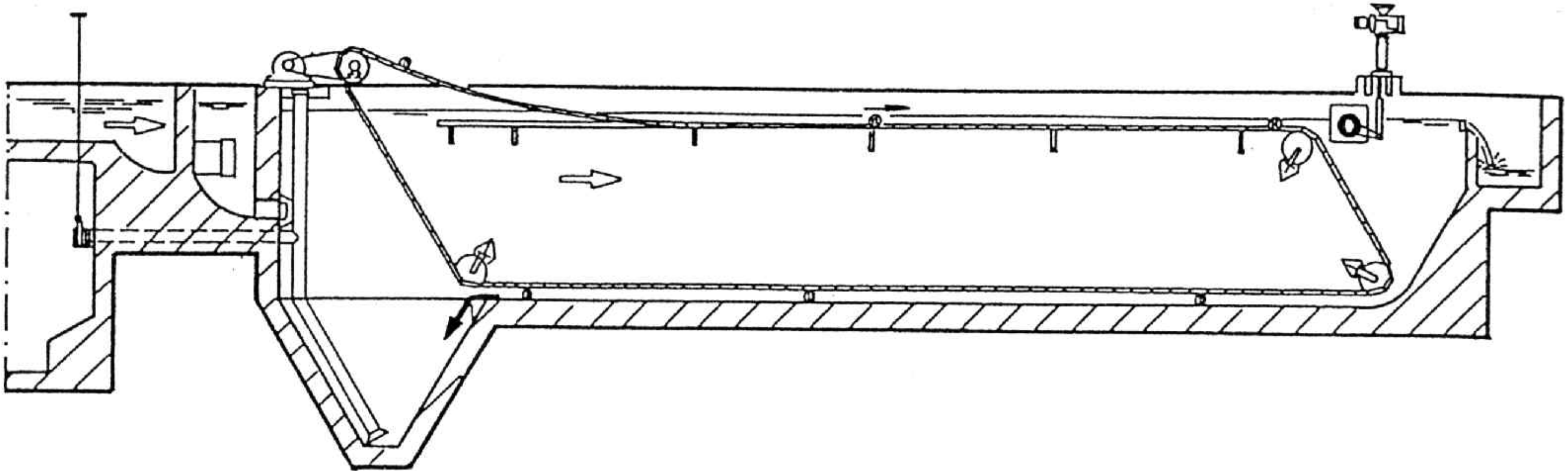
Sludge drain
DN 400 St 37

inflow
DN 600St 37

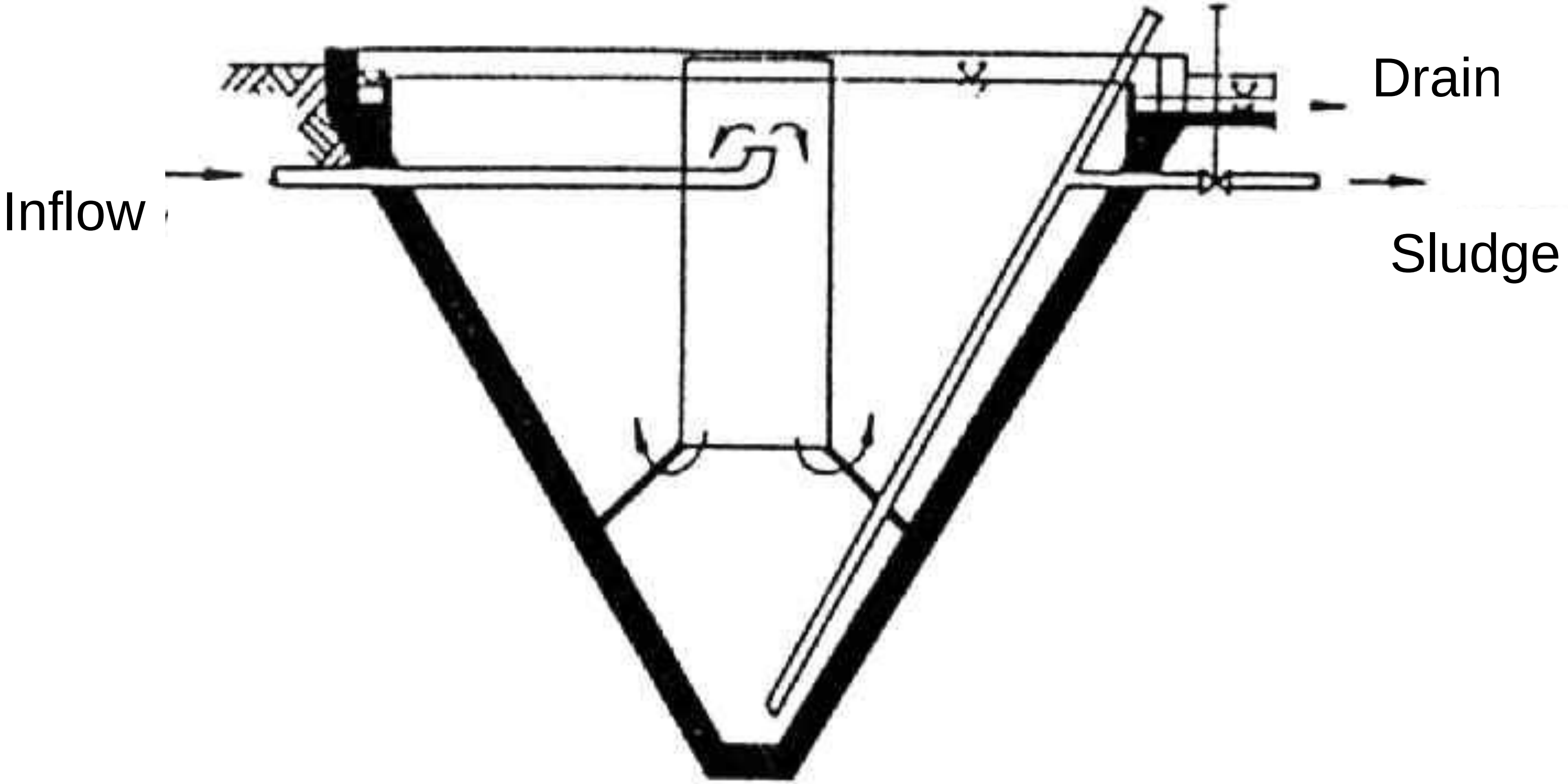
settling cross

turbulence chamber

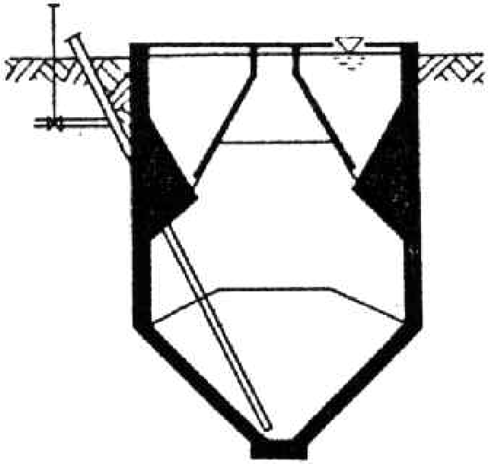
Rectangular tank with horizontal water flow

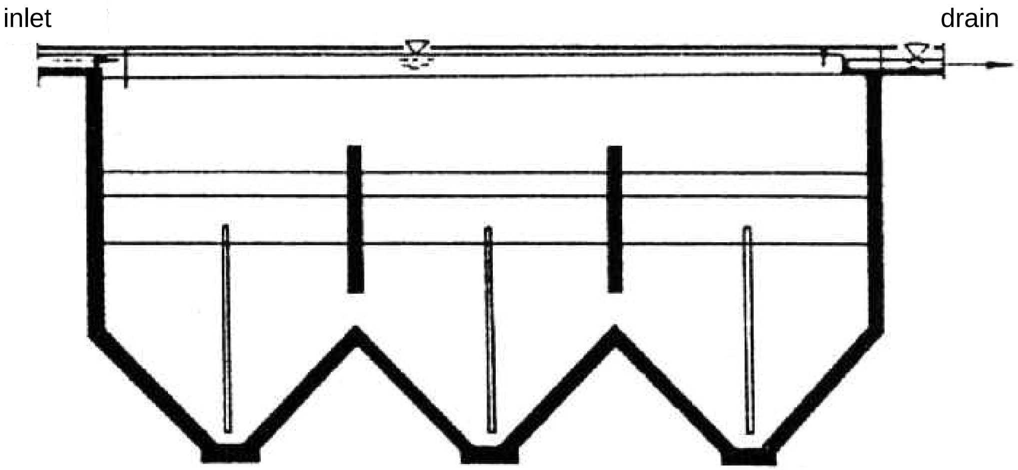


Precipitation tank with vertical water flow

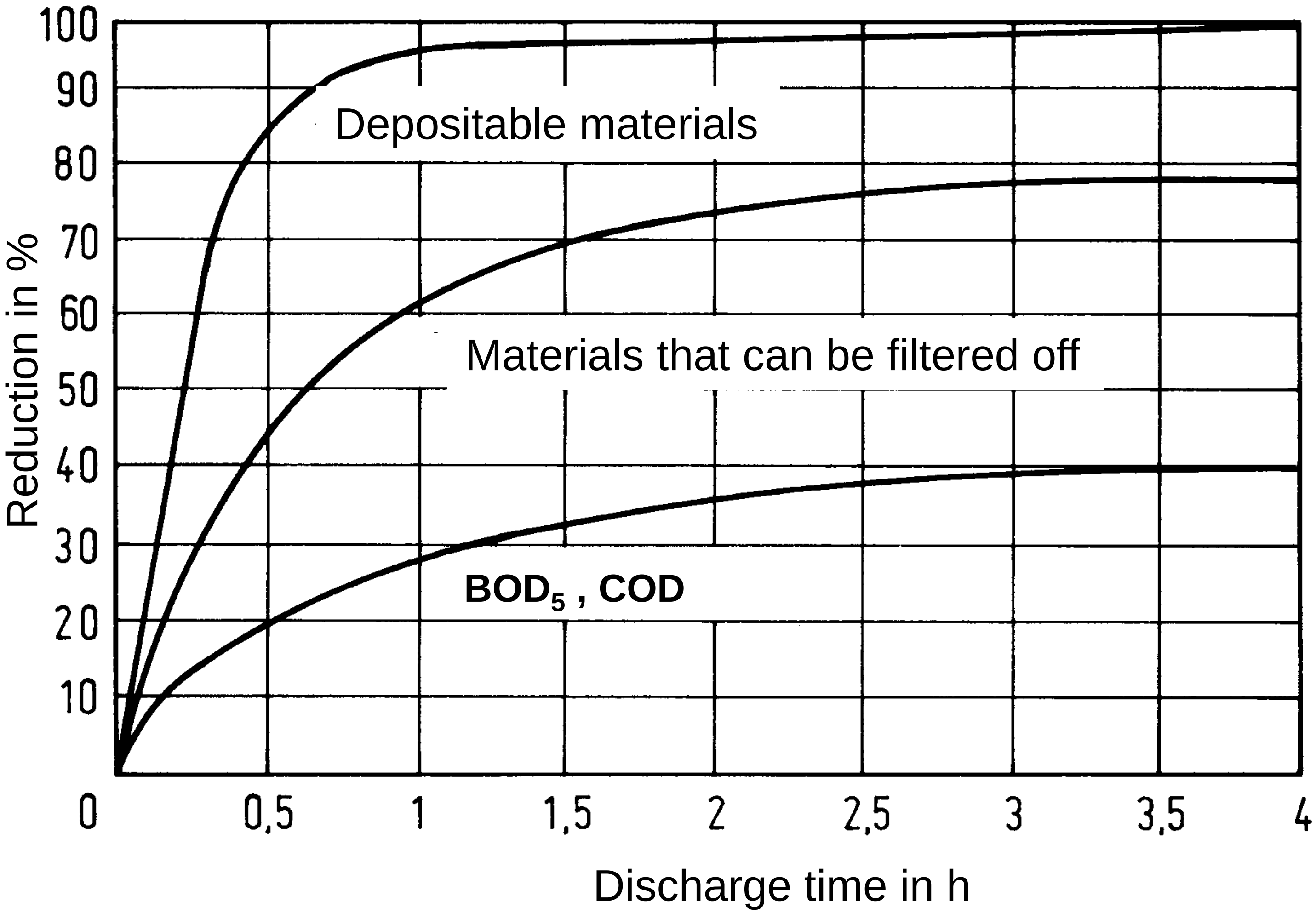


Cross- and axial section of an Emscherwell



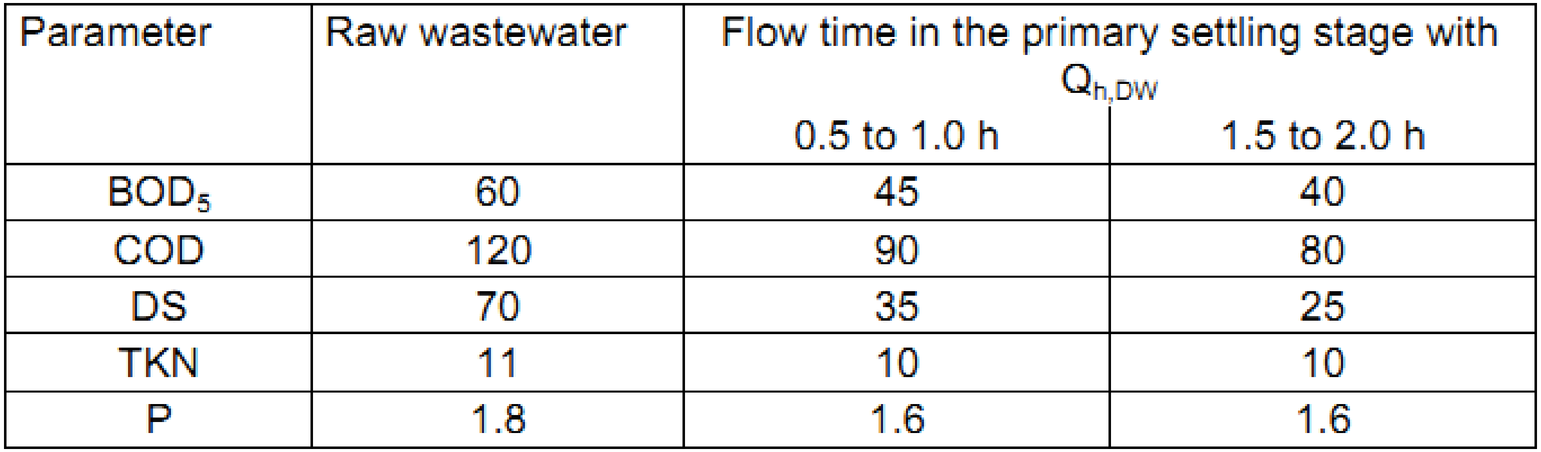


Decrease of pollutions in the municipal wastewater depending on settling time



Inhabitant-specific loads in g/(I·d)

Inhabitant-specific loads in g/(I·d), which are undercut on 85% of the days, without taking into account sludge liquor



Parameter	Raw wastewater	Flow time in the primary settling stage with $Q_{h,DW}$	
		0.5 to 1.0 h	1.5 to 2.0 h
BOD_5	60	45	40
COD	120	90	80
DS	70	35	25
TKN	11	10	10
P	1.8	1.6	1.6