14.1 Geometric formulas

Geometric formulas		
rectangle	A = a x b	
rectangular prism	A = 2x (a x b+a x c+b x c)	V = a x b x c
trapezium	$A = \frac{a+c}{2} \times h$	
trapeziform prism		$V = \frac{h}{3} \times h (a \times b + c \times d + \sqrt{a \times b \times c \times d})$
circle	$A = \pi \times r^2$	$C = 2 \times \pi \times r$
cylinder	A (mantle) = $2 \times \pi \times r \times h$	$V = \pi \times r^2 \times h$
sphere (ball)	$A = 4 \times \pi \times r^2$	$V = \frac{4}{3} \times \pi \times r^3$
spherical segment	$A = 2 \times \pi \times r \times h$	$V = \pi \times h^2 \times (r - \frac{h}{3})$
cone	A (mantle) = $\pi \times r \times s$	$V = \pi \times r^2 \times \frac{h}{3}$
law of pythagoras	$a^2 + b^2 = c^2$	sides of 90° triangle: 3 / 4 / 5
tangent	a / b	tan 45° = 1
		tan 30° = 0.577
		tan 60° = 1.732

Table 45: Geometric formulas

14.2 Energy requirement and cost of pumping

	A	B	C	D	E	F	G	H	I
1	Energy requirement and cost of pumping								
2	flow rate	main flow h/d	flow rate per hour	pump high	assumed head loss	efficiency of pump	required power of pump	cost of energy	annual energy cost
3	m^3/d	h	m^3/h	m	m	η	kw	ECU/kWh	ECU
4	**26**	**10**	2.6	**10**	**3**	**0.5**	0.18	**0.15**	100.85

C4 = A4 / B4

G4 = 9.81 x (D4 + E4) x C4 / F4 / 3600

I4 = B4 x G4 x 365 x H

Table 46: Energy requirement and cost of pumping

14.3 Sedimentation and flotation

The performance of a domestic-wastewater settler is sufficient when the effluent contains less than 0.2ml/l settleable sludge after a 2h jar test.

The general formula for calculating the surface area for floatation and sedimentation tanks is:

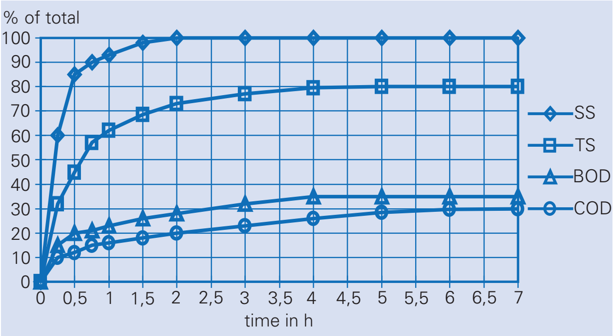
> Water surface [m²] = water volume [m³/h] /
> slowest settling (floatation) velocity [m/h].

Settling and floatation velocity can be calculated by observing the settling process in a glass cylinder. The formula is:

> Settling (floatation) velocity [m/h] =
> height of cylinder [m] / settling (floatation) time [h]

Flocculent sludge has a settling velocity between 0.5 and 3 m/h.
The velocity in a sand trap should not exceed 0.3 m/s [1000 m/h].
The minimum cross section area is then:

> Area [m²] = flow [m³/s] / 0.3 [m/s], or
> Area [m²] = flow [m³/h] / 1000 [m/h]



Appendix_1:
Removal rates in settling tests of domestic wastewater

The above graph shows the results of settling tests in a jar test under batch conditions (SS = settleable solids, TS = total solids; COD is measured as $CODKMnO_4$). The curve might be different in through-flow settlers. The more turbulent the flow, the lesser the removal rate of settleable solids; however, BOD- and COD-removal rates increase with more complete mixing of old and new wastewater.

14.4 Flow in partly filled round pipes

	A	B	C	D	E	F	G	H	I	J
1	Flow in partly filled round pipes									
2	pipe	flow height	flow area	moisted area/m	hydraulic radius	slope	rough ness	flow speed	flow	
3	chosen	given	calcul.	calcul.	calcul.	chosen	estimat.	calcul.	calcul.	calcul.
4	d	h/d	A	U	rhy	s	rf	v	Q	Q
5	m	m/m	m²	m	m	%		m/s	l/s	m³/h
6	**0.1**	0.15	0.00074	0.080	0.0093	**1.0%**	**0.35**	0.21	0.153	0.55
7	**0.1**	0.25	0.00154	0.105	0.0147	**1.0%**	**0.35**	0.31	0.478	1.72
8	**0.1**	0.35	0.00245	0.127	0.0194	**1.0%**	**0.35**	0.40	0.969	3.49
9	**0.1**	0.50	0.00393	0.157	0.0250	**1.0%**	**0.35**	0.49	1.932	6.96
10	**0.1**	0.75	0.00632	0.210	0.0302	**1.0%**	**0.35**	0.58	3.641	13.11

Table 47:
Flow in partly filled round pipes

Formulas of spreadsheet for “flow in partly filled pipes” (after Kutter’s short formula)

C6 = 0.295 x (A6/2) ^ 2

All figures – as here 0.295 – are geometrical constants, referring to the flow height in relation to the diameter of the pipe.

D6 = 1.591 x (A6 / 2)

E6 = C6 / D6

H6 = (100 x SQRT (E6) / (G6 + SQRT (E6))) x SQRT (E6 x F6)

I6 = C6 x H6 x 1000

J6 =I6 x 3.6

C7 = 0.614 x (A7 / 2) ^ 2

D7 = 2.094 x (A7 / 2)

E7 = C7 / D7

H7 = (100 x SQRT (E7) / (G7 + SQRT (E7))) x SQRT (E7 x F7)

I7 = C7 x H7 x 1000

J7 = I7 x 3,6

C8 = 0,98 x (A8 / 2) ^ 2

D8 = 2,532 x (A8 / 2)

E8 = C8 / D8

H8 = (100 x SQRT (E8) / (G8 + SQRT (E8))) x SQRT(E8 x F8)

I8 = C8 x H8 x 1000

J8 = I8 x 3.6

C9 = 1.571 x (A9 / 2) ^2

D9 = 3.142 x (A9 / 2)

E9 = C9 / D9

H9 = (100 x SQRT (E9) / (G9 + SQRT (E9))) x SQRT (E9 x F9)

I9 = C9 x H9 x 1000

J9 = I9 x 3.6

C10 = 2.528 x (A10 / 2) ^ 2

D10 = 4.19 x (A10 / 2)

E10 = C10 / D10

H10 = (100 x SQRT (E10) / (G10 + SQRT (E10))) x SQRT (E10 x F10)

I10 = C10 x H10 x 1000

J10 = I10 x 3.6

14.5 Conversion factors of US-units

Conversion factors of US-units				
item	US-unit	SI-unit	US/SI-unit	SI/US-unit
length	in ft (12in) yd (3ft) mi (1,760yd)	cm (10mm) m (100mm) m km (1,000m)	2.540 0.305 0.914 1.609	0.394 3.281 1.094 0.621
area	in^2 ft^2 yd^2 acre mi^2	cm^2 m^2 m^2 hectar (10,000m^2) km^2	6.452 0.093 0.836 0.405 2.590	0.155 10.764 1.196 2.471 0.386
volume	in^3 ft^3 ft^3 gallon yd^3 (202gal) acre-foot	cm^3 liter m^3 litre m^3 m^3	16.387 28.317 0.0283 3.785 0.765 1.2335	0.061 0.035 35.314 0.264 1.308 0.811
force / mass	lb oz lb (16oz) ton (short) (2,000lb) ton (long) (2,240lb)	N g kg (1,000kg) t (1,000kg) t (1,000kg)	4.448 28.350 0.454 0.907 1.016	0.225 0.035 2.205 1.102 0.984
pressure	in H_2O lb/in^2 lb/in^2	Pa (N/m^2) kPa (kN/m^2) Pa (N/m^2)	204.88 6.895 47.88	0.005 0.145 0.021
flow rate	gal/min gal/d gal/min (1,440gal/d)	l/s (86.4m^3/d) l/s m^3/d (0.0116l/s)	0.0631 0.0000438 0.00379	15.850 22,825 264
energy + power	Btu hp-h kWh Ws hp	kJ MJ kJ J kW	1.055 2.685 3,600 1,000 0.746	0.948 0.373 0.00028 0.001 1.341
temperature	°F °F	°C K	0.56(°F-32) 0.56(°F+460)	1.8(°C)+32 1.8(°K)-460

Table 48: Conversion factors of US-units