RULES AND STANDARDS

Activated Sludge Expert
Calculation of single stage activated sludge plants
according to DWA Standard A-131

Project: Viesite (1500 CE, 185 m3/dnn, 30 m3/st)

Calculated by: Date: 07.12.2016.

Configuration of plant:

- Activated sludge tank(s)
- Secondary settling

Treatment objectives:

- Removal of org. carbon
- Nitrification

Secondary settling: Type of tank(s) Hopper-bottom tank, Flow characteristics vertical RT!

Size class and load cases:

Size class: 77 kg BOD_5/d

Calculated load cases:

- Load case 1: Dimensioning
- Load case 2: Proof of nitrification at lowest temperature
- Load case 3: Calculation of oxygen uptake at highest temperature
- Load case 4: Special load

Calculation based on BOD

	Load case	1	2	3	4	
Inflow:						
Daily dry weather flow rate	$Q_{DW,d}$	185	185	185	185	m^3/d
Hourly dry weather flow as 2hr mean	$Q_{DW,h}$	18	18	18	18	m^3/h
Concentrations:						
COD	$C_{COD,IAT}$	779	779	779	779	mg/l
Dissolved COD	$S_{COD,IAT}$	0	0	0	0	mg/l
BOD_5	$C_{BOD,IAT}$	486	486	486	486	mg/l
COD/BOD_5 ratio	-	1.60	1.60	1.60	1.60	-
Filterable solids	$X_{SS,IAT}$	303	303	303	303	mg/l
Total Kjeldahl-Nitrogen	$C_{TKN,IAT}$	101.1	101.1	101.1	101.1	mg/l
Ammonia nitrogen	$S_{NH4,IAT}$	95.7	95.7	95.7	95.7	mg/l
Nitrate nitrogen	$S_{NO3,IAT}$	0.2	0.2	0.2	0.2	mg/l
Phosphorus	$C_{P,IAT}$	10.8	10.8	10.8	10.8	mg/l
Alkalinity	$S_{ALK,IAT}$	7.00	7.00	7.00	7.00	mmol/l
Load:						
COD	$B_{d,COD}$	144	144	144	144	kg/d
Dissolved COD	$B_{d,SCOD}$	0	0	0	0	kg/d
BOD_5	$B_{d,BOD}$	90	90	90	90	kg/d
Filterable solids	$B_{d,XSS}$	56	56	56	56	kg/d
Total Kjeldahl-Nitrogen	$B_{d,TKN}$	18.7	18.7	18.7	18.7	kg/d
Ammonia nitrogen	$B_{d,NH4}$	17.7	17.7	17.7	17.7	kg/d
Nitrate nitrogen	$B_{d,NO3}$	0.0	0.0	0.0	0.0	kg/d
Phosphorus	$B_{d,P}$	2.0	2.0	2.0	2.0	kg/d

Biological reactor, Load case 1:			
Temperature in the biol. reactor	T	12.0	Deg C
Nitrogen balance:			
Influent C_{TKN} + S_{NO3}	C_N	101.2	mg/l
Nitrogen incorporated in biomass	$X_{orgN,BM}$	24.3	mg/l
Ammonia nitrogen in the effluent	$S_{NH4,EST}$	0.0	mg/l
Organic nitrogen in the effluent	$S_{orgN,EST}$	0.0	mg/l
Nitrogen nitrified	$S_{NO3,N}$	76.8	mg/l
Nitrate nitrogen in the effluent (Setpoint)	$S_{NO3,EST}$	30.0	mg/l
Nitrogen to denitrify	$S_{NO3,D}$	46.9	mg/l
Required denitrification capacity	$S_{NO3,D}/C_{BOD}$	0.096	kg/kg
Chosen denitrification share	V_D/V_{AT}	0.00	-
Existing denitrification capacity	$S_{NO3,D}/C_{BOD}$	0.000	kg/kg
Nitrate nitrogen denitrified	$S_{NO3,D}$	0.0	mg/l
Nitrate nitr. in the effluent (existing)	$S_{NO3,EST}$	76.9	mg/l
Required recirculation ratio	RC	0.00	-
Phosphorus removal:			
Phosphorus in the influent	$C_{P,IAT}$	10.8	mg/l
Embedded in biomass (normal uptake)	$X_{P,BM}$	4.9	mg/l
Embedded in biomass (enhanced uptake)	$X_{P,BioP}$	0.0	mg/l
Phosphorus in the effluent (existing)	$S_{PO4,EST}$	5.9	mg/l
Dry matter suspended solids in the biological reactor:			
Permitted susp. solids in the effl. of the biol. reactor	SS_{AT}	5.02	kg/m^3
Chosen susp. solids in the effl. of the biol. reactor	SS_{AT}	5.00	kg/m^3
Sludge age and load specifics:			
Required sludge age	$t_{SS,Dim}$	8.2	d
Required mass of suspended solids	req.$M_{SS,AT}$	900	kg
Required volume of biol. reactor	V_{AT}	119	m^3
Chosen volume of biol. reactor	V_{AT}	180	m^3
Sludge age (existing)	t_{SS}	13.7	d
Aerobic sludge age (existing)	$t_{SS,aer.}$	13.7	d
Safety factor (existing)	SF	2.99	-
BOD_5 volume load	$B_{R,BOD}$	0.50	kg/(m^3*d)
BOD_5 sludge load	$B_{SS,BOD}$	0.10	kg/(kg*d)
Sludge production:			
...from carbon removal	$SP_{d,C}$	66	kg/d
...from external carbon source	$SP_{d,extC}$	0	kg/d
...from biol. phosphorus removal	$SP_{d,BioP}$	0	kg/d
...from precipitation	$SP_{d,Prec}$	0	kg/d
Total daily sludge production	SP_d	66	kg/d
Oxygen uptake:			
...for carbon removal	$OU_{d,C}$	102	kg/d
...for nitrification	$OU_{d,N}$	61	kg/d
...carbon removal by denitrification	$OU_{d,D}$	0	kg/d
Total daily uptake	OU_d	163	kg/d
Peak factor carbon respiration	f_C	1.15	-

Peak factor ammonium oxidation	f_N	2.00	-
Maximum hourly uptake rate	OU_h	9.4	kg/h
Required oxygen transfer	alpha*OC_h	13.0	kg/h
Alkalinity:			
Alkalinity in the effluent	$S_{ALK,EST}$	-5.07	mmol/l

Biological reactor, Load case 2:			
Temperature in the biol. reactor	T	10.0	Deg C
Nitrogen balance:			
Influent C_{TKN} + S_{NO3}	C_N	101.2	mg/l
Nitrogen incorporated in biomass	$X_{orgN,BM}$	24.3	mg/l
Ammonia nitrogen in the effluent	$S_{NH4,EST}$	0.0	mg/l
Organic nitrogen in the effluent	$S_{orgN,EST}$	0.0	mg/l
Nitrogen nitrified	$S_{NO3,N}$	76.8	mg/l
Chosen denitrification share	V_D/V_{AT}	0.00	-
Existing denitrification capacity	$S_{NO3,D}/C_{BOD}$	0.000	kg/kg
Nitrate nitrogen denitrified	$S_{NO3,D}$	0.0	mg/l
Nitrate nitr. in the effluent (existing)	$S_{NO3,EST}$	76.9	mg/l
Phosphorus removal:			
Phosphorus in the influent	$C_{P,IAT}$	10.8	mg/l
Embedded in biomass (normal uptake)	$X_{P,BM}$	4.9	mg/l
Embedded in biomass (enhanced uptake)	$X_{P,BioP}$	0.0	mg/l
Phosphorus in the effluent (existing)	$S_{PO4,EST}$	5.9	mg/l
Dry matter suspended solids in the biological reactor:			
Permitted susp. solids in the effl. of the biol. reactor	SS_{AT}	5.02	kg/m^3
Chosen susp. solids in the effl. of the biol. reactor	SS_{AT}	5.00	kg/m^3
Sludge age and load specifics:			
Required sludge age	t_{SS}	13.2	d
Aerobic sludge age (existing)	$t_{SS,aer.}$	13.2	d
Safety factor (existing)	SF	2.38	-
BOD_5 volume load	$B_{R,BOD}$	0.50	kg/(m^3*d)
BOD_5 sludge load	$B_{TS,BOD}$	0.10	kg/(kg*d)
Sludge production:			
...from carbon removal	$SP_{d,C}$	68	kg/d
...from external carbon source	$SP_{d,extC}$	0	kg/d
...from biol. phosphorus removal	$SP_{d,BioP}$	0	kg/d
...from precipitation	$SP_{d,Prec}$	0	kg/d
Total daily sludge production	SP_d	68	kg/d
Oxygen uptake:			
...for carbon removal	$OU_{d,C}$	99	kg/d
...for nitrification	$OU_{d,N}$	61	kg/d
...carbon removal by denitrification	$OU_{d,D}$	0	kg/d
Total daily uptake	OU_d	160	kg/d
Peak factor carbon respiration	f_C	1.15	-
Peak factor ammonia oxidation	f_N	2.00	-
Maximum hourly uptake rate	OU_h	9.2	kg/h
Required oxygen transfer	alpha*OC_h	12.6	kg/h
Alkalinity:			
Alkalinity in the effluent	$S_{ALK,EST}$	-5.07	mmol/l

Biological reactor, Load case 3:			
Temperature in the biol. reactor	T	20.0	Deg C
Nitrogen balance:			
Influent C_{TKN} + S_{NO3}	C_N	101.2	mg/l
Nitrogen incorporated in biomass	$X_{orgN,BM}$	24.3	mg/l
Ammonia nitrogen in the effluent	$S_{NH4,EST}$	0.0	mg/l
Organic nitrogen in the effluent	$S_{orgN,EST}$	0.0	mg/l
Nitrogen nitrified	$S_{NO3,N}$	76.8	mg/l
Nitrate nitrogen in the effluent (Setpoint)	$S_{NO3,EST}$	25.0	mg/l
Nitrogen to denitrify	$S_{NO3,D}$	51.9	mg/l
Required denitrification capacity	$S_{NO3,D}/C_{BOD}$	0.107	kg/kg
Chosen denitrification share	V_D/V_{AT}	0.00	-
Existing denitrification capacity	$S_{NO3,D}/C_{BOD}$	0.000	kg/kg
Nitrate nitrogen denitrified	$S_{NO3,D}$	0.0	mg/l
Nitrate nitr. in the effluent (existing)	$S_{NO3,EST}$	76.9	mg/l
Required recirculation ratio	RC	0.00	-
Phosphorus removal:			
Phosphorus in the influent	$C_{P,IAT}$	10.8	mg/l
Embedded in biomass (normal uptake)	$X_{P,BM}$	4.9	mg/l
Embedded in biomass (enhanced uptake)	$X_{P,BioP}$	0.0	mg/l
Phosphorus in the effluent (existing)	$S_{PO4,EST}$	5.9	mg/l
Dry matter suspended solids in the biological reactor:			
Permitted susp. solids in the effl. of the biol. reactor	SS_{AT}	5.02	kg/m^3
Chosen susp. solids in the effl. of the biol. reactor	SS_{AT}	5.00	kg/m^3
Sludge age and load specifics:			
Sludge age (existing)	t_{SS}	15.3	d
Aerobic sludge age (existing)	$t_{SS,aer.}$	15.3	d
Safety factor (existing)	SF	7.36	-
BOD_5 volume load	$B_{R,BOD}$	0.50	kg/(m^3*d)
BOD_5 sludge load	$B_{SS,BOD}$	0.10	kg/(kg*d)
Sludge production:			
...from carbon removal	$SP_{d,C}$	59	kg/d
...from external carbon source	$SP_{d,extC}$	0	kg/d
...from biol. phosphorus removal	$SP_{d,BioP}$	0	kg/d
...from precipitation	$SP_{d,Prec}$	0	kg/d
Total daily sludge production	SP_d	59	kg/d
Oxygen uptake:			
...for carbon removal	$OU_{d,C}$	113	kg/d
...for nitrification	$OU_{d,N}$	61	kg/d
...carbon removal by denitrification	$OU_{d,D}$	0	kg/d
Total daily uptake	OU_d	174	kg/d
Peak factor carbon respiration	f_C	1.15	-
Peak factor ammonia oxidation	f_N	2.00	-
Maximum hourly uptake rate	OU_h	9.8	kg/h
Required oxygen transfer	alpha*OC_h	14.6	kg/h
Alkalinity:			

Alkalinity in the effluent	$S_{ALK,EST}$	-5.07 mmol/l

Biological reactor, Load case 4:			
Temperature in the biol. reactor	T	9.0	Deg C
Nitrogen balance:			
Influent C_{TKN} + S_{NO3}	C_N	101.2	mg/l
Nitrogen incorporated in biomass	$X_{orgN,BM}$	24.3	mg/l
Ammonia nitrogen in the effluent	$S_{NH4,EST}$	0.0	mg/l
Organic nitrogen in the effluent	$S_{orgN,EST}$	0.0	mg/l
Nitrogen nitrified	$S_{NO3,N}$	76.8	mg/l
Nitrate nitrogen in the effluent (Setpoint)	$S_{NO3,EST}$	80.0	mg/l
Nitrogen to denitrify	$S_{NO3,D}$	-3.1	mg/l
Required denitrification capacity	$S_{NO3,D}/C_{BOD}$	-0.006	kg/kg
Chosen denitrification share	V_D/V_{AT}	0.00	-
Existing denitrification capacity	$S_{NO3,D}/C_{BOD}$	0.000	kg/kg
Nitrate nitrogen denitrified	$S_{NO3,D}$	0.0	mg/l
Nitrate nitr. in the effluent (existing)	$S_{NO3,EST}$	76.9	mg/l
Required recirculation ratio	RC	0.00	-
Phosphorus removal:			
Phosphorus in the influent	$C_{P,IAT}$	10.8	mg/l
Embedded in biomass (normal uptake)	$X_{P,BM}$	4.9	mg/l
Embedded in biomass (enhanced uptake)	$X_{P,BioP}$	0.0	mg/l
Phosphorus in the effluent (existing)	$S_{PO4,EST}$	5.9	mg/l
Dry matter suspended solids in the biological reactor:			
Permitted susp. solids in the effl. of the biol. reactor	SS_{AT}	5.02	kg/m^3
Chosen susp. solids in the effl. of the biol. reactor	SS_{AT}	5.00	kg/m^3
Sludge age and load specifics:			
Sludge age (existing)	t_{SS}	13.0	d
Aerobic sludge age (existing)	$t_{SS,aer.}$	13.0	d
Safety factor (existing)	SF	2.12	-
BOD_5 volume load	$B_{R,BOD}$	0.50	kg/(m^3*d)
BOD_5 sludge load	$B_{SS,BOD}$	0.10	kg/(kg*d)
Sludge production:			
...from carbon removal	$SP_{d,C}$	69	kg/d
...from external carbon source	$SP_{d,extC}$	0	kg/d
...from biol. phosphorus removal	$SP_{d,BioP}$	0	kg/d
...from precipitation	$SP_{d,Prec}$	0	kg/d
Total daily sludge production	SP_d	69	kg/d
Oxygen uptake:			
...for carbon removal	$OU_{d,C}$	98	kg/d
...for nitrification	$OU_{d,N}$	61	kg/d
...carbon removal by denitrification	$OU_{d,D}$	0	kg/d
Total daily uptake	OU_d	159	kg/d
Peak factor carbon respiration	f_C	1.15	-
Peak factor ammonia oxidation	f_N	2.00	-
Maximum hourly uptake rate	OU_h	9.2	kg/h
Required oxygen transfer	alpha*OC_h	12.4	kg/h
Alkalinity:			

Alkalinity in the effluent	$S_{ALK,EST}$	-5.07	mmol/l

Secondary settling

Type of tank(s): Hopper-bottom tank		
Flow characteristics: vertical		
Decisive wastewater flow	$Q_{WW,H}$	30 m^3/h
Sludge volume index, Return sludge ratio:		
Sludge volume index (chosen)	SVI	120 l/kg
Thickening time	t_{Th}	1.8 h
Suspended solids in the bottom sludge	SS_{BS}	10.0 kg/m^3
Chosen ratio SS_{RS}/SS_{BS}		1.00 -
Suspended solids in return sludge	SS_{RS}	10.0 kg/m^3
Chosen return sludge ratio with $Q_{h,WW}$	RS	1.00 -
Permitted susp. solids concentration in the influent	SS_{IST}	5.02 kg/m^3
Chosen susp. solids concentration in the influent	SS_{EAT}	5.00 kg/m^3
Surface area, Number and dimension of tank(s):		
Permitted sludge volume load	qSV	650 $l/(m^2*h)$
Permitted surface overflow rate	qA	2.00 m/h
Number of tanks	a	2
Chosen diameter	D_{ST}	6.00 m
Diameter of stilling drum	D_{SD}	0.50 m
Diameter at the bottom	D_b	1.00 m
Slope of hopper walls	x	1.70 -
Surface area (existing)	A_{ST}	57 m^2
Effective surface area	A_{ST}	57 m^2
Sludge volume load (existing)	qSV	318 $l/(m^2*h)$
Surface overflow rate (existing)	qA	0.53 m/h
Depth of tank(s):		
Clear water zone	h_1	0.62 m
Separation / Return flow zone	h_2	1.33 m
Density flow / Storage zone	h_3	0.72 m
Thickening / Sludge removal zone	h_4	3.32 m
Decisive depth of tank(s)	h_{ST}	6.00 m
Vertical height of wall below water level	h_s	1.75 m
Depth of inlet below water level	h_e	2.30 m