

Technical Description

Randstad Relief Plant

Project ID: 1 822 520

200 000 m³/d Wastewater Treatment Facility



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1 Introduction

This technical description outlines the Activated Sludge (AS) (CAS) alternative for the **Randstad Relief Plant Project ID 1 822 520** Water Resource Recovery Facility (WRRF) in **Netherlands**. As outlined below, the design capacity of the proposed facility is **200 000** m³/d.

This document outlines the overview of the proposed treatment process, the basis of design and preliminary design information by process unit.



2 Overview of the proposed Activated Sludge Process

The Process Scheme accompanying this document provides a schematic of the above unit processes as well as the flow connectivity among them.

As shown in the process scheme, influent flows through the preliminary treatment where screening and grit removal takes place.

After preliminary treatment, flow is directed to the primary clarifier(s), where suspended solids will be partially removed. Following primary treatment, flow is directed to the equalization tank(s) from where wastewater goes to the CAS for biological treatment.

Biological treatment in 3 CAS train(s) is proposed.

The activated sludge process proposed in this design is the Modified Ludzack-Ettinger (MLE) process configuration for total nitrogen removal. The MLE treatment consists of a first anoxic zone which receives wastewater, Return Activated Sludge (RAS), and an internal MLSS recycle stream from the end of the aerobic zone. The main function of the first anoxic zone is to reduce nitrate to nitrogen gas (denitrification) while removing some carbonaceous materials. Aerobic zones follow the anoxic zone where oxidation of remaining carbonaceous materials BOD and ammonia to nitrate take place. Internal recycle is provided to pump nitrate-rich water back to the anoxic zone. The anoxic zones are not aerated, and MLSS is kept in suspension by mechanical mixers.

In the aerobic zones, fine-bubble aeration provides the oxygen required for the aerobic biological reaction, as well as airflow required to maintain MLSS in suspension.

Process sizing is carried out using a series of steady-state and dynamic simulations in an iterative manner to determine the required process volumes and airflows to achieve acceptable effluent quality. All process unit sizing and operational parameters (i.e. sludge age, sludge production, etc.) are determined by this iterative sizing approach.

Treated effluent from the biological reactor flows to the coagulation tank, where coagulant is added to achieve the required effluent phosphorus limit.

Effluent flows from the coagulation tank to the secondary clarifier unit which gravity-settles the suspended biomass and inert solids to achieve the required effluent TSS limits.

Elimination of pathogens using UV-radiation takes place before discharge.

Excess sludge from the phase separation step is directed to the sludge storage tank before the thickening process. From the storage tank the sludge is conditioned by a flocculation-enhancing polymer and directed to the mechanical thickener. The sludge is thickened in the mechanical thickener and is sent to a blending tank where it is mixed with the primary sludge. From the blending tank the mixed sludge is directed to dewatering. The sludge is conditioned by a flocculation-enhancing polymer and directed to the dewatering unit. The dewatered sludge is collected in a container to be transported away from the facility for reuse or disposal. Reject water from thickening and dewatering processes is directed back to the first reactor zone.



3 Process Design Basis

Table 1 shows the influent characteristics and effluent limits used as the basis of design, which are based on the provided information and on certain assumptions made during the design.

Table 1. Influent characteristics and effluent requirements used as the basis of design

Parameters	Influent Characteristics	Units	Effluent Limits	Units
Average design flow	200 000	m ³ /d	-	-
Peak Daily Flow ($Q_{\text{Peak Daily Flow}}$)	600 000	m ³ /d	-	-
Design peak flow after flow equalization (Q_{peakEQ})	8 333	m ³ /h	-	-
Chemical Oxygen Demand (COD)	550	mg/l	125	mg/l
Biochemical Oxygen Demand (BOD ₅)	250	mg/l	25	mg/l
Total Suspended Solids (TSS)	338	mg/l	35	mg/l
Total Kjeldahl Nitrogen (TKN)	45	mg/l	-	-
Total Nitrogen (TN)	-	-	10	mg/l
Total Phosphorus (TP)	10	mg/l	1	mg/l
Alkalinity (as CaCO ₃)	350	mg/l	-	-
Influent pH	7	-	-	-
Design minimum wastewater temperature (T_{min})	8.8	°C	-	-
Design maximum wastewater temperature (T_{max})	19.7	°C	-	-

Absolute compliance requirements have been selected and used in process design.

selected and used in process design.

The chemical coagulation system is required based on process simulation results to achieve TP compliance



3.1 Influent Loads

Table 2. Influent loads

Item/Parameter	Value	Unit
COD Load	110 000	kg/d
BOD ₅ Load	50 000	kg/d
TSS Load	67 600	kg/d
TKN Load	9 000	kg/d
TP Load	2 000	kg/d



4 Process Units

4.1 Preliminary Treatment

4.1.1 Coarse Screen(s)

Coarse screens are provided to remove large objects prior to the secondary treatment process and to protect the following preliminary treatment steps.

Table 3. Technical Specification of Coarse Screens

Item/Parameter	Value	Unit
Design flow	600 000	m ³ /d
Opening size	6	mm
Estimated screenings volume	14 447	l/d

4.1.2 Grit Removal

Grit removal is provided to capture sand, grit, and other fine materials.

Table 4. Technical Specification of Grit Removal

Item/Parameter	Value	Unit
Design flow	600 000	m ³ /d
Grit removal type	Vortex	-
Estimated grit quantity	10 000	l/d

4.2 Primary Treatment

4.2.1 Primary Clarification

Primary sedimentation is provided to reduce organic and solid load to the biological treatment. Suspended solids are gravity-settled to the bottom of the secondary clarifier and then pumped directly to the solids handling and dewatering processes.



Table 5. Technical Specification of the primary clarifier(s)

Item/Parameter	Value	Unit
Average design flow	200 000	m ³ /d
Peak design flow	600 000	m ³ /d
Number of units - Duty	6	-
Side water depth	3.5	m
Shape of primary clarifier	Circular	-
Surface area of primary clarifier	1 018	m ²
Clarifier diameter	36	m
Design surface overflow rate at average flow conditions	2	m ³ /m ² /h
Design surface overflow rate at peak flow conditions	4	m ³ /m ² /h
Actual surface overflow rate at average flow conditions	1.36	m ³ /m ² /h
Actual surface overflow rate at peak flow conditions	4.09	m ³ /m ² /h
Primary Clarifier TSS removal rate	60	%
Primary sludge volume	1 164	m ³ /d
Solid content of primary sludge	35 000	mg/l

4.2.2 Equalization tank

Equalization tank attenuates flows throughout the plant.

Table 6. Technical Specification of Equalization tank

Item/Parameter	Value	Unit
Design flow	600 000	m ³ /d
Total volume of tank	16 667	m ³
Total air requirement	7 401	Nm ³ /h
Mixing type of equalization tank	Aeration without mixing equipment	-



4.3 Secondary Biological Treatment – Activated Sludge Process

4.3.1 Biological Reactors

The required reactor volume, airflow and operating conditions are determined by a number of steady-state and dynamic simulations to meet the effluent quality requirements.



Table 7. Technical Specification of Activated Sludge Reactors

Item/Parameter	Value	Unit
Average design flow	200 000	m ³ /d
Peak design flow	200 000	m ³ /d
Number of biological train(s)	3	-
Total volume of reaction zones per train	45 174	m ³
Anoxic volume per train	7 111	m ³
Aerobic volume per train	38 063	m ³
Water depth in biological reactors	5	m

Table 8. Design and Operational Parameters of Activated Sludge Reactors

Item/Parameter	Value	Unit
Design basis	SRT	-
Design aerobic SRT at T _{min}	7.6	d
Operational aerobic SRT at T _{min}	7.6	d
Total SRT	9.02	d
Activated Sludge process sizing model		-
HRT of anoxic zones at average flow	2.56	hrs
HRT of aerobic zones at average flow	13.7	hrs
HRT of anoxic zones at peak flow	2.56	hrs
HRT of aerobic zones at peak flow	13.7	hrs
Food to Volatile Mass Ratio	0.13	kg BOD/kg VSS.d
MLSS concentration	3 006	mg/l
MLVSS concentration	2 048	mg/l
IR (Internal recycle) flowrate	500 000	m ³ /d
RAS (Return Activated Sludge) flowrate	100 000-300 000	m ³ /d
Excess sludge (dry solids)	44 805	kg/d



4.3.2 Process Aeration

Aeration is provided in the aerobic zones to maintain mixing and provide sufficient oxygen for biological processes.

Table 9. Process Aeration Technical Specification

Item/Parameter	Value	Unit
Dissolved Oxygen setpoint	2	mg/l
Actual dissolved oxygen concentration in aerobic reactors	2	mg/l
Average AOR	54 298	kg/d
Standard oxygen transfer efficiency	29	%
Alpha factor	0.65	-
Beta correction factor for salts and ions	0.95	-
Process air demand (min)	48 328	Nm ³ /h
Process air demand (average)	52 733	Nm ³ /h
Process air demand (max)	60 858	Nm ³ /h
Total mixing air requirement for aerobic zones	24 551	Nm ³ /h
Total air requirement for mixing and process aeration	52 733	Nm ³ /h

Conditions of the normalized air demand calculations: T = 0°C, p = 1.013 bar, RH = 0%

4.4 Chemical Phosphorus Removal/Coagulation

Prior to solids separation, chemical addition is provided to precipitate phosphorus and to enhance removal of suspended particles.

Table 10. Technical Specification of Chemical Phosphorus Removal/Coagulation

Item/Parameter	Value	Unit
Total ferric chloride dosage prior to solids separation (37 % solution)	24 146	l/d
Mass of metal in dosage	2 768	kg/d
Active metal concentration in solution	12.74	%
Design molar ratio	1.19	-
Number of unit(s) coagulation tank	3	units
Coagulation tank volume	417	m ³
Chemical storage capacity ¹	72	m ³

¹Assuming 3 days storage capacity



4.5 Phase Separation

4.5.1 Secondary Clarification

Clarification is provided to allow a quiescent settling zone where suspended solids are gravity-settled to the bottom of the clarifier. Settled solids are then pumped directly to the solids handling and dewatering processes.

Table 11. Basic secondary clarification Information

Item/Parameter	Value	Unit
Average design flow	200 000	m ³ /d
Peak design flow	200 000	m ³ /d
Number of units	12	units
Side water depth	4	m
Shape of clarifier	Circular	-
Surface area of clarifier	836	m ²
Diameter of clarifier	33	m
Surface overflow rate at average flow conditions	0.83	m ³ /m ² /h
Surface overflow rate at peak flow conditions	0.83	m ³ /m ² /h
Design surface overflow rate at average flow condition	1	m ³ /m ² /h
Design surface overflow rate at peak flow condition	2	m ³ /m ² /h
Target solids loading rate	120	kg/m ² /d
Actual solids loading rate	120	kg/m ² /d
Target peak solid loading rate	180	kg/m ² /d
Actual peak solid loading rate	120	kg/m ² /d
HRT at average condition	1.92	hrs
HRT at peak condition	1.92	hrs
Secondary Clarifier model type	Manual	-

4.6 Disinfection

4.6.1 UV Disinfection

Through passage of UV light into the water, inactivation of bacteria, viruses, and protozoa is accomplished.



Table 12. Technical Specification of UV Disinfection

Item/Parameter	Value	Unit
Number of units - Duty	4	units
Number of units - Standby	-	units
UV dose	119	mW-s/cm ²

4.7 Sludge Management

4.7.1 Pre-thickening Sludge storage tank

The sludge storage tank is provided as a buffer to allow intermittent thickening operation.

The sludge storage tank is provided as a buffer to allow intermittent thickening and dewatering operation.

Surplus Activated Sludge is stored in the the buffer tank(s).

Table 13. Technical Specification of Pre-thickening Sludge storage tank

Parameters	Value	Unit
Number of Pre-thickening Sludge storage tank	1	-
Pre-thickening Sludge storage tank volume	14 935	m ³
Retention time	48	h
Dry solid content	0.6	%
Tank mixing type	Mixing	-

4.7.2 Mechanical Pre-thickening Unit

Sludge flow from the sludge storage tank is directed to mechanical thickening.



Table 14. Technical Specification of Mechanical Thickener Unit

Item/Parameter	Value	Unit
Mechanical Thickener Type	Mechanical belt thickener	-
Number of Units	1	-
Solid Capture rate	0.9	-
Thickened sludge flow	806	m ³ /d
Dry solids content	50 000	g/m ³
Polymer dosing (0.1 m/m% solution)	134	m ³ /d
Reject Flow	6 795	m ³ /d

4.7.3 Blending Tank

Primary and secondary excess sludge is mixed in the newly constructed blending tank downstream thickening unit.

Table 15. Technical Specification of Blending Tank

Parameters	Value	Unit
Number of Blending tanks	1	units
Total Volume of Blending tank	1 970	m ³
Blending tank depth	5	m
Retention time	1	day
Dry solid content	4.11	%

4.7.4 Dewatering Unit – Decanter Centrifuge

Sludge from the blending tank is directed to the decanter centrifuge(s).



Table 16. Technical Specification of the Decanter Centrifuge(s)

Item/Parameter	Value	Unit
Number of Dewatering units	2	-
Solid Capture rate	0.95	-
Daily sludge cake production (dry solids)	308	m ³ /d
Dry solids content	250 000	g/m ³
Dry solid content percentage	25	%
Sludge production	77 000	kgDS /d
Polymer dosing (0.1 m/m% solution)	608	m ³ /d
Reject Water	2 270	m ³ /d

4.7.5 Polymer System

Polyelectrolyte is used throughout various process units to improve solids separation performance.

Table 17. Technical Specification of the Polymer Systems

Polymer System	Value	Unit
Sludge Thickening	134	m ³ /d
Sludge Dewatering	608	m ³ /d

5 Summary mass balance table

Parameter name/Measuringpoint	Raw Influent	Primary Treatment Effluent	Upstream Secondary Phase Separation	Secondary Phase Separation Overflow	Final Effluent	Primary Sludge	Secondary Phase Separation - Underflow	Sludge Thickening Influent	Dewatering Influent	Return Flow	Unit
COD Concentration	550	353	2 202	31	31	34 251	4 375	4 375	35 103	2 780	mg/l
BOD Concentration	248	186	503	4.73	4.73	10 869	1 001	1 001	9 831	636	mg/l
TSS Concentration	339	137	2 982	20	20	35 000	6 000	6 000	41 140	3 784	mg/l
TKN Concentration	45	44	147	3.33	3.33	272	292	292	1 148	186	mg/l
TN Concentration	45	44	154	9.49	9.49	272	298	298	1 150	192	mg/l
Ammonia Concentration	28	28	0.97	0.95	0.95	28	0.95	0.95	16.99	1.01	mg/l
Nox Concentration	-	-	6.31	6.17	6.17	-	6.17	6.17	2.48	6.26	mg/l
TP Concentration	10	9.58	127	1.53	1.53	81	253	253	910	161	mg/l
Orthophosphate Concentration	7.5	7.5	2.86	0.63	0.63	7.5	0.63	0.63	4.68	2.23	mg/l
COD Load	110 000	70 143	881 524	6 272	6 272	39 857	874 538	32 668	69 159	1 949 889	kg/d

BOD Load	49 654	37 005	201 532	948	948	12 648	200 125	7 476	19 368	446 215	kg/d
TSS Load	67 881	27 153	1 193 811	4 009	4 009	40 729	1 199 427	44 805	81 053	2 654 156	kg/d
TKN Load	9 000	8 684	59 020	667	667	316	58 275	2 177	2 261	130 190	kg/d
TN Load	9 000	8 684	61 548	1 903	1 903	316	59 508	2 223	2 266	134 579	kg/d
Ammonia Load	5 625		390	190	190	33	189	7.07	33	705	kg/d
TP Load	2 000	1 905	50 934	306	306	95	50 628	1 891	1 793	112 643	kg/d
Orthophosphate Load	1 500	1 491	1 144	125	125	8.73	125	4.67	9.22	1 562	kg/d