9327
DS Smith, Sittingbourne, UK
Water Treatment Plant

System Description

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1	24/10/16	Revised In Accordance With Design Review	IJP	MB
2	09/11/2016	Updated Condensate System and Effluent System	CM	IJP
3	08/02/2017	Added Equipment Name/Tag Tables and General Update	CM	IJP
4	01/05/18	Revised to as built	IJP	MB
5	21/05/18	Updated	IJP	MB
6	18/07/18	Added Sign off boxes	IJP	MB

1. Contents

2. Introduction

The Kemsley Mill site is currently supplied with Steam & Electricity from a CHP Plant (K1), constructed in 1994 by the former John Brown organisation. The CHP plant (and all associated assets) is owned by DS Smith, but operated by E.On UK.
The K1 plant encompasses a demin plant designed & constructed by the former Dewplan organisation (High Wycombe) which has performed well over the past 20 plus years. The control system of which is based on the former Allen Bradley Series 5 PLC system and as highlighted as a result of a recent lightning strike at the plant, is now almost completely obsolescent leaving the site vulnerable in terms of supporting ongoing CHP operations (K1).
The Dewplan plant was configured to provide approximately 203 m^3/h of demineralised (Make-Up) water (generally in line with the requirements of High Pressure Water Tube Boilers as defined in BS2486:1997), along with any available Condensate Returns up to a total continuous flow of 370 m^3/h. This original configuration accommodated the requirements of up to 7 Paper Machines spread across the 2 Mill sites, Kemsley & Sittingbourne.
As the DS Smith organisation has evolved its Paper Making business, the number of Paper Machines (PM's) has reduced to just 3 units – with complete closure of the Sittingbourne Mill. As a consequence, Steam demand has significantly reduced – typical values witnessed during several recent site visits are in the region of 210 m^3/h, comprised of approximately 70 m^3/h of Make-Up and 140 m^3/h of Condensate.
Presumably as a result of process and efficiency improvements at the remaining PM's, the proportion of Condensate as a percentage of Boiler Feed Flow has dramatically increased from around 45% to approximately 65%. Previously, the Sittingbourne Mill, situated approximately 2 miles from the Kemsley Mill, resulted in Condensate being returned at a temperature close to Ambient, whereas currently, all Condensate is returned at temperatures in the region 85-90°C.

3. Design Basis

3.1. Raw Water Design Analysis

The raw water analysis adopted as the design basis for the system

Ionic & Physical Parameters

	As Analysed by Envirogen (17th March 2016)	Original Design Values (Dewplan 1994)
Calcium (mg/l as $CaCO_3$)	312.5	267
Magnesium (mg/l as $CaCO_3$)	15.2	33
Sodium (mg/l as $CaCO_3$)	36.9	16
Potassium (mg/l as $CaCO_3$)	3.5	19
Total Cations:	368.1	335.0
Alkalinity (mg/l as $CaCO_3$)	280.4	265
Sulphate (mg/l as $CaCO_3$)	37.5	45.0
Chloride (mg/l as $CaCO_3$)	42.3	16
Nitrate (mg/l as $CaCO_3$)	17.2	9
Total Anions:	377.4	335.0
Silica (mg/l as SiO_2)	8.3	6
pH	7.3	NR
CO_2 (mg/l as $CaCO_3$)	31.8	NR
pH	7.3	NR
Turbidity (NTU)	< 0.9	NR
Total Iron (µg/l as Fe)	7.0	NR
Dissolved Iron (µg/l as Fe)	5.0	NR
Suspended Solids (mg/l)	< 2	NR

TOC Concentration & Composition

Sample Description	TOC *(ppb as C)*	POC *(ppb as C)*	DOC *(ppb as C)*	DOC Composition *(ppb as C)*					
				Hydrophobics	Hydrophilics				
					Bio-Polymers	Humics	Building Blocks	LMW Neutrals	LMW Acids
Raw Water	518	28	490	35	48	198	98	111	0

TOC = Total Organic Carbon

POC = Particulate Organic Carbon - i.e. 'Filterable'

DOC = Dissolved Organic Carbon - i.e. 'Non-Filterable'

3.2. Treated Water Specification

3.2.1. Makeup Plant

Treated Water Quality at the outlet of the new Cation/Anion/Mixed Bed streams, will meet or exceed the following specification

No.	Parameter	Unit	Limit	Comments
1	Cation (Acid) Conductivity at 25°C	µS/cm	<0.2	Cation conductivity is the conductivity of water measured downstream of a strongly basic cation exchanger at continuous flow
2	Sodium (Na) and Potassium (K)	mg/l	<0.01	
3	Iron (Fe)	mg/l	<0.02	
4	Copper (Cu)	mg/l	<0.003	
5	Silicon dioxide (SiO_2)	mg/l	<0.02	
6	Oil/Grease	mg/l	<0.1	
7	Total Organic Content (TOC)	mg/l	<0.2	
8	pH Value	-	>9.2	The adjustment of the pH value will be done in the K3 feedwater tank
9	Oxygen (O_2)	mg/l	<0.1	The adjustment of the O_2 value will be done in the K3 feedwater tank
10	Total Hardness (Ca + Mg)	mmol/l	-	Demineralised water

Design Average Flow

- 150 m^3/h with only one ‘stream’ available (for a maximum of 28 days)
- 195 m^3/h with both streams available

3.2.2. Condensate Plant

Treated Water Quality at the outlet of the existing Mixed Bed units (2 off), assuming they can be successfully and suitably refurbished, will meet or exceed the following specification

	Parameter	Unit	Limit	Comment
1	Cation (Acid) Conductivity	µS/cm	< 0.2	✓ (Mixed Bed outlet ≈ 0.1)
2	Sodium (Na) & Potassium (K)	mg/l	< 0.1	✓
3	Iron (Fe)	mg/l	< 0.02	Subject to influent conditions
4	Copper (Cu)	mg/l	< 0.003	Subject to influent conditions
5	Silica (SiO_2)	mg/l	< 0.02	✓
6	Oil/Grease	mg/l	< 0.1	✓
7	+	mg/l	< 0.2	Subject to influent conditions
8	pH	-	> 9.2	NA - Adjusted at the K3 plant
9	Oxygen (O_2)	mg/l	< 0.1	NA - Adjusted at the K3 plant
10	Total Hardness (Ca + Mg)	mmol/l	-	✓

Design Average Flow

- 185 m^3/h with one unit in service

4. Process & Technical Discussion

4.1. Raw Water Analyses

The analysis results of several raw water samples are summarised in the table below.

	Original Design 1994	09-Jul-15	22-Jul-15	28-Jul-15	03-Aug-15	10-Aug-15	14-Sep-15	17-Mar-16
Calcium	267.0	330.0	340.0	335.0	315.0	327.5	327.5	312.5
Magnesium	33.0	15.6	16.1	16.5	15.4	15.6	14.6	15.2
Sodium	16.0	39.1	39.1	42.3	34.9	41.4	36.2	36.9
Potassium	19.0	3.6	3.7	3.9	3.3	4.7	3.4	3.5
Total Cations:	335.0	388.2	398.9	397.7	368.6	389.2	381.7	368.1
Alkalinity	265	276.0	277.0	274.0	267.0	272.0	293.0	280.4
Sulphate	45.0	43.9	41.6	48.3	35.5	40.6	35.9	37.5
Chloride	16	45.4	44.0	44.7	43.4	44.3	42.7	42.3
Nitrate	9	21.2	20.7	20.3	19.1	20.5	18.4	17.2
Silica	6	9.5	9.4	9.1	9.5	9.3	9.9	8.3
$CO_{2\ (Assumed)}$	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Total Anions:	351.0	386.5	383.3	387.2	365.0	377.4	390.0	377.4
TOC	NR	< 1	< 1	< 1	< 1	< 1	< 1	< 1

Originating from the Sonora boreholes, the raw water supply displays the common characteristics of a subterranean Limestone/Chalk aquifer supply, namely…

- High Hardness (Calcium & Magnesium)
- High alkalinity (Bicarbonate)
- Moderately high levels of Total Dissolved Solids (TDS)
- Relatively low levels of TOC (Discussed in the separate section below)
- Relatively stable composition (based on comparison with Original design values and recent analyses)

Additionally, although no historic data is available, Turbidity (closely but not directly associated with Suspended Solids) values are quite low, as would be expected and demonstrated in the samples obtained on 17th March 2016 with a value of 0.9 NTU (Nephelometric Turbidity Units)

5. Process Description

The following is an overview of the process units incorporated within the scope of supply and their process operations.
The process is divided into sections which are made up of a combination of existing plant and new plant that will defined in the document.

1. Raw Water Abstraction Pumps
2. Water Treatment System
    a. Raw Water Tank
    b. Makeup System
    c. Makeup Tank
    d. Makeup Forwarding System
    e. Condensate System
3. Reserve Feed Water Tanks
4. Effluent System
5. Regeneration System

The plant is designed to maintain the level in the RFW tanks that feed the boiler feed water systems to K1, K2 and K3 plants.
The feed to RFW will be a blend of treated condensate and makeup water.
The preference will be to utilise treated condensate with any shortfall using makeup water

5.1. Raw Water Abstraction Pumps

Equipment name	Equipment Tag on P&ID
Abstraction Pump A	9-RAW-PU-001 A
Abstraction Pump B	9-RAW-PU-001 A
Abstraction Pump A/B Discharge PSL	9-RAW-003/004-PSL
Abstraction Pump FIT	9-RAW-005-FIT
Culvert LSLL	9-RAW-001-LSLL

The DS Smith operated borehole pumps supply water into the lagoons where they are transferred via a culvert to the raw water abstraction sump.
The water is abstracted from the raw water abstraction sump via two Raw Water Abstraction Pumps, they operate on a duty / standby arrangement with one pump capable of providing the full required flowrate to the system.
The pumps are self-priming to allow for extraction from a sump below ground level. The pumps priming system will utilise a vacuum pump that will require a seal water source, this will be provided using a solenoid that will open when the pump starts and closes when the pump stops.
There are a number of different points of use for the raw water, one of which is the raw water tank for the water treatment plant.
The control signals for the pumps will be integrated into the new water treatment plant control system.
The motor starters for the pumps are located in the existing water treatment plant MCC.
The pumps are fixed speed pumps current the flow requirements for each utility will be controlled at point of use. They will be upgraded to variable speed drives that will be manually set to achieve the required pressure in the system.
The pumps each have an emergency stop button that is connected to the MCC to stop the pump, this is separate than the main water treatment plant emergency stop system.

Alarms

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Action	Tested
Abstraction Pump A/B Alarm					Standby Pump Starts	
Abstraction Pump A Alarm & Abstraction Pump B Alarm					Abstraction Pump System Alarm	
Abstraction Pump Discharge Low Pressure Alarm	Abstraction Pump Discharge PSL	Low	OFF		Abstraction Pump A/B Alarm	

Abstraction Pumps Low Flow Alarm	Abstraction Pump Flow Transmitter	Low			Abstraction Pump A/B Alarm	
Culvert low level Alarm	Culvert Low Level Switch	Low	OFF		Abstraction Pump System Alarm	
Abstraction Pump A/B Fault					Abstraction Pump A/B Alarm	
Abstraction Pump System Alarm					Shutdown Abstraction Pumps	

The duty of the pumps will be cycled when the Operating Timer exceeds the **Operating Time Setpoint**

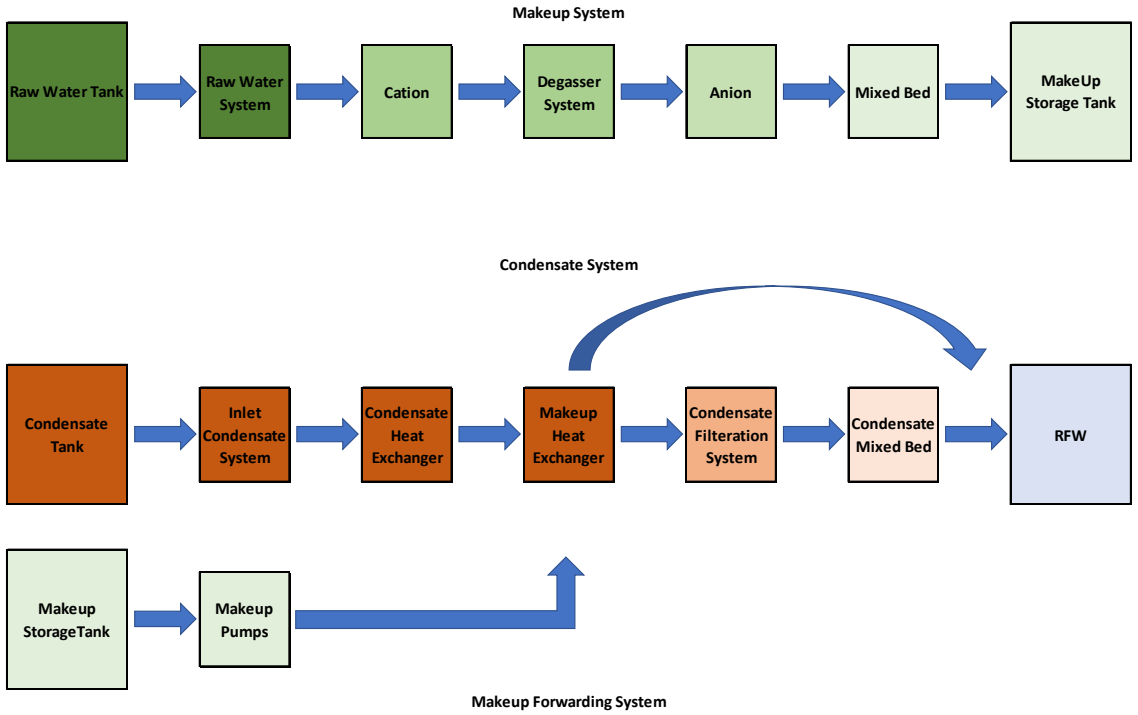
Setpoints

Setpoint	Default	Current	Tested
Operating Time Setpoint	8 hours		
Operating Speed Setpoint	80%		

5.2. Water Treatment System

The water treatment system is divided into five sections

- Raw Water Tank
- Makeup System
- Makeup Storage Tank
- Makeup forwarding system
- Condensate System



The demand of water to the RFW tank is dependent on its current level. If the level is greater than the RFW Tank Level High Setpoint then the RFW Demand Setpoint will be zero, if the level is less that the RFW Tank Level Low Setpoint then the RFW Demand Setpoint will be 100%. If the level is between the two setpoints then the RFW Demand Setpoint will be proportional.

The RFW Demand Setpoint will be satisfied by the sum of the Condensate Flow Setpoint and the Makeup Forwarding Flow Setpoint.

The Condensate System uses the condensate control valve to adjust the flow using the Condensate FIT to achieve the Condensate Flow Setpoint. There is a maximum (185m3/hr) and minimum (channelling) flow that can be achieved by the system

The Makeup Forwarding System uses the makeup pump A/B VSD to adjust the flow using the Makeup Forwarding FIT to achieve the Makeup Forwarding Flow Setpoint

The Makeup System will independantly control its throughput in order to maintain the level in the Makeup Storage Tank, it will do this in all the Water Treatment Plant Operating Modes.

There are several modes of operation of the water treatment plant

- Startup Mode
- Condensate Level Mode
- Condensate Temperature Mode

- **Startup Mode**

  The water treatment system will operate in Startup Mode after a complete shutdown, it will remain in this mode for a period of time as determined by the Startup Timer Setpoint after which it will transition to the Condensate Level Mode.
  In this mode of operation, the Makeup Forwarding Flow Setpoint will be set to the RFW Demand Setpoint, up to the maximum throughput of the plant (200m3/hr) and the Condensate Flow Setpoint will be zero.
  The Makeup system will control its throughput in order to maintain the level in the Makeup Storage Tank

- **Condensate Level Mode**

  When the condensate mixed bed inlet temperature is less than 38 C, the system will operate in Condensate Level Mode.
  In this mode the condensate flow control valve will be controlled by the level in the condensate tank. If the level is greater than the Condensate Tank Level High Setpoint then the Condensate Flow Setpoint will be set to 100%. If the level is less than the Condensate Tank Level Low Setpoint then the Condensate Flow Setpoint will be set to zero. If the tank level is between the two setpoints then the Condensate Flow Setpoint will be proportional.
  The Makeup Flow Setpoint will then be set as the RFW Demand Setpoint minus the Condensate Flow Setpoint.
  The Makeup system will control its throughput in order to maintain the level in the Makeup Storage Tank

- **Condensate Temperature Mode**

  When the condensate mixed bed inlet temperature is greater than 38 C, the system will operate in Condensate Temperature Mode.
  In this mode the Condensate Flow Setpoint is adjusted according to the condensate mixed bed inlet temperature. As the condensate mixed bed inlet temperature increases the Condensate Flow Setpoint decreases. As the condensate mixed bed inlet temperature decreases the Condensate Flow Setpoint increases
  The Makeup Flow Setpoint will then be set as the RFW Demand Setpoint minus the Condensate Flow Setpoint.
  The Makeup system will control its throughput in order to maintain the level in the Makeup Storage Tank

Setpoints

Setpoint	Default	Current	Tested
RFW Tank Level High Setpoint	90%		
RFW Tank Level Low Setpoint	70%		
Condensate Tank Level High Setpoint	90%		
Condensate Tank Level Low Setpoint	50%		
Startup Timer Setpoint	30 mins		

5.2.1. Raw Water Tank

Equipment name	Equipment Tag on P&ID
Raw Water Tank	9-RAW-TK-001
Raw Water Tank LT	9-RAW-015-LT
Raw Water Tank Inlet Valve	9-RAW-LCV-021
Raw Water Tank LSLL	9-RAW-016-LSLL

The Raw Water Tank is an existing GRP tank of 90m3 working volume.
The control signals of the tank and its instruments will be integrated into the new control system Raw Water Tank LT controls the Raw Water Tank Inlet Valve to maintain the Raw Water Tank Level. If the Raw Water Tank Level is below the Raw Water Tank Inlet Valve Open Setpoint the valve is fully open, if the Raw Water Tank Level is above the Raw Water Tank Inlet Valve Closed Setpoint then the valve is fully closed. If the Raw Water Tank Level is between the setpoints then the valve is proportionally open.

Alarms

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Action	Tested
Raw Water Tank High Alarm	Raw Water Tank LT	High	90%		Alarm Only	
Raw Water Tank Low Alarm	Raw Water Tank LT	Low	20%		Alarm Only	
Raw Water Tank Low Low Alarm	Raw Water Tank LT	Low	10%		Makeup System Alarm	
	Raw Water Tank LSL	Low	OFF			

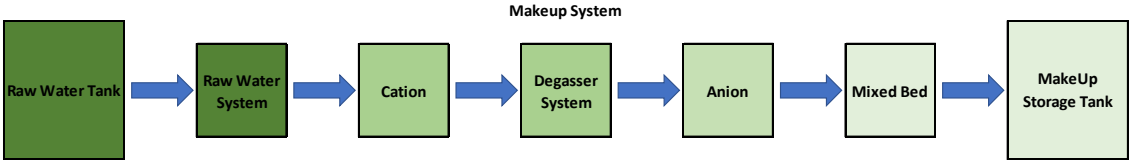
Setpoints

Setpoint	Default	Current	Tested
Raw Water Tank Inlet Valve Open Setpoint	50%		
Raw Water Tank Inlet Valve Closed Setpoint	80%		

5.2.2. Make-Up System

The core of the proposed system utilises the Dow UPCORE® process, in dual compartment vessels, offering the functionality and process benefits of both weak and strong ion exchange, in a compact and economical arrangement. The process incorporates both counter-current and thoroughfare regeneration processes, yielding high quality de-ionised water with minimised chemical use and effluent production. The adoption of both weak and strong resins, further bolsters the plant's capabilities to produce low TOC water and tolerance to naturally occurring organic material in the feed water.

The Makeup plant is used to provide demineralised water to the Makeup Storage Tanks this will then be used to make up any limitation to the condensate return available to fulfil the downstream requirement of the CHP plants and also for regenerations of the Makeup and Condensate plants.



The Makeup Water Treatment System is designed to produce demineralised water using Ion Exchange (IX) technology.
The Makeup System consists of two 100% trains based on the Dow proprietary UPCORE process, with dual chamber units for both the cation exchanger and the anion exchanger to contain both weak and strong resins in the same column. The units are designed based on downflow service and upflow regeneration.
Each train includes a Cation Vessel, Anion Vessel and Makeup Mixed Bed Vessel. The installed Degasser is common and will be utilised by both trains.
The regeneration of the Cation and Anion vessels are simultaneous and the regeneration of the Makeup Mixed Bed Vessel is carried out independently, however the vessels will operate as one train.
Each train will be allocated as Duty or Standby train illustrating which will be in operation when there is a demand for Makeup Water.
Each train is capable of producing 199m3/hr of demineralised water.

Alarms

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Raw Water Tank Low Low Alarm					Makeup System Alarm	
SBS System Alarm					Makeup System Alarm	
Raw Water Pump System Alarm					Makeup System Alarm	
Raw Water Filtration System Alarm					Makeup System Alarm	
Cation Alarm					Makeup Train A/B Alarm	
Degasser System Alarm					Makeup System Alarm	
Degasser Pump Alarm					Makeup System Alarm	
Anion Alarm					Makeup Train A/B Alarm	
Makeup Mixed Bed Alarm					Makeup Train A/B Alarm	
Makeup Storage Tank High Alarm					Makeup System Alarm	
Cation Inlet CL High Alarm	Cation Inlet CL Monitor	High	0 ppm		Makeup System Alarm	
Raw Water TOC High Alarm	Raw Water TOC Monitor	High	600 ppb		Makeup System Alarm	
Raw Water Conductivity High Alarm	Raw Water Conductivity Monitor	High	1000 us/cm		Makeup System Alarm	
Makeup TOC High Alarm	Makeup TOC Monitor	High	0 ppm		Makeup Train A/B Alarm	
Makeup Sodium High Alarm	Makeup Sodium Monitor	High	10 ppb		Makeup Train A/B Alarm	

Makeup Silica High Alarm	Makeup Silica Monitor	High	20 ppb		Makeup Train A/B Alarm	
Makeup Conductivity High Alarm	Makeup Mixed Bed A/B Conductivity Monitor	High	0.2 uS/cm		Makeup Train A/B Alarm	
MakeUp Tank Level High Alarm	Makeup Storage Tank LIT	High	90%		Makeup System Alarm	
Makeup Train A/B Alarm					Standby Train Runs	
Makeup Train A Alarm & Makeup Train B Alarm					Makeup System Alarm	
Makeup System Alarm					Shutdown Makeup System	

Setpoints

Setpoint	Default	Current	Tested
Anion Conductivity Analyser Regen Setpoint	0.2 uS/com		
Capacity Alarm Setpoint	2100 m3		
No. Regen Cycles For Mixed Bed Regen	28		
Standby Rinse Timer Setpoint	3 hours		
Online Rinse Timer Setpoint	10 mins		

5.2.2.1. Makeup System Operating Modes

The Makeup system as can operate in one of three modes

- Make-Up System Automatic Mode
- Make-Up System Semi-Automatic Mode
- Make-Up System Manual Mode

Make-Up System Automatic Mode

This will be the usual operating mode of the Makeup system.

The Duty Makeup Train will operate in **Service Mode** until it has reached its **Capacity Alarm Setpoint** at which point it will be reallocated to Standby Train and progress to **Regen Mode** automatically.
The Standby Train will be changed to the Duty Train and will then change mode dependant on the setting of the setting of the **Rinse On Service Toggle**. If it is on the train will enter Rinse Mode followed by **Service Mode**, if it is off the train will automatically enter **Service Mode** and start production.

If the **Anion Conductivity Analyser Regen Setpoint** is exceeded the Duty Train will be changed to Standby Train and will change mode according to the percentage of the **Current Treated Volume** against the **Capacity Alarm Setpoint**. If the percentage is 90% (Setpoint is adjustable) or more the Train is changed to **Regen Mode** and a regen is commenced, if the percentage is less than 90% (Setpoint is adjustable) then the train is moved to **Regen Required mode** and a regen is not commenced until the **Regen Start Button** is pressed on the pop-up.
The Standby Train will be changed to the Duty Train and will then change mode dependant on the setting of the setting of the **Rinse On Service Toggle**. If it is on the train will enter **Rinse Mode** followed by **Service Mode**, if it is off the train will automatically enter **Service Mode** and start production.

The Standby Train will enter Rinse mode automatically when the **Standby Rinse Timer Setpoint** is exceeded.

Make-Up System Semi-Automatic Mode

The Duty Makeup Train will operate in **Service Mode** until it has reached its **Capacity Alarm Setpoint**, it will remain in service mode until the operator presses the **Regen Start Button** on the pop-up at which point the vessel will progress to **Regen Mode**.
The Standby Train will be changed to the Duty Train and will then change mode dependant on the setting of the setting of the **Rinse On Service Toggle**. If it is on the train will enter Rinse Mode followed by **Service Mode**, if it is off the train will automatically enter **Service Mode** and start production.

If the **Anion Conductivity Analyser Regen Setpoint** is exceeded the Duty Train will be changed to Standby Train and a regen is not commenced until the **Regen Start Button** is pressed on the pop-up.
The Standby Train will be changed to the Duty Train and will then change mode dependant on the setting of the setting of the **Rinse On Service Toggle**. If it is on the train will enter **Rinse Mode** followed by **Service Mode**, if it is off the train will automatically enter **Service Mode** and start production.

The Standby Train will enter Rinse mode automatically when the **Standby Rinse Timer Setpoint** is exceeded.

Make-Up System Manual Mode

A manual mode of operation of the Makeup System will be provided allowing for the operator to initiate all sequence controls on the system. Great care must be taken in this operating mode and a full knowledge of the system is required to prevent damage to equipment and downstream processes.

5.2.2.2. Makeup Train Operating Mode

Each of the Makeup Trains will be in one of the following modes.

- Make-Up Train Offline Mode
- Make-Up Train Standby Mode
- Make-Up Train Service Mode
- Make-Up Train Rinse Mode
- Make-Up Train Regen Required Mode
- Make-Up Train Regeneration Mode

Make-Up Train Offline Mode

The Offline mode is selected when an alarm is raised on the Makeup train or the mode is manually selected by the operator. The train immediately moves to Standy Train and all valves are closed. Once a train is in in Offline mode an operator interaction is required to transition to a different status

Make-Up Train Standby Mode

The Standby mode is selected when a Train has operating capacity and is either the Duty Train but there is no demand for Makeup or it is the Standby train. The train will automatically transition to service as per the demand for Makeup flow.

Make-Up Train Service Mode

The Service mode is selected to provide water to equipment downstream. Totalized throughput or breaching of conductivity levels will trigger a signal for transition from Service to Regeneration dependant on the operating mode.

Make-Up Train Rinse Mode

The Rinse mode is selected periodically to ensure that the quality output from the system is maintained during extended shutdown. The Rinse Mode will commence when the **Standby Rinse Timer** which accumulates the amount of time in Standby Mode has exceeded the **Standby Rinse Timer Setpoint**.
The rinse is carried out with the regen pump taking water from the demin storage tank. It is split into two phases, each for a configurable time period, which are Cation & Anion Rinse and Mixed Bed Rinse.
The Rinse Mode is also selected when the Train is transitioning from Standby Mode to Service Mode, but only when the **Rinse On Service Toggle** is active.
The length of the rinse is configured by the **Rinse Duration Timer Setpoint.**

Make-Up Train Regen Required Mode

The Regen Required mode is selected to transition the Makeup Train towards a Regeneration sequence. Under certain conditions an operator interaction via pop-up windows is required to transition from Regen Required Mode to Regeneration Mode, as detailed in the Make-Up System Operating Modes section.

Make-Up Train Regeneration Mode

When a Makeup Train is placed into Regeneration, the control system will execute the required sequence of steps to regenerate the resins.
The Regeneration mode follows the Regen Required mode.
At the completion of the final step in the Regeneration mode, the control system triggers a transition from Regeneration to Standby.
In Regeneration mode, the operator has access to the Regen Override via the operator interface

- **Regen Auto** allows the time remaining timers to time out, automatically, in sequence.
- **Regen Step Hold** stops the time remaining timers, effectively prolonging any step to the desired time.
- **Regen Off** stops the time remaining timers, and de-energizes the equipment associated with the current step.
- **Regen Step Advance** is available to manually proceed to the next step in the sequence, regardless of time remaining. This feature is only available after selection of the override to Regen Off. The flow totalizer will not reset if the operator has chosen to step out of the sequence with the Regen Step Advance. This totalizer is reset only after normal completion of a Regeneration sequence.

5.2.2.3. Make-Up System Regeneration

The Regeneration mode is selected to regenerate the resin in the Demineraliser Train.
The Cation / Anion regeneration includes a Cation sequence and an Anion sequence; the vessel regenerations are carried out concurrently. Rinse Recycle is performed concurrently through the cation and then the anion to inlet of the regen pump.

- **Cation Regeneration**

The Cation Regeneration commences with a compaction step where the demin water is forced up through both beds at a high velocity to force the resin to be compacted against the top nozzle plate of the respective compartment.
Due to the provision of freeboard in both compartments this also acts as a backwash step to remove particulates particularly from the WAC bed.
The next regeneration step is to establish the dilution flow for the acid which is also up through the vessel, this is done whilst slowly reducing the compaction flow to ensure that the resin remains compacted. The acid concentration in the dilution water is then increased to the first acid concentration setpoint and held.
The acid concentration is then increased to the second acid concentration setpoint during which a second dilution flow is introduced at the bottom of the WAC compartment to dilute the acid concentration further. This is followed by the third acid concentration setpoint.
Once the appropriate quantity of regeneration chemical has been added the chemical flow is stopped and the dilution flow becomes the displacement flow which slowly removes the residual chemical from the vessel.
The resin is now allowed to settle to the bottom nozzle plate of the compartment.
Once settled fully a rinse recycle flow is established through the cation vessel and associated anion vessel, this flow bypasses the degasser.
There is the potential to carry out an air scrub and backwash of the cation vessel this will be a manual process with the air supplied by the regeneration blowers.

- **Anion Regeneration**

The Anion Regeneration commences with a compaction step where the demin water is forced up through both beds at a high velocity to force the resin to be compacted against the top nozzle plate of the respective compartment.
The next regeneration step is to establish the dilution flow for the caustic which is also up through the vessel, this is done whilst slowly reducing the compaction flow to ensure that the resin remains compacted. The caustic concentration in the dilution water is then increased to the caustic concentration setpoint and held.
Once the appropriate quantity of regeneration chemical has been added the chemical flow is stopped and the dilution flow becomes the displacement flow which slowly removes the residual chemical from the vessel.
The resin is now allowed to settle to the bottom nozzle plate of the compartment.
Once settled fully a rinse recycle flow is established through the anion vessel and associated cation vessel, this flow bypasses the degasser.

- **Mixed Bed Regeneration**

During the Regeneration cycle, the cation and anion resins are separated within the vessel by Backwashing the Polisher. The cation resin is more dense than the anion resin and, therefore,

settles to the bottom of the vessel during the Backwash and Settle steps of the Regeneration. With the cation resin separated from the anion resin, dilute acid and caustic can be pumped through the respective beds. The acid and caustic will reverse the exchange reaction and remove the ions collected during the Service cycle.
Acid and Caustic are injected into the cation and anion sections of the resin bed during the Injection step. The chemicals exit the bed through the collector outlet.
The Displacement step next pushes the volume of chemical in the bed, through the bed, at the same velocity as the injection step.
The Caustic Rinse step flushes residual caustic from the upper portion of the vessel through the Collector outlet so that it does not contaminate the cation resin bed during the Full Bed Rinse.
The Full Bed Rinse will expel most of the remaining regenerant chemicals from the resin bed and beneath the nozzle plate of the vessel through the Rinse Outlet Valve to the waste stream.
The Drain Down step will lower the water level to the top of the Anion resin bed in preparation for the mixing step. The water above the resin must be removed to avoid re-layering of the cation and anion resin beds when the mixing action is stopped.
The Air Mix step will mix the cation and anion resins by introducing air into the bottom of the vessel and expelling it through the Air Outlet Valve. During this step, the Drain Down Outlet will be opened for the first five minutes to avoid resin relayering. When the mix step is finished, the water level will be below the top of the bed, which will ensure that the cation and anion resin will not settle into separate layers.
The vessel must be refilled after the resin is mixed so that the vessel can be vented and re-pressurized prior to the Final Rinse. The Final Rinse step will provide flow through the Polisher to the waste stream for a preset time and until the desired water quality is achieved. Following that the vessel will enter a rinse where the outlet from the vessel is recirculated through the regen pumps to the inlet of the vessel forming a closed loop

Note: for the Condensate Mixed Bed regen, the caustic injection will be heated up to 50°C

5.2.2.4. Sodium Bisulphite Dosing System

Equipment name	Equipment Tag on P&ID
SBS Pump A/B	10-DER-PU-004 A/B
SBS Tank	10-DER-TK-001
Raw Water FIT	10-RAW-001-FIT
Raw Water CL Monitor	10-RAW-001-AIT
SB Pump FS A/B	10-DER-001/002-FS
SB Tank LSL	10-DER-001-LSL

The SMBS dosing system is made up of two duty/standby positive displacement pumps with each pump capable of producing the full flow requirement.
The SMBS is dosed in order to counteract the oxidising effect of Sodium Hypochlorite and the resulting Free Chlorine. This is important as a reducing environment can also adversely affect Ion Exchange plants, encouraging the growth of certain micro-organisms that can cause slimes resulting in poor resin exchange kinetics and high DP's.
When dissolved in water, sodium bisulfite (SBS) is formed from SMBS: $Na_2S_2O_5 + H_2O \rightarrow 2\ NaHSO_3$ SBS then reduces hypochlorous acid according to: $2NaHSO_3 + 2HOCl \rightarrow H_2SO_4 + 2HCl + Na_2SO_4$ In theory, 1.34 mg of sodium metabisulfite will remove 1.0 mg of free chlorine. In practice, however, 3.0 mg of sodium metabisulfite is normally used to remove 1.0 mg of chlorine.
The dosing injection point is upstream of the Raw Water Pumps, ensuring effective mixing and maximising the contact time ahead of water entry into the respective Cation vessel for effective Chlorine reduction.
The SMBS should be of food-grade quality and free of impurities. SMBS should not be cobalt-activated. Sodium bisulfite aqueous solutions can oxidize readily when exposed to air. A typical solution life can vary with concentration as follows:

- Concentration 10 (wt %) Solution life 1 week
- Concentration 20 (wt %) Solution life 1 month
- Concentration 30 (wt %) Solution life 6 months

The pump speed will be ratio controlled against the Pre-Raw Water Pump FIT with the setpoint trimmed using the Pre-Raw Water Pump CL Monitor.

The pumps are installed with flow switches that are connected directly to the pumps causing a pump fault if no flow is detected.

The following alarms are related to the system

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Sodium Bisulphite A/B Alarm	Sodium Bisulphate Pump A/B FS	Low	OFF		Standby Pump Starts	

Sodium Bisulphite A/B Fault					Sodium Bisulphite A/B Alarm	
Sodium Bisulphite A Alarm & Sodium Bisulphite B Alarm					Sodium Bisulphite System Alarm	
Sodium Bisulphite Tank Low Alarm	Sodium Bisulphite Tank LIT	Low	10%		Sodium Bisulphite System Alarm	
	Sodium Bisulphate Tank LSL	Low	OFF		Sodium Bisulphite System Alarm	
Sodium Bisulphite System Alarm					Shutdown Sodium Bisulphite Pumps	

The duty of the pumps will be cycled when the Operating Timer exceeds the **Operating Time Setpoint**

The following setpoints are related to the system

Setpoint	Default	Current	Tested
SBS Pump 100% Speed Setpoint	200 m3/hr		
Operating Time Setpoint	8 Hours		

5.2.2.5. Raw Water Pump System

Equipment name	Equipment Tag on P&ID
Raw Water Pump A/B/C	10-RAW-PU-001 A/B/C
Raw Water Pump VFD A/B/C	10-RAW-001/002/003-VFD
Makeup Storage Tank LIT	10-DEM-TK-002
Raw Water FIT	10-RAW-001-FIT
Raw Water Pump PIT	10-RAW-001-PIT

Raw water is drawn from the Raw Water Tank and delivered to the downstream Cation Vessels by the three Raw Water Pumps.
The pumps will be operated in a duty/duty/standby system whereby two pumps are sufficient to provide the full flow through the cation vessels.
The level in the makeup storage tank controls the speed of the pumps. There is a minimum flow for any one makeup stream to prevent channelling through the vessel, if the flow required is below this minimum the duty makeup stream going into standby mode.

The following alarms are related to the system

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Raw Water Pump A/B/C Alarm					Standby Pump Starts	
Raw Water Pump A/B/C Fault					Raw Water Pump A/B/C Alarm	
Raw Water Low Flow Alarm	Raw Water FIT	Low	10% lower than setpoint		Raw Water Pump A/B/C Alarm	
Raw Water Pump Low Pressure Alarm	Raw Water Pump PIT	Low	1 bar		Raw Water Pump A/B/C Alarm	
Raw Water Pump A Alarm & Raw Water Pump B Alarm & Raw Water Pump C Alarm					Raw Water Pump System Alarm	
Raw Water Pump High Pressure Alarm	Raw Water Pump PIT	High	6 bar		Raw Water Pump System Alarm	

Raw Water High Flow Alarm	Raw Water FIT	High	10% higher than setpoint		Raw Water Pump System Alarm	

The duty of the pumps will be cycled when the Operating Timer exceeds the **Operating Time Setpoint**

The following setpoints are related to the system

Setpoint	Default	Current	Tested
Makeup System Low Flow Setpoint	60 m3/hr		
Operating Time Setpoint	8 Hours		
Makeup Storage Tank High Level Setpoint	90%		
Makeup Storage Tank Low Level Setpoint	50%		

5.2.2.6. Raw Water Filtration System

Equipment name	Equipment Tag on P&ID
Raw Water Strainer	10-RAW-FL-001 A/B
Raw Water Bag Filter	10-RAW-FL-002 A/B
Raw Water Strainer PDIT A/B	10-RAW-001/002-PDIT
Raw Water Pump PIT	10-RAW-001-PIT
Raw Water Filters PIT	10-RAW-002-PIT

The Raw Water Filtration System is made up of two automatic back flushing Raw Water Strainers and two accompanying security Raw Water Bag Filters.
The strainer and filter arrangement will be operated both online simultaneously, however each system has the capability to operate with the maximum service flow in the event of required manual isolation and maintenance.
The Raw Water Strainers are installed with wedge wire candles of 50µm
The Raw Water Bag Filters are installed with filter bags of 25µm.

The back flushing sequence of the Raw Water Strainer is carried out periodically when a timer has exceeded a setpoint or when the Raw Water Strainer PDIT returns a high differential pressure reading. The backflush sequence takes place on one element in the Raw Water Strainer at a time therefore does not interrupt the service operation of the strainer in backflush.
The control of the backwash sequence is determined by the dedicated local control panel of the Raw Water Strainers

A required change of filter for the Raw Water Bag Filter will be signalled by a High Differential Pressure Alarm across the Post Raw Water Pump PIT and Post Raw Water Filters PIT.

The following alarms are related to the system

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Raw Water Filtration High DP Alarm	Raw Water Pump PIT & Raw Water Filters PIT	High Differential	1 Bar		None	
Raw Water Filtration High High DP Alarm	Raw Water Pump PIT & Raw Water Filters PIT	High Differential	1.5 Bar		Raw Water Filter System Alarm	

5.2.2.7. Cation Vessel System

Equipment name	Equipment Tag on P&ID
Cation Vessel A/B	10-DEM-DN-001 A/B
Cation Inlet PIT A/B	10-RAW-003/004-PIT
Cation Mid PIT A/B	10-DEM-001/003-PIT
Cation Outlet PIT A/B	10-DEM-002/004-PIT
Cation FIT A/B	10-RAW-002/003-FIT

The Cation vessels employ the Dow UPCORE® process that operates in a down-flow service, up-flow regen configuration. Water enters the top compartment of the vessel across a nozzle plate and onto the resin bed below comprising of Weak Acid Cation (WAC) exchange resin. The WAC resin, operating in the Hydrogen form, exchanges only the Calcium & Magnesium ions associated with the Alkalinity (Bicarbonate) in the water, producing a stream of partially de-cationised water, rich in Carbonic Acid (disassociated Carbon Dioxide in solution).
The water then passes to the lower chamber via a Nozzle Plate and contacts the Strong Acid Cation (SAC) exchange resin. The SAC resin also operating in the Hydrogen form now exchanges any remaining Calcium & Magnesium ions, along with the Sodium and Potassium ions, resulting in a relatively dilute solution of 'Strong' acids (Sulphuric, Hydrochloric and Nitric) along with the previously formed 'Weak' Carbonic acid. The process fluid then passes out of the vessel via a Nozzle Plate and through a resin trap that will protect downstream systems in the event of a nozzle failure.
Reactive Silica (SiO2) is also affected in the SAC chamber, where it is ionised into the 'Weak' Silicic Acid for subsequent removal (ion exchange) in the downstream Anion unit.
Flow is monitored by the Pre Cation FIT on the inlet to each Cation Vessel and totalized based on Rinse, Recycle, Preservice Rinse and Service. The totalizer is reset automatically when the Makeup Train has completed a regeneration sequence.
The vessel is installed with resin loading ports at each of the compartments. The ports are situated immediately above the lower Nozzle Plate and immediately below the centre Nozzle Plate. These are then used to facilitate the loading of new resins and removal of old/damaged/fouled resin

The following alarms are related to the system

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Cation Top Compartment High Differential Alarm	Cation Inlet PIT & Cation Mid PIT	High Differential	1.5 Bar		Cation System Alarm	
Cation Bottom Compartment High Differential Alarm	Cation Mid PIT & Cation Outlet PIT	High Differential	1.5 Bar		Cation System Alarm	

Cation High Differential Alarm	Cation Inlet PIT & Cation Outlet PIT	High Differential	2.9 Bar		Cation System Alarm	

5.2.2.8. Degasser System

Equipment name	Equipment Tag on P&ID
Degasser Tower	10-DEM-DA-001
Degasser Sump	10-DEM-TK-001
Degasser Blower A/B	10-BIR-BW-001 A/B
Degasser Blower A/B FSL	10-BIR-001/002-FS
Degasser LIT	10-DEM-001-LIT
Degasser LSL	10-DEM-001-LSL
Degasser LSH	10-DEM-001-LSH

The de-cationised water enters the Degasser Tower via the top of the packed tower, where the water cascades down over plastic packing material, which maximise the surface area available for Gas Transfer, to collect in the Degasser Sump.
Atmospheric air is delivered to base of the Degasser Tower by the two Degasser Blowers which passes up through the tower stripping CO_2 from the water into the air, which then exits the top of the Tower and to atmosphere.
The Blowers will be operated in a duty /standby system whereby one blower is sufficient to provide the full flow required.
The Degasser Sump is fitted with a Degasser LIT, Degasser LSH, and a Degasser LSL.
The Degasser Sump has a high-level overflow that overflows to the drain sump.

The following alarms are related to the system

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Degasser Blower A/B Alarm					Standby Pump Starts	
Degasser Blower A/B Fault					Degasser Blower A/B Alarm	
Degasser Blower A Alarm & Degasser Blower B Alarm					Degasser System Alarm	
Degasser Blower A/B Low Flow Alarm	Degasser Blower A/B FSL	Low	OFF		Degasser Blower A/B Alarm	
Degasser Sump High Level Alarm	Degasser LIT	High	90%		Degasser System Alarm	
	Degasser LSH	High	OFF		Degasser System Alarm	

Degasser Sump Low Level Alarm	Degasser LIT	Low	10%		Degasser System Alarm	
	Degasser LSL	Low	OFF		Degasser System Alarm	

The duty of the Blowers will be cycled when the Operating Timer exceeds the **Operating Time Setpoint**

The following setpoints are related to the system

Setpoint	Default	Current	Tested
Operating Time Setpoint	8 Hours		

5.2.2.9. Degasser Pump System

Equipment name	Equipment Tag on P&ID
Degasser Pump A/B/C	10-DEM-PU-001 A/B/C
Anion FIT A/B	10-DEM-001/002-FIT
Degasser Pump VFD A/B/C	10-DEM-001/002/003-VFD
Degasser Pump PIT	10-DEM-005-PIT

Degassed water is drawn from the Degasser Sump and delivered to the downstream Anion Vessels by the three Degasser Pumps.
The pumps will be operated in a duty/duty/standby system whereby two pumps are sufficient to provide the full flow from the makeup plant.
The pump speed is controlled proportional to the level in the degasser sump – the higher the level the faster the pumps will run. There are two setpoints on the SCADA system that enable the operator to control at what level the pumps operate at Min speed (35%) or Max Speed (100%).

The following alarms are related to the system

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Degasser Pump A/B/C Alarm					Standby Pump Starts	
Degasser Pump A/B/C Fault					Degasser Pump A/B/C Alarm	
Anion Low Flow Alarm	Anion FIT	Low	10% Deviation		Degasser Pump A/B/C Alarm	
Anion High Flow Alarm	Anion FIT	High	10% Deviation		Degasser Pump A/B/C Alarm	
Degasser Pump Low Pressure Alarm	Degasser Pump PIT	Low	2 bar		Degasser Pump A/B/C Alarm	
Degasser Pump High Pressure Alarm	Degasser Pump PIT	High	6 bar		Degasser Pump System Alarm	
Degasser Pump A Alarm & Degasser Pump B					Degasser Pump System Alarm	

Alarm & Degasser Pump C Alarm						

The duty of the Blowers will be cycled when the Operating Timer exceeds the **Operating Time Setpoint**

The following setpoints are related to the system

Setpoint	Default	Current	Tested
Operating Time Setpoint	8 Hours		
Degasser Pump Min Speed Level Setpoint	90%		
Degasser Pump Max Speed Level Setpoint	30%		

5.2.2.10. Anion Vessels

Equipment name	Equipment Tag on P&ID
Anion Vessel A/B	10-DEM-DN-002 A/B
Anion Inlet PIT A/B	10-DEM-006/009-PIT
Anion Intermediate PIT A/B	10-DEM-007/010-PIT
Anion Outlet PIT A/B	10-DEM-008/011-PIT
Anion FIT A/B	10-DEM-001/002-FIT
Anion COND Monitor	10-DEM-001/002-AIT

The Anion vessels employ the Dow UPCORE® process that operates in a down-flow service, up-flow regen configuration. Water enters the top compartment of the vessel via a nozzle plate onto the resin bed below comprising of Weak Based Anion (WBA) exchange resin. The WBA resin, operating in the Hydroxide form, despite the confusing terminology, exchanges the majority of only the Strong acid solutions (Sulphuric, Hydrochloric and Nitric) in the water, producing a stream of partially de-ionised water, but still containing relatively high quantities of Weak Carbonic and Silicic acids and some leakage of Strong acids.
The water then passes to the lower chamber via a Nozzle Plate, passing directly down onto the Strong Based Anion (SBA) exchange resin. The SBA resin also operating in the Hydroxide form now exchanges any remaining Strong acids and in particular, the Weak Carbonic and Silicic acids, to produce a moderately high quality de-ionised water, with low levels of Silica (typically < 2 µS/cm & < 20 ppb SiO_2). The de-ionised water now passes from the vessel via a Nozzle Plate.
Flow is monitored by the Pre Anion FIT on the inlet to each Anion Vessel and totalized based on Rinse, Recycle, Preservice Rinse and Service. The totalizer is reset automatically when the Makeup Train has completed a regeneration sequence.
The vessel is installed with resin loading ports at each of the compartments. The ports are situated immediately above the lower Nozzle Plate and immediately below the centre Nozzle Plate. These are then used to facilitate the loading of new resins and removal of old/damaged/fouled resin

The following alarms are related to the system

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Anion Top Compartment High Differential Alarm	Anion Inlet PIT & Anion Mid PIT	High Differential	1.5 Bar		Anion System Alarm	
Anion Bottom Compartment High Differential Alarm	Anion Mid PIT & Anion Outlet PIT	High Differential	1.5 Bar		Anion System Alarm	
Anion High Differential Alarm	Anion Inlet PIT & Anion Outlet PIT	High Differential	2.9 Bar		Anion System Alarm	

5.2.2.11. Makeup Mixed Bed Units

Equipment name	Equipment Tag on P&ID
Makeup Mixed Bed Vessel A/B	10-DEM-DN-003 A/B
Makeup Mixed Bed Inlet PIT A/B	10-DEM-012/018-PIT
Makeup Mixed Bed Outlet PIT A/B	10-DEM-013/019-PIT
Makeup Mixed Bed COND Monitor	10-DEM-010/011-AIT

The Mixed Bed unit operates in the conventional down-flow mode, with water entering via a distributor above the resin bed. The resin bed comprises an intimately mixed combination of Cation & Anion resins in a 40:60% ratio thereby maximising* the useable volume of high quality de-ionised water produced whilst balancing the different operating capacities of the specific ion exchange resin types.

* In order to optimise treated water quality, the Mixed Bed is operated at approximately 50 Bed Volumes per hour (bvh). However, due to the very high quality of the de-ionised water exiting the Anion unit(s) this would equate to an operating capacity equivalent to some 4 weeks of continuous (24/7) operation. This should be considered an absolute maximum value, as there is the potential for the phenomena of Silica and or Organics polymerisation when units are operated for extended periods – and especially at 'higher' operating temperatures (i.e. even the high end of the normal ambient range). For this reason, it is common practice to regenerate Mixed Beds more frequently – typically once every 2 weeks or possibly more frequently should operational experience indicate.

Flow is monitored by the Pre Makeup Mixed Bed FIT on the inlet to each Mixed Bed Vessel and totalized based on Rinse, Recycle, Preservice Rinse and Service. The totalizer is reset automatically when the Makeup Train has completed a regeneration sequence.

The vessel is installed with resin loading ports that are used to facilitate the loading of new resins and removal of old/damaged/fouled resin.

The following alarms are related to the system

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
MakeUp Mixed Bed High Differential Alarm	Cation Inlet PIT & Cation Outlet PIT	High Differential	1.5 Bar		None	

5.2.3. Makeup Storage Tank

Equipment name	Equipment Tag on P&ID
Makeup Storage Tank	10-DEM-TK-002
Makeup Tank LIT	10-DEM-002-LIT
Makeup Tank LSL	10-DEM-002-LSL
Makeup Tank LSH	10-DEM-002-LSH

The Make-Up Storage tank has a working capacity of 600 m^3 and is sized to enable a continuous supply of 150m3/hr to meet maximum plant demand whilst allowing for all regeneration requirements.
The Makeup Storage tank has a Makeup Tank LSL and Makeup Tank LSH. The Makeup Storage Tank also has a high-level overflow that overflows to the drain sump.

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Makeup Tank High Alarm	Makeup Tank LT	High	90%		Makeup System Alarm	
Makeup Tank High Alarm	Makeup Tank LSH	High	OFF		Makeup System Alarm	
Makeup Tank Low Alarm	Makeup Tank LT	Low	20%		Alarm Only	
Makeup Tank Low Low Alarm	Makeup Tank LT	Low	10%		Makeup Forwarding System Alarm	
Makeup Tank Low Low Alarm	Makeup Tank LSL	Low	OFF		Makeup Forwarding System Alarm	

5.2.4. Make-Up Forwarding System

Equipment name	Equipment Tag on P&ID
Reserve Feed Water Storage Tank A/B	9-FED-TK-001 A/B
Makeup Pump A/B	10-DEM-PU-002 A/B
Makeup Pump VFD A/B	10-DEM-001/002-VFD
Makeup FIT	10-DEM-003-FIT
Makeup Pump Discharge PIT	10-DEM-014-PIT

Deionised water is drawn from the Make-Up Storage Tank and delivered to the Reserve Feed Water Tanks by the two Makeup Pumps.
The pumps will be operated in a duty/standby system whereby one pump is sufficient to provide the full flow from the makeup plant.
The control of the Makeup Pump VFD will be according to the Makeup FIT with a setpoint determined by the level in the Reserve Feed Water Storage Tanks.

The following alarms are related to the system

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Makeup Pump A/B Alarm					Standby Pump Starts	
Makeup Pump A/B Fault					Makeup Pump A/B Alarm	
Makeup Low Flow Alarm	Anion FIT	Low	10% Deviation		Makeup Pump A/B Alarm	
Makeup High Flow Alarm	Anion FIT	High	10% Deviation		Makeup Pump A/B Alarm	
Makeup Pump Low Pressure Alarm	Makeup Pump PIT	Low	2 bar		Makeup Pump A/B Alarm	
Makeup Pump High Pressure Alarm	Degasser Pump PIT	High	6 bar		Makeup Forwarding System Alarm	
Makeup Pump A Alarm & Makeup Pump B Alarm					Makeup Forwarding System Alarm	
Makeup Tank Level Low Low Alarm					Makeup Forwarding System Alarm	

The duty of the Pumps will be cycled when the Operating Timer exceeds the **Operating Time Setpoint**

The following setpoints are related to the system

Setpoint	Default	Current	Tested
Operating Time Setpoint	8 Hours		

5.2.5. Condensate System

The Condensate system is made up of both new components and components that will be reused from the original water treatment plant and integrated into the new plant.

The process elements of the Condensate System that are to be reutilized are:

- Condensate Tank
- Condensate Pump System
- Condensate Strainers
- Condensate Heat Exchanger
- Reserve Feed Water Tanks

The process elements of the Condensate System that are to be newly installed are:

- Condensate Turbidity Dump System
- Condensate Filter System
- Condensate Mixed Bed

The following alarms are related to the system and are controlled by the DCS

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Condensate Tank Alarm					Condensate System Alarm	
Condensate Pump System Alarm					Condensate System Alarm	
Makeup Heat Exchanger Alarm					Condensate System Alarm	
Condensate Filter System Alarm					Condensate System Alarm	
Condensate Mixed Bed System Alarm					Condensate System Alarm	
Condensate System Alarm					Shutdown Condensate System	

5.2.5.1. Condensate Tank

Equipment name	Equipment Tag on P&ID
Condensate Tank	9-CON-TK-001
Condensate Tank LT	9-CON-021-LT
Condensate Tank LSLL	9-CON-020-LSLL
Post Makeup HX Makeup TIT	10-DEM-002-TIT
Post Makeup HX Condensate TIT	10-CON-002-TIT
Makeup Pump A/B	10-DEM-PU-002 A/B
Makeup Pump VFD A/B	10-DEM-001/002-VFD
Condensate Line 1 Turbidity Transmitter	10-CON-001-AIT
Condensate Line 2 Turbidity Transmitter	10-CON-002-AIT
Condensate Line 3 Turbidity Transmitter	10-CON-003-AIT
Condensate Line 1 Conductivity Transmitter	TBA
Condensate Line 2 Conductivity Transmitter	TBA
Condensate Line 3 Conductivity Transmitter	TBA
Condensate Line 1 pH Transmitter	TBA
Condensate Line 2 pH Transmitter	TBA
Condensate Line 3 pH Transmitter	TBA

The condensate tank has a working volume of 250 m^3 and collects the returned condensate from all three streams. The tank is lagged for personnel protection.

The returned condensates enter in three streams from:
- Kemsley Mill 3
- Kemsley Mill 4
- Kemsley Mill 6 and Sittingbourne 15 and 16

The Condensate Tank is installed with a dump valve prior to the tank inlet that can diverts condensate to the drain system before it enters the tank.

Alarms - DCS

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Condensate Line 1/2/3 Turbidity High Alarm	Condensate Line 1/2/3 Turbidity Transmitter	High	15 NTU		Open Condensate Line 1/2/3 Dump Valve	
Condensate Line 1/2/3 Conductivity High Alarm	Condensate Line 1/2/3 Conductivity Transmitter	High	XXX		Open Condensate Line 1/2/3 Dump Valve	

Condensate Line 1/2/3 pH High Alarm	Condensate Line 1/2/3 pH Transmitter	High	XXX		Open Condensate Line 1/2/3 Dump Valve	
Condensate Tank Level High Alarm	Condensate Tank LT	High	XXX		Open Condensate Line 1 Dump Valve & Open Condensate Line 2 Dump Valve & Open Condensate Line 3 Dump Valve	

Alarms

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Condensate Tank Level High Alarm	Condensate Tank LT	High	90%		None	
Condensate Tank Level Low Alarm	Condensate Tank LT	Low	XXX		None	
Condensate Tank Level Low Low Alarm	Condensate Tank LT	Low	XXX		Condensate Tank Alarm	
Condensate Tank Level Low Low Alarm	Condensate Tank LSLL	Low	OFF		Condensate Tank Alarm	

5.2.5.2. Condensate Pumps

Equipment name	Equipment Tag on P&ID
Condensate Pump A/B	9-CON-PU-001 A/B
Post Condensate Mixed Bed Flow Control Valve	10-DEM-FV-007
Condensate Pump PSL A/B	9-CON-027/028-PSL
Condensate Tank LSLL	9-CON-020-LSLL
Post Makeup HX Condensate TIT	10-CON-002-TIT
Post Makeup HX Makeup TIT	10-DEM-002-TIT
Condensate Strainer PDSH A/B	9-CON-029/030-PDSH
Condensate Pump PIT	10-CON-001-PIT

The condensate pumps are used to drive the condensate through the Condensate treatment system.
The pumps will be operated in a duty/standby system whereby one pump is sufficient to provide the full flow required.
The pumps are operated at a fixed speed, the flowrate from the pumps is adjusted with the Post Condensate Mixed Bed Flow Control Valve.

The following alarms are related to the system

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Condensate Pump A/B Alarm					Standby Pump Starts	
Condensate Pump A/B Fault					Condensate Pump A/B Alarm	
Condensate Low Flow Alarm	Condensate FIT	Low	10% Deviation		Condensate Pump A/B Alarm	
Condensate High Flow Alarm	Anion FIT	High	10% Deviation		Condensate Pump A/B Alarm	
Condensate Pump Low Pressure Alarm	Condensate Pump A/B PSL	Low	2 bar		Makeup Pump A/B Alarm	
Condensate Pump A Alarm & Condensate Pump B Alarm					Condensate Pump System Alarm	

The duty of the Pumps will be cycled when the Operating Timer exceeds the **Operating Time Setpoint**

The following setpoints are related to the system

Setpoint	Default	Current	Tested
Operating Time Setpoint	8 Hours		

5.2.5.3. Condensate Strainer System

Equipment name	Equipment Tag on P&ID
Condensate Strainer A/B	9-CON-FL-001 A/B
Condensate Strainer PDSH A/B	9-CON-029/030-PDSH

The condensate passes through two Condensate Strainers with a 25 micron filter size which operate in a duty/standby system.

The following will initiate a backwash of the strainer and a change in duty, this is carried out automatically by the local control panel:

- Strainer timer setpoint exceeded
- Condensate Strainer PDSH high PDSH alarm

5.2.5.4. Condensate Heat Exchanger

Equipment name	Equipment Tag on P&ID
Condensate Heat Exchanger	9-CON-EX-001
Reserve Feed Water Tank A/B	9-FED-TK-001 A/B

The existing Condensate Heat Exchanger is to used to precool the inlet condensate by exchanging heat with the treated condensate that is passing to the RFW tanks.
This will both allow more condensate to be cooled at the makeup heat exchanger and ensure thet maximum heat is retained in the final condensate the RFW tanks.
There will be no control across the heat exchanger and it was form an equilibrium temperature in the precooled condensate to the new water treatment plant.

5.2.5.5. Makeup Heat Exchanger

Equipment name	Equipment Tag on P&ID
Makeup Heat Exchanger	10-DEM-EX-001
Makeup Pump A/B	10-DEM-PU-002 A/B
Makeup TIT	10-DEM-001-TIT
Makeup Heated TIT	10-DEM-002-TIT
Condensate Intermediate TIT	10-CON-001-TIT
Condensate Mixed Bed Inlet TIT	10-CON-002-TIT

The Makeup Heat Exchanger unit is installed to exchange heat between the condensate stream and the makeup stream to achieve the desired inlet temperature setpoint to the Condensate Mixed Bed Vessels. The Makeup Heat Exchanger has a Pre Makeup HX Makeup TIT, Post Makeup HX Makeup TIT, Pre Makeup HX Condensate TIT and a Post Makeup HX Condensate TIT to monitor the temperature of the inlet and out let streams.

The overall control strategy will manage the flows around the makeup and condensate system to maintain the Condensate Mixed Bed Inlet TIT High Temperature Setpoint

The stream temperatures around the makeup heat exchanger will be displayed on the SCADA screen.

The following alarms are related to the system

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Makeup Post HX High Temperature Alarm	Makeup HX Makeup Outlet TIT	High	70C		Makeup HX Alarm	
Condensate Mixed Bed Inlet High Temperature Alarm	Makeup HX Condensate Outlet TIT	High	49C		Makeup HX Alarm	

5.2.5.6. Condensate Filter System

Equipment name	Equipment Tag on P&ID
Condensate Filter A/B/C/D	10-CON-FL-001 A/B/C/D
Condensate Filter Inlet PIT	10-CON-001-PIT
Condensate Filter Outlet PIT	10-CON-002-PIT

The Condensate Filter System, comprising four stainless steel filter housings in parallel will be installed upstream of the Condensate Mixed Beds.
Each filter housing contains twenty-four 40" depth cartridge filters and is capable of a nominal filtration flow of maximum 90 m^3/h.
During filter cartridge maintenance, one filter housing will be isolated at a time, by keeping approach velocities at lower values filtration effectiveness and filter life are significantly improved.

The following alarms are related to the system

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Condensate Filter Differential Pressure High Alarm	Condensate Filter Inlet PIT & Condensate Filter Outlet PIT	Differential High	1 bar		None	
Condensate Filter Differential Pressure High High Alarm	Condensate Filter Inlet PIT & Condensate Filter Outlet PIT	Differential High	1.5 bar		Condensate Filter System Alarm	
Condensate Filter Inlet Pressure High Alarm	Condensate Filter Inlet PIT	High	6 bar		Condensate Filter System Alarm	

5.2.5.7. Condensate Mixed Bed

Equipment name	Equipment Tag on P&ID
Condensate Mixed Bed A/B	10-DEM-DN-001 A/B
Condensate Mixed Bed Inlet PIT A/B	10-CON-003/004-PIT
Condensate Mixed Bed Outlet PIT A/B	10-DEM-016/017-PIT
Condensate Mixed Bed Conductivity Transmitter A/B	10-DEM-007/008-AIT

The Condensate Mixed Bed unit operates in the conventional down-flow mode, with water entering via a distributor above the resin bed. The resin bed comprises an intimately mixed combination of Cation & Anion resins in a 50:50% ratio thereby maximising the useable volume of high quality de-ionised water produced whilst balancing the different operating capacities of the specific ion exchange resin types.
The regeneration will be carried out approximately every 90 hours.
Flow is monitored on the inlet to each Condensate Mixed Bed Vessel and totalized based on Rinse, Recycle, Preservice Rinse and Service.
The totalizer is reset automatically when the vessel has completed a regeneration sequence.
The vessel is installed with resin loading ports that are used to facilitate the loading of new resins and removal of old/damaged/fouled resin.

The following alarms are related to the system

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Condensate Mixed Bed A/B High Differential Alarm	Cation Inlet PIT & Cation Outlet PIT	High Differential	2.5 Bar		Condensate Mixed Bed A/B Alarm	
Condensate Mixed Bed A/B Conductivity High Alarm					Condensate Mixed Bed A/B Alarm	
Condensate Mixed Bed A/B Alarm					Start standby	
Condensate Mixed Bed A Alarm & Condensate Mixed Bed B Alarm					Condensate Mixed Bed System Alarm	

The following setpoints are related to the system

Setpoint	Default	Current	Tested
Condensate Mixed Bed Throughput	4000 m3		

5.3. Reserve Feed Water Storage Tank

Equipment name	Equipment Tag on P&ID
Reserve Water Storage Tank A/B	4-FED-TK-001 A/B
RFW Tank LT	4-FED-003-LT
Reserve Water Storage Tank LSLL A/B	4-FED-001/002-LSLL
Reserve Water Storage Tank LI A/B	4-FED-005/006-LI

The Reserve Feed Water Storage Tanks collect water from both the condensate and makeup systems. There are two tanks, both with a nominal capacity of 450 m^3.
The tanks can be used in isolation if maintenance on either one is required or connected in parallel to provide up to four hours storage.
The Reserve Feed Water Storage Tanks are equipped with a Reserve Feed Water Storage Tank LSLL, a Reserve Feed Water Storage Tank LI and a common Reserve Feed Water Storage Tank LT.

The following alarms are related to the system

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
RFW Tank Level High Alarm	RFW Tank LT	High	90%		Alarm Only	
RFW Tank Level Low Alarm	RFW Tank LT	Low	20%		Alarm Only	
RFW Tank Level Low Low Alarm	RFW Tank LT	Low	10%		Alarm Only	

5.4. Effluent System

The Effluent system is made up of both new components and components that will be reused from the original water treatment plant and integrated into the new plant.

The process elements of the Effluent System that are to be reutilized are:

- Effluent mixing Tanks

The process elements of the Effluent System that are to be newly installed are:

- Effluent Pumps
- Effluent neutralisation chemical injection
- Effluent Sump

5.4.1. Effluent Sump

Equipment name	Equipment Tag on P&ID
Effluent Sump	10-EFF-TK-001
Effluent Sump LIT	10-EFF-001-LIT
Effluent Sump LS	10-EFF-001-LS

During the regeneration sequences of the cation, anion, and mixed bed units, the chemical effluent flows are directed into the Effluent Sump. The Effluent Sump also collects waste from the raw water filters, as well as miscellaneous waste streams from the plant that enter the floor drain system. The sump has a working volume of 22 m^3. The Effluent Sump is fitted with an Effluent Sump LIT and an Effluent Sump LS.

Alarms

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Effluent Sump Level High Alarm	Effluent Sump LIT	High	90%		Alarm Only	
Effluent Sump Level Low Alarm	Effluent Sump LIT	Low	10%		Alarm Only	
Effluent Sump Level Low Alarm	Effluent Sump LSH	Low	10%		Alarm Only	

5.4.2. Effluent Pumps

Equipment name	Equipment Tag on P&ID
Effluent Pump A/B	10-EFF-PU-001 A/B
Effluent Pump PIT A/B	10-EFF-001/002-PIT
Effluent Tank LSLL A/B	9-EFF-001/002-LSLL

Effluent is drawn from the Effluent Sump through the neutralization system, and into the Effluent Tanks by the Effluent Pumps. There are two effluent pumps that operate on a duty/standby system so that one pump can provide the full flow from the effluent tank. Each pump has an Effluent Pump PIT on the outlet,

Alarms

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Effluent Pump A/B Alarm					Standby Pump Starts	
Effluent Pump A/B Fault					Effluent Pump A/B Alarm	
Effluent Low Flow Alarm	Effluent FIT	Low	10% Deviation		Effluent Pump A/B Alarm	
Makeup High Flow Alarm	Effluent FIT	High	10% Deviation		Effluent Pump A/B Alarm	
Makeup Pump Low Pressure Alarm	Effluent Pump PIT	Low	2 bar		Effluent Pump A/B Alarm	
Makeup Pump High Pressure Alarm	Effluent Pump PIT	High	6 bar		Effluent Pump System Alarm	
Effluent Pump A Alarm & Makeup Pump B Alarm					Effluent Pump System Alarm	

The duty of the Pumps will be cycled when the Operating Timer exceeds the **Operating Time Setpoint**

Setpoints

Setpoint	Default	Current	Tested
Operating Time Setpoint	8 Hours		

5.4.3. Effluent Mixing Tanks

Equipment name	Equipment Tag on P&ID
Effluent Mixing Tank A/B	9-EFF-TK-001 A/B
Effluent Tank LIT A/B	9-EFF-003/004-LT
Effluent Tank LSLL A/B	9-EFF-001/002-LSLL

The Effluent Mixing Tanks are operated in a duty/standby batch system where one tank will be filled during a regen, then neutralised and emptied, then the duty will switch to the other tank ready for the next regen.

Each tank is fitted with an Effluent Tank LIT and an Effluent Tank LSLL and has a high level overflow.

Alarms

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Effluent Mixing Tank Level High Alarm	Effluent Mixing Tank A/B LT	High	90%		Alarm Only	
Effluent Mixing Tank Level Low Alarm	Effluent Mixing Tank A/B LT	Low	10%		Alarm Only	
Effluent Mixing Tank Level Low Alarm	Effluent Mixing Tank A/B LSLL	Low	10%		Alarm Only	

5.4.4. Effluent Neutralisation System

Equipment name	Equipment Tag on P&ID
Effluent Recirculation pH Transmitter A/B	10-EFF-001/002-AIT

The Effluent Neutralisation System is comprised of two Effluent Recirculation pH transmitters, a discharge line, an acid dosing inlet, and a caustic dosing inlet.

If the Effluent Recirculation pH transmitter reads within the discharge pH setpoint range for a set period, the discharge line will be opened, and the recirculation line closed.

If the Effluent Recirculation pH transmitter reads below the discharge pH setpoint range, the recirculation line will remain open and the caustic injection line will open to increase the pH. The caustic solution is made up to 10% NaOH in the caustic injection cabinet.

If the Effluent Recirculation pH transmitter reads above the discharge pH setpoint range, the recirculation line will remain open and the acid injection line will open to decrease the pH. The caustic solution is made up to 10% H2SO4 in the acid injection cabinet.

Alarms

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Acid Injection Timeout	Dosing Timer	High	5 mins		Effluent Neutralisation System Alarm	
Caustic Injection Timeout	Dosing Timer	High	5 mins		Effluent Neutralisation System Alarm	

Setpoints

Setpoint	Default	Current	Tested
High Discharge Setpoint	pH 8		
Low Discharge Setpoint	pH 6		

5.5. Regeneration System

The regeneration system is made up of equipment that is utilised by all of the other systems to regenerate resins and also to neutralise the effluent.

5.5.1. Regeneration Blowers

Equipment name	Equipment Tag on P&ID
Regen Blower A/B	10-DER-BW-001 A/B
Regen Blower VFD A/B	10-DER-001/002-VFD
Regen Blower System Drain Valve	10-DER-FV-023
Regen Blower PS A/B	10-DER-001/002-PIT
Regen Blower PIT	10-DER-004-PIT

Atmospheric air is delivered to the Cation Vessels for air scour and the Makeup Mixed Beds and Condensate Mixed Beds for resin mixing after regeneration by two Regeneration Blowers.
The Blowers will be operated in a duty/standby system whereby one blower is sufficient to provide the full flow required for the Condensate Mixed Bed Resin Mixing and one blower is sufficient to provide the full flow required for the Makeup Mixed Bed Resin Mixing.
Each blower will be installed into an acoustic enclosure to attenuate the noise generated.
The Regen Blower VFD will be set manually with the Regen Blower VFD Setpoint for each of the different applications.
The start-up of the blowers for both mixed bed mixing routines will be automatic according to the regeneration sequence
The start-up of the blowers for the Cation Airscrub sequence will be a manual process initiated by the operator
The Regen Blower System Drain Valve will open whenever the regeneration blowers are not in service to remove any fluid in the pipework.

Alarms

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Regen Blower A/B Alarm					Standby Blower Starts	
Regen Blower A/B Fault					Regen Blower A/B Alarm	
Regen Blower Low Pressure Alarm	Regen Blower PIT	Low	1 bar		Regen Blower A/B Alarm	
Regen Blower High Pressure Alarm	Regen Blower PIT	High	3 bar		Regen Blower System Alarm	
Regen Blower A Alarm &					Regen Blower	

Regen Blower B Alarm					System Alarm	

The duty of the Blowers will be cycled when the Operating Timer exceeds the **Operating Time Setpoint**

Setpoints

Setpoint	Default	Current	Tested
Operating Time Setpoint	8 Hours		

5.5.2. Regeneration Pump System

Equipment name	Equipment Tag on P&ID
Regen Pump A/B/C	10-DER-PU-001 A/B/C
Regen Pump VFD A/B/C	10-DER-004/005/006-VFD
Post Regen Pump PIT	10-DER-005-PIT
Acid Dilution Demin FIT	10-DER-002-FIT
Caustic Dilution Demin FIT	10-DER-004-FIT
Pre Cation FIT A/B	10-RAW-002/003-FIT
Pre Anion FIT A/B	10-DEM-001/002-FIT
Pre Makeup mixed Bed FIT A/B	10-DEM-003/004-FIT
Pre Condensate Mixed Bed FIT A/B	10-CON-001/002-FIT

Demineralised water is drawn from the Makeup Storage Tank and delivered to the various regeneration applications by the three Regeneration Pumps.
The pumps will be operated in a duty/duty/standby system whereby two pumps are sufficient to provide the full flow for regeneration steps.

The Regen Pumps will be controlled by Regen Pump VFDs, which will adjust both the speed and discharge pressure to meet the demands of the regen cycles.

The Regen Pump discharge pressure will be controlled by the Post Regen Pump PIT and the Regen Pump discharge flow rate by the following flow transmitters:

- Acid Dilution Demin FIT
- Caustic Dilution Demin FIT
- Pre Cation FIT A/B
- Pre Anion FIT A/B
- Pre Makeup mixed Bed FIT A/B
- Pre Condensate Mixed Bed FIT A/B

The start of the regeneration pumps will be automatic according to the regeneration sequence

The following will put the Operating Pump into Alarm mode

- Post Regen Pump PIT Low pressure alarm

The following will put all Pumps into Alarm mode

- Post Regen Pump PIT High pressure alarm

Alarms

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Regen Pump A/B/C Alarm					Standby Pump Starts	

Regen Pump A/B/C Fault					Regen Pump A/B/C Alarm	
Regen Pump Low Pressure Alarm	Regen Pump PIT	Low	1 bar		Regen Pump A/B/C Alarm	
Regen Pump High Pressure Alarm	Regen Pump PIT	High	6 bar		Regen Pump System Alarm	
Regen Pump High Flow Alarm	Regen Pump FIT	High	10% Higher Than Setpoint		Regen Pump System Alarm	
Regen Pump Low Flow Alarm	Regen Pump FIT	Low	10% Lower Than Setpoint		Regen Pump System Alarm	
Regen Pump A/B/C Alarm & Regen Pump A/B/C Alarm					Regen Pump System Alarm	

The duty of the Pumps will be cycled when the Operating Timer exceeds the **Operating Time Setpoint**

Setpoints

Setpoint	Default	Current	Tested
Operating Time Setpoint	8 Hours		
Regen Pump Pressure Setpoint	3 bar		

5.5.3. Acid Regeneration System

Equipment name	Equipment Tag on P&ID
Bulk Acid Tank	9-DER-TK-001
Acid Dosing Pump A/B	10-DER-PU-002 A/B
Acid Dilution Demin FIT	10-DER-002-FIT
Acid Dosing Pump Outlet FIT	10-DER-001-FIT
Acid Dosing Skid Outlet Conductivity Transmitter	10-DER-001-AIT

Dilute acid for regeneration of the Cation Vessel and Makeup and Condensate Mixed Beds is supplied by the Acid Regeneration System. This equipment also provides acid for the Effluent System.
Concentrated acid is drawn from the Bulk Acid Tank by two Acid Dosing Pumps. The pumps will be operated in a duty/standby system, whereby one pump is sufficient to provide the maximum required flow.
Changes in pump stroke are only applied when the Acid Pump is running. Pump stroke is held at last value if the Acid Pump is not running.
The reaction between Sulphuric acid and water is highly exothermic therefore the regeneration system will stabilise flow of the dilution water before the acid pump is started. The regeneration system will be installed with a section of lined pipe that will allow the exothermic reaction to dissipate.
The acid regeneration system is installed with two block and bleed systems, one before, and on after the Acid Dosing Pumps. When the Acid Dosing Pumps are running the two block valves are open and the bleed valve is closed. When the Acid Dosing Pumps stop the block valves are closed and the bleed valve is open, this ensures that dilution water and concentrated acid cannot mix within the regeneration system unless during operation.

Unique presets are adjustable by the operator via the operator interface to set the rate of chemical injection. There is one preset for each of the regeneration steps. The control system automatically applies the appropriate preset to the stroke positioner based on the intended operation.
The operator will be limited to a range of possible speed selections for each phase to minimise the chance of overdosing

Acid Dilution Demin FIT monitors the supply of dilution water to the chemical mixing tee and controls the flow.

Acid Dosing Pump Outlet FIT monitors the flow of concentrated acid to the mixing tee to confirm the correct amount of acid dosing.

Acid Dosing Skid Outlet Conductivity Transmitter monitors the concentration of dilute acid to the downstream processes after the chemical mixing tee.

Warning beacons will be illuminated during the operation of the Acid Pumps, they will also be illuminated during the regen step before the acid pump is activated in order to alert personnel of the imminent start of the acid pumps.

The dilution flow is established before any chemical addition takes place. After chemical addition takes place the dilution flow continues for a minimum of 2 mins, this can be included in the subsequent step, for example displacement. This continued dilution flow is also in the event of the Acid Pump System Alarm.

The Acid Regeneration System is installed with block and bleed valves, these are used to provide an air break between the concentrated chemical and the dilution water.

When the chemical injection is not being pumped both block valves will be closed and the bleed valve will be opened.

When the chemical is being pumped both block valves will be opened and the bleed will be closed.

In order to flush any concentrated chemical residue from the bleed line and also any chemical that passes the pressure relief valve a dilution tank is installed in the chemical cabinet.
This dilution tank holds 100l of water and is installed with a flush line of fresh water that causes the tank to overflow and flush out any residual chemical. The solenoid on the flush line is open whenever chemical is being dosed. The solenoid remains open for 5 mins after dosing is completed to ensure all drops from the bleed line are flushed.

If a high conductivity alarm in the dilution tank is raised, regardless of the current sequence, the flush valve is opened for a duration of 5 mins after the conductivity is reduced below the alarm level.

Alarms

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Acid Pump A/B/C Alarm					Standby Pump Starts	
Acid Pump A/B/C Fault					Acid Pump A/B/C Alarm	
Acid Pump Low Flow Alarm	Acid Pump FIT	Low	10% Lower Than Setpoint		Acid Pump A/B/C Alarm	
Acid Pump High Flow Alarm	Acid Pump FIT	High	10% Higher Than Setpoint		Acid Pump System Alarm	
Dilution Flow High Alarm	Acid Dilution FIT	High	10% Lower Than Setpoint		Acid Pump System Alarm	
Dilution Flow Low Alarm	Acid Dilution FIT	Low	10% Higher Than Setpoint		Acid Pump System Alarm	
Acid Low Conductivity Alarm	Acid Conductivity Monitor	Low	10% Lower Than Setpoint		Acid Pump A/B/C Alarm	

Acid Low Conductivity Alarm	Acid Conductivity Monitor	High	10% Higher Than Setpoint		Acid Pump System Alarm	
Acid Dilution Tank Conductivity Alarm	Acid Dilution Tank Conductivity Monitor	High	1000 uS/cm		Acid Pump System Alarm & Flush activated	
Acid Dilution Tank Flow Low Alarm	Acid Dilution Tank FSL	Low	OFF		Acid Pump System Alarm	
Acid Pump A/B/C Alarm & Acid Pump A/B/C Alarm					Acid Pump System Alarm	
Acid Pump System Alarm					Shutdown acid pump system and continue dilution water flow for min 2 mins.	

The duty of the Pumps will be cycled when the Operating Timer exceeds the **Operating Time Setpoint**

Setpoints

Setpoint	Default	Current	Tested
Operating Time Setpoint	8 Hours		

5.5.4. Caustic Regeneration System

Equipment name	Equipment Tag on P&ID
Bulk Caustic Tank	9-DER-TK-002
Caustic Dosing Pump A/B	10-DER-PU-003 A/B
Caustic Dilution Demin FIT	10-DER-004-FIT
Caustic Dosing Pump Outlet FIT	10-DER-003-FIT
Caustic Dosing Skid Outlet Conductivity Transmitter	10-DER-002-AIT

Dilute caustic for regeneration of the Anion Vessel and Makeup and Condensate Mixed Beds is supplied by the Caustic Regeneration System. This equipment also provides caustic for the Effluent System.
Concentrated Caustic is drawn from the Bulk Caustic Tank by two Caustic Dosing Pumps. The pumps will be operated in a duty/standby system, whereby one pump is sufficient to provide the maximum required flow.
Changes in pump stroke are only applied when the Caustic Pump is running. Pump stroke is held at last value if the Caustic Pump is not running.
The regeneration system will stabilise flow of the dilution water before the Caustic pump is started.
The Caustic regeneration system is installed with two block and bleed systems, one before, and on after the Caustic Dosing Pumps. When the Caustic Dosing Pumps are running the two block valves are open and the bleed valve is closed. When the Caustic Dosing Pumps stop the block valves are closed and the bleed valve is open, this ensures that dilution water and concentrated Caustic cannot mix within the regeneration system unless during operation.

Unique presets are adjustable by the operator via the operator interface to set the rate of chemical injection. There is one preset for each of the regeneration steps. The control system automatically applies the appropriate preset to the stroke positioner based on the intended operation.
The operator will be limited to a range of possible speed selections for each phase to minimise the chance of overdosing

Caustic Dilution Demin FIT monitors the supply of dilution water to the chemical mixing tee and controls the flow.

Caustic Dosing Pump Outlet FIT monitors the flow of concentrated Caustic to the mixing tee to confirm the correct amount of Caustic dosing.

Caustic Dosing Skid Outlet Conductivity Transmitter monitors the concentration of dilute Caustic to the downstream processes after the chemical mixing tee.

Warning beacons will be illuminated during the operation of the Caustic Pumps, they will also be illuminated during the regen step before the Caustic pump is activated in order to alert personnel of the imminent start of the Caustic pumps.

The dilution flow is established before any chemical addition takes place. After chemical addition takes place the dilution flow continues for a minimum of 2 mins, this can be included in the subsequent step, for example displacement. This continued dilution flow is also in the event of the Caustic Pump System Alarm.

The Caustic Regeneration System is installed with block and bleed valves, these are used to provide an air break between the concentrated chemical and the dilution water.

When the chemical injection is not being pumped both block valves will be closed and the bleed valve will be opened.

When the chemical is being pumped both block valves will be opened and the bleed will be closed.

In order to flush any concentrated chemical residue from the bleed line and also any chemical that passes the pressure relief valve a dilution tank is installed in the chemical cabinet.
This dilution tank holds 100l of water and is installed with a flush line of fresh water that causes the tank to overflow and flush out any residual chemical. The solenoid on the flush line is open whenever chemical is being dosed. The solenoid remains open for 5 mins after dosing is completed to ensure all drops from the bleed line are flushed.

If a high conductivity alarm in the dilution tank is raised, regardless of the current sequence, the flush valve is opened for a duration of 5 mins after the conductivity is reduced below the alarm level.

Alarms

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Caustic Pump A/B/C Alarm					Standby Pump Starts	
Caustic Pump A/B/C Fault					Caustic Pump A/B/C Alarm	
Caustic Pump Low Flow Alarm	Caustic Pump FIT	Low	10% Lower Than Setpoint		Caustic Pump A/B/C Alarm	
Caustic Pump High Flow Alarm	Caustic Pump FIT	High	10% Higher Than Setpoint		Caustic Pump System Alarm	
Dilution Flow High Alarm	Caustic Dilution FIT	High	10% Lower Than Setpoint		Caustic Pump System Alarm	
Dilution Flow Low Alarm	Caustic Dilution FIT	Low	10% Higher Than Setpoint		Caustic Pump	

					System Alarm	
Caustic Low Conductivity Alarm	Caustic Conductivity Monitor	Low	10% Lower Than Setpoint		Caustic Pump A/B/C Alarm	
Caustic Low Conductivity Alarm	Caustic Conductivity Monitor	High	10% Higher Than Setpoint		Caustic Pump System Alarm	
Caustic Dilution Tank Conductivity Alarm	Caustic Dilution Tank Conductivity Monitor	High	1000 uS/cm		Caustic Pump System Alarm & Flush activated	
Caustic Dilution Tank Flow Low Alarm	Caustic Dilution Tank FSL	Low	OFF		Caustic Pump System Alarm	
Caustic Pump A/B/C Alarm & Caustic Pump A/B/C Alarm					Caustic Pump System Alarm	
Caustic Pump System Alarm					Shutdown Caustic pump system and continue dilution water flow for min 2 mins.	

The duty of the Pumps will be cycled when the Operating Timer exceeds the **Operating Time Setpoint**

Setpoints

Setpoint	Default	Current	Tested
Operating Time Setpoint	8 Hours		

5.5.5. Caustic Heat Exchanger

Equipment name	Equipment Tag on P&ID
Caustic Heat Exchanger	10-DER-EX-001
Makeup Heat Exchanger	10-DEM-EX-001
Post Caustic HX TIT	10-DER-001-TIT
Caustic HX Flow Control Valve	10-DER-FV-051

The Caustic Heat Exchanger is installed between the Regen Pumps and Caustic Dosing Skid to provide demin water at 45°C to the Caustic Dosing skid for use in the regeneration of the Condensate Mixed Bed. The Caustic Heat Exchanger uses the condensate stream before it enters the makeup heat exchanger to provide the heating to the demin stream, and returns the condensate to the cooled condensate stream after the Makeup Heat Exchanger.

The temperature of the outlet demin stream is monitored by the Post Caustic HX TIT which will regulate the flow of Condensate through the Caustic HX Flow Control Valve as follows:

- If the Post Caustic HX TIT reads below the temperature setpoint, Caustic HX Flow Control Valve will increase flow.
- If the Post Caustic HX TIT reads above the temperature setpoint, Caustic HX Flow Control Valve will reduce flow.

Alarms

Alarm	Instrument	Type	Default Setpoint	Current Setpoint	Effect	Tested
Caustic Dilution Temperature High Alarm	Caustic Dilution TIT	High	49C		Caustic Heat Exchanger System Alarm	

The duty of the Pumps will be cycled when the Operating Timer exceeds the **Operating Time Setpoint**

Setpoints

Setpoint	Default	Current	Tested
Caustic Dilution Temperature Setpoint	45C		

5.5.6. Regeneration Sequences

The following tables show the regeneration sequences of the vessels.

Table 6.1 Cation Vessel

Exchange bed	Regeneration stage description	Flowrate (m3/h)	Duration (mins)	Volume (m3)
CATION	Delay	0	26.86	0.0
	Compaction	141	3	7.1
	0.8% Caustic	85.4	22.9	32.6
	1.5 % Caustic	85.4	19.9	28.3
	2 Dilution	42.6	0	14.1
	3% Caustic	85.4	9.94	14.1
	3 Dilution	170.6	0	28.3
	Displacement	84.6	25.7	36.2
	Settle	0.0	10.0	0.0
	Rinse Recycle*	199.0	30.0	0.0
		∑	148.300	160.7

* Rinse Recycle shared with Cation and Anion

Table 6.2 Anion Vessel

Exchange bed	Regeneration stage description	Flowrate (m3/h)	Duration (mins)	Volume (m3)
ANION	Compaction	128.0	3.0	6.4
	3.5% Caustic	33.2	20.3	11.2
	Displacement	31.7	85.0	44.9
	Settle	0.0	10.0	0.0
	Rinse Recycle*	199.0	30.0	0.0
		∑	148.3	62.5

* Rinse Recycle shared with Cation and Anion

Table 6.3 Cation Vessel & Anion Vessel combined

Exchange bed	Cation Regeneration Stage	Anion Regeneration Stage	Flowrate (m3/h)	Duration (mins)	Volume (m3)

CATION/ANION	Delay	Compaction	128.0	3.00	0.0
	Delay	3.5% Caustic	33.2	20.30	11.2
	Delay	Displacement	31.7	3.56	1.9
	Compaction		172.7	3.00	8.6
	0.8% Caustic		117.1	22.90	5.9
	1.5 % Caustic & Dilution 1		159.7	19.90	53.0
	3% Caustic & Dilution 2		287.7	9.94	95.4
	Displacement		116.3	25.70	49.8
	Settle	Settle	0.0	10.00	0.0
	Rinse Recycle	Rinse Recycle	-	30.00	0.0
			∑	148.300	225.8

Table 6.4 Makeup Mixed Bed Vessel

Exchange bed	Regeneration stage description	Flowrate (m3/h)	Duration (mins)	Volume (m3)
MAKEUP MIXED BED	Backwash	21.6	20.0	7.2
	Settling	0.0	10.0	0.0
	Downward 5% Caustic	9.3	31.0	4.8
	Upward 6% Caustic	9.3	26.0	4.8
	Downward Displacement	8.7	41.0	5.9
	Upward Displacement	9.0	46.0	6.2
	Drain down	0.0	10.0	0.0
	Air mix	AIR	15.0	AIR
	Vessel fill low	15.5	14.0	3.6
	Vessel fill high	77.3	2.0	2.6
	Final rinse	77.3	15.0	19.3
		∑	158.0	54.4

Table 6.5 Condensate Mixed Bed Vessel

Exchange bed	Regeneration stage description	Flowrate (m3/h)	Duration (mins)	Volume (m3)
CONDENSATE MIXED BED	Backwash	38.0	30.0	19.0
	Settling	0.0	10.0	0.0
	Downward 5% Caustic @50°C	9.4	29.3	4.6
	Upward 5% Caustic	9.0	44.1	4.4
	Downward Displacement	9.0	48.3	7.2
	Upward Displacement	8.8	33.5	7.1
	Drain down	0.0	15.0	0.0
	Air mix	AIR	15.0	AIR
	Settling	0.0	10.0	0.0
	Vessel fill low	9.0	12.4	0.0
	Vessel fill high	185.0	0.6	0.0
	Final rinse	185.0	7.5	0.0
		∑	178.2	42.3

5.6. K3 Raw Pump

Equipment name	Equipment Tag on P&ID
K3 Raw Pump A/B	

The K3 Raw pumps are used to drive the raw water from the raw water tank to K3 plant.
The pumps will be operated in a duty/standby system whereby one pump is sufficient to provide the full flow required.
The pumps are operated at a variable speed, the flowrate from the pumps is using a direct motor speed setpoint entered onto the SCADA screen.
The pumps will be started when a signal is received from the client or when the operator operates the pump in manual mode.

The following will put the Operating Pumps into Alarm mode and Switch Duty:

- Condensate Pump PSL Low Pressure Alarm

The following will put all Pumps into Alarm mode and inhibit running.

- Condensate Tank LSLL Low Level Alarm.
- Post Makeup HX Condensate TIT High Temperature Alarm
- Condensate Strainer PDSH High Differential Pressure Alarm
- Condensate filter high diff pressure alarm

5.7. K3 Treated Pump

5.8. Air Blast Cooler

The Air Blast cooler system is used to reduce the temperature of the K3 treated water stream to less than 50C to ensure compliance with the inlet specification on K3 plant.

The K3 treated water stream is cooled by exchanging heat with a glycol stream passing through a plate heat exchanger.

The glycol is recirculated from the heat exchanger to a holding tank where it is pumped back up to pressure again.

The Glycol is then passed through an air blast cooler system that removes heat from the Glycol loop, before passing it back through the heat exchanger.

The Glycol loop is installed with an inlet pressure transmitter at the inlet to the heat exchanger, the outlet of the heat exchanger passes unrestricted into the glycol tank therefore will be at a fixed pressure. The inlet pressure to the heat exchanger will be monitored as any rise in this pressure will indicate an increase in pressure drop across the heat exchanger.

The K3 treated water is installed with a pressure transmitter on the inlet to the heat exchanger