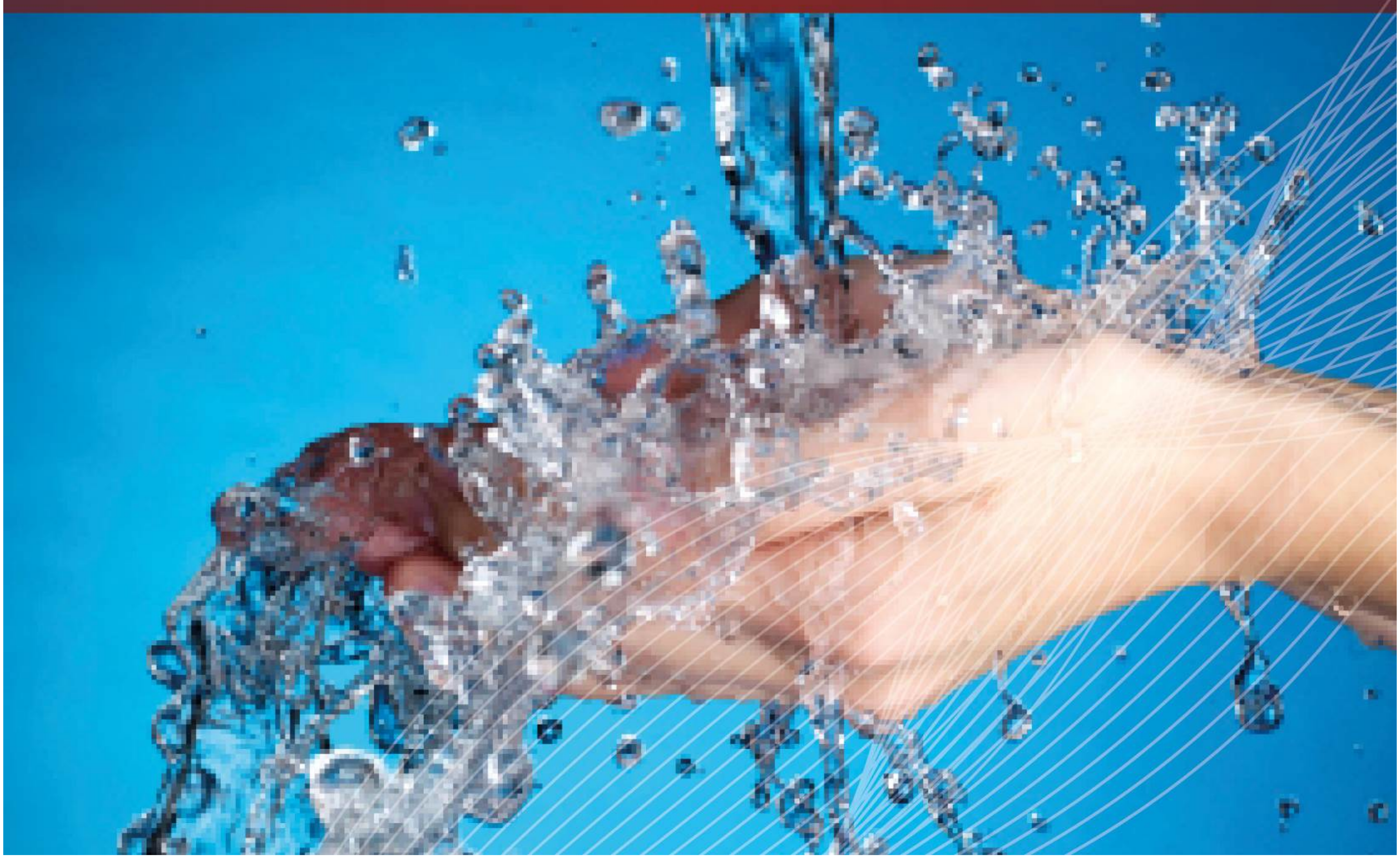
Australian Water Recycling
Centre of Excellence

Demonstration of Robust Water Recycling
Interim Operating Manual

A report of a study funded by the
Australian Water Recycling Centre of Excellence

A. Knight, J. Zhang, M. Packer, P. Scales, S. Gray, October 2015



Demonstration of robust water recycling: Interim Operating Manual

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About the Australian Water Recycling Centre of Excellence

The mission of the Australian Water Recycling Centre of Excellence is to enhance management and use of water recycling through industry partnerships, build capacity and capability within the recycled water industry, and promote water recycling as a socially, environmentally and economically sustainable option for future water security.

The Australian Government has provided $20 million to the Centre through its National Urban Water and Desalination Plan to support applied research and development projects which meet water recycling challenges for Australia's irrigation, urban development, food processing, heavy industry and water utility sectors. This funding has levered an additional $40 million investment from more than 80 private and public organisations, in Australia and overseas.

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This is an Interim report and needs to be updated by AAD and once the plant is at Davis Station. A maintenance manual should also be written.

1. Workplace Health and Safety

1.1 General

The AWTP is a hazardous work environment and as such, all Operators working within AWTP boundaries must have undergone sufficient induction and training procedures to ensure that they are able to carry out their work in a safe manner.

Operators working on the AWTP must have met, as a minimum, the following prerequisites:

A SPWWTP site induction

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An AWTP site induction

Operator training as provided by a senior operator

Current vaccinations against Hepatitis A and B

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During the induction and training processes, the risk mitigation philosophy employed at the AWTP will be explained in detail. Briefly, the philosophy consists of the following elements:

An initial risk assessment to identify risks associated with any task to be undertaken by Operators

Identification and implementation of risk mitigating actions to reduce risks to Operators

Safe Work Instructions (SWIs) to ensure Operators are aware of risks associated with tasks and can carry them out safely.

Safe Work Instructions (SWI), Risk Assessments and other OHS documentation are located in the AWTP OHS Folder.

Ensure on-site at Davis Station

1.2 Safe Plant Operation

The AWTP is a complex process which contains chemical, biological, mechanical and physical hazards. Operating the AWTP under conditions other than those outlined in this Operating Manual may create localised hazards within the AWTP and lead to hazardous waste products, equipment and instrument damage, and a high risk of severe injury to Operators.

Unless Maintenance personnel are present, the AWTP is only to be operated as outlined in this Operating Manual.

During routine equipment servicing and other routine maintenance tasks that must be carried out by AWTP Maintenance, the AWTP may be operated under a variety of conditions not outlined in this manual. In these instances, Operators are to defer to the authority of Maintenance and operate the AWTP as instructed.

The operational and control philosophies of the AWTP are such that a large number of adjustments need to be made across the plant at all times. Such adjustments are beyond the abilities of a single operator, and as such the AWTP has been designed to run in Auto mode at all times. **Operation in Manual mode should not be attempted without a member of Maintenance on hand to supervise.**

1.3 Isolation of Equipment

The AWTP is a batch process which, under normal operations, has all items of equipment in the treatment train operating in series. As such, equipment cannot be isolated for routine maintenance

while the plant is operating, as this cannot occur without immediately rendering the equipment unavailable and causing a shut down.
All drives are fitted with local isolation switches, allowing pumps to be locked out during routine maintenance tasks. Routine maintenance tasks which require drives to be isolated, and the drive ID are listed below, and the relevant SWIs located in the AWTP OHS Folder.

Replacement of RO feed filter (**isolate RO feed pump L3113**)
Replenishment of media in calcite contactor (**isolate RO feed pump L3113**)

Such tasks should be carried out while the plant is not operating and the feed tank levels are such that sufficient time to carry out the task is available. **Physically locking out drives is imperative to ensure they are not remotely started while maintenance is being carried out.** If possible, it is desirable to padlock the isolation switch for the duration of the maintenance task. At the minimum, the isolation switch should be tagged for the duration of the maintenance task.

Should any item of equipment display signs of failure or poor performance, the AWTP should be shut down with the nearest available E-Stop, and Maintenance notified of the problem immediately.

1.4 Safeguards

The AWTP has several inherent hazards across its four Sections. These are outlined in greater detail in the AWTP Induction document. The safeguards in each Section are outlined below. **Each Section is fitted with E-Stops for emergency shutdown.**

Section 1

Ozone contact tank is fitted with pressure relief valve and ozone destructor
Ozone alarm is installed in Section, will alarm and shut down plant if excess ozone detected

Figure x – Atmospheric ozone detector, Ozonation system, Section 1

Section 2

Pressure relief valve on RO feed line prevents vessels from becoming over pressurized

Figure x – RO pressure relief valve, RO system, Section 2

Section 3

Calcite contactor has safety chain to prevent vessel from falling forwards

Section 4

Perspex screen installed in front of chemical dosing pumps to protect Operators from burst lines
Extensive bunding and segregation of process chemicals to prevent spills mixing and creating hazardous products

1.5 Safety Inspections

As part of the weekly Operator duties at the AWTP, a Routine Inspection of each Section of the AWTP and its surrounds must be carried out. The Routine Inspection Template (RIT), located in Section x.x.x of this manual, may be used as a basis for Shutdown and Start Up Inspection events. The following sections describe how to use the RIT to carry out specific Inspection events.

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PRIOR TO SHUTDOWN

If the plant is to be shut down, Operators must ensure that sufficient SMBS solution is available for RO membrane perseveration. The SMBS solution carboy must be at least half full (10 L or more) and the date of production must be no more than 30 days old.

Figure x – Location of SMBS solution in Section 4 chemical bunds

AFTER A SHUTDOWN

After a shut down has been completed, Operators should carry out a Routine Inspection to ensure that all Sections are safe and no leaks are evident. For extended periods of shut down, it may be necessary to drain water from the various tanks throughout the plant to prevent microbial growth during shut down. Should such a situation arise, Operators will follow Maintenance instructions.

BEFORE START-UP OR RE-START

If the AWTP has been offline for a lengthy period of time, or has been drained of water, start up will be handled by Maintenance.

1.6 General Operating Safety

During normal plant operation, Operators will be required to undertake a range of tasks, each with differing inherent risk levels. The relevant risk assessments and other OHS documentation for all Operator tasks are located in the OHS Folder, and SWIs for each task are located in the AWTP OHS Folder.

There are general safety rules which apply to ALL tasks involved with the AWTP. These are listed below.

Safety glasses to be worn by Operators and visitors at all times when within the AWTP perimeter
Latex or nitrile gloves to be worn during any sampling event
PPE to be worn as instructed by SWI for a given task

1.7 Electrical Safety

The AWTP conforms to AS XXXX for electrical safety.

AAD to add

1.8 Chemical Safety

The AWTP utilises a range of chemicals during normal operation. These are listed below:

Sodium hypochlorite, 8 wt%
Sodium metabisulfite (SMBS) powder
Sulphuric acid, 10 wt%
Hydrochloric acid, 32 wt%
Sodium hydroxide, 40 wt%
Calcium carbonate, granulated
Ozone gas (generated on site)
Conductivity standards (salt solutions)
pH standards
Turbidity (formazin) standards
Free chlorine standards
Free chlorine measurement reagents
Ozone in water measurement reagents

These chemicals are used in various ways during normal operation, with some being automatically dosed when required, and others requiring an Operator to manually add chemicals to the CIP tank in Section 4 when prompted by the SCADA control program. The MSDS for each of these chemicals is available in the MSDS box affixed to the staircase on the eastern side of the AWTP.

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Figure x – Location of MSDS for chemicals used in the AWTP

Operators should not undertake any work involving the manual handling of chemicals without first reading the appropriate chemical MSDS, risk assessments and SWIs for the task.

As with all Operator tasks in the AWTP, chemical tasks have differing inherent risk levels. However, the following general safety rules apply to ALL tasks involving chemicals:

PPE must be worn as outlined in SWIs. Minimum PPE is **ALWAYS** latex gloves and safety glasses.
Chemicals must **NEVER** be mixed by an Operator unless specifically instructed by either the SCADA control program or Maintenance.
The following chemical combinations must be avoided at all costs: SMBS and acid (hydrochloric or sulphuric); sodium hypochlorite and acid (hydrochloric and sulphuric). These combinations may cause the formation of toxic hydrogen sulphide or chlorine gases, respectively.
ALWAYS switch on the exhaust fan when entering Section 4, and switch off when leaving.
All chemical spills must be cleaned up with either paper towel (< 100 mL) or using the hazardous chemical spill kit located on the western end of the upper level of the AWTP.

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Figure x – Exhaust fan and power switch in Section 4 of the AWTP

Figure x – HAZCHEM spill kit on upper level of AWTP

2. WTP System Overview

2.1 Acronyms and Abbreviations

AWTP – Advanced Water Treatment Plant

BAC – Biologically Active Carbon

CCP – Critical Control Point

CEB – Chemically Enhanced Backwash

CIP – Clean in Place

CoC – Chemical of Concern

FD – Functional Design

HACCP – Hazard Analysis and Critical Control Points

JSEA – Job Safety and Environmental Analysis

LRV – Log Reduction Value

MBR – Membrane Bioreactor

MF – Microfiltration

OHS – Occupational Health and Safety

RA – Risk Assessment

RO – Reverse Osmosis

SCADA – Supervisory Control and Data Acquisition

SWI – Safe Work Instruction

UV – Ultraviolet disinfection

2.2 General Description of AWTP

The AWTP is designed to purify membrane bioreactor (MBR) effluent from a secondary waste water treatment plant by passing the effluent through several treatment processes. Secondary effluent enters the plant and passes through seven processes, or barriers, consisting of ozonation, ceramic microfiltration (MF), bacterially activated carbon (BAC), reverse osmosis (RO), ultraviolet disinfection (UV), calcite filtration, and chlorination. These barriers are described in greater detail in Section 2.4.1.

The AWTP operates as a semi-batch process and has been designed such that its throughput capabilities can easily handle the expected volumes of waste water flow at Davis Station. When a predetermined MBR effluent level is reached in the AWTP feed tank, the AWTP feed pump will start to treat the effluent at a fixed flow rate. Provided no critical control point (CCP) limits are exceeded, the product water is classed as potable and sent to freshwater storage. If one or more CCP limits are exceeded, the product water is sent back to the head of works to be retreated.

2.2.1. LOCATION

The AWTP is located at SPWWTP in New Town, Hobart. An aerial view of the SPWWTP showing the location of the AWTP and other key areas is given in Figure x below.

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2.2.2. WTP SITE BOUNDARIES

The AWTP is bounded by a road to its northern and eastern sides, and by a flagged rope on its southern and western sides. These boundaries are shown in Figures x – x below.

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2.2.3. PLANT ACCESS

The AWTP has the following levels of security:

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2.2.4. SERVICE WATER SUPPLY

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The ATWP service water is taken from the potable water line on the southern side of the plant. Maintenance are responsible for connecting/disconnecting/maintaining the AWTP service water supply. The service water supply is shown in Figure x.

Figure x – Service water supply for AWTP

2.3 Raw and Treated Water Quality Issues

The production of an effluent suitable for disposal in the pristine environment of Antarctica and for the production of drinking water from wastewater requires that contaminants are extensively removed. Concentrations of particulate matter, nutrients (nitrogen and phosphorus) and organic compounds need to be significantly reduced, and this is predominantly achieved in the upstream secondary wastewater treatment process (the MBR).

The MBR produces a high quality effluent, but further purification of the water is required to remove remaining pathogens (bacteria, virus, protozoa and helminths) that may cause infection and disease, and chemicals of concern (CoCs), a range of specific chemicals) that pose environmental and health concerns. Pathogens and CoCs are extensively removed by the AWTP.

The small size of the site at Davis Station means that wastewater flows are low and that any discharged contaminants are less diluted than they would be in a larger municipal wastewater collection system. Therefore, there is the potential for higher peak concentrations of contaminants within the Davis wastewater system than for a larger wastewater system, which requires additional treatment processes above what might normally be implemented. This is of particular concern for pathogens, since pathogen loads may become significantly elevated if someone or several people at the station fall ill. Equalisation of the wastewater quality occurs in the MBR tanks over a period of at least 24 hours, and this will reduce the magnitude of instantaneous contaminant peaks. However, higher average concentrations may still occur because of the overall reduced dilution effects.

2.3.1. RAW WATER QUALITY DATA

The DAWTP feedwater is the MBR treated effluent supplied from a detention tank. Table x.x.x below presents the minimum standard MBR effluent quality requirements. The parameters marked * are expected values and the parameters marked # are the DAWTP design feedwater quality specifications, and therefore, the MBR effluent must meet this criteria. Values obtained from the Davis Advanced Water Treatment Plant Function Description version 1.4 dated 27 June 2014 (AAD, 2014).

Table 3.1 DAWTP Feedwater Quality (minimum standard MBR effluent requirements)

Parameter	Value
Biochemical Oxygen Demand (BOD5)*	<20mg/L
Suspended Solids (SS)*	<10mg/L
Total Nitrogen (TN)*	<10mg/L
Turbidity*	Max: 1NTU
pH*	Min: 6 Max: 8
Ammonia#	<5mg/L
Phosphorous#	<5mg/L
Bromide#	Upper limit for bromide to be calculated
True colour#	<10HU
TOC / DOC#	<10mg/L

2.3.2. TREATED WATER QUALITY OBJECTIVES

The AWTP will produce both potable water for storage in the Davis Station potable water system, and an RO concentrate stream for discharge to the environment. Based on data obtained during plant validation, the RO concentrate stream is non-toxic and will not pose a threat to marine environments, provided the AWTP operates as designed. The potable water produced must conform with the Australian Drinking Water Guidelines (ADWG) and have properties as outlined in Table x.

Table x – Product water quality requirements for AWTP

Parameter	Minimum value	Maximum Value	Units	Comment
Turbidity		**0.05**	**NTU**	
pH	**6**	**8**		
Chlorine residual	**0.05**		**mg/L**	**Ensure adequate disinfection after detention time**
alkalinity	**40**		**mg/L CaCO3**	**Prevent corrosion in water system**
TDS		**500**	**mg/L**	
Iron		**0.05**	**mg/L**	

Manganese		**0.02**	**mg/L**	
Aluminium		**0.1**	**mg/L**	
Ammonia		**0.1**	**mg/L**	
Bromate		**0.02**	**mg/L**	**ADWG**
colour		**5**	**HU**	
Taste & odour		**Acceptable**		**Based on subjective taste test**
Total coliforms		**0**	**org/100mL**	**ADWG**
Ecoli		**0**	**org/100mL**	**ADWG**
THMs		**0.2**	**mg/L**	
NDMA		**100**	**ng/L**	**ADWG 6, version 2.0, Updated Dec 2013**

2.4 Overview of Treatment

The AWTP consists of 7 unit processes. Of these, 5 are designed to remove or inactivate pathogens: ozonation, ceramic microfiltration (MF), reverse osmosis (RO), ultra-violet disinfection (UV) and chlorination. CoCs are removed by the MBR, ozone, CMF, biologically activated carbon (BAC) filter and RO. The calcite contactor is not designed to remove or inactivate pathogens or CoCs, but is necessary to re-mineralise the high purity RO permeate so it is less corrosive to pipework.

The significant number of unit processes (or barriers) for pathogen and CoC removal/inactivation provides additional security in case one barrier fails. The removal/inactivation of pathogens is measured by Log Removal Values (LRVs), and refers to the removal efficiency of the process in logarithmic units such that 90% removal is equivalent to 1 LRV, 99% removal to 2 LRV, 99.9% removal to 3 LRV and 99.99% to 4 LRV.

2.4.1. TREATMENT PROCESS OVERVIEW

Ozonation

Ozonation is the first treatment of the AWTP and is used to oxidise chemical compounds and to inactivate pathogens by oxidation. Ozone is a highly reactive chemical that is produced from oxygen, which can degrade virus and the cell walls of bacteria and protozoa, as well as reacting with other compounds within water. The effectiveness of ozone for inactivation of virus and bacteria is high, but higher ozone concentrations are required for protozoa removal. Ozone is not effective for helminth inactivation.

The residual ozone concentration provides a measure of the ozone effectiveness for pathogen and CoC removal, with high residual concentrations providing higher LRV for pathogens. The feed water quality to the ozone unit can dramatically affect its performance, as the ozone will rapidly react with organic compounds and particles coming from the MBR. This will reduce the residual ozone concentration and hence the effectiveness of the barrier for pathogen inactivation and CoC removal. Therefore, it is important that the feed from the MBR remain of good quality to provide effective ozone treatment.

Ceramic Membrane Microfiltration (MF)

The MF removes particulate matter, pathogens and some CoCs by filtering the water through small pores (holes) and by adsorbing virus on the membrane surface. As the CMF physically removes pathogens and compounds from the water, a fouling layer will build up on the membrane surface that increases the pressure required for filtration and needs to be removed by backwashing of the filters with clean water. For this reason, two individual filters are used by the AWTP – one which is currently the duty filter, and one which is undergoing a backwash or other cleaning cycle.

As the backwashing is usually not 100% effective, chemically enhanced backwashing (CEB) is practiced every set number of backwashes. A CEB involves addition of either sodium hypochlorite or sulphuric acid to the backwash water to provide additional cleaning of the membrane. Residual ozone in the feed to the CMF will also assist in keeping the membranes clean.

As the filter removes fine particles, the turbidity of the filtrate should be very low and is typically <0.5 NTU and often <0.2 NTU. Failure of the CMF may occur if the membrane is cracked or its seals are faulty, and this will be detected by either a leak test or a pressure decay test (PDT). After the plant goes into standby following production of a batch of water, a PDT is carried out to confirm the integrity of the MF membranes. A PDT involves pressurising the permeate with compressed air and measuring the decrease in pressure over time as the air is released from the permeate side of the membrane to the feed side.

Bacterially Activated Carbon (BAC)

The BAC filter operates by passing MF filtrate through a bed of granular carbon media. The carbon media consists of highly porous particles which can act as both adsorption sites for contaminants and a substrate for bacterial growth. CoCs and other contaminants that have been oxidised by the ozonation barrier can be more easily metabolised by the bacteria in the BAC filter, making it particularly effective downstream from the ozone barrier. As more chemicals are metabolised by the bacteria in the BAC filter the waste products and excess bacteria build up within the media, leading to fouling and increasing head loss across the filter. As such, periodic backwashing of the filter is required to restore optimal operational conditions, and is usually carried out on a "volume processed" basis. The backwash cannot take place until the plant is in standby mode. Turbidity of the filtrate is monitored and is usually <0.2 NTU.

Reverse Osmosis (RO)

The RO barrier removes pathogens, chemicals and salts from water by using high pressures (up to 13 bar) to force pure water through a semi-permeable membrane. The RO membranes (or filters) are susceptible to rapid fouling because they remove almost everything from the feed water, and these contaminants can rapidly build up on the membrane surface. Therefore, cross flow filtration is used – the feed water passes along the membrane surface with only a fraction of the water passing through the RO membranes while the remaining water is used to sweep the surface of the membrane clean.

Each RO unit has two process streams: the filtered permeate that has passed through the membrane, and the rejected concentrate (or brine) that contains the contaminants. In order to increase the amount of permeate produced from the overall RO process, a portion of the concentrate is recycled and mixed with more feed (BAC filtrate) in the RO mix tank. The RO feed first passes through a cartridge filter to remove any particulate matter, as this will rapidly foul the membrane even with the cross flow to keep the surface clean. The pressure drop across the cartridge filter is monitored to indicate when the filter needs to be replaced.

The rejection of salts is determined by measuring the conductivity of the feed and permeate for each RO unit, and this is used as an indication that the membrane is working properly and does not have any holes where feed may by-pass the membrane. At the end of each processing period (when the plant is in standby), a PDT is carried out verify the integrity of the RO membranes. Both conductivity and the PDT are used to confirm membrane integrity.

UV Disinfection (UV)

The RO permeate is subsequently treated by UV disinfection as it flows through two UV reactors. The reactors use strong ultraviolet light at a wavelength of 254 nm to inactivate pathogens, with the intensity of the light related to the degree of inactivation. The intensity of light is measured by a sensor in each reactor and the ability of water to absorb light, and therefore reduce the effectiveness of the UV disinfection process, is measured by the UV transmittance sensor. The dose of UV radiation is used to determine the effectiveness of disinfection and this is related to the time the water spends in the UV unit, the intensity of light from the UV lamp and the ability of water to absorb the UV light.

Calcite Contactor

UV treated water flows through the calcite contactor, which passes water through a bed of calcite granules. The calcite granules dissolve and release calcium carbonate into the water. The addition of calcium carbonate to the water reduces the corrosiveness of the pure RO permeate and improves the taste of the water. Replenishment of the calcite granules is required periodically as the calcite dissolves. The need for replenishment can be determined by pH and conductivity measurements of water that has passed through the calcite contactor.

Chlorination

The last barrier in the AWTP is chlorination. Chlorine, in the form of sodium hypochlorite, is added to the water as a disinfectant and the chlorinated water held in a contact tank for a set period of time to allow the chlorine to inactivate pathogens. Two contact tanks operate in parallel, with one tank filling while the other tank is holding the water for the required contact time.

Water is chlorinated as it is fed to the duty contact tank, and the water in both tanks is recirculated. The recirculation ensures the contents of both the filling and holding contact tank are homogenous and allows the free chlorine concentration in each tank to be measured via the recirculation streams. Provided no CCPs limits were exceeded during production, the product water is classed as potable and sent to freshwater storage. If one or more CCP limits were exceeded, the product water is sent back to the AWTP feed tank to be retreated.

2.4.2. DESIGN FLOW RATES

The AWTP operates as a semi-batch process and has been designed such that its throughput capabilities can easily handle the expected volumes of waste water flow at Davis Station. When a predetermined MBR effluent level is reached in the AWTP feed tank, the AWTP feed pump (L3030) will start to treat the effluent at a fixed flow rate. Depending on the recovery achieved across the RO barrier, the product and effluent flowrates are as shown in Table x below.

Stream	RO Recovery	
	70%	80%
AWTP Feed	20 L/min	20 L/min
Ocean Outfall	5 – 7 L/min	3 – 6 L/min
RO Permeate Flow	13 – 15 L/min	14 – 17 L/min
AWTP Product Flow	60 L/min	60 L/min

Table x highlights the batch nature of the AWTP, with feed flow provided at a fixed rate and product flow, which consists of the contents of the duty chlorination contact tank after it has completed its contact time, also leaving at a fixed rate.

2.5 Process Performance Critical Control Points

To ensure that the required LRV for a particular unit process has been reached, the unit process must be operated in a manner known to produce or exceed the required LRV. For instance, chlorination is known to be effective for 4 LRV virus if the concentration X time (CT value) exceeds 22 mg.min/L and the pH <8.5, the turbidity is <2 NTU and the temperature >10˚C. Therefore, by measuring the concentration of free chlorine at the end of the hold time the CT value can be calculated. Additionally the pH, turbidity and temperature are also measured to confirm they are within the required operating ranging to confirm 4 LRV for virus. In this example, the required CT value is the Critical Control Point (CCP) for this unit process, as operating the process to meet this CCP value ensures the required LRV for pathogens is achieved.

Each barrier designed for pathogen removal has a set of operating conditions and CCPs that are required to ensure the appropriate LRV for each barrier. Further details of the CCPs and required operating conditions are given in the Recycled Water Quality Management Plan for the Davis Station Advanced Water Treatment Plant.

Ozonation and RO are the two most important barriers for CoC removal. Operation of these unit processes in-line with the conditions required for pathogen removal will also ensure a high removal efficiency for CoCs. Optimised operation of the BAC will also ensure removal of CoCs, although on-line verification of the operation is not possible.

The AWTP critical control points, limits and associated instrumentation are given in the Recycled Water Quality Management Plan for the Davis Station Advanced Water Treatment Plant.

2.5.1 MBR Effluent Quality (AWTP feed)

The performance of the MBR unit upstream of the AWTP will affect the ability of the AWTP to produce treated water of the desired quality. The overall MBR effluent quality is measured using the surrogates of ammonia, turbidity, pH and temperature as discussed below. CCPs are outlined in the Recycled Water Quality Management Plan for the Davis Station Advanced Water Treatment Plant.

2.5.2 Oxidation control (Ozonation barrier)

Ozonation is a critical barrier in terms of pathogen removal and the degradation (oxidation) of CoCs and other organic contaminants. The ozone dose and the ozone residual are the key CCPs for this barrier, and CCPs are outlined in the Recycled Water Quality Management Plan for the Davis Station Advanced Water Treatment Plant.

2.5.3 Filtration Control (MF barrier)

The MF is a critical barrier for both pathogen reduction and the removal of particulate matter from the AWTP feed water. Pressure Decay Tests are used to directly verify membrane integrity, although these are not measured continuously. Turbidity is used as a surrogate measurement for MF performance, with a verification PDT on both membranes carried out when production ceases and the plant goes into standby mode. CCPs are outlined in the Recycled Water Quality Management Plan for the Davis Station Advanced Water Treatment Plant.

2.5.4 Reverse Osmosis Control (RO barrier)

The RO barrier is a critical barrier for both pathogen and CoC removal. In terms of pathogen removals, different LRVs can be claimed from either a PDT or using conductivity as a surrogate measurement for membrane performance. As with the MF barrier, the PDT cannot be carried out until the AWTP is in standby mode. CCPs are outlined in the Recycled Water Quality Management Plan for the Davis Station Advanced Water Treatment Plant.

2.5.5 Disinfection Control (UV barrier)

The UV barrier is a critical barrier in terms of pathogen removal, with one of the highest LRVs for any barrier in the AWTP. The performance of the barrier is measured by a calculated dose of UV light, which is measured manually during weekly sampling.

2.5.6 Final pH Correction Control (Calcite Contactor)

The calcite contactor is a critical barrier in terms of the final water quality and the efficacy of chlorination. The high purity RO permeate is unstable and will corrode metal and concrete infrastructure, and needs to be stabilised with calcium carbonate. This adds some minerals (ie conductivity) back into the RO permeate, and increases the pH to the range at which chlorination is most effective. The pH is the surrogate measure for the performance of the calcite contactor.

2.5.7 Disinfection Control (Chlorination barrier)

The chlorination barrier is a critical barrier in terms of pathogen removal, with one of the highest LRVs for any barrier in the AWTP. The performance of the barrier is measured via a concentration X time calculation, which can be carried out using continuously logged data. It is important to note that the contact tank chlorine analysers (L3198 and L3205) and NOT the feed chlorine analyser are the CCP instruments for this barrier, as they continuously measure the concentration of chlorine in the water as it is held for its contact time. CCPs are outlined in the Recycled Water Quality Management Plan for the Davis Station Advanced Water Treatment Plant.

2.6 Plant Operational Control

The AWTP is designed for robust, remote operation, which entails maximum automation and minimal operator intervention. This section outlines the AWTP operational control philosophy, and the modes of operation under which the AWTP can be run.

2.6.1. GENERAL OPERATING PHILOSOPHY

In order to ensure robust operation, the AWTP operating system has been designed to minimise direct operator involvement and maximise the amount of operation which can be carried out with either the AWTP control systems or, if operator intervention is required, via remote access. The AWTP is capable of autonomously:

Starting up when sufficient feed water is available

Operating without operator inputs

Monitoring all performance variables and CCPs

Accepting or rejecting treated water based on plant performance

Carrying out membrane integrity (PDT) tests

Carrying out CEBs on MF system

Carrying out periodic backwashes on BAC filter
Preserving RO membranes during lengthy standby periods

The ability of the AWTP to perform these operations autonomously limits the operator requirements to the following:

Replacement of bulk chemicals
Replacement of RO feed cartridge filter
Replenishment of media in calcite contactor
Periodic instrument verifications/calibrations
Periodic inspections
Periodic maintenance
Periodic manual cleaning of RO membranes as requested by AWTP control system

2.6.2. AUTOMATIC OPERATING MODE

Automatic operating mode is the default setting of the AWTP and the only operating mode in which the AWTP control systems will operate. For automatic operating mode to function, **all** equipment in the AWTP must be switched to "automatic" operation mode (see Section 6.8). When all equipment is in "automatic" mode, and the AWTP is online, the control system will start, operate and shut down the AWTP as required, with no operator intervention required.

Routine maintenance tasks (ie replacement of RO feed cartridge filter) may be carried out when the plant is online and in standby mode. However, due to the nature of the automatic operating mode control philosophy, manually isolating a pump drive will cause the overall AWTP control system to go into fault status. Following completion of routine tasks, all faults must be cleared and equipment returned to automatic operating mode to enable the AWTP control systems to operate the plant.

2.6.3. MANUAL OPERATING MODE

If no such thing as "Maintenance"....need to stipulate when Manual is OK to use. Perhaps "as directed by SWI"?

Manual operating mode is ONLY to be used under the supervision of Maintenance personnel.

Manual operating mode allows operators to manually control drives and other equipment in the AWTP. However, when equipment is in manual operation mode, the AWTP control sequences will not function and as such equipment can potentially be damaged or production of off specification water can occur. Due to these reasons, manual operating mode must not be used without supervision by maintenance.
Manual mode may be used during a dry start up of the plant, or following major maintenance events, for instance annual replacement of the RO membranes and UV lamps.

2.6.4. EMERGENCY OPERATING MODES

Should an emergency situation arise within the AWTP, such as an ozone detection alarm, a burst pressure vessel in the RO process, or an electrical fire, Operators must use the E-stops located throughout the plant to take the entire plant offline and reduce the risks of the hazard worsening. Operators should take any possible actions to bring the emergency situation under control, provided these actions do not pose a risk to their personal safety.

Maintenance should be informed immediately and their instructions followed until such time as they arrive on site to resolve the issue.

2.6.6. ALARMS SYSTEM

AAD to add

3. Description of Main Components

3.1. Electrical Panels

The mains power and circuit boards for the AWTP are located within the PLC/Electrical Panel in Section 5 of the AWTP. **Operators must not open the PLC/Electrical Panel unless instructed by Maintenance.**

There won't be a Section 5 in Davis, to be updated

Replace with new picture when at Davis

Figure x – AWTP electrical panel, Section 5

3.2. Ozone System

Located on the left hand side of Section 1 of the AWTP, The Ozonation System is the first barrier of the AWTP, and is responsible for injecting ozone into the AWTP feed water and maintaining the ozone level in the water as it flows through the Contact Tanks. The Functional Description for this System can be found in Appendix X.

The Ozonation System contains the following key components:

- The Oxygen Generator (L3043) which strips pure oxygen from air through a Pressure Swing Absorption (PSA) process. This unit generates a continuous supply of dry and clean oxygen gas which is delivered to the Ozone Generator.

Figure x – Oxygen generator, ozone system, Section 1

- The Ozone Generator (L3042) receives the oxygen gas and passes it through a high voltage current to create ozone gas. The ozone gas from the generator is passed through the Ozone in Gas monitor (L3265) which measures the concentration of ozone in the gaseous stream. The gas then travels to the injection loop for injection into the feed water stream.

Figure x – Ozone generator, ozone system, Section 1

- The Circulation Pump (L3038) and Ozone Injector (L3039) are the main components of the injection loop. The high pressure circulation pump forces the feed water through a section of small diameter pipe, which significantly increases its flow velocity. This high-velocity flow stream is connected to the ozone gas stream via a venturi injection system that draws the ozone gas from the Ozone Generator under the vacuum created by the high velocity flow stream, where it is injected into the feed water and dispersed into solution.

Figure x – Recirculation pump and ozone injection, ozone system, Section 1

- The Contact Tank (L3034) acts as a mixing vessel, permitting continuous circulation of the ozonated feed water to allow sufficient contact time for the dissolved ozone gas to disperse and achieve the desired pathogen reduction and chemical oxidation. The tank is specially designed with an internal baffle that ensures all the water circulating through it remains in contact with ozone gas for a minimum time.

Figure x – Ozone contact tank, ozone system, Section 1

- The Process Instruments in the Ozonation System measure various operational parameters. The most important of these instruments is the Ozone Residual Analyser (L3045), which measures the concentration of ozone in the discharge line from the Contact Tank. The value from this instrument is used to control the amount of ozone that is generated and injected into the product water.

Figure x – Ozone Residual Analyser (bottom instrument), Ozone System, Section 1

3.3. Ceramic Membrane Microfiltration

The MF system is responsible for filtering the ozonated process water before it continues on to downstream processes. It is located on the right hand side of Section 1 of the AWTP. The Functional Description for the MF system can be found in Appendix X.

During ozonation, the oxidisation of chemical contaminants produces solid waste materials which are entrained in the process stream and can cause significant fouling of downstream processes, in particular the RO membranes. Pre-treatment of the process water via MF removes these contaminants. Furthermore, the ceramic membrane material has a catalytic effect on both the oxidising effects of ozone gas and the destruction of excess ozone gas.

There are two ceramic MF membranes in the MF system (L3049 and L3061), which operate sequentially. One membrane acts as the duty membrane while the other undergoes backwashing, either with water or a chemically enhanced cleaning solution, and remains on standby. Chemically enhanced backwashes are performed after a pre-determined number of water backwashes. Typical trans-membrane pressures during normal operation are in the range of 20 – 30 kPa.

Could drop when we get cleaner feed

Figure x – MF Filters and back flush tank, MF, Section 1

3.4. BAC Filter

The biological activated carbon (BAC) filter is located in the back left corner of Section 2 of the AWTP. The Functional Description for the BAC Filter System can be found in Appendix X. MF filtrate is the feed material to the filter, and flows through the BAC bed under gravity before discharging to the RO mix tank.

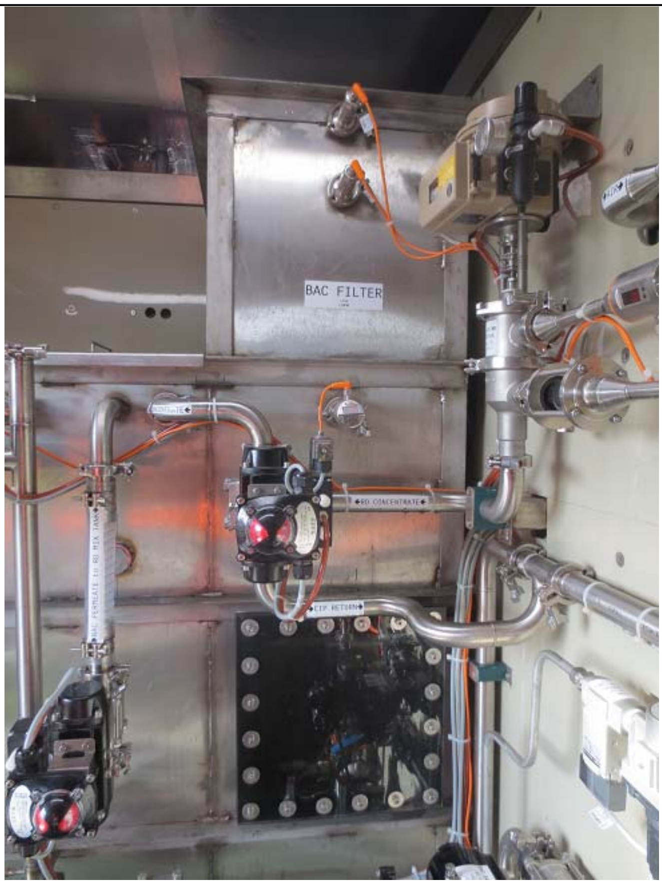


Figure x – BAC Filter, BAC, Section 2

The BAC filter vessel contains approximately 1.3 m of carbon granules. Bacterial populations living within pores in the carbon granules strip organic and inorganic contaminants from the process water and convert them to energy via metabolic pathways. Depending on the contaminant profile of the feed water, different bacterial colonies will form based on their ability to metabolise contaminants.

The BAC filter is back flushed with both air and Service water when the plant is in Standby mode. This back flushing serves to remove any waste products that accumulate in the filter due to the presence of the bacterial colonies. The aeration step further removes biological waste products and stimulates bacterial growth.

Figure x – BAC filter interior, BAC, Section 2. MF filtrate enters the BAC through the channel on the left. During back flushing, back flush water flows into the channel on the right and into the waste tank.

3.6. RO System

The main components of the RO system are the RO mix tank (L3107); a high pressure RO Feed Pump (L3113); and the five RO pressure vessels (L3123, L3128, L3133, L3138 and L3143) and membranes. The Functional Description for the RO System can be found in Appendix X. The RO mix tank is attached to the BAC filter and takes up the majority of the left hand wall of Section 2. The high pressure RO Feed Pump and the RO concentrate plumbing take up the rear wall, with the RO pressure vessels taking up the right hand wall of Section 2.

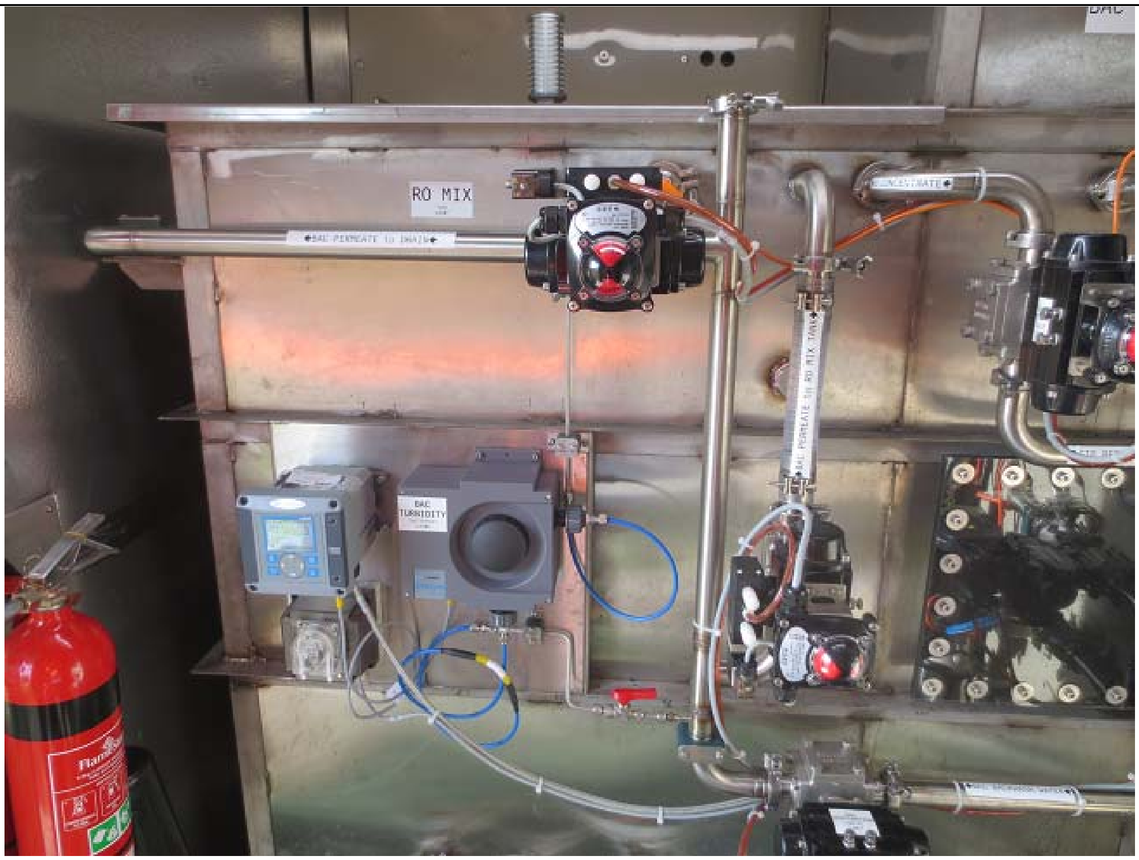


Figure x – RO Mix tank, RO, Section 2

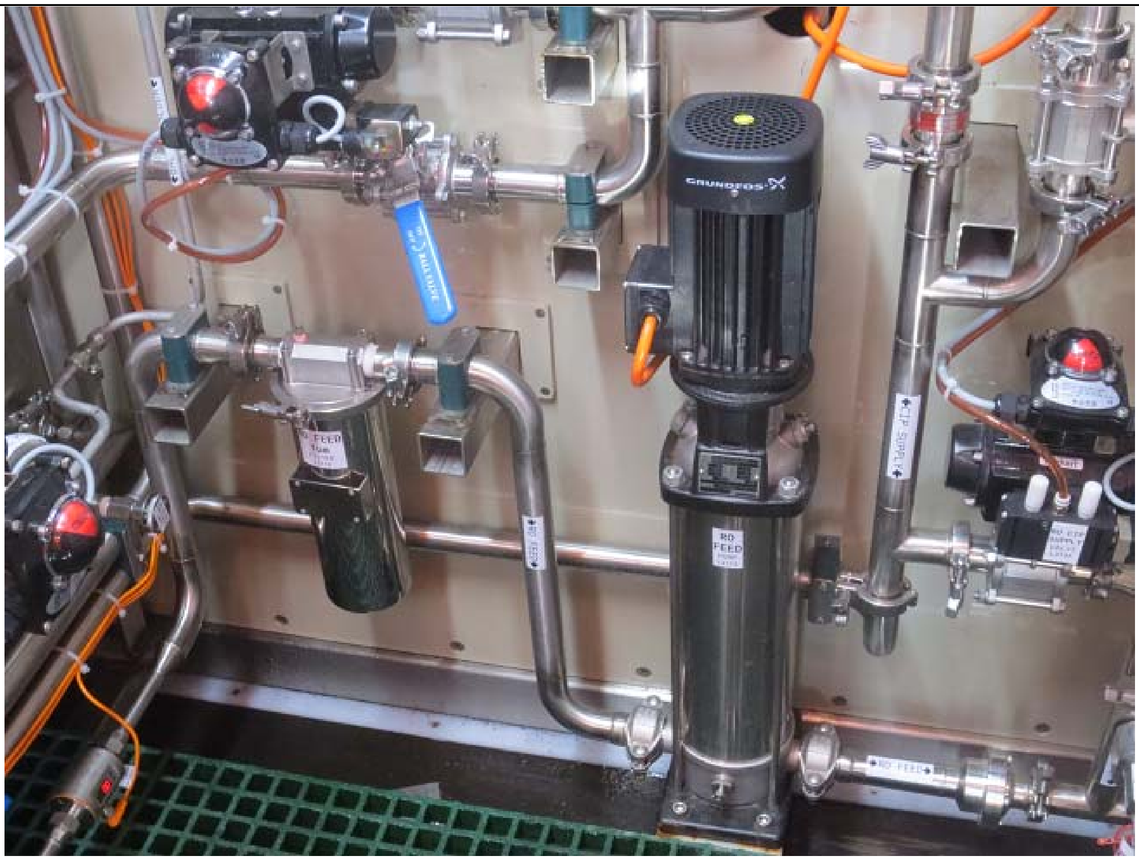


Figure x – Cartridge filter and high pressure feed pump, RO, Section 2

Figure x – RO pressure vessels, RO, Section 2

BAC filtrate flows into the RO mix tank, which is also fed with a percentage of the RO concentrate stream. The mixed water is passed through a 1 micron cartridge filter (L3112) to remove any trace remnants of BAC or other solid contaminants, and then pumped through the five pressure vessels in series. Each vessel contains a spiral wound RO membrane. Water enters the vessel on the concentrate side and flows through the membranes under pressure to the permeate side. The majority of dissolved material in the feed water cannot pass through the membranes, and as a result the total dissolved solid concentration (measured in the process by conductivity) increases on the concentrate side and is drastically reduced on the permeate side. The RO permeate is passed to the RO Permeate Tank (L3162) in Section 3.

Figure x – RO permeate tank, RO, Section 3

RO concentrate passes through a proportional control valve (L3273) and is split into waste and concentrate recycle streams. The proportion of concentrate recycled is regulated to keep the conductivity of the RO feed approximately constant during normal operation.

The RO system requires several different cleaning routines, which are outlined in SWIs located in Section x.x.x of this operating manual. Importantly, the membranes must be preserved in SMBS solution during periods of extended Standby or a shut down. Operators are responsible for preparing and maintaining the 6 wt% SMBS solution as outlined in the appropriate SWI.

3.9. UV System

A fixed volume (around 380 L) of RO permeate is stored in the RO permeate tank for use in backwashes and other cleaning processes as required. RO permeate designated for the Product stream is passed through the UV system to provide additional disinfection by destroying pathogens. The UV system is located on the lower left hand wall of Section 3, below the RO Permeate Tank. The Functional Description of the UV System can be found in Appendix X.

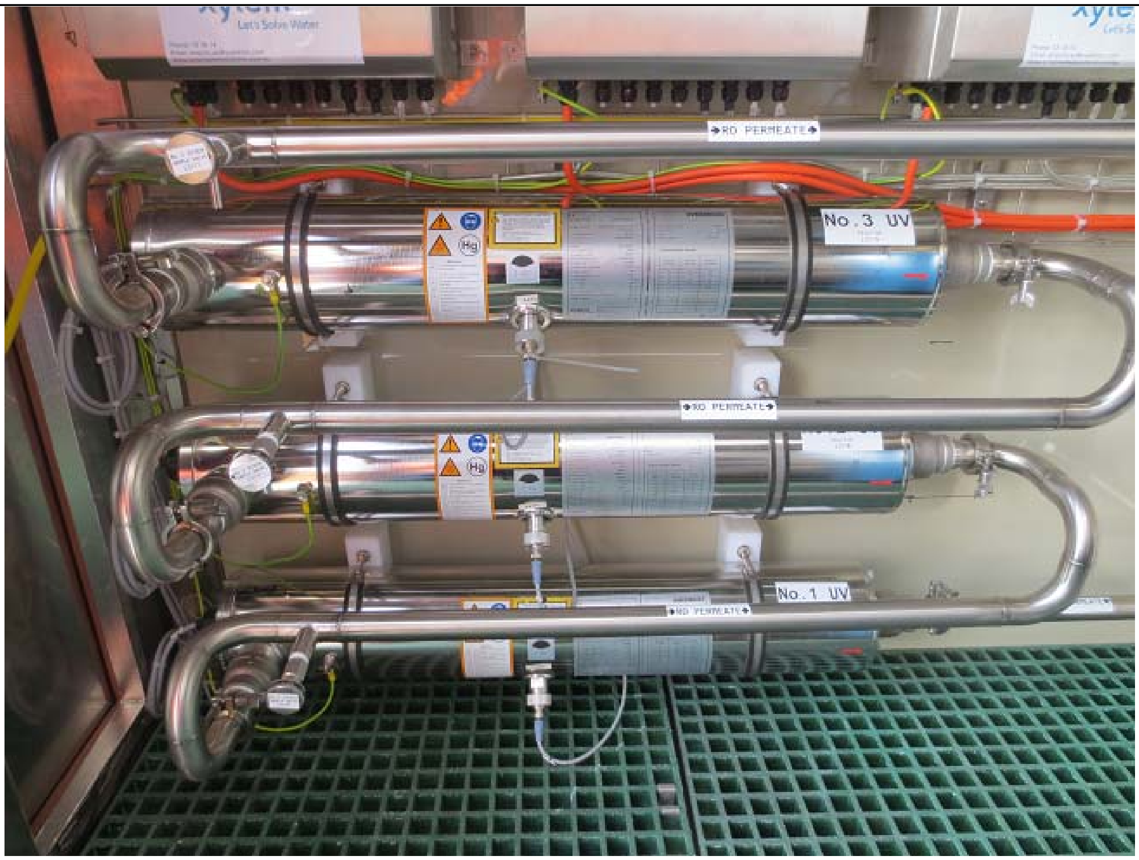


Figure x – UV reactors, UV, Section 3

The UV system operates by applying UV radiation to process water as it flows through the UV vessels. Two UV reactors (L3166 and L3170) are installed in series, with two being in operation at all times and the duty reactors cycled each time the plant leaves Standby. UV lamps within the reactors act as a source of UV radiation. Once treated with UV, the process water passes through the Calcite Contactor (L3179) before the final chlorination barrier.

3.10. Calcite Contactor

The Calcite Contactor does not represent a treatment barrier of the AWTP as it does not reduce pathogen or contaminant levels in the process water stream. However, it is an essential system component in terms of introducing dissolved calcium and carbonate ions into the process water to act as natural buffers and prevent the product water from becoming exceptionally corrosive.

Figure x – Calcite contactor, Section 3

3.11. Chlorination

Chlorine dosing is the final barrier in the AWTP and provides a final disinfection treatment step before the Product water is pumped to the discharge point. The chlorine dosing and Contact Tanks are located on the right hand side of Section 3. The Functional Description of the Chlorination System can be found in Appendix X.

Process water flows from the Calcite Contactor and is dosed with chlorine in the form of 8 wt% sodium hypochlorite solution. The process water/sodium hypochlorite mixture is passed through a Static Mixer (L3183) to disperse the hypochlorite throughout the process water. The concentration of chlorine in the dosed feed water is measured with an online chlorine analyser (L3198).

Take another photo when the nice new static mixer gets installed

Figure x – Static mixer, Chlorine Dosing, Section 4

The chlorinated water is discharged to a Contact Tank (either of L3193 and L3200) and retained for a specified period of time to ensure that the requisite contact time for the prescribed pathogen reduction is met. There are two contact tanks, with the chlorinated contents of one tank being held or discharged while the other tank fills with freshly chlorinated process water. The residual chlorine concentration of the process water in each tank is measured with chlorine analysers (L3205 and L3275) and is used to accept or reject a batch of Product water based on minimum residual chlorine levels.

Figure x – Chlorine contact tanks and chlorine meters, Chlorine Dosing, Section 3

3.12. Service Water

The service water for the AWTP can be either of RO permeate or mains water. RO permeate is used for many of the CEB and CIP procedures within the AWTP, whilst mains water is used for high rate backwashing of the BAC filter.

3.13. Service & Control Air

The service and control air in the AWTP are both fed from the AWTP central compressor (L3230). Service air is used for air scouring both the MF and BAC filters, whilst control air is used to open and close all pneumatic valves within the AWTP.

New photo when installed at Davis

Figure x – Service and control air, Section 5

3.14. CIP Cleaning System

In order to reduce maintenance requirements, the AWTP has been designed so that all barriers can be cleaned in situ using a Clean in Place (CIP) system. The CIP tank is located on the right hand side of Section 4 of the AWTP, with automatically dosed chemicals stored in the chemical bunds on the left hand side of Section 4. The Functional Description of the CIP System can be found in Appendix X

Figure x – Chemical bunds and dosing pumps, CIP, Section 4

The philosophy of this system involves using a single, centralised CIP tank, into which cleaning chemicals are dosed as required and pumped to the relevant barrier for cleaning procedures. Of the multiple barriers in the AWTP, only the MF and RO membranes require extensive cleaning with the CIP system. These cleaning procedures are described in more detail in the Functional Descriptions of the MF and RO membranes, respectively.

Figure x – CIP tank, CIP, Section 4

3.15. Chemical Dosing Systems

Chemicals which are used frequently by the AWTP are dosed using the Chemical Dosing Pumps in Section 4 of the AWTP. The dosing pumps and the bulk chemicals which they dose are located on the left hand side of Section 4. The following bulk chemicals are stored and dosed on site:

- Sodium hypochlorite, 8 wt% (MF CEB)_
- Sulphuric acid, 10 wt% (MF CEB)
- SMBS, 6 wt% solution (RO membrane preservation)
- Sodium hypochlorite, 8 wt% (Chlorination)

Update what hypochlorite concentration is taken to Davis Station

Update what hypochlorite concentration is taken to Davis Station

A low level switch is contained in the chemical storage drums, and the plant will stop if these are activated. Therefore, it is an important Operator task to monitor and replace chemicals when required.

3.16. Instrumentation

The AWTP is a dynamic process which is designed to operate autonomously. For successful automatic operation, a significant amount of instrumentation is required so that a multitude of process parameters can be measured in real time, allowing data to be fed to the AWTP control programs and process adjustments made as required.

In addition to providing process data to the AWTP control programs, several instruments throughout the AWTP are also CCP instruments. These instruments measure a process parameter (turbidity, pH etc) and ensure that it is within the specified operating range to achieve the necessary hazard reduction for a given barrier. CCP instrumentation is discussed in Section 2.5, and is listed again here where a CCP instrument is of the instrument type being discussed.

3.16.1 CHLORINE ANALYSERS

Chlorine analysers are located in the Chlorine Dosing system in Section 3. There are three analysers that measure the chlorine concentration in the dosed feed water and the residual chlorine concentration in the water being held/discharged from each contact tank.

Operators will be required to verify and, if necessary, calibrate chlorine analysers periodically. Appropriate SWIs for these tasks are located in Section x.x.x.

Figure x – Chlorine analysers, Chlorine Dosing system, Section 3

3.16.2 CONDUCTIVITY ANALYSERS

The conductivity of several process streams in the AWTP is constantly logged as a means of analysing the performance of each barrier. Of particular importance are the conductivity reductions across each membrane in the RO system. The concentrate and permeate streams from each of the RO pressure vessels are measured via in line conductivity analysers. For a list of conductivity analysers associated with each barrier, refer to the appropriate FD.

Figure x – Conductivity analysers, RO system, Section 2

Operators will be required to verify and, if necessary, calibrate conductivity analysers periodically. Appropriate SWIs for these tasks are located in Section x.x.x.

FLOW SWITCHES

Flow switches are located on the turbidity meters to ensure flow to these instruments.

3.16.3 LEVEL SWITCHES

Level switches in the AWTP are used to indicate when the level of process water in a vessel is either “hi”, or “hi hi”, triggering an appropriate sequence in the overall control program. For a list of level switches associated with each barrier, refer to the appropriate FD.

Figure x – Level switches, BAC, Section 2

Level sensors should not be adjusted or removed by operators. Should SCADA readouts indicate a level sensor is faulty, Operators must contact Maintenance.

3.16.4 MAGNETIC FLOWMETERS

The AWTP has magnetic flowmeters installed in each Section. In keeping with the design philosophy of the AWTP, all magnetic flowmeters are of the same make, model and flow capacity. For a list of magnetic flowmeters associated with each barrier, refer to the appropriate FD.

Inputs on magnetic flowmeters should not be altered by Operators. Should SCADA readouts indicate a magnetic flowmeter is faulty, Operators must contact Maintenance.

Figure x – Magnetic flowmeter used throughout AWTP

3.16.5 OZONE RESIDUAL ANALYSERS

There are two ozone residual analysers in Section 1, used to measure the ozone concentrations in the discharge from the ozone contact tank (L3045) and in the MF filtrate (L3083).

Operators will be required to verify and, if necessary, calibrate ozone residual analysers periodically. Appropriate SWIs for these tasks are located in Section x.x.x.

Need to confirm the calibration routine of these sensors. Zero reading and use of Hach ozone procedure on-site.

Figure x – Ozone Residual Analyser (bottom instrument), Ozone System, Section 1

3.16.6 PH AND TEMPERATURE TRANSMITTERS

The AWTP has pH and temperature transmitters in various lines in Section 1 (to analyse feed properties), Section 3 (to ensure effective chlorination), and Section 4 (to ensure CIP solutions meet specifications). These transmitters are often coupled with others and their readings displayed on a single instrument. For a list of pH and temperature transmitters associated with each barrier, refer to the appropriate FD.

Operators will be required to verify and, if necessary, calibrate pH meters periodically. Appropriate SWIs for these tasks are located in Section x.x.x.

Figure x – Dual display for turbidity and pH transmitters (top), MF, Section 1

3.16.7 PRESSURE GAUGES

There are several pressure gauges located throughout the AWTP, most notably in Sections 1 and 2 where they are included as part of the ozone generation and injection equipment, the MF and BAC air scouring systems, and as pneumatic controls for the proportional valves in the RO system. For a list of pressure gauges associated with each barrier, refer to the appropriate FD.

Pressure gauges should not be altered by Operators. The operational pressures for all pressure gauges are marked on the gauge faces. Should the gauge read a pressure other than the operational pressure, Maintenance must be contacted.

Figure x – Pressure indicator in RO system, Section 2

3.16.8 PRESSURE/LEVEL TRANSMITTERS

Pressure transmitters are used in the AWTP to both measure the pressure in certain process streams and measure tank levels via hydrostatic pressure. For a list of pressure/level transmitters associated with each barrier, refer to the appropriate FD.

Inputs on pressure/level transmitters should not be altered by Operators. Should SCADA readouts indicate transmitters are faulty, Operators must contact Maintenance.

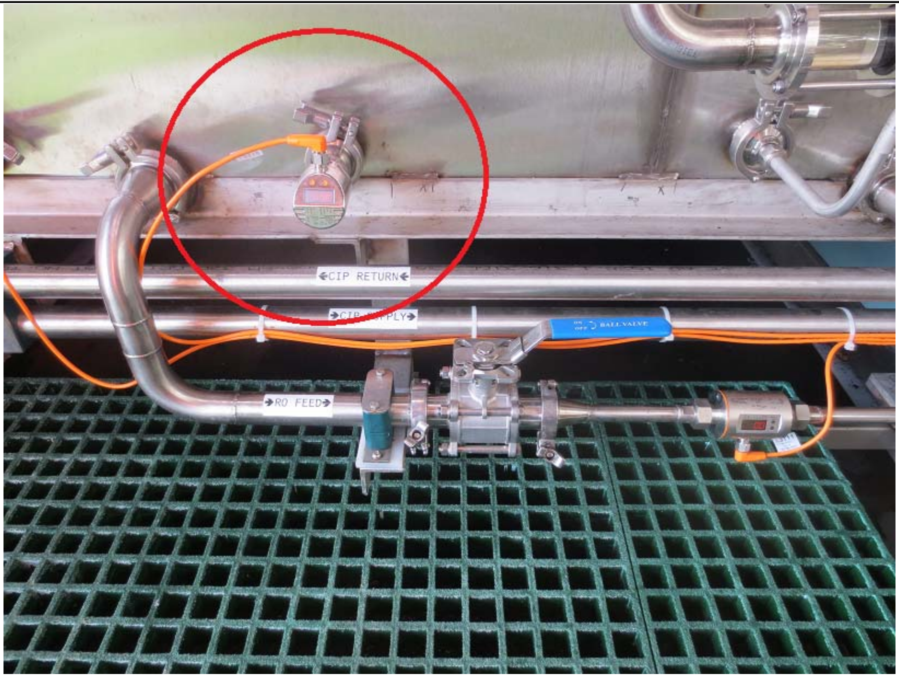


Figure x – Pressure transmitter functioning as level transmitter, RO mix tank, Section 2

3.16.9 TURBIDITY ANALYSERS

The AWTP has Hach turbidity analysers for the MF filtrate and the BAC filtrate. Feed turbidity is also monitored by instrumentation in the MBR plant, as the MBR effluent is the AWTP feed.

Operators will be required to verify and, if necessary, calibrate turbidity analysers periodically. Appropriate SWIs for these tasks are located in Section x.x.x.

Figure x – Turbidity analyser, BAC filtrate line, Section 2

3.17. Valves

The AWTP contains the following types of valves, which will be briefly described in the following section.

- Manually operated valves (open/close ball valves)
- Automatically operated valves (two way, three way and proportional)
- Pressure relief valves (pressure activated)
- Sample valves (manually operated proportional open/close valves)

Should any valve fail to function as required, Operators must contact Maintenance immediately.

3.17.1 Manual valves

Manual valves are located at various locations throughout the AWTP and are primarily used for isolation purposes during maintenance routines. For a list of manual valves associated with each barrier, refer to the appropriate FD.

Operators should not adjust the position of manual valves unless instructed to do so by Maintenance.

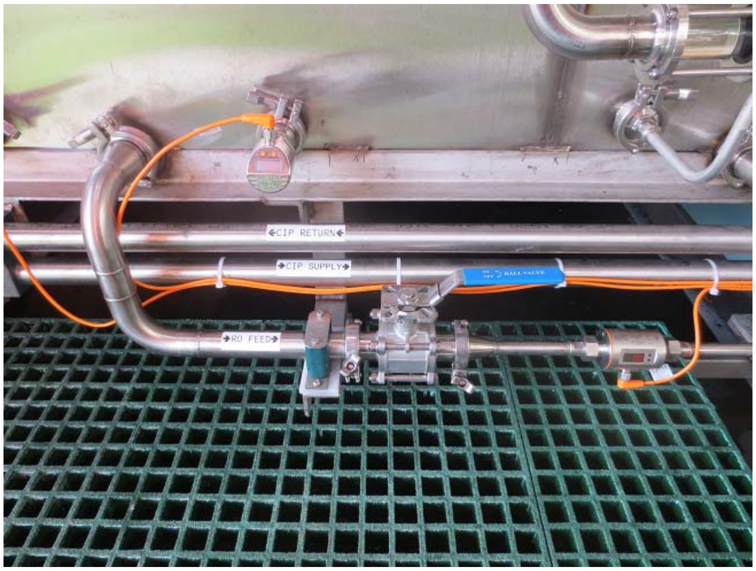


Figure x – manual isolation valve, RO feed line, RO system, Section 2

3.17.2 Automatic valves

Automatically operated valves are controlled by the AWTP control system and provide feedback to indicate their current status. They are either two way valves that open/close to allow flow in a given line, three way valves that direct flow between different lines, or proportional flow valves that vary the volume of influent liquid reporting to the outlet lines. For a list of automatic valves associated with each barrier, refer to the appropriate FD.

Operators should not physically adjust automatic valve settings unless instructed to do so by Maintenance.

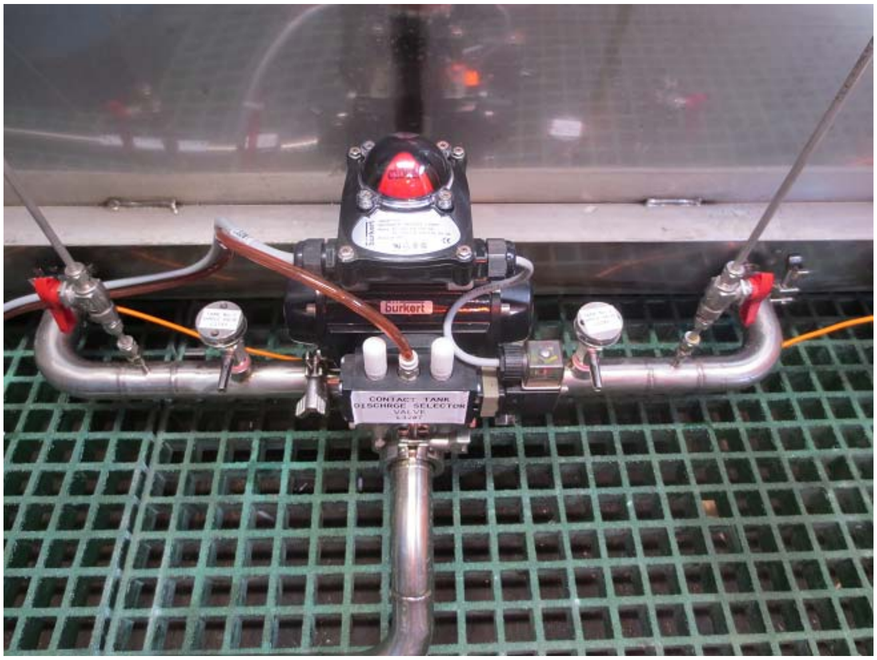


Figure x – three way automatic valve, Chlorine Dosing, Section 3

Figure x – Proportional flow valve, RO system, Section 2

3.17.3 Pressure Relief Valves

Barriers and process equipment that may be subject to pressure build-ups during regular operation have been fitted with pressure relief valves which will release excessive pressure in the event of such an occurrence, preventing potentially hazardous equipment failures.

Figure x – pressure relief valve on ozone contact tank, Ozonation System, Section 1

3.17.4 Sample valves

Each Section of the AWTP has multiple sample valves for collecting samples during plant operation. These are manually controlled, tap style valves. Safely collecting samples from these valves is outlined in detail in the appropriate SWIs.

Figure x – Sample valve on RO concentrate line, RO system, Section 2

4. Troubleshooting

Common Troubleshooting issues will be documented as part of the Plant Diary kept by Operators. These issues, and their resolution, will be discussed with Maintenance and a Troubleshooting procedure (and associated SWI) agreed upon for Operators to carry out in the event the incident recurs. Commonly encountered issues and their resolutions are discussed in this Section.

Operators must not attempt to troubleshoot or rectify any issues without first discussing with Maintenance.

5. Plant Maintenance

5.1. Regular Operational Tasks

Tasks expected to be regularly carried out by Operators are briefly discussed in this Section. SWIs for carrying out these tasks and the associated Risk Assessments are located in the AWTP OHS folder.

8.1.1 Weekly Inspections

Upon arriving on site at the AWTP, Operators perform a Weekly Inspection to ensure the plant is operating as intended, no obvious hazards are visible, and process chemicals are sufficient for the day's operation. This Inspection is carried out using the Routine Inspection Checklist located in Section x.x.x.

8.1.2 Plant Diary

The plant diary must be filled out weekly. This is an electronic document which is located on the SCADA PC in the AWTP office of the SPWWTP. Plant diary entries include but are not limited to the following items: Routine Inspection outcomes; review of operational trends and acknowledgement of obvious operational issues; OHS considerations; maintenance considerations; other items of concern.

Update for Davis Station

8.1.3 Chemical handling

AWTP Operators are required to maintain AWTP chemical levels by changing over bulk chemical containers in Section 4 of the AWTP, making up 6 wt% solutions of SMBS for RO membrane preservation, or manually adding chemicals to the CIP mix tank as requested by the SCADA Control program or Maintenance. SWIs for carrying out these tasks and the associated Risk Assessments are located in the AWTP OHS folder.

8.1.4 Sampling

Various samples will be required for instrument verification measurements and AWTP water quality testwork. SWIs for carrying out these tasks and the associated Risk Assessments are located in the AWTP OHS folder.

8.1.5 Instrument checks and calibrations

All instruments in the AWTP require routine checks and calibrations during normal operations. Depending on the mode of operation of the AWTP, the frequency of these checks can vary. A list of instruments that require checking and calibration is given in Section x.x.x. SWIs for carrying out these tasks and the associated Risk Assessments are located in the AWTP OHS folder.

8.1.6 Filter Maintenance

Whilst the majority of equipment and instrumentation maintenance will be carried out periodically, this is carried out by AWTP Maintenance and, if Operator involvement is required, it will be under the supervision of Maintenance. However, during routine operation of the AWTP, Operators will have to carry out maintenance on the RO feed cartridge filter and the calcite contactor. The RO feed filter needs to be replaced when the pressure drop across the filter exceeds a critical limit, and the calcite contactor needs to be topped up with media after treating approximately 600,000 L of water when either of the pH or conductivity of the discharged water drop below alarm limits. SWIs for carrying out these tasks and the associated Risk Assessments are located in the AWTP OHS folder.

8.2. Membrane fouling and Cleaning

The RO membranes require cleaning as they become fouled. As the specific flowrate rate reduces towards 1.09 $L.m^{-2}.bar^{-1}$ and the recovery reduces towards 60% the membranes should be cleaned so that the operation of the membranes is maintained above the flowrate and recovery required for reliable operation of the RO pressure decay test.

8.3. Cleaning Procedure

Cleaning solutions are made manually and the cleaning procedure is semi-automated. When the condition is met, the caustic clean is requested by the system first, and requires 90L of caustic solution. The recipe requires 95 mL of 50 wt% caustic (NaOH) solution to be added to 90L of water. Once the solution is made, press the start button on the CIP window and the cleaning of the RO membranes with caustic solution is automatically undertaken. At the end of the caustic clean, the caustic solution is discharged from the CIP tank to the Waste Water tank.

The membranes are flushed with water (XX L) between the caustic and acid clean. This is performed by filling the CIP tank with town water and selecting recipe number X. Once flushed the rinse water is discharged from the CIP tank to the Waste Water tank

Then the system will request acid cleaning and the recipe requires addition of 130 mL of 32.5% HCl solution to 90L of water. Once the solution is made, press the start button on the CIP window recipe number XX is selected and the cleaning of the RO membranes with caustic solution is automatically undertaken.. At the end of the acid clean, the acid solution is discharged from the CIP tank to the Waste Water tank and flushed with water as described above. The system is now ready for production.

Further details are contained in the SWI and risk assessment located in the AWTP OHS folder.

8.4. RO Membrane Storage

To preserve the integrity of the RO membranes, they must be stored in sodium metabisulphite if they are to be out of service for more than 48 hours. Dosing of the sodium metabisulphite occurs via the control system and is automated, but requires sodium metabisulphite solution to be available. Sodium metabisulphite solution must be regularly made in accordance with the SWI and the level of solution maintained above x L.

8.5. Weekly Checks

8.5.1 Weekly OHS checks

The AWTP has several OHS systems that require weekly checks to ensure they are operating as intended and can be relied upon in the event of an emergency. The following OHS items should be checked weekly, and the outcomes of the checks recorded in the relevant Section of the OHS folder.

- Safety eyewash station, Section 4
- Portable safety showers, Exterior
- PPE supplies, Control Container

Revise for Davis

8.6. Monthly Checks

- Section 4 consumables (reagents, gloves, battery levels on HH instruments, pocket blowtorch fuel, sample bottles, cartridge filters)

8.7. PERIODIC CHECKS

14. Appendices

Appendix A – Equipment, Instrumentation, Valve IDs

OZONATION		
Location	**Type**	**Description**
L3030	Pump	Ozone System -Feed Pump
L3031	Instrument	Ozone System - Feed Flow
L3032	Instrument	Ozone System - Feed Pressure
L3033	Instrument	Ozone System - Feed Temperature
L3034	Vessel	Ozone System - Reaction Tank 480Lt
L3035	Valve	Ozone System - Water Trap Valve
L3036	Vent	Ozone System - Ozone Destructor
L3037	Valve	Ozone System - Pre Ozone Circulation Sample Valve
L3038	Pump	Ozone System - Circulation Pump
L3039	Valve	Ozone System - Ozone Injector
L3040	Valve	Ozone System - Post Ozone Circulation Sample Valve
L3041	Instrument	Ozone System - Circulation Ozone Concentration
L3042	Instrument	Ozone System - Ozone Generator
L3043	Instrument	Ozone System - Oxygen Generator
L3044	Valve	Ozone System - Discharge Sample Valve
L3045	Instrument	Ozone System - Discharge Ozone Concentration
L3265	Instrument	Ozone System - Ozone In Gas Concentration
L3266	Instrument	Ozone System - Ozone Gas Pressure Switch
L3267	Instrument	Ozone System - Ozone in Air Concentration

CERAMIC MICROFILTRATION		
Location	**Type**	**Description**
L3047	Valve	MF Filter No.1 - Supply Inet Valve
L3048	Instrument	MF Filter No.1 - Supply Pressure
L3049	Filter	MF Filter No.1
L3050	Valve	MF Filter No.1 - Air Scour Valve
L3051	Valve	MF Filter No.1 - Flush Valve
L3052	Valve	MF Filter No.1 - CIP Return Valve
L3053	Valve	MF Filter No.1 - Drain Valve
L3054	Instrument	MF Filter No.1 - Discharge Pressure
L3055	Valve	UF/MF Filter No.1 - PDT Supply Valve
L3057	Valve	MF Filter No.1 - Discharge Valve
L3058	Valve	UF/MF Filter No.1 - Backflush Valve
L3059	Valve	MF Filter No.2 - Supply Inet Valve
L3060	Insturment	MF Filter No.2 - Supply Pressure
L3061	Filter	MF Filter No.2
L3062	Valve	MF Filter No.2 - Air Scour Valve
L3063	Valve	MF Filter No.2 - Flush Valve
L3064	Valve	MF Filter No.2 - CIP Return Valve
L3065	Valve	MF Filter No.2 - Drain Valve
L3066	Instrument	MF Filter No.2 - Discharge Pressure
L3067	Valve	MF Filter No.2 - PDT Supply Valve
L3069	Valve	MF Filter No.2 - Discharge Valve
L3070	Valve	MF Filter No.2 - Backflush Valve
L3071	Regulator	MF Filter - Air Scour Regulator

L3072	Regulator	MF Filter - PDT Regulator
L3073	Regulator	MF Filter - Backwash Pressure Regulator No.1
L3074	Valve	MF Filter - Backwash Pressure Valve No.1
L3075	Regulator	MF Filter - Backwash Pressure Regulator No.2
L3076	Valve	MF Filter - Backwash Pressure Valve No.2
L3077	Valve	MF Filter Backflush - Tank Drain/Pressurise Valve
L3078	Vessel	MF Filter Backflush - Tank
L3079	Instrument	MF Filter Backflush - Tank Pressure
L3080	Valve	MF Filter Backflush - Tank Pressure Relief Valve
L3081	Instrument	MF Filter Backflush - Tank Level Switch
L3082	Valve	MF Filter Backflush - CIP Supply Valve
L3083	Instrument	MF Filter - Discharge Ozone Concentration
L3084	Valve	MF Filter - Discharge Sample Valve
L3085	Valve	MF Filter - Sample Supply Isolation Valve
L3086	Valve	MF Filter - Sample Return Isolation Valve
L3087	Pump	MF Filter - Sample Pump
L3088	Instrument	MF Filter - Discharge Turbidity

BAC FILTRATION		
Location	**Type**	**Description**
L3090	Vessel	BAC Filter - Tank
L3091	Instrument	BAC Filter - Hi Hi Level Switch
L3092	Instrument	BAC Filter - Hi Level Switch
L3093	Instrument	BAC Filter - Headloss
L3094	Regulator	BAC Filter - Air Scour Regulator
L3095	Valve	BAC Filter - Air Scour Supply Valve
L3096	Valve	BAC Filter - Discharge Sample Valve
L3097	Valve	BAC Filter - Flush/Feedforwards Valve
L3098	Valve	BAC Filter - Hi Flow Backwash Valve
L3099	Valve	BAC Filter - Hi Flow Backwash Rate Valve
L3100	Valve	BAC Filter - Lo Flow Backwash Rate Valve
L3101	Valve	BAC Filter - Drain Valve
L3102	Valve	BAC Filter - Sample Supply Isolation Valve
L3103	Valve	BAC Filter - Sample Return Isolation Valve
L3104	Pump	BAC Filter - Sample Pump
L3105	Instrument	BAC Filter - Discharge Turbidity

REVERSE OSMOSIS		
Location	Type	Description
L3107	Vessel	RO - Mixing Tank
L3108	Instrument	RO - Mixing Tank High Level Switch
L3109	Instrument	RO - Mixing Tank Low Level Switch
L3110	Instrument	RO - Mixing Tank Level
L3111	Instrument	RO - Supply Flow
L3112	Filter	RO - 1um PreFilter
L3113	Pump	RO - Feed Pump
L3114	Valve	RO - Feed Pump Discharge Isolation Valve
L3115	Valve	RO - CIP Supply Valve
L3116	Valve	RO - Pressure Relief Valve
L3117	Instrument	RO - Feed Pressure
L3118	Instrument	RO - PDT Membranes Empty Switch
L3119	Valve	RO - Drain Valve
L3121	Instrument	RO - Membrane No.1 Feed Conductivity
L3122	Valve	RO - Membrane No.1 Feed Sample Valve
L3123	Filter	RO - Membrane No.1
L3124	Instrument	RO - Membrane No.1 Permeate Conductivity
L3125	Valve	RO - Membrane No.1 Permeate Sample Valve
L3126	Instrument	RO - Membrane No.2 Feed Conductivity
L3127	Valve	RO - Membrane No.2 Feed Sample Valve
L3128	Filter	RO - Membrane No.2
L3129	Instrument	RO - Membrane No.2 Permeate Conductivity
L3130	Valve	RO - Membrane No.2 Permeate Sample Valve

L3131	Instrument	RO - Membrane No.3 Feed Conductivity
L3132	Valve	RO - Membrane No.3 Feed Sample Valve
L3133	Filter	RO - Membrane No.3
L3134	Instrument	RO - Membrane No.3 Permeate Conductivity
L3135	Valve	RO - Membrane No.3 Permeate Sample Valve
L3136	Instrument	RO - Membrane No.4 Feed Conductivity Monitor
L3137	Valve	RO - Membrane No.4 Feed Sample Valve
L3138	Filter	RO - Membrane No.4
L3139	Instrument	RO - Membrane No.4 Permeate Conductivity
L3140	Valve	RO - Membrane No.4 Permeate Sample Valve
L3141	Instrument	RO - Membrane No.5 Feed Conductivity
L3142	Valve	RO - Membrane No.5 Feed Sample Valve
L3143	Filter	RO - Membrane No.5
L3144	Instrument	RO - Membrane No.5 Permeate Conductivity
L3145	Valve	RO - Membrane No.5 Permeate Sample Valve
L3146	Instrument	RO - Membrane No.5 Concentrate Conductivity
L3147	Valve	RO - Membrane No.5 Concentrate Sample Valve
L3269	Instrument	RO - PDT Pressure Transmitter
L3270	Instrument	RO - Concentrate Conductivity
L3271	Instrument	RO - Permeate Conductivity
L3148	Valve	RO - CIP Return Valve
L3149	Valve	RO - Back Pressure Control Valve
L3150	Instrument	RO - Concentrate Flow
L3151	Valve	RO - Conductivity Control Valve
L3152	Instrument	RO - Permeate Pressure
L3153	Instrument	RO - Permeate Flow

L3154	Instrument	RO - Combined Permeate Conductivity
L3273	Instrument	RO - Brine Flow
L3155	Valve	RO - Combined Permeate Sample Valve
L3156	Type	RO - Permeate to Storage/Feed Forwards Selector Valve
L3157	Valve	RO - PDT Regulator
L3158	Regulator	RO - PDT Supply Valve
L3159	Valve	RO - PDT Nonreturn Valve
L3161	Valve	RO - Membrane Flush Valve
L3162	Valve	RO - Permeate Tank
L3163	Vessel	RO - Permeate Tank Level

UV TREATMENT		
Location	**Type**	**Description**
L3165	Instrument	UV - Transmissivity
L3166	Instrument	UV - Reactor No.1
L3167	Vessel	UV - Reactor No.1 Intensity
L3168	Instrument	UV - Reactor No.1 Temperature
L3169	Instrument	UV - Reactor No.1 Discharge Sample Valve
L3170	Valve	UV - Reactor No.2
L3171	Vessel	UV - Reactor No.2 Intensity
L3172	Instrument	UV - Reactor No.2 Temperature
L3173	Instrument	UV - Reactor No.2 Discharge Sample Valve

CALCITE FILTRATION		
Location	**Type**	**Description**
L3179	Vessel	Calcite - Filter

CHLORINATION		
Location	**Type**	**Description**
L3181	Instrument	Cl - Feed Water Temperature
L3182	Valve	Cl - Feed Water Sample Valve
L3183	Mixer	Cl - Static Mixer
L3184	Valve	Cl - Sample Supply Isolation Valve
L3185	Valve	Cl - Sample Return Isolation Valve
L3186	Pump	Cl - Sample Pump
L3187	Instrument	Cl - Chlorine Concentration
L3188	Instrument	Cl - pH
L3189	Valve	Cl - Chlorinated Water Sample Valve
L3190	Valve	Cl - Water to Drain or Contact Tanks Selector Valve
L3192	Valve	Cl - Contact Tank Feed Selector Valve
L3193	Vessel	CL - Contact Tank No.1
L3194	Instrument	CL - Contact Tank No.1 Level
L3195	Valve	Cl - Contact Tank No.1 Sample Supply Isolation Valve
L3196	Valve	Cl - Contact Tank No.1 Sample Return Isolation Valve
L3197	Pump	Cl - Contact Tank No.1 Sample Pump
L3198	Instrument	Cl - Contact Tank No.1 Chlorine Concentration
L3199	Valve	CL - Contact Tank No.1 Sample Valve
L3200	Vessel	CL - Contact Tank No.2
L3201	Instrument	CL - Contact Tank No.2 Level
L3202	Valve	Cl - Contact Tank No.2 Sample Supply Isolation Valve
L3203	Valve	Cl - Contact Tank No.2 Sample Return Isolation Valve
L3204	Pump	Cl - Contact Tank No.2 Sample Pump

L3205	Instrument	Cl - Contact Tank No.2 Chlorine Concentration
L3275	Instrument	Cl - Chlorine Concentration Analyser
L3206	Valve	CL - Contact Tank No.2 Sample Valve
L3207	Valve	Cl - Contact Tank Discharge Selector Valve
L3208	Pump	Cl - Contact Tank Discharge Pump
L3209	Valve	Cl - Destination Selector Valve

CIP SYSTEM		
Location	**Type**	**Description**
L3213	Vessel	CIP - Tank
L3214	Heater	CIP - Tank Heater
L3215	Instrument	CIP - Tank Temperature
L3216	Instrument	CIP - Tank Level
L3217	Instrument	CIP - Tank Hi Level
L3218	Instrument	CIP - pH
L3219	Valve	CIP - Tank Sample Valve
L3220	Instrument	CIP - Conductivity
L3274	Instrument	CIP - Chemical Status
L3221	Instrument	CIP - Flow
L3222	Pump	ClP - Circulation Pump
	Instrument	CIP - Circulation Loop Pressure
L3224	Valve	CIP - Re Circulation Loop Valve
L3225	Valve	CIP - Re Circulation Loop Pressure Relief Valve
L3226	Valve	CIP - Destination Selector Valve
L3227	Valve	CIP - Station Water Supply Valve

L3228	Valve	CIP - Permeate Supply Valve

COMPRESSED AIR		
Location	**Type**	**Description**
L3230	Pump	Air - 10 Bar Air Compressor
L3231	Vessel	Air - Plant Air Receiver
L3232	Valve	Air - Plant Air Receiver Pressure Relief Valve
L3233	Valve	Air - Plant Air Isolation Valve
L3234	Regulator	Air - Instrument Air Regulator

CHEMICAL DOSING AND DRAINAGE		
Location	**Type**	**Description**
L3236	Pump	Dosing - Caustic to CIP Pump
L3237	Instrument	Dosing - Caustic Drum Empty
L3238	Pump	Dosing - Acid to CIP Pump
L3239	Instrument	Dosing - Acid Drum Empty
L3240	Pump	Dosing - MSBS to CIP Pump
L3241	Instrument	Dosing - MSBS Drum Empty
L3242	Pump	Dosing - Chlorine to Chlorine System Pump
L3243	Instrument	Dosing - Chlorine Drum Empty
L3244	Pump	Dosing - Anti-scalant to RO System Pump
L3245	Instrument	Dosing - Anti-scalant Drum Empty
L3278	Vessel	Drainage - Drain Tank
L3279	Pump	Drainage - Drain Tank Discharge Pump
L3280	Instrument	Drainage - Drain Tank Level Switch

L3281	Instrument	Support - Ozone/UF EStop
L3282	Instrument	Support - RO EStop
L3283	Instrument	Support - CIP EStop
L3284	Instrument	Support - UV/Chlorine EStop
L3285	Instrument	Support - General EStop

Appendix B - HMI Screens

Appendix C – Material and Safety Data Sheets

Appendix D - SWIs

Appendix E – Functional Descriptions

Davis Advanced Water Treatment Plant – Overall Control System

FUNCTIONAL DESCRIPTION

AUTHORS			
Author		**Institution**	
Michael Packer		Australian Antarctic Division	
VERSION CONTROL REVISION HISTORY			
Version	**Date revised**	**Section Revised**	**Revision**
1.0	21/3/2014	NA	First Draft – Packer
APPROVAL			
Version	**Date Approved**	**Person Approving**	

Table of Contents

PURPOSE

This Functional Requirements Specification details the operation of the Overall Control (OA) System that manages the overall control of the Davis Advanced Waste Water Treatment Plant (Davis AWWTP). It includes a full description of the modes of operation plus the system interlocks and alarms. All the PLC and SCADA programming done for this system will be executed according to this document.

SCOPE

This Functional Requirements Specification applies to the operation of the OA System and associated equipment.

The equipment associated with the OA System includes all equipment listed in section 0 of this document.

The operation of the OA System will be completely automated in line with the expectations of the project to make a system that required minimal or no operator input and also to increase the safety and consistency of the system.

The Davis AWWTP has a dedicated Alan Bradley ControlLogix 5000 PLC and this will be used to control the OA System. The Davis AWWTP also has a dedicated Citect SCADA system which will be used as an interface to monitor and control the system.

DEFINITIONS

PC	Personal Computer
SCADA	Supervisory Control and Data Acquisition
MCC	Motor Control Centre
Historical Trends	A Historical Trend is a series of measurements taken at a regular interval of a field based variable.
User	A user is an individual who is using a system or piece of equipment
AWWP	Advanced Waste Water Treatment Plant, a treatment plant that process water to a very high standard.

REFERENCES

	Title	*Reference*
1	*Davis AWTP P&ID – Ozone and Backwash*	*27/13/07 Sheet 1 of 4*
2	*Davis AWTP P&ID – MF and BAC*	*27/13/07 Sheet 2 of 4*
3	*Davis AWTP P&ID – RO*	*27/13/07 Sheet 3 of 4*
4	*Davis AWTP P&ID – UV, Calcite and Chlorine*	*27/13/07 Sheet 4 of 4*
5	*Davis AWTP – Functional Description*	
6	*Davis AWTP – MF Functional Description*	
7	*Davis AWTP – MF Cleaning Functional Description*	
8	*Davis AWTP – BAC Functional Description*	
9	*Davis AWTP – RO Functional Description*	
10	*Davis AWTP – UV Functional Description*	
11	*Davis AWTP – CL Functional Description*	
12	*Davis AWTP – CIP Functional Description*	
13	*Davis AWTP – Citect Users Manual*	
14	*Davis AWTP – Operator Manual*	

MATERIALS AND EQUIPMENT

SCADA

The Citect SCADA system provides operators with control over, and feedback from, the OA System. The OA System will be displayed on a number of graphics pages in the Davis AWWTP project of the AAD SCADA system. The Citect system will also provide alarming, trending and reporting functionality for the OA System.

PLC

The dedicated Davis AWWT ControlLogix 5000 system will be used to control the OA System. This PLC is located in the Electrical Control Panel for the Davis AWWTP and is linked via Ethernet to the Davis Intranet.

Equipment - Instruments

Instrument ID	Description	Range
L3031	Ozone System - Feed Flow	0…50 L/min
L3032	Ozone System - Feed Pressure	0…100 °C

Equipment - Drives

Equipment ID	Description
L3030	Ozone System -Feed Pump
L3208	Cl - Contact Tank Discharge Pump

Equipment – Solenoid Valves

Note: It is assumed that all gates and diverters have position feedback.

Equipment ID	Description
L3207	Cl - Contact Tank Discharge Selector Valve
L3209	Cl - Destination Selector Valve

1.1 Equipment – Control Valves

Equipment ID	Description
	None

1.2 Equipment – PID Control Loops

Equipment ID	Description
L3030_PID	Ozone System - Feed Pump - PID Control Loop

OPERATIONAL DESCRIPTION

Overview

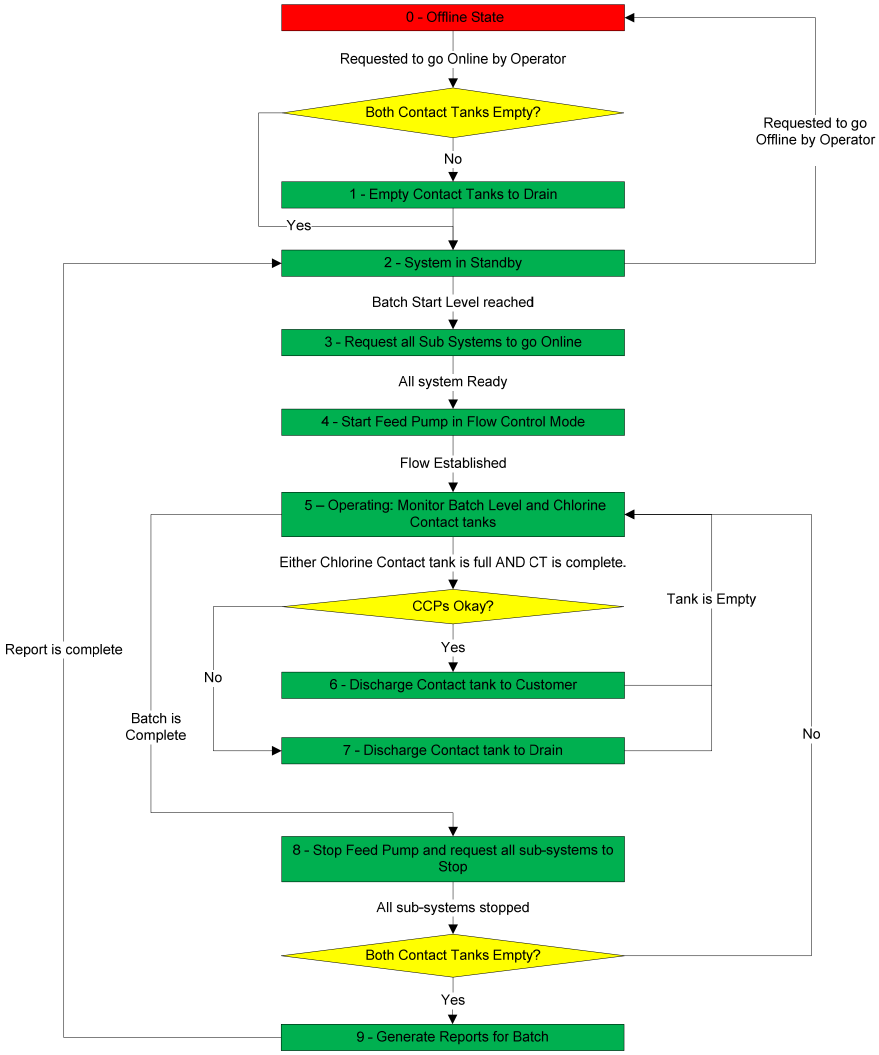
The OA System is responsible for bringing all the sub systems online when it detects that a batch of water is ready to be processed, tracking the batch through the system and shutting the sub-systems down at the end of a batch.

The OA System contains the following key components:

- Feed pump. This is the primary feed pump that delivers product water to the system. The pump is a variable speed pump and controls the flow of product water through the system to the set point specified.
- Overall monitoring and control of all sub systems. The OA System can start and stop all the sub systems. It also monitors them for failure and to ensure that the CCP values are achieved.
- Chlorine Contact Tanks Discharge system. The OA system is responsible for discharging the completed batches of water in the Chlorine Contact Tanks to either the drain or the storage tanks depending on whether the CCP have all achieved their minimum values during the batch.

The OA System starts and stops all the associated equipment. This sequence will also monitor all alarms and interlocks to ensure that the system is always operating safely and within the design parameters.

OA System - Sequence



OA System - Set Points

Maximum Headloss

This is the headloss in the Filter that will trigger a OAkwash at the end of the current batch.

Default Value: 75 mBar.

Range: 0 – 100 mBar

Maximum Turbidity

This is the Maximum Turbidity of the filtered water that will trigger a OAkwash at the end of the current batch.

Default Value: 5 NTU.

Range: 0 – 10 NTU

1.2.1 *Filtrate Turbidity*

This is the Turbidity value that the filtered water must achieve before it is allowed to flow forwards to the RO System.

Default Value: 3 NTU.

Range: 0 – 10 NTU

1.2.2 *Air Scour Time*

This is the amount of time that the Air Scour runs for.

Default Value: 60 Seconds.

Range: 0 – 600 Seconds

1.2.3 *Low Rate OAkflush Time*

This is the amount of time that the Low Rate OAk Flush runs for.

Default Value: 60 Seconds.

Range: 0 – 600 Seconds

1.2.4 *High Rate OAkflush Time*

This is the amount of time that the High Rate OAk Flush runs for.

Default Value: 60 Seconds.

Range: 0 – 600 Seconds

OA System - Alarms

Equipment Fault

Cause: Any piece of equipment which is required by the Sequence has either been switched to the Manual Mode or has faulted. In either case the equipment is no longer available to the Sequence, therefore an Equipment fault is generated.

Check Steps: Every step except Step 0 (Offline)

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: All equipment must have any faults reset and be switched OAk to the Auto Mode. Once all equipment is available the fault can be reset by pressing the “Fault Reset/Continue” button.

1.2.5 *Plant Air Pressure Low Fault*

Cause: The system was not able to achieve the required turbidity within 5 minutes of starting up. This suggests that something is wrong with the filter media.

Check Steps: Step 4

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Determine what is causing the excess turbidity and recitfy. The fault can be reset by pressing the “Fault Reset/Continue” button.

High Turbidity – Start-up

Cause: The system was not able to achieve the required turbidity within 5 minutes of starting up. This suggests that something is wrong with the filter media.

Check Steps: Step 4

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Determine what is causing the excess turbidity and recitfy. The fault can be reset by pressing the “Fault Reset/Continue” button.

1.2.6 *OA High Level*

Cause: The system has detected that the level in the filter has reached the high level during normal operation and will overflow soon. This suggests that filter is blocked and needs immediate OAkwashing.

Check Steps: Step 5

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it. When it is reset it will trigger a OAkwash immediately.

Reset Requirements: The fault can be reset by pressing the “Fault Reset/Continue” button.

1.2.7 *OA OAkwash High Level*

Cause: The system has detected that the level in the filter has reached the high high level during a OAkwash operation and will overflow soon. This suggests that OAkwash outlet is blocked (most likely with carbon).

Check Steps: Step 7 – 9.

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Clear the blockage. The fault can be reset by pressing the “Fault Reset/Continue” button.

1.2.8 *Supply Flow Stopped (InFeed Flow)*

Cause: The system has detected that the level in the filter has reached the high high level during a OAkwash operation and will overflow soon. This suggests that OAkwash outlet is blocked (most likely with carbon).

Check Steps: Step 7 – 9.

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Clear the blockage. The fault can be reset by pressing the “Fault Reset/Continue” button.

OPERATIONAL INTERLOCKS

The following is a list of interlocks which are specific to certain pieces of equipment. Each drive can have up to eight independent interlocks and some of these interlocks can be masked under certain conditions, these conditions are listed in the “Mask” column.

Equipment Interlocks

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA
5	None	NA
6	None	NA
7	None	NA

8	None	NA

EQUIPMENT USAGE

This table details the steps of each sequence that each piece of equipment is requested to operate (run or open) in.

Equipment ID	Description	Sequence Steps
L3104	OA Filter - Sample Pump	4 – 6
L3095	OA Filter - Air Scour Supply Valve	2, 7, 8
L3097	OA Filter - Flush/Feedforwards Valve	8, 9
L3098	OA Filter - Hi Flow OAkwash Valve	9
L3101	OA Filter - Drain Valve	4, 6

PROCESS INTERFACES

Not Applicable

ASSUMPTIONS AND EXCLUSIONS

-

CONTROL SYSTEM

Manual Control

Whilst none of the automatic sequences are running any piece of equipment can be operated in the manual mode. This means that the operator will be able to change the state of any piece of equipment provided they change the equipment to Manual Mode first as per the standard operating philosophy for equipment.

Auto Control

Whilst any of the automatic sequences are running all equipment associated with those sequences must be in the automatic mode. If any piece of equipment is switched to the manual mode during operation of an automatic sequence the sequence will stop operating and generate a fault. It is the responsibility of the operator to ensure that switching equipment to manual during automatic operation will not cause damage to equipment and/or product.

Operator Notification

Where appropriate the operator will be prompted by the system to ensure that the operator is present and aware of the current stage in the process. This system will take the form of a popup asking the operator to confirm that they are aware by clicking on an “Okay” or simular button.

ALARM DEFINITION AND MANAGMENT

In addition to the standard alarms that are generated for standard pieces of equipment the following system specific alarms will be provided.

- *Equipment Interlock:* If any piece of equipment required by this process cell faults or is switched to the manual mode whilst the sequence is running the sequence will go into the fault mode. An equipment fault alarm will be generated when this occurs.

All alarms are generated within the PLC controller and displayed and logged on the SCADA system as per the Citect User Manual, the list of alarms associated with each standard piece of equipment can also be found in this document.

POWER FAILURE

When the power is restored after a power failure, the system will be reset with all sequences stopped and in the default state. However the Batch numbers, etc will be retained such that the sequences, when restarted, will start from where they left off when the power failure occurred.

Davis Advanced Water Treatment Plant – Ozonation System

FUNCTIONAL DESCRIPTION

AUTHORS	
Author	**Institution**
Michael Packer	Australian Antarctic Division

VERSION CONTROL REVISION HISTORY			
Version	**Date revised**	**Section Revised**	**Revision**
1.0	21/3/2014	NA	First Draft – Packer
1.1	10/06/2014	All	"As Built" Version
1.3	16/06/2014	All	Comments from Jianhua Zhang and Stephen Grey
1.4	11/03/2015	All	Update by M Packer
1.5	29/05/2015	6.3, 7.1 & 7.2	Added Ambient Ozone sensor and included LRV calculations.

APPROVAL		
Version	**Date Approved**	**Person Approving**

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PURPOSE

This Functional Requirements Specification details the operation of the Ozonation System that forms the First Barrier in the Davis Advanced Water Treatment Plant (Davis AWTP) and the Second Barrier in the complete system (which includes the Davis Secondary Level MBR WWTP that will supply water to the Davis AWTP). It includes a full description of the modes of operation plus the system interlocks and alarms. All the PLC and SCADA programming done for this system will be executed according to this document.

SCOPE

This Functional Requirements Specification applies to the operation of the Ozonation System and associated equipment.

The equipment associated with the Ozonation System includes all equipment listed in section 0 of this document.

The operation of the Ozonation System will be completely automated in line with the expectations of the project to make a system that required minimal or no operator input and also to increase the safety and consistency of the product.

The Davis AWTP has a dedicated Alan Bradley ControlLogix 5000 PLC and this will be used to control the Ozonation System. The Davis AWTP also has a dedicated Citect SCADA system which will be used as an interface to monitor and control the system.

DEFINITIONS

PC	Personal Computer
SCADA	Supervisory Control and Data Acquisition
MCC	Motor Control Centre
Historical Trends	A Historical Trend is a series of measurements taken at a regular interval of a field based variable.
User	A user is an individual who is using a system or piece of equipment
AWTP	Advanced Water Treatment Plant, a treatment plant that process water to a very high standard.

REFERENCES

	Title	Reference
1	*Davis AWTP P&ID – Ozone and Backwash*	*27/13/07 Sheet 1 of 4*
2	*Davis AWTP P&ID – MF and BAC*	*27/13/07 Sheet 2 of 4*
3	*Davis AWTP P&ID – RO*	*27/13/07 Sheet 3 of 4*
4	*Davis AWTP P&ID – UV, Calcite and Chlorine*	*27/13/07 Sheet 4 of 4*
5	*Davis AWTP – Functional Description*	
6	*Davis AWTP – MF Functional Description*	
7	*Davis AWTP – MF Cleaning Functional Description*	
8	*Davis AWTP – BAC Functional Description*	
9	*Davis AWTP – RO Functional Description*	
10	*Davis AWTP – UV Functional Description*	
11	*Davis AWTP – CL Functional Description*	
12	*Davis AWTP – CIP Functional Description*	
13	*Davis AWTP – Citect Users Manual*	
14	*Davis AWTP – Operator Manual*	

MATERIALS AND EQUIPMENT

SCADA

The Citect SCADA system provides operators with control over, and feedback from, the Ozonation System. The Ozonation System will be displayed on a number of graphics pages in the Davis AWTP project of the AAD SCADA system. The Citect system will also provide alarming, trending and reporting functionality for the Ozonation System.

PLC

The dedicated Davis AWWT ControlLogix 5000 system will be used to control the Ozonation System. This PLC is located in the Electrical Control Panel for the Davis AWTP and is linked via Ethernet to the Davis Intranet.

Equipment - Instruments

Instrument ID	Description	Range
L3031	Ozone System - Feed Flow	0.2...50 l/min
L3032	Ozone System - Feed Pressure	-1.00...10.00 bar
L3033	Ozone System - Feed Temperature	-50...150 °C
L3041	Ozone System - Circulation Ozone Concentration	0 - 50 mg/Lt
L3045	Ozone System - Discharge Ozone Concentration	0 - 50 mg/Lt
L3265	Ozone System - Ozone In Gas Concentration	0 - 50 mg/Lt
L3267	Ozone System - Ozone in Air Concentration Alarm	0 - 1 ppm
L3266	Ozone System - Ozone Gas Pressure Switch	On/Off

Equipment - Drives

Equipment ID	Description
L3038	Ozone System - Circulation Pump
L3042	Ozone System - Ozone Generator
L3043	Ozone System – Oxygen Generator

Equipment – Solenoid Valves

Note: It is assumed that all Valves have position feedback.

Equipment ID	Description
Lxxx6	Ozone System – Ozone Supply Valve

1.3 Equipment – Control Valves

Equipment ID	Description
	None

1.4 Equipment – PID Control Loops

Equipment ID	Description
L3042_PID	Ozone System - Ozone Generator - PID Control Loop

OPERATIONAL DESCRIPTION

Overview

The Ozonation System is responsible for injecting ozone into the treated water and maintaining the ozone level in the water as it flows through the Contact Tank.

The Ozonation System contains the following key components:

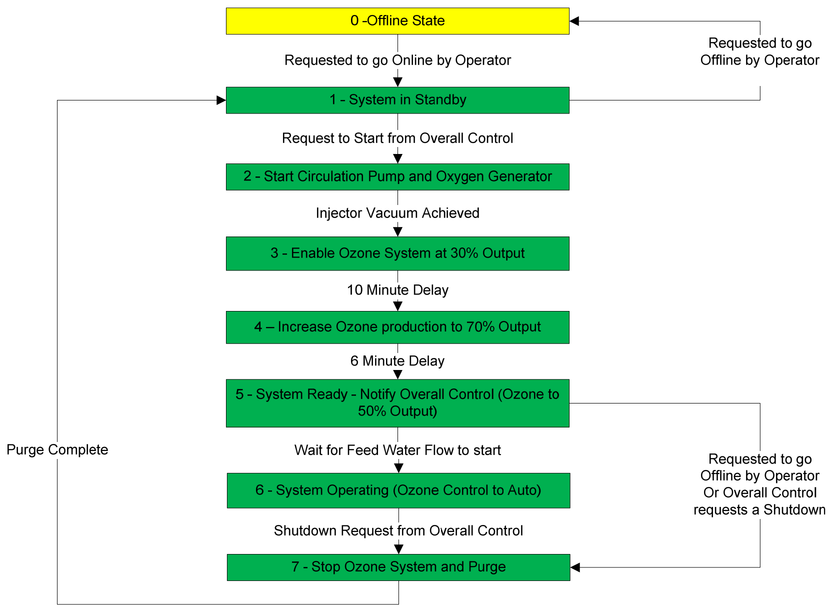
- Oxygen Generator (L3043) which separates oxygen from air through a Pressure Swing

Absorption (PSA) process. This unit generates a continuous supply of dry and clean oxygen gas which is delivered to the Ozone Generator.

- Ozone Generator (L3042) takes the oxygen gas and applies a high voltage to it to create ozone gas. Ozone is an unstable, pale blue gas that is a powerful oxidising agent which is highly effective at destroying pathogens and breaking down complex molecules. It is dangerous to humans at high concentrations (>100ppb) and caution must be exercised when working around it (refer to the MSDS for Ozone). The ozone gas from the generator is injected into the product water.
- Circulation Pump (L3038) and Ozone Injector (L3039). The high pressure circulation pump forces the process water through a venturi injection system that draws the ozone gas from the Ozone Generator into the water and disperses into solution in the product water.
- Contact Tank (L3034). The product water is continuously circulated through the Contact Tank to allow sufficient time for the dissolved Ozone gas to mix well through the entire contents of the tank and to kill pathogens and oxidise chemicals to the desired level. The tank is specially designed with an internal baffle that ensures all the water circulating through it remains in contact with the ozone for a minimum time.
- Process Instruments. There are several instruments in the system that measure various parameters. The most important of these is the Ozone Residual Instrument that measures the concentration of the ozone both in the circulation loop and the discharge line from the Contact Tank. The values from these instruments are used to control the amount of ozone that is generated and injected into the product water.
- The system includes an ambient ozone detection system which monitors for the presence of ozone gas in the local environment and will shut down the system if an excessive level is detected. This is a safety system for the protection of operators.

The Ozonation System starts and stops all the associated equipment based on the sequence detailed in Section 0 and Section 0. This sequence will also monitor all alarms and interlocks to ensure that the system is always operating safely and within the design parameters.

Ozonation System - Sequence



Ozonation System – Sequence Notes

Startup and Running Ozone Concentration Control

Whilst the Sequence is in Circulation Mode (Step 5) and prior to the Product Water flow starting, the Ozone Generator is run at 50% output to maintain an ozone presence in the system. Once the Product Water flow starts and the sequence moves to the Normal Operation mode (Step 6) the concentration is controlled to the *Normal Operation Ozone Concentration* setpoint (see Section 0) using the *Discharge Ozone Concentration* (L3045) instrument. The discharge instrument is not used during startup as there is no flow through the system (only internal circulation), hence no ozone will be present at this instrument. The output of the Ozone Generator during normal operation is calculated based on the inlet flow to the plant as follows:

$$Ozone\ Output\ (\%) = \frac{Water\ Flow\ \left({}^{lt}/_{min}\right) * Ozone\ Consumption\ Rate\ \left(\frac{Nmg}{lt}\right)}{Ozone\ Production_{Max}\left(\frac{Nmg}{min}\right)}$$

This value is trimmed (max 10%) by the PID Control loop (*L3042_PID*) output to adjust for variations in feed water quality.

LRV Calculation - Virus

Whilst the System is operating the LRV for virus is calculate as follows:

$$LRV_{Virus} = 11.3938 \times 1.0726^{Temperature} \times Ozone\ Residual$$

IF this calculation results in a value less than 2.0 then:

$$LRV = 2.0$$

LRV Calculation - Bacteria

Whilst the System is operating the LRV for bacteria is the same value as that of Virus.

LRV Calculation - Protozoa

No credits are claimed for Protozoa, therefore the value for Protozoa is 0.0.

EQUIPMENT USAGE

This table details the steps of each sequence that each piece of equipment is requested to operate (run or open) in.

Equipment ID	Description	Sequence Steps								
		0 (Offline)	1	2	3	4	5	6	7	100 (Fault)
L3038	Ozone System - Circulation Pump	Stopped	Stopped	Running	Running	Running	Running	Running	Running	Stopped
L3042	Ozone System - Ozone Generator	Stopped	Stopped	Stopped	Running @ 30%	Running @ 70%	Running @50%	Running	Stopped	Stopped
L3043	Ozone System – Oxygen Generator	Stopped	Running	Running	Running	Running	Running	Running	Running	Stopped
L3042_PID	Ozone System - Ozone Generator - PID Control Loop	Manual Output at 0%	Manual Output at 0%	Manual Output at 0%	Manual Output at 0%	Manual Output at 0%	Manual Output at 0%	Auto	Manual Output at 0%	Manual Output at 0%
Lxxx6	Ozone System – Ozone Supply Valve	Closed	Open	Open	Open	Open	Open	Open	Open	Closed

Ozonation System - Set Points

Normal Operation Ozone Concentration

This is the Ozone Concentration at the outlet of the Contact Tank that the system attempts to maintain during normal operation when Product Water is being feed forwards to the MF Filter.

Default Value: 0.5mg/L

Range: 0 – 5mg/L

Approximate Ozone Consumption Rate

This is the approximate consumption rate of Ozone by the Feed Water in mg/L. It is used to calculate the required output of the Ozone Generator. This value must be entered based on the quality of the feed water.

Default Value: 13mg/L

Range: 0 – 50mg/L

Ozonation System - Alarms

Equipment Fault

Cause: Any piece of equipment which is required by the Sequence has either been switched to the Manual Mode or has faulted. In either case the equipment is no longer available to the Sequence, therefore an Equipment fault is generated.

Check Steps: Every step except Step 0 (Offline)

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: All equipment must have any faults reset and be switched back to the Auto Mode. Call Maintenance if required. Once all equipment is available the fault can be reset by pressing the "Fault Reset/Continue" button. When this fault is reset the sequence will go to Step 0 and restart the Ozonation Sequence from the start. This is done as the ozone concentration in the Contact Tank may have dropped below the minimum requirements whilst the system has been in fault.

Low Ozone Concentration – Operation

Cause: The system was not able to achieve the ozone discharge concentration setpoint during normal operation. This suggests that either something has failed in the Ozone generation system or that the quality of the incoming water is so poor that the Ozonation system cannot deliver sufficient ozone for effective disinfection to occur.

Check Steps: Step 6

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Determine why the Ozonation System is not producing sufficient ozone to achieve the setpoint and rectify. Call Maintenance if required. The fault can be reset by pressing the “Fault Reset/Continue” button. When this fault is reset the sequence will go to Step 0 and restart the Ozonation Sequence from the start. This is done as the ozone concentration in the Contact Tank may have dropped below the minimum requirements whilst the system has been in fault.

Low Ozone Production Detected

Cause: The system has detected the quantity of Ozone in the Gas has dropped to an unacceptable low level indicating there is a problem with the Ozone or Oxygen Generator.

Check Steps: Step 3 - 6

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Determine why the Ozone Generator is producing such a low percentage of Ozone and rectify. Call Maintenance if required. The fault can be reset by pressing the “Fault Reset/Continue” button. When this fault is reset the sequence will go to Step 0 and restart the Ozonation Sequence from the start. This is done as the ozone concentration in the Contact Tank may have dropped below the minimum requirements whilst the system has been in fault.

Ozone Leak Detected

Cause: The system has detected an excessive level of ozone in the atmosphere around the Ozonation System indicating that there is an Ozone gas leak in the system somewhere.

Check Steps: All steps

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Determine where the Ozone is leaking out of the system and repair. Call Maintenance if required. The fault can be reset by pressing the “Fault Reset/Continue” button. When this fault is reset the sequence will go to Step 0 and restart the Ozonation Sequence from the start. This is done as the ozone concentration in the Contact Tank may have dropped below the minimum requirements whilst the system has been in fault.

Inductor Vacuum Failure

Cause: The system has detected that insufficient vacuum is being generated by the Ozone Inductor. This may indicate either a failure of the inductor or the flow through the inductor may be insufficient to generate a vacuum.

Check Steps: Step 3 - 7

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Determine why the Inductor is not generating a vacuum and repair. Call Maintenance if required. The fault can be reset by pressing the “Fault Reset/Continue” button. When this fault is reset the sequence will go to Step 0 and restart the Ozonation Sequence from the start. This is done as the ozone concentration in the Contact Tank may have dropped below the minimum requirements whilst the system has been in fault.

OPERATIONAL INTERLOCKS

The following is a list of interlocks which are specific to certain pieces of equipment. Each drive can have up to eight independent interlocks and some of these interlocks can be masked under certain conditions, these conditions are listed in the “Mask” column.

Equipment Interlocks

L3038 Ozone System - Circulation Pump

Interlock	Description	Mask
1	L3267 - Ozone System - Ozone in Air Concentration – Hi Hi Alarm	NA
2	L3032 - Ozone System - Feed Pressure – Hi Hi Alarm	NA
3	None	NA
4	None	NA
5	None	NA
6	None	NA
7	None	NA
8	None	NA

L3042 Ozone System - Ozone Generator

Interlock	Description	Mask
1	L3267 - Ozone System - Ozone in Air Concentration – Hi Hi Alarm	NA
2	L3032 - Ozone System - Feed Pressure – Hi Hi Alarm	NA
3	L3038 – Ozone System – Circulation Pump – NOT Running	Auto Mode
4	Lxxx6 – Ozone System – Ozone Supply Valve – NOT Open	Auto Mode
5	L3266 - Ozone System - Ozone Gas Pressure Switch – No Vacuum	Auto Mode
6	L3043 – Ozone System – Oxygen Generator – NOT Running	Auto Mode
7	None	NA
8	None	NA

L3043 Ozone System – Oxygen Generator

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA
5	None	NA
6	None	NA

7	None	NA
8	None	NA

Lxxx6 Ozone System – Ozone Supply Valve

Interlock	Description	Mask
1	L3266 - Ozone System - Ozone Gas Pressure Switch – No Vacuum	Auto Mode
2	None	NA
3	None	NA
4	None	NA

PROCESS INTERFACES

Not Applicable

ASSUMPTIONS AND EXCLUSIONS

-

CONTROL SYSTEM

Manual Control

Whilst none of the automatic sequences are running any piece of equipment can be operated in the manual mode. This means that the operator will be able to change the state of any piece of equipment provided they change the equipment to Manual Mode first as per the standard operating philosophy for equipment.

Auto Control

Whilst any of the automatic sequences are running all equipment associated with those sequences must be in the automatic mode. If any piece of equipment is switched to manual mode during operation of an automatic sequence the sequence will stop operating and generate a fault. It is the responsibility of the operator to ensure that switching equipment to manual during automatic operation will not cause damage to equipment and/or product.

Operator Notification

Where appropriate the operator will be prompted by the system to ensure that the operator is present and aware of the current stage in the process. This system will take the form of a popup asking the operator to confirm that they are aware by clicking on an “Okay” or simular button.

ALARM DEFINITION AND MANAGMENT

In addition to the standard alarms that are generated for standard pieces of equipment the following system specific alarms will be provided.

- *Equipment Interlock:* If any piece of equipment required by this process cell faults or is switched to the manual mode whilst the sequence is running the sequence will go into the fault mode. An equipment fault alarm will be generated when this occurs.

All alarms are generated within the PLC controller and displayed and logged on the SCADA system as per the Citect User Manual, the list of alarms associated with each standard piece of equipment can also be found in this document.

POWER FAILURE

When the power is restored after a power failure, the system will be reset with all sequences stopped and in the default state. However the Batch numbers, etc will be retained such that the sequences, when restarted, will start, where possible from where they left off when the power failure occurred.

Davis Advanced Water Treatment Plant – MF Filter System

FUNCTIONAL DESCRIPTION

AUTHORS	
Author	**Institution**
Michael Packer	Australian Antarctic Division

VERSION CONTROL REVISION HISTORY			
Version	**Date revised**	**Section Revised**	**Revision**
1.0	23/3/2014	NA	First Draft – Packer
1.1	13/09/2014	All	"As Built" version
1.2	15/10/2014	7.2.1 Sequence Notes	Added PDT calculation
1.3	5/03/2015	Sequence, Setpoints and Alarms	Added Leak Test to Sequence
1.4	26/04/2015	Equipment & Interlocks	Added Turbidity Sample No Flow Switch, Interlock and LRVs

APPROVAL		
Version	**Date Approved**	**Person Approving**

Table of Contents

PURPOSE

This Functional Description details the operation of the Ceramic Micro Filtration (MF) System that forms the Second Barrier in the Davis Advanced Water Treatment Plant (Davis AWTP) and the Third Barrier in the complete system (which includes the Davis Secondary Level MBR WWTP that will supply water to the Davis AWTP). It includes a full description of the modes of operation plus the system interlocks and alarms. All the PLC and SCADA programming done for this system will be executed according to this document.

SCOPE

This Functional Description applies to the operation of the MF System and associated equipment.

The equipment associated with the MF System includes all equipment listed in section 0 of this document.

The operation of the MF System will be completely automated in line with the expectations of the project to make a system that requires minimal or no operator input and also to increase the purity and consistency of the product water.

The Davis AWTP has a dedicated Alan Bradley ControlLogix 5000 PLC and this will be used to control the MF System. The Davis AWTP also has a dedicated Citect SCADA system which will be used as an interface to monitor and control the system.

DEFINITIONS

PC	Personal Computer
SCADA	Supervisory Control and Data Acquisition
Historical Trends	A Historical Trend is a series of measurements taken at a regular interval of a field based variable.
User	A user is an individual who is using a system or piece of equipment
AWTP	Advanced Water Treatment Plant, a treatment plant that process water to a very high standard.

REFERENCES

	Title	Reference
1	Davis AWTP P&ID – Ozone and Backwash	27/13/07 Sheet 1 of 4
2	Davis AWTP P&ID – MF and BAC	27/13/07 Sheet 2 of 4
3	Davis AWTP P&ID – RO	27/13/07 Sheet 3 of 4
4	Davis AWTP P&ID – UV, Calcite and Chlorine	27/13/07 Sheet 4 of 4
5	Davis AWTP – Functional Description	
6	Davis AWTP – MF Functional Description	
7	Davis AWTP – MF Cleaning Functional Description	
8	Davis AWTP – BAC Functional Description	
9	Davis AWTP – RO Functional Description	
10	Davis AWTP – UV Functional Description	
11	Davis AWTP – CL Functional Description	
12	Davis AWTP – CIP Functional Description	
13	Davis AWTP – Citect Users Manual	
14	Davis AWTP – Operator Manual	

MATERIALS AND EQUIPMENT

SCADA

The Citect SCADA system provides operators with control over, and feedback from, the MF System. The MF System will be displayed on a number of graphics pages in the Davis AWTP project of the AAD SCADA system. The Citect system will also provide alarming, trending and reporting functionality for the MF System.

PLC

The dedicated Davis AWWT ControlLogix 5000 system will be used to control the MF System. This PLC is located in the Electrical Control Panel for the Davis AWTP and is linked via Ethernet to the Davis Intranet.

Equipment - Instruments

Instrument ID	Description	Range
L3032	MF System - Feed Pressure	-1.00...10.00 bar
L3054	MF Filter No.1 - Discharge Pressure	-1.00...10.00 bar
L3066	MF Filter No.2 - Discharge Pressure	-1.00...10.00 bar
L3079	MF Filter Backflush - Tank Pressure	-1.00...10.00 bar
L3081	MF Filter Backflush - Tank Level Switch	2 levels, On/Off
L3083	MF Filter - Discharge MF Concentration	0 - 5 mg/Lt
Lxxx1	MF Filter – Turbidity Sample No Flow Switch	On/Off
L3088	MF Filter - Discharge Turbidity	0 – 5 NTU

Equipment - Drives

Equipment ID	Description
L3087	MF Filter - Sample Pump

Equipment – Solenoid Valves

Note: It is assumed that all gates and diverters have position feedback.

Equipment ID	Description
L3047	MF Filter No.1 - Supply Inlet Valve
L3050	MF Filter No.1 - Air Scour Valve
L3051	MF Filter No.1 - Flush Valve
L3052	MF Filter No.1 - CIP Return Valve
L3053	MF Filter No.1 - Drain Valve
L3055	MF Filter No.1 - PDT Supply Valve
L3057	MF Filter No.1 - Discharge Valve
L3058	MF Filter No.1 - Backflush Valve
L3059	MF Filter No.2 - Supply Inlet Valve
L3062	MF Filter No.2 - Air Scour Valve
L3063	MF Filter No.2 - Flush Valve
L3064	MF Filter No.2 - CIP Return Valve
L3065	MF Filter No.2 - Drain Valve
L3067	MF Filter No.2 - PDT Supply Valve
L3069	MF Filter No.2 - Discharge Valve
L3070	MF Filter No.2 - Backflush Valve
L3074	MF Filter - Backwash Pressure Valve No.1
L3076	MF Filter - Backwash Pressure Valve No.2
L3077	MF Filter Backflush - Tank Drain/Pressurise Valve
L3082	MF Filter Backflush - CIP Supply Valve

Equipment – Control Valves

Equipment ID	Description
	None

Equipment – PID Control Loops

Equipment ID	Description
	None

OPERATIONAL DESCRIPTION

Overview

The MF System is responsible for filtering the process water through the Ceramic Membranes and monitoring the condition of each membrane.

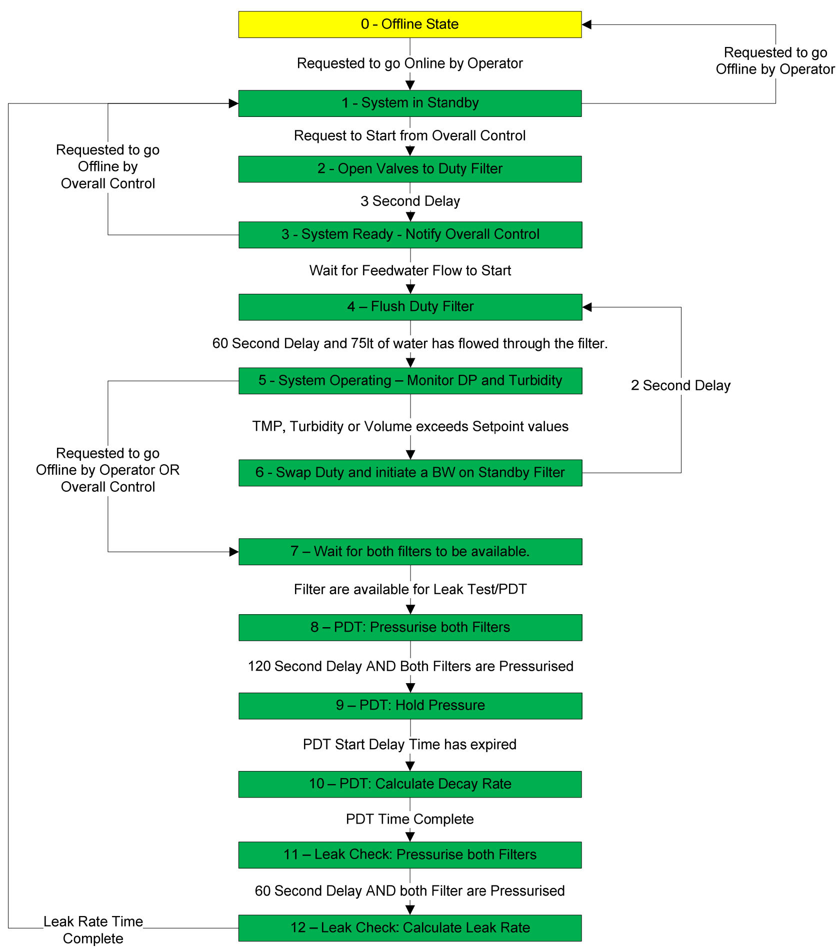
The MF System contains the following key components:

- Two ceramic membrane filters which separate suspended solids out of the Process Water by physical separation. The filters operate in "Dead End" mode whereby there is no cross flow across the membranes, all the supplied Process Water is filtered through the membranes. The membranes have a pore size of 0.1µm, any suspended particles larger than this will be retained on the surface of the filter.
- Having two filters allows for the system to run continuously in a Duty/Standby configuration where only one filter is being used at any given time. The valves in the system are setup to allow for a change over between filters without impacting on the Process Water flow.
- Once the Duty filter becomes sufficiently fouled (based on TMP and/or processed volume) the system will switch the flow over to Standby filter and initiate a cleaning cycle on the other filter to restore its membrane function. Refer to the *MF Cleaning Functional Description* for details on how the cleaning system works.
- Ceramic Filters have been selected over more traditional polymeric filters as they are much more robust and require far less maintenance. They are also highly resistant to chemical attack and research indicated that there is a catalytic effect that occurs on their surface which is created by the Ozone/Ceramic interaction.
- Pressure Decay Test (PDT) system: To confirm that the integrity of the membranes is maintained the PDT system can pressurise the permeate side of the membranes and measure how quickly the pressure decays. If there are no cracks, etc in the membranes then the air can only escape by permeating through the membrane which is a slow process that is limited by the pore size and surface tension effect. Consequently if this rate is below a predetermined value the membranes are deemed to be intact. After a PDT is conducted a leak test is also conducted with all the valves closed. This allows a more accurate PDT value to be calculated and also provides an indication of leaking valves in the system.
- Process Instruments. There are several instruments in the system that measure various parameters. The most important of these are the permeate Turbidity Analyser and the

Trans Membrane Pressure (TMP) sensors that measure the performance of the filters and the degree to which they are fouled. These values. along with the amount of Process Water that has been processed by each filter, is used to initiate a change over to the Standby filter and a cleaning cycle to start.

The MF System starts and stops all the equipment associated with the Ceramic Filters. This sequence will also monitor all alarms and interlocks to ensure that the system is always operating safely and within the design parameters.

Sequence - MF System



MF System – Sequence Notes

Flush Volume

The flush volume in Step 4 is calculated based on the actual flow through the Ozonation system.

Pressure Decay Test

- The PDT Calculation is based on the following formula:

$$PDT\ Rate = \left[\frac{PDT\ Pressure_{Start} - PDT\ Pressure_{Stop}}{Decay\ Time}\right] - Leak\ Rate$$

- The PDT calculation is delayed for a period of time after the filter stops being pressurised. This is done to allow for the non-linear decay of the pressure that occurs in the early part of the test to be ignored. The PDT Start Pressure is recorded at this point.
- The TMP is calculated based on the difference between the feed pressure to the Ozone System (L3032) and the respective filtrate side pressure transmitter (L3054 or L3066).
- The Leak Rate is calculated based on the following formula:

$$Leak\ Rate = \frac{Pressure_{Start} - Pressure_{Stop}}{Decay\ Time}$$

The Leak test is conducted after the PDT with all the valves closed and the value is used to correct the PDT Rate.

LRV – Virus

If the Leak Decay Rate is less than 1.37kPa/min then the credible LRV for virus is 1.0

LRV – Bacteria

As above.

LRV – Protozoa

If the Leak Decay Rate is less than 1.37kPa/min then the credible LRV for protozoa is 4.0

EQUIPMENT USAGE

This table details the steps of each sequence that each piece of equipment is requested to operate (run or open) in.

Equipment ID	Description	Sequence Steps													
		0 (Offline)	1	2	3	4	5	6	7	8	9	10	11	12	100 (Fault)
L3047	MF Filter No.1 - Supply Inlet Valve	Closed	Open IF No.1 is Duty	Open IF No.1 is Duty	Open IF No.1 is Duty	Open IF No.1 is Duty	Open IF No.1 is Duty	Open IF No.1 is Duty	Closed	Closed	Closed	Closed	Closed	Closed	Open IF No.1 is Duty
L3050	MF Filter No.1 - Air Scour Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3051	MF Filter No.1 - Flush Valve	Closed	Open IF No.1 is Duty	Open	Open IF No.1 is Duty	Open IF No.1 is Duty	Closed	Open	Closed	Open	Open	Open	Closed	Closed	Open IF No.1 is Duty
L3052	MF Filter No.1 - CIP Return Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3053	MF Filter No.1 - Drain Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3055	MF Filter No.1 - PDT Supply Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Closed	Closed	Open	Closed	Closed
L3057	MF Filter No.1 - Discharge Valve	Closed	Closed	Open IF No.1 is Duty	Closed	Closed	Open IF No.1 is Duty	Open IF No.1 is Duty	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3058	MF Filter No.1 - Backflush Valve	Closed	Open	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3059	MF Filter No.2 - Supply Inlet Valve	Closed	Open IF No.2 is Duty	Open IF No.2 is Duty	Open IF No.2 is Duty	Open IF No.2 is Duty	Open IF No.2 is Duty	Open IF No.2 is Duty	Closed	Closed	Closed	Closed	Closed	Closed	Open IF No.2 is Duty
L3062	MF Filter No.2 - Air Scour Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3063	MF Filter No.2 - Flush Valve	Closed	Open IF No.2 is Duty	Open	Open IF No.2 is Duty	Open IF No.2 is Duty	Closed	Open	Closed	Open	Open	Open	Open	Closed	Open IF No.2 is Duty
L3064	MF Filter No.2 - CIP Return Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3065	MF Filter No.2 - Drain Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed

Equipment ID	Description	Sequence Steps													
		0 (Offline)	1	2	3	4	5	6	7	8	9	10	11	12	100 (Fault)
L3067	MF Filter No.2 - PDT Supply Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Closed	Closed	Open	Closed	Closed
L3069	MF Filter No.2 - Discharge Valve	Closed	Closed	Open IF No.2 is Duty	Closed	Closed	Open IF No.2 is Duty	Open IF No.2 is Duty	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3070	MF Filter No.2 - Backflush Valve	Closed	Open	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3074	MF Filter - Backwash Pressure Valve No.1	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3076	MF Filter - Backwash Pressure Valve No.2	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3077	MF Filter Backflush - Tank Drain/Pressurise Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3082	MF Filter Backflush - CIP Supply Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3087	MF Filter - Sample Pump	Stop	Stop	Stop	Stop	Run	Run	Run	Stop	Stop	Stop	Stop	Stop	Stop	Stop

Set Points - MF System

Maximum Trans Membrane Pressure (TMP)

This is the maximum Trans Membrane Pressure (TMP) that is allowed before a Backwash on the Duty Filter is initiated.

Default Value: 2 Bar

Range: 0 – 5 Bar

Maximum Discharge Turbidity

This is the maximum Turbidity of the permeate that is allowed before a Backwash is initiated on the Duty Filter.

Default Value: 0.5 NTU

Range: 0 – 4 NTU

Pressure Decay Test Start Delay

This is the amount of time in seconds after the filters have stopped being pressurised that the Start Pressure for the PDT test is recorded.

Default Value: 120 Seconds

Range: 0 – 1200 Seconds

Pressure Decay Test (PDT) Maximum Decay Rate

This is maximum allowable Decay Rate detected by a PDT, beyond which an alarm will be generated.

Default Value: 1.4 kPa/minute.

Range: 0.001 – 20 kPa/minute

Pressure Decay Test (PDT) Decay Time

This is time that is allowed for the pressure in the filters to decay during a PDT.

Default Value: 10 Minute

Range: 1 – 60 Minutes

Leak Test Decay Time

This is time that is allowed for the pressure in the filters to decay during a post PDT leak test.

Default Value: 2 Minute

Range: 1 – 10 Minutes

Leak Test Maximum Decay Rate

This is maximum allowable Decay Rate detected by the leak test, beyond which an alarm will be generated.

Default Value: 0.3 kPa/minute.

Range: 0.001 – 20 kPa/minute

Maximum Volume before a Backwash

This is the maximum volume of processed water that is allowed to flow through the Duty Filter before a Backwash is initiated.

Default Value: 2000 Litres

Range: 1000 – 10000 Litres

MF System - Alarms

Equipment Fault

Cause: Any piece of equipment which is required by the Sequence has either been switched to the Manual Mode or has faulted. In either case the equipment is no longer available to the Sequence, therefore an Equipment fault is generated.

Check Steps: Every step except Step 0 (Offline)

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: All equipment must have any faults reset and be switched back to the Auto Mode. Call Maintenance if required. Once all equipment is available the fault can be reset by pressing the “Fault Reset/Continue” button.

No.1 Filter Failed Pressure Decay Test (PDT)

Cause: The rate of pressure decay detected for Filter No.1 by the PDT exceeded the maximum allowable rate (as set in section 0). This indicates that there is a leak in the system somewhere in the filter itself.

Check Steps: Step 8

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Determine where the leak in the system is and repair it. The fault can be reset by pressing the “Fault Reset/Continue” button.

No.2 Filter Failed Pressure Decay Test (PDT)

Cause: The rate of pressure decay detected for Filter No.2 by the PDT exceeded the maximum allowable rate (as set in section 0). This indicates that there is a leak in the system somewhere in the filter itself.

Check Steps: Step 8

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Determine where the leak in the system is and repair it. The fault can be reset by pressing the "Fault Reset/Continue" button.

Both Filters are Blocked and Unavailable

Cause: Both filters have exceeded their backwash requirements and have not been backwashed. This is usually due to a problem with the CIP system.

Check Steps: Step 5

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Determine why the Filters have not been backwashed and rectify. The fault can be reset by pressing the "Fault Reset/Continue" button.

No.1 Filter Failed Leak Test

Cause: The rate of pressure decay detected for Filter No.1 during the Leak Test exceeded the maximum allowable rate (as set in section 0). This indicates that there is a leak in the system somewhere, most probably a valve seat.

Check Steps: Step 12

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Determine where the leak in the system is and repair it. The fault can be reset by pressing the "Fault Reset/Continue" button.

No.2 Filter Failed Leak Test

Cause: The rate of pressure decay detected for Filter No.2 during the Leak Test exceeded the maximum allowable rate (as set in section 0). This indicates that there is a leak in the system somewhere, most probably a valve seat.

Check Steps: Step 12

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Determine where the leak in the system is and repair it. The fault can be reset by pressing the "Fault Reset/Continue" button.

OPERATIONAL INTERLOCKS

The following is a list of interlocks which are specific to certain pieces of equipment. Each drive can have up to eight independent interlocks and some of these interlocks can be masked under certain conditions, these conditions are listed in the "Mask" column.

Equipment Interlocks

L3047 - MF Filter No.1 - Supply Inlet Valve

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

L3051 - MF Filter No.1 - Flush Valve

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

L3055 - MF Filter No.1 - PDT Supply Valve

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

L3057 - MF Filter No.1 - Supply Inlet Valve

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

L3058 - MF Filter No.1 - Backflush Valve

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

L3059 - MF Filter No.2 - Supply Inlet Valve

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

L3063 - MF Filter No.2 - Flush Valve

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

L3067 - MF Filter No.2 - PDT Supply Valve

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

L3069 - MF Filter No.2 - Discharge Valve

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

L3070 - MF Filter No.2 - Backflush Valve

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

L3087 - MF Filter - Sample Pump

Interlock	Description	Mask
1	Lxxx1 – MF Filter – Turbidity Sample No Flow Switch	None
2	None	NA
3	None	NA
4	None	NA
5	None	NA
6	None	NA
7	None	NA
8	None	NA

PROCESS INTERFACES

Not Applicable

ASSUMPTIONS AND EXCLUSIONS

-

CONTROL SYSTEM

Manual Control

Whilst none of the automatic sequences are running any piece of equipment can be operated in the manual mode. This means that the operator will be able to change the state of any piece of equipment provided they change the equipment to Manual Mode first as per the standard operating philosophy for equipment.

Auto Control

Whilst any of the automatic sequences are running all equipment associated with those sequences must be in the automatic mode. If any piece of equipment is switched to the manual mode during operation of an automatic sequence the sequence will stop operating and generate a fault. It is the responsibility of the operator to ensure that switching equipment to manual during automatic operation will not cause damage to equipment and/or product.

Operator Notification

Where appropriate the operator will be prompted by the system to ensure that the operator is present and aware of the current stage in the process. This system will take the form of a popup asking the operator to confirm that they are aware by clicking on an “Okay” or simular button.

ALARM DEFINITION AND MANAGMENT

In addition to the standard alarms that are generated for standard pieces of equipment the following system specific alarms will be provided.

- *Equipment Interlock:* If any piece of equipment required by this process cell faults or is switched to the manual mode whilst the sequence is running the sequence will go into the fault mode. An equipment fault alarm will be generated when this occurs.

All alarms are generated within the PLC controller and displayed and logged on the SCADA system as per the Citect User Manual, the list of alarms associated with each standard piece of equipment can also be found in this document.

POWER FAILURE

When the power is restored after a power failure, the system will be reset with all sequences stopped and in the default state. However the Batch numbers, etc will be retained such that the sequences, when restarted, will start from where they left off when the power failure occurred.

Davis Advanced Water Treatment Plant – MF Filter Cleaning System

FUNCTIONAL DESCRIPTION

AUTHORS	
Author	**Institution**
Michael Packer	Australian Antarctic Division

VERSION CONTROL REVISION HISTORY			
Version	**Date revised**	**Section Revised**	**Revision**
1.0	23/3/2014	NA	First Draft – Packer
1.1	08/09/2014	All	Updated for “As Built”
1.2	03/04/2015	All	Added “Manual Clean” functionality

APPROVAL		
Version	**Date Approved**	**Person Approving**

Table of Contents

PURPOSE

This Functional Requirements Specification details the operation of the Ceramic Micro Filtration (MF) Cleaning System that forms part the Davis Advanced Waste Water Treatment Plant (Davis AWWTP). It includes a full description of the modes of operation plus the system interlocks and alarms. All the PLC and SCADA programming done for this system will be executed according to this document.

SCOPE

This Functional Requirements Specification applies to the operation of the MF Cleaning System and associated equipment.

The equipment associated with the MF Cleaning System includes all equipment listed in section 0 of this document.

The operation of the MF Cleaning System will be completely automated in line with the expectations of the project to make a system that required minimal or no operator input and also to increase the safety and consistency of the.

The Davis AWWTP has a dedicated Alan Bradley ControlLogix 5000 PLC and this will be used to control the MF Cleaning System. The Davis AWWTP also has a dedicated Citect SCADA system which will be used as an interface to monitor and control the system.

DEFINITIONS

PC	Personal Computer
SCADA	Supervisory Control and Data Acquisition
MCC	Motor Control Centre
Historical Trends	A Historical Trend is a series of measurements taken at a regular interval of a field based variable.
User	A user is an individual who is using a system or piece of equipment
AWWP	Advanced Waste Water Treatment Plant, a treatment plant that process water to a very high standard.

REFERENCES

	Title	*Reference*
1	*Davis AWWTP P&ID – MF and BAC Systems*	*27/13/07 Sheet 1 of 4*
2	*Citect User Manual*	
3	*Citect Users Guide Version 5*	
4	*Functional Description*	
5		
6		
7		

MATERIALS AND EQUIPMENT

SCADA

The Citect SCADA system provides operators with control over, and feedback from, the MF Cleaning System. The MF Cleaning System will be displayed on a number of graphics pages in the Davis AWWTP project of the AAD SCADA system. The Citect system will also provide alarming, trending and reporting functionality for the MF Cleaning System.

PLC

The dedicated Davis AWWT ControlLogix 5000 system will be used to control the MF Cleaning System. This PLC is located in the Electrical Control Panel for the Davis AWWTP and is linked via Ethernet to the Davis Intranet.

Equipment - Instruments

Instrument ID	Description	Range
L3032	MF System - Feed Pressure	-1.00...10.00 bar
L3054	MF Filter No.1 - Discharge Pressure	-1.00...10.00 bar
L3066	MF Filter No.2 - Discharge Pressure	-1.00...10.00 bar
L3079	MF Filter Backflush - Tank Pressure	-1.00...10.00 bar
L3081	MF Filter Backflush - Tank Level Switch	2 levels, On/Off
L3083	MF Filter - Discharge MF Concentration	0 - 50 mg/Lt
L3088	MF Filter - Discharge Turbidity	0 – 5 NTU

Equipment - Drives

Equipment ID	Description
L3087	MF Filter - Sample Pump

Equipment – Solenoid Valves

Note: It is assumed that all gates and diverters have position feedback.

Equipment ID	Description

L3047	MF Filter No.1 - Supply Inlet Valve
L3050	MF Filter No.1 - Air Scour Valve
L3051	MF Filter No.1 - Flush Valve
L3052	MF Filter No.1 - CIP Return Valve
L3053	MF Filter No.1 - Drain Valve
L3055	MF Filter No.1 - PDT Supply Valve
L3057	MF Filter No.1 - Discharge Valve
L3058	MF Filter No.1 - Backflush Valve
L3059	MF Filter No.2 - Supply Inlet Valve
L3062	MF Filter No.2 - Air Scour Valve
L3063	MF Filter No.2 - Flush Valve
L3064	MF Filter No.2 - CIP Return Valve
L3065	MF Filter No.2 - Drain Valve
L3067	MF Filter No.2 - PDT Supply Valve
L3069	MF Filter No.2 - Discharge Valve
L3070	MF Filter No.2 - Backflush Valve
L3074	MF Filter - Backwash Pressure Valve No.1
L3076	MF Filter - Backwash Pressure Valve No.2
L3077	MF Filter Backflush - Tank Drain/Pressurise Valve
L3082	MF Filter Backflush - CIP Supply Valve

1.5 Equipment – Control Valves

Equipment ID	Description
	None

1.6 Equipment – PID Control Loops

Equipment ID	Description
	None

OPERATIONAL DESCRIPTION

Overview

The MF Cleaning System is responsible cleaning the ceramic micro filters by back flushing them when they become blocked.

The MF Cleaning System contains the following key components:

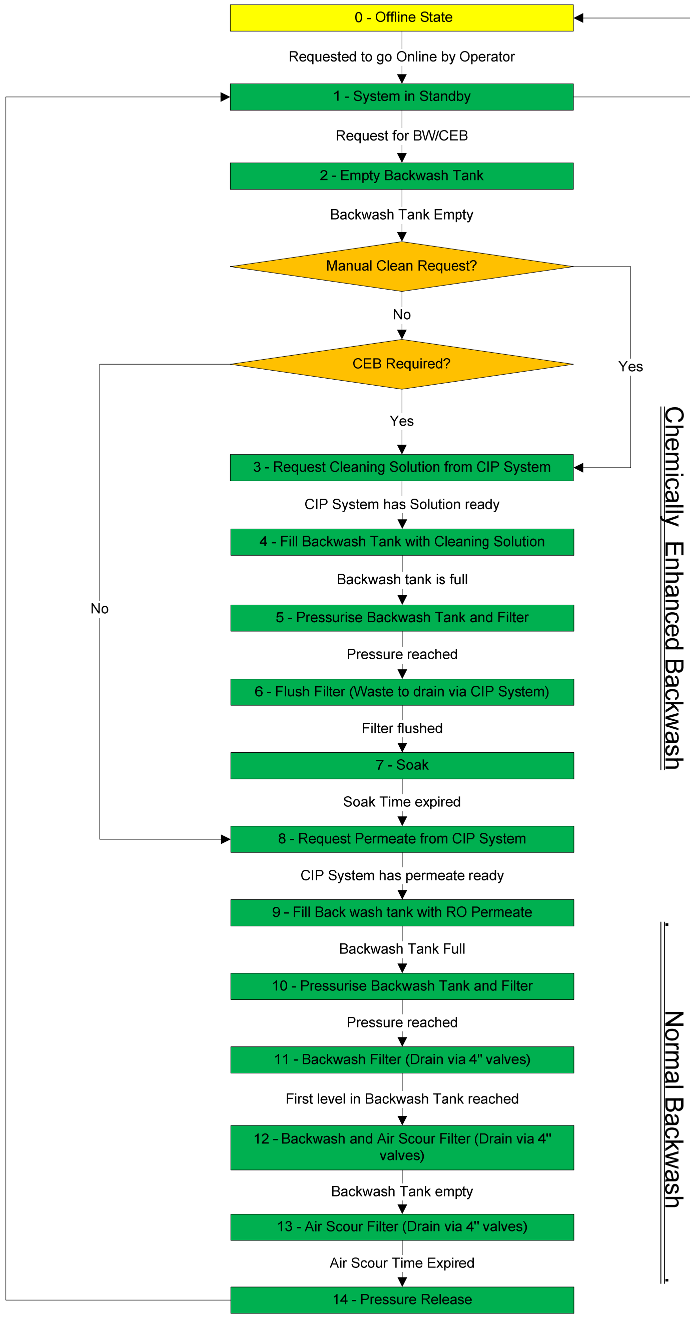
- Backwash system: The backwash system consists of a pressure tank which can be filled with cleaning fluid from the CIP System. This tank can then be pressurised with compressed air which is used to force the cleaning water back through the membranes to remove built up fouling material.
- There are two types of backwashes: Normal Backwash and Chemically Enhanced Backwash (CEB). The normal backwash is simply a back flush of the filter with clean water to remove built up fouling material. The back flush includes an air scour step where compressed air is

blown across the filter surface to enhance the removal of fouling material. A Chemically Enhanced Backwash (CEB) uses chemical (hypochlorite or sulphuric acid) to enhance the effectiveness of the cleaning process. A CEB first fills the membrane with a cleaning solution which is allowed to soak for an extended period of time after which a Normal Backwash is conducted to remove the cleaning solution and the dissolved fouling materials.

- Dirty backwash water and any associated chemical are drained from the filters to the Drain Tank and are pumped back to the head of works for there.
- Normal Backwashed are initiated by the MF System based on several parameters, refer to the *MF System Functional Description* for details. CEBs are initiated after a predetermined number of Normal Backwashes have been conducted.
- When required a manual clean of either Filter can be initiated by the Operator. When triggered this will wash the filter in the same way as a CEB but will use the selected “Manual Clean Recipe” instead of the standard CEB recipe. This is used for periodic cleans of the filter to remove fouling that can’t be removed with the standard CEB recipe.
- The MF Cleaning System works in conjunction with the CIP System to deliver the correct recipe for the type of backwash being conducted, refer to the *CIP System Functional Description* for details.

The MF Cleaning System starts and stops all the equipment associated with the cleaning of the Ceramic Filters. This sequence will also monitor all alarms and interlocks to ensure that the system is always operating safely and within the design parameters.

MF Cleaning System – Sequence



MF Cleaning System – Sequence Notes

- None

EQUIPMENT USAGE

This table details the steps of each sequence that each piece of equipment is requested to operate (run or open) in.

Equipment ID	Description	Sequence Steps															
		0 (Offline)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	100 (Fault)
L3047	MF Filter No.1 - Supply Inlet Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3050	MF Filter No.1 - Air Scour Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open if Cleaning No.1	Open if Cleaning No.1	Closed	Closed	Closed
L3051	MF Filter No.1 - Flush Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3052	MF Filter No.1 - CIP Return Valve	Closed	Closed	Closed	Closed	Closed	Open if Cleaning No.1	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3053	MF Filter No.1 - Drain Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open if Cleaning No.1	Open if Cleaning No.1	Open if Cleaning No.1	Open if Cleaning No.1	Closed	Closed
L3055	MF Filter No.1 - PDT Supply Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3057	MF Filter No.1 - Discharge Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3058	MF Filter No.1 - Backflush Valve	Closed	Open	Closed	Closed	Open if Cleaning No.1	Open if Cleaning No.1	Closed	Closed	Closed	Open if Cleaning No.1	Open if Cleaning No.1	Closed	Closed	Closed	Closed	Closed
L3059	MF Filter No.2 - Supply Inlet Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3062	MF Filter No.2 - Air Scour Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open if Cleaning No.2	Open if Cleaning No.2	Closed	Closed	Closed
L3063	MF Filter No.2 - Flush Valve	Closed	Closed	Closed	Closed	Closed	Closed	Open	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed

Equipment ID	Description	Sequence Steps															
		0 (Offline)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	100 (Fault)
L3064	MF Filter No.2 - CIP Return Valve	Closed	Closed	Closed	Closed	Closed	Open if Cleaning No.2	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3065	MF Filter No.2 - Drain Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open if Cleaning No.2	Open if Cleaning No.2	Open if Cleaning No.2	Open if Cleaning No.2	Closed	Closed
L3067	MF Filter No.2 - PDT Supply Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3069	MF Filter No.2 - Discharge Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3070	MF Filter No.2 - Backflush Valve	Closed	Closed	Closed	Closed	Open if Cleaning No.2	Open if Cleaning No.2	Closed	Closed	Closed	Open if Cleaning No.2	Open if Cleaning No.2	Closed	Closed	Closed	Closed	Closed
L3074	MF Filter - Backwash Pressure Valve No.1	Closed	Closed	Closed	Closed	Open	Open	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed
L3076	MF Filter - Backwash Pressure Valve No.2	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Open	Closed	Closed	Closed	Closed	Closed
L3077	MF Filter Backflush - Tank Drain/Pressurise Valve	Closed	Open	Closed	Closed	Open	Open	Closed	Closed	Closed	Open	Open	Closed	Closed	Closed	Closed	Closed
L3082	MF Filter Backflush - CIP Supply Valve	Closed	Closed	Closed	Open	Closed	Closed	Closed	Closed	Open	Closed	Closed	Closed	Closed	Closed	Closed	Closed

Set Points - MF Cleaning System

Air Scour Time

This is the amount of time that the Air Scour of the Filters continues for after the combined Backwash and Air Scour has finished.

Default Value: 5 Seconds.

Range: 2 – 20 Seconds

1.6.1 *Soaking Time*

This is the amount of time that the filters are soaked in CEB Cleaning fluid for.

Default Value: 180 Seconds.

Range: 20 – 600 Seconds

1.6.2 *Number of Backwashes before a CEB*

This is the number of backwashes that can occur before a CEB is initiated.

Default Value: 15.

Range: 5 – 30

1.6.3 *Backwash Recipe Number*

This is the recipe number that is used to for a Normal Backwash. Refer to the *CIP System Functional Description* for how this is used.

Default Value: 1.

Range: 1 - 7

1.6.4 *CEB Recipe Number*

This is the recipe number that is used to for a CEB. Refer to the *CIP System Functional Description* for how this is used.

Default Value: 2.

Range: 1 – 7

1.6.5 *Manual Clean Recipe Number*

This is the recipe number that is used when a manual clean of the MF initiated. Refer to the *CIP System Functional Description* for how this is used.

Default Value: 2.

Range: 1 - 7

MF Cleaning System - Alarms

Equipment Fault

Cause: Any piece of equipment which is required by the Sequence has either been switched to the Manual Mode or has faulted. In either case the equipment is no longer available to the Sequence, therefore an Equipment fault is generated.

Check Steps: Every step except Step 0 (Offline)

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: All equipment must have any faults reset and be switched back to the Auto Mode. Once all equipment is available the fault can be reset by pressing the “Fault Reset/Continue” button.

OPERATIONAL INTERLOCKS

The following is a list of interlocks which are specific to certain pieces of equipment. Each drive can have up to eight independent interlocks and some of these interlocks can be masked under certain conditions, these conditions are listed in the “Mask” column.

Equipment Interlocks

L3050 - MF Filter No.1 - Air Scour Valve

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.6.6 *L3052 - MF Filter No.1 - CIP Return Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.6.7 *L3053 - MF Filter No.1 - Drain Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.6.8 *L3058 - MF Filter No.1 - Backflush Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.6.9 *L3062 - MF Filter No.2 - Air Scour Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.6.10 *L3064 - MF Filter No.2 - CIP Return Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.6.11 *L3065 - MF Filter No.2 - Drain Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.6.12 *L3070 - MF Filter No.2 - Backflush Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.6.13 *L3074 - MF Filter - Backwash Pressure Valve No.1*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.6.14 *L3076 - MF Filter - Backwash Pressure Valve No.2*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.6.15 *L3077 - MF Filter Backflush - Tank Drain/Pressurise Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.6.16 *L3082 - MF Filter Backflush - CIP Supply Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

PROCESS INTERFACES

Not Applicable

ASSUMPTIONS AND EXCLUSIONS

-

CONTROL SYSTEM

Manual Control

Whilst none of the automatic sequences are running any piece of equipment can be operated in the manual mode. This means that the operator will be able to change the state of any piece of equipment provided they change the equipment to Manual Mode first as per the standard operating philosophy for equipment.

Auto Control

Whilst any of the automatic sequences are running all equipment associated with those sequences must be in the automatic mode. If any piece of equipment is switched to the manual mode during operation of an automatic sequence the sequence will stop operating and generate a fault. It is the responsibility of the operator to ensure that switching equipment to manual during automatic operation will not cause damage to equipment and/or product.

Operator Notification

Where appropriate the operator will be prompted by the system to ensure that the operator is present and aware of the current stage in the process. This system will take the form of a popup asking the operator to confirm that they are aware by clicking on an “Okay” or simular button.

ALARM DEFINITION AND MANAGMENT

In addition to the standard alarms that are generated for standard pieces of equipment the following system specific alarms will be provided.

- *Equipment Interlock:* If any piece of equipment required by this process cell faults or is switched to the manual mode whilst the sequence is running the sequence will go into the fault mode. An equipment fault alarm will be generated when this occurs.

All alarms are generated within the PLC controller and displayed and logged on the SCADA system as per the Citect User Manual, the list of alarms associated with each standard piece of equipment can also be found in this document.

POWER FAILURE

When the power is restored after a power failure, the system will be reset with all sequences stopped and in the default state. However the Batch numbers, etc will be retained such that the sequences, when restarted, will start from where they left off when the power failure occurred.

Davis Advanced Water Treatment Plant – Biologically Activated Carbon (BAC) Filter System

FUNCTIONAL DESCRIPTION

AUTHORS	
Author	**Institution**
Michael Packer	Australian Antarctic Division

VERSION CONTROL REVISION HISTORY			
Version	**Date revised**	**Section Revised**	**Revision**
1.0	21/3/2014	NA	First Draft – Packer
1.1	12/09/2014	All	"As Built" version
1.2	15/10/2014	8.2 Alarms	Added "No Water Level Rise" Alarm. Updated alarm names and general formatting tidyup.
1.3	10/11/2014	7	Updated the Sequence Diagram
1.4	26/04/2015	Equipment and Interlocks	Added Turbidity Sample No Flow switch and Interlock

APPROVAL		
Version	**Date Approved**	**Person Approving**

Table of Contents

PURPOSE

This Functional Requirements Specification details the operation of the Biologically Activated Carbon (BAC) Filter System that forms the Third Barrier in the Davis Advanced Waste Water Treatment Plant (Davis AWWTP). It includes a full description of the modes of operation plus the system interlocks and alarms. All the PLC and SCADA programming done for this system will be executed according to this document.

SCOPE

This Functional Requirements Specification applies to the operation of the BAC System and associated equipment.

The equipment associated with the BAC System includes all equipment listed in section 0 of this document.

The operation of the BAC System will be completely automated in line with the expectations of the project to make a system that required minimal or no operator input and also to increase the safety and consistency of the product water.

The Davis AWWTP has a dedicated Alan Bradley ControlLogix 5000 PLC and this will be used to control the BAC System. The Davis AWWTP also has a dedicated Citect SCADA system which will be used as an interface to monitor and control the system.

DEFINITIONS

PC	Personal Computer
SCADA	Supervisory Control and Data Acquisition
Historical Trends	A Historical Trend is a series of measurements taken at a regular interval of a field based variable.
User	A user is an individual who is using a system or piece of equipment
AWWP	Advanced Waste Water Treatment Plant, a treatment plant that process water to a very high standard.

REFERENCES

	Title	*Reference*
1	*Davis AWWTP P&ID – Ozone and Backwash*	*27/13/07 Sheet 1 of 4*
2	*Citect User Manual*	
3	*Citect Users Guide Version 5*	
4	*Functional Description*	
5		
6		
7		

MATERIALS AND EQUIPMENT

SCADA

The Citect SCADA system provides operators with control over, and feedback from, the BAC System. The BAC System will be displayed on a number of graphics pages in the Davis AWWTP project of the AAD SCADA system. The Citect system will also provide alarming, trending and reporting functionality for the BAC System.

PLC

The dedicated Davis AWWT ControlLogix 5000 system will be used to control the BAC System. This PLC is located in the Electrical Control Panel for the Davis AWWTP and is linked via Ethernet to the Davis Intranet.

Equipment - Instruments

Instrument ID	Description	Range
L3091	BAC Filter - Hi Hi Level Switch	On/Off
L3092	BAC Filter - Hi Level Switch	On/Off
L3093	BAC Filter - Headloss	0…100 mBar
Lxxx4	BAC Filter – Turbidity Sample No Flow Switch	On/Off
L3105	BAC Filter - Discharge Turbidity	0 - 10 NTU

Equipment - Drives

Equipment ID	Description
L3104	BAC Filter - Sample Pump

Equipment – Solenoid Valves

Equipment ID	Description
L3095	BAC Filter - Air Scour Supply Valve
L3097	BAC Filter - Flush/Feedforwards Valve
L3098	BAC Filter - Hi Flow Backwash Valve
L3101	BAC Filter - Drain Valve
Lxxxx	BAC Filter – Feed Forwards Valve

1.7 Equipment – Control Valves

Equipment ID	Description
	None

1.8 Equipment – PID Control Loops

Equipment ID	Description
	None

OPERATIONAL DESCRIPTION

Overview

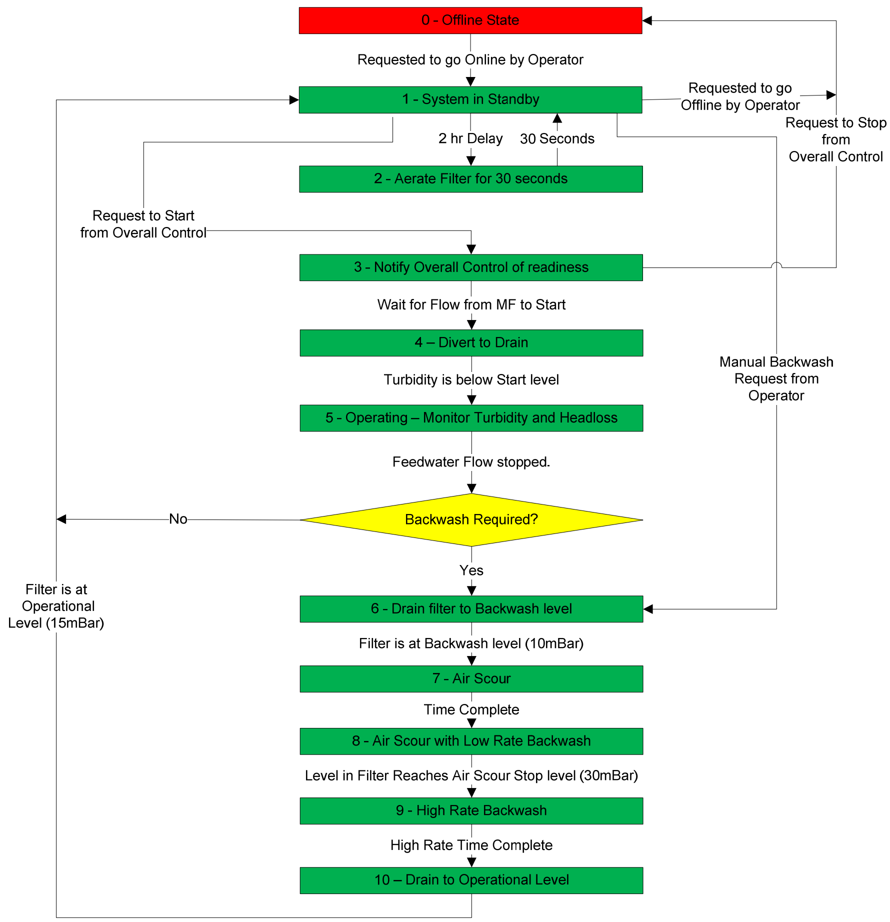
The BAC System is responsible for filtering the process water through the BAC filter, monitoring it's performance and backwashing the filter when required.

The BAC System contains the following key components:

- The BAC Filter removes contaminants from the product water through two mechanisms: Absorption directly into the carbon and consumption by the biofilm growing on the carbon.
- As the biomass in the filter increases the filter will gradually become blocked. This will result in an increase of headloss across the filter.
- To clean the filter a backwash system is included. The backwash system operates by firstly scouring the filter with air to break up the biomass and then by pushing clean water back through filter to flush out the suspended biomass. The dirty water is returned to the plant drain tank for disposal.
- Under normal operation the carbon in the filter will need periodic replenishment and possible replacement.
- Whilst the filter is off-line between batches it is periodically blasted with air to maintain a minimum dissolved oxygen level to keep the aerobic bacteria alive.

The BAC System starts and stops all the associated equipment. This sequence will also monitor all alarms and interlocks to ensure that the system is always operating safely and within the design parameters.

BAC System - Sequence



BAC System – Sequence Notes

- A backwash of the filter is triggered either on high Turbidity, High Headloss or the maximum Filtered Volume of processed water. It can also be manually initiated by an operator when the system is in the Standby Step (Step 1).
- The Filtered Volume is totalised when the MF Sequence is operating (i.e. not flushing) and is based on the Plant In-feed flow (L3031). It is reset when a backwash is completed.

EQUIPMENT USAGE

This table details the steps of each sequence that each piece of equipment is requested to operate (run or open) in.

Equipment ID	Description	Sequence Steps											
		0 (Offline)	1	2	3	4	5	6	7	8	9	10	100 (Fault)
L3104	BAC Filter - Sample Pump	Stopped	Stopped	Stopped	Run	Run	Run	Run	Stopped	Stopped	Stopped	Stopped	Stopped
L3095	BAC Filter - Air Scour Supply Valve	Closed	Closed	Open	Closed	Closed	Closed	Closed	Open	Open	Closed	Closed	Closed
L3097	BAC Filter - Flush/Feedforwards Valve	Forward	Forward	Forward	Forward	Forward	Forward	Forward	Forward	Back wash	Back wash	Forward	Forward
L3098	BAC Filter - Hi Flow Backwash Valve	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Closed	Open	Closed	Closed
L3101	BAC Filter - Drain Valve	Closed	Closed	Closed	Closed	Open	Closed	Open	Closed	Closed	Closed	Closed	Closed
Lxxx	BAC Filter – Feed Forwards Valve	Closed	Closed	Closed	Closed	Closed	Open	Closed	Closed	Closed	Closed	Closed	Closed

BAC System - Set Points

Required Filtrate Turbidity to start feeding to the RO

This is the required turbidity of the filtrate from the BAC Filter column on startup, below which the product water will be allowed to feed forwards to the RO system.

Default Value: 0.2 NTU.

Range: 0 – 5 NTU

1.8.1 *Maximum Turbidity*

This is the Maximum Turbidity of the filtered water that will trigger a backwash at the end of the current batch.

Default Value: 5 NTU.

Range: 0 – 10 NTU

Maximum Headloss

This is the headloss in the Filter that will trigger a backwash at the end of the current batch.

Default Value: 75 mBar.

Range: 0 – 100 mBar

1.8.2 *Maximum Volume*

This is the maximum volume of water since the last backwash that is permitted before backwash is initiated.

Default Value: 25000 L.

Range: 5000 – 50000 L

1.8.3 *Air Scour Time*

This is the amount of time that the Air Scour in the Backwash cycle runs for.

Default Value: 60 Seconds.

Range: 0 – 600 Seconds

1.8.4 *High Rate Backflush Time*

This is the amount of time that the High Rate Back Flush in the backwash cycle runs for.

Default Value: 60 Seconds.

Range: 0 – 600 Seconds

BAC System - Alarms

Equipment Fault

Cause: Any piece of equipment which is required by the Sequence has either been switched to the Manual Mode or has faulted. In either case the equipment is no longer available to the Sequence, therefore an Equipment fault is generated.

Check Steps: Every step except Step 0 (Offline)

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: All equipment must have any faults reset and be switched back to the Auto Mode. Once all equipment is available the fault can be reset by pressing the “Fault Reset/Continue” button.

High Turbidity during Start-up

Cause: The system was not able to achieve the required turbidity within 30 minutes of starting up. This suggests that something is wrong with the filter media.

Check Steps: Step 4

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Determine what is causing the excess turbidity and recitfy. The fault can be reset by pressing the “Fault Reset/Continue” button.

1.8.5 *High Water Level in BAC Filter Chamber*

Cause: The system has detected that the level in the filter has reached the high level during normal operation and will overflow soon. This suggests that filter is blocked and needs immediate backwashing.

Check Steps: Step 5

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it. When it is reset it will trigger a backwash immediately.

Reset Requirements: The fault can be reset by pressing the “Fault Reset/Continue” button.

1.8.6 *High Water Level in BAC Filter Chamber during Backwash*

Cause: The system has detected that the level in the filter has reached the high high level during a backwash operation and will overflow soon. This suggests that backwash outlet is blocked (most likely with carbon).

Check Steps: Step 7 – 9.

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Clear the blockage. The fault can be reset by pressing the “Fault Reset/Continue” button.

1.8.7 *No Water Level rise in BAC Filter Chamber during Backwash*

Cause: The system has detected that the level in the filter has not risen during the low rate backwash step. This suggests that the station water supply has been interrupted. To prevent excessive air scouring of the media the system will fault if it detects that the station water supply is not available

Check Steps: Step 5.

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Confirm the cause of water loss and rectify the problem. The fault can be reset by pressing the “Fault Reset/Continue” button.

OPERATIONAL INTERLOCKS

The following is a list of interlocks which are specific to certain pieces of equipment. Each drive can have up to eight independent interlocks and some of these interlocks can be masked under certain conditions, these conditions are listed in the “Mask” column.

Equipment Interlocks

L3104 - BAC Filter - Sample Pump

Interlock	Description	Mask
1	Lxxx4 – BAC Filter – Turbidity Sample No Flow Switch	None
2	None	NA
3	None	NA
4	None	NA
5	None	NA
6	None	NA
7	None	NA
8	None	NA

L3095 - BAC Filter - Air Scour Supply Valve

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.8.8 *L3097 - BAC Filter - Flush/Feedforwards Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA

3	None	NA
4	None	NA

1.8.9 *L3098 - BAC Filter - Hi Flow Backwash Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.8.10

1.8.11 *L3101 - BAC Filter - Drain Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.8.12 *Lxxx - BAC Filter – Feed Forwards Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

PROCESS INTERFACES

Not Applicable

ASSUMPTIONS AND EXCLUSIONS

-

CONTROL SYSTEM

Manual Control

Whilst none of the automatic sequences are running any piece of equipment can be operated in the manual mode. This means that the operator will be able to change the state of any piece of equipment provided they change the equipment to Manual Mode first as per the standard operating philosophy for equipment.

Auto Control

Whilst any of the automatic sequences are running all equipment associated with those sequences must be in the automatic mode. If any piece of equipment is switched to the manual mode during operation of an automatic sequence the sequence will stop operating and generate a fault. It is the responsibility of the operator to ensure that switching equipment to manual during automatic operation will not cause damage to equipment and/or product.

Operator Notification

Where appropriate the operator will be prompted by the system to ensure that the operator is present and aware of the current stage in the process. This system will take the form of a popup asking the operator to confirm that they are aware by clicking on an “Okay” or simular button.

ALARM DEFINITION AND MANAGMENT

In addition to the standard alarms that are generated for standard pieces of equipment the following system specific alarms will be provided.

- *Equipment Interlock:* If any piece of equipment required by this process cell faults or is switched to the manual mode whilst the sequence is running the sequence will go into the fault mode. An equipment fault alarm will be generated when this occurs.

All alarms are generated within the PLC controller and displayed and logged on the SCADA system as per the Citect User Manual, the list of alarms associated with each standard piece of equipment can also be found in this document.

POWER FAILURE

When the power is restored after a power failure, the system will be reset with all sequences stopped and in the default state. However the Batch numbers, etc will be retained such that the sequences, when restarted, will start from where they left off when the power failure occurred.

Davis Advanced Water Treatment Plant – Reverse Osmosis (RO) System

FUNCTIONAL DESCRIPTION

AUTHORS	
Author	**Institution**
Michael Packer	Australian Antarctic Division

VERSION CONTROL REVISION HISTORY			
Version	**Date revised**	**Section Revised**	**Revision**
1.0	21/3/2014	NA	First Draft – Packer
1.4	4/04/2015	All	Updated for “As Built”
1.5	29/05/2015	7.2.1	Minor updates and added LRV

APPROVAL		
Version	**Date Approved**	**Person Approving**

Table of Contents

PURPOSE

This Functional Requirements Specification details the operation of the Reverse Osmosis (RO) Filter System that forms the Fourth Barrier in the Davis Advanced Water Treatment Plant (Davis AWTP) and the Fifth Barrier in the complete system (which includes the Davis Secondary Level MBR WWTP that will supply water to the Davis AWTP). It includes a full description of the modes of operation plus the system interlocks and alarms. All the PLC and SCADA programming done for this system will be executed according to this document.

SCOPE

This Functional Requirements Specification applies to the operation of the RO System and associated equipment.

The equipment associated with the RO System includes all equipment listed in section 0 of this document.

The operation of the RO System will be completely automated in line with the expectations of the project to make a system that required minimal or no operator input and also to increase the safety and consistency of the system.

The Davis AWTP has a dedicated Alan Bradley ControlLogix 5000 PLC and this will be used to control the RO System. The Davis AWTP also has a dedicated Citect SCADA system which will be used as an interface to monitor and control the system.

DEFINITIONS

PC	Personal Computer
SCADA	Supervisory Control and Data Acquisition
MCC	Motor Control Centre
Historical Trends	A Historical Trend is a series of measurements taken at a regular interval of a field based variable.
User	A user is an individual who is using a system or piece of equipment
AWTP	Advanced Water Treatment Plant, a treatment plant that process water to a very high standard.

REFERENCES

	Title	Reference
1	Davis AWTP P&ID – Ozone and Backwash	27/13/07 Sheet 1 of 4
2	Davis AWTP P&ID – MF and BAC	27/13/07 Sheet 2 of 4
3	Davis AWTP P&ID – RO	27/13/07 Sheet 3 of 4
4	Davis AWTP P&ID – UV, Calcite and Chlorine	27/13/07 Sheet 4 of 4
5	Davis AWTP – Functional Description	
6	Davis AWTP – MF Functional Description	
7	Davis AWTP – MF Cleaning Functional Description	
8	Davis AWTP – BAC Functional Description	
9	Davis AWTP – RO Functional Description	
10	Davis AWTP – UV Functional Description	
11	Davis AWTP – CL Functional Description	
12	Davis AWTP – CIP Functional Description	
13	Davis AWTP – Citect Users Manual	
14	Davis AWTP – Operator Manual	

MATERIALS AND EQUIPMENT

SCADA

The Citect SCADA system provides operators with control over, and feedback from, the RO System. The RO System will be displayed on a number of graphics pages in the Davis AWWTP project of the AAD SCADA system. The Citect system will also provide alarming, trending and reporting functionality for the RO System.

PLC

The dedicated Davis AWWT ControlLogix 5000 system will be used to control the RO System. This PLC is located in the Electrical Control Panel for the Davis AWTP and is linked via Ethernet to the Davis Intranet.

Equipment - Instruments

Instrument ID	Description	Range
L3108	RO - Mixing Tank High Level Switch	On/Off
L3109	RO - Mixing Tank Low Level Switch	On/Off
L3110	RO - Mixing Tank Level	0...150 mBar
L3111	RO - Supply Flow	0...50 Lt/min
L3117	RO - Feed Pressure	0...25 Bar
L3118	RO - PDT Membranes Empty Switch	On/Off
L3121	RO - Membrane No.1 Feed Conductivity	0...10,000 uS/m
L3124	RO - Membrane No.1 Permeate Conductivity	0...200 uS/m
L3126	RO - Membrane No.2 Feed Conductivity	0...10,000 uS/m
L3129	RO - Membrane No.2 Permeate Conductivity	0...200 uS/m
L3131	RO - Membrane No.3 Feed Conductivity	0...10,000 uS/m
L3134	RO - Membrane No.3 Permeate Conductivity	0...200 uS/m
L3136	RO - Membrane No.4 Feed Conductivity	0...10,000 uS/m
L3139	RO - Membrane No.4 Permeate Conductivity	0...200 uS/m
L3141	RO - Membrane No.5 Feed Conductivity	0...10,000 uS/m
L3144	RO - Membrane No.5 Permeate Conductivity	0...200 uS/m
L3146	RO - Membrane No.5 Concentrate Conductivity	0...10,000 uS/m
L3269	RO - PDT Pressure Transmitter	0...20 Bar
L3150	RO - Concentrate Flow	0...20 Lt/min
L3152	RO - Permeate Pressure	0...5 Bar
L3153	RO - Permeate Flow	0...20 Lt/min
L3154	RO - Combined Permeate Conductivity	0...200 uS/m
L3273	RO - Brine Flow	0...20 Lt/min
L3163	RO - Permeate Tank Level	0...70 mBar
Lxxx3	RO – 1μm Feed Filter Differential Pressure	± 1Bar

Equipment - Drives

Equipment ID	Description
L3113	RO - Feed Pump

Equipment – Solenoid Valves

Note: It is assumed that all gates and diverters have position feedback.

Equipment ID	Description
L3115	RO - CIP Supply Valve
L3119	RO - Drain Valve
L3148	RO - CIP Return Valve
L3156	RO - Permeate to Storage/Feed Forwards Selector Valve
L3158	RO - PDT Supply Valve
L3161	RO - Membrane Flush Valve

1.9 Equipment – Control Valves

Equipment ID	Description
L3149	RO - Back Pressure Control Valve
L3151	RO - Conductivity Control Valve

1.10 Equipment – PID Control Loops

Equipment ID	Description
L3110_PID	RO - Mixing Tank Level – PID Control Loop
L3113_PID	RO - Feed Pump - PID Control Loop
L3149_PID	RO - Back Pressure Control Valve - PID Control Loop
L3153_PID	RO - Permeate Flow – PID Control Loop
L3151_PID	RO - Conductivity Control Valve - PID Control Loop

OPERATIONAL DESCRIPTION

Overview

The RO System is responsible for filtering the process water through the RO Membranes, monitoring it's performance and cleaning the filter when required.

The RO System contains the following key components:

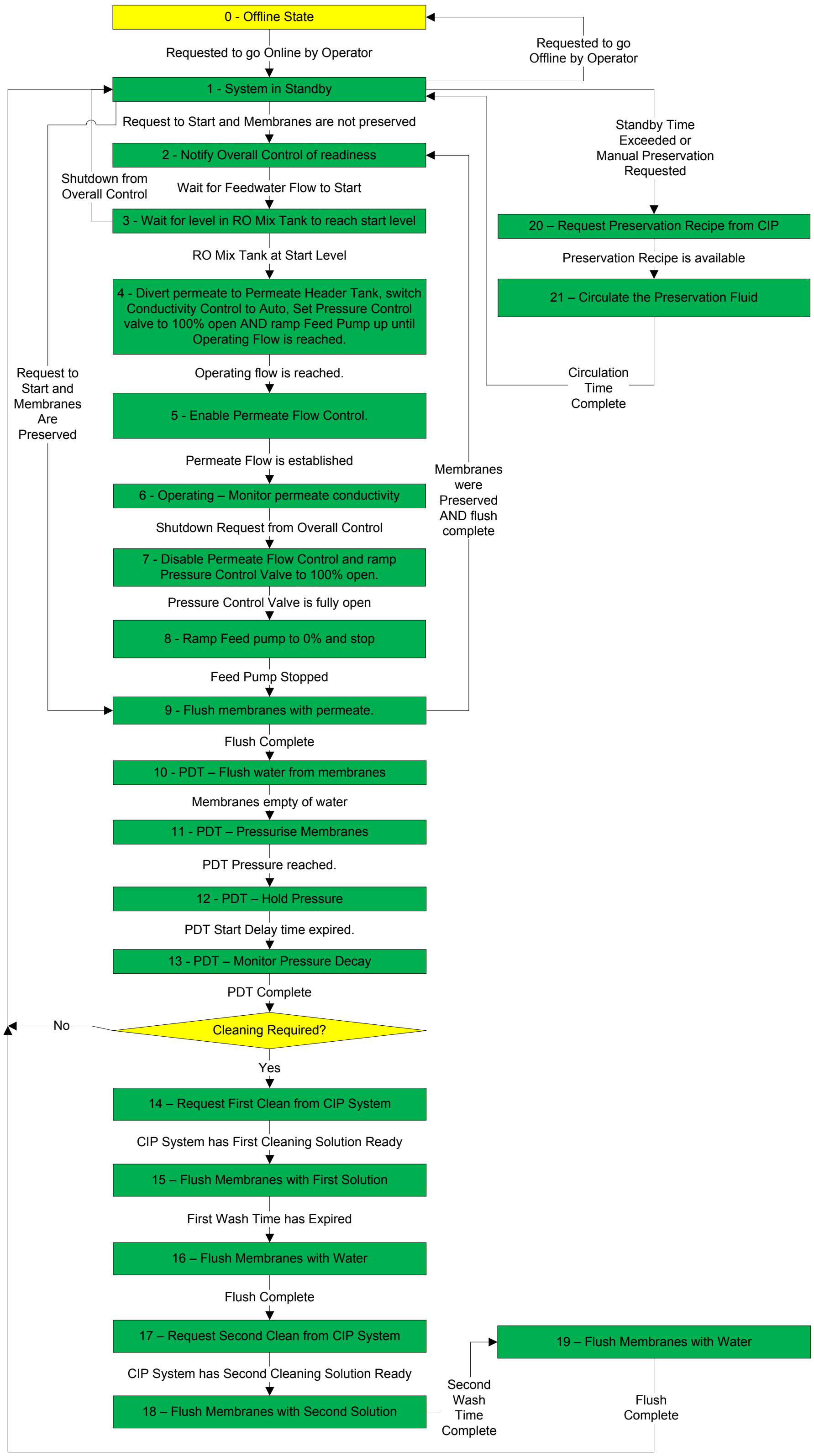
- The RO Mix tank, which received product water from the BAC Filter and the returned concentrate from the end of the RO Filter train. The feed water to the RO Filter train is drawn from this tank.
- RO Feed Pump and pre filter, the RO Feed pump supplies the process water under pressure to the RO Filter train. The flow delivered by this pump is controlled by varying the speed of the pump.
- There is a 1µm pre filter prior to the pump to protect the RO Filter train from any large particles that may be in the system.
- The RO Filter train consists of five 4" elements connected in series as a single stage filter. There is a pressure controlling valve at the end of the train that allows for the pressure

within the filter to be controlled and hence the permeate flow.

- Each filter element has individual monitoring of feed and permeate conductivity. The final element also has concentrate discharge conductivity monitoring.
- The flow of feed, permeate and concentrate are individually monitored.
- The concentrate flow is split between going to the ocean outfall and being return the mixing tank by a 3-way control valve. This split is used to control the recovery of the system.
- The system includes a Permeate Header tank that is filled with RO Permeate and used to flush the concentrate side of the membranes prior to shutting the system down.
- The RO Filter is also connected to the CIP system to allow the membranes to be cleaned on a periodic basis. Cleaning consists of flushing the membranes with a heated alkaline cleaning solution, flushing with water and then flushing with a heated acidic solution before a final flush with water
- Because the RO system can be shutdown for lengthy periods of time there is a system to automatically flush the membranes with a preservation solution to prevent biological activity.
- The system includes a Pressure Decay Test (PDT) system to test the integrity of the membranes at the end of each batch of water.

The RO System starts and stops all the associated equipment based on the sequence detailed in Section 0 and Section 0. This sequence will also monitor all alarms and interlocks to ensure that the system is always operating safely and within the design parameters.

RO System - Sequence



RO System – Sequence Notes

Recovery Control

The split between flow of permeate and flow of brine to Ocean is set based on the desired Recovery Rate in percent (refer Section 0). The setpoint for the Permeate Flow Control Loop is generated based on the incoming flow (as measured by *L3031 Ozone System Feed Flow*) multiplied by the recovery rate. The setpoint for the Brine Discharge Flow Control Loop is generated base on the incoming flow multiplied by 1 minus the recovery rate.

Feed Flow Rate Control

The Feed Flow Control Loop is used to control the flow of concentrate to the filter by varying the speed of the Feed Pump (L3113). Its setpoint is provided directly from the operator setpoint (refer section 0)

Filter Pressure Control

The pressure in the filter is controlled by varying the position of the *Pressure Control Valve (L3149)*. This valve is controlled by the Back Pressure Control Valve PID Loop Controller (L3149_PID). The setpoint for this loop is either provided directly during the startup or in cascade mode from the Permeate Flow Control Loop when the filter is operating normally.

Permeate Flow Control

The flow of permeate is controlled by varying the pressure in the filter. This pressure is controlled the Filter Pressure Control Loop (refer Section 0) and the setpoint for this loop, when it in the Cascade mode is generated by the Permeate Flow Control Loop.

Brine Flow Control

The flow of Brine to the Ocean is controlled by varying the position of the *Conductivity Control Valve (L3151)*. This valve is directly controlled by the *Conductivity Control Valve - PID Control Loop* and the setpoint for this loop is generated based on the Recovery Rate and the flow through the system – refer section 0).

Mix Tank Level Control

The level in the Mix Tank is controlled by using the output of the Mix Tank Level Control Loop to trim the setpoints to the Permeate Flow Control Loop and the Brine Discharge Control Loop by ± 1 L/m. If the level in the Mix Tank is rising above the setpoint then the Permeate and Brine Flow Setpoints are increased above the inflow rate to bring the level back down. If the level drops below the setpoint then the Permeate and Brine Setpoints are reduced below the inflow rate.

Pressure Decay Test Calculation

The PDT Calculation is based on the following formula:

$$PDT\ Rate = \frac{PDT\ Pressure_{Start} - PDT\ Pressure_{Stop}}{Decay\ Time}$$

The PDT calculation is delayed for a period of time after the filter stops being pressurised. This is done to allow for the non-linear decay of the pressure that occurs in the early part of the test to be ignored. The PDT Start Pressure is recorded at this point.

Normalised Permeate Flow Calculation

The Normalised Permeate Flow is calculated as follows:

$$NPF({}^{L}/_{min} \cdot bar) = \frac{Permeate\ Flow\ ({}^{L}/_{min})}{Feed\ Pressure(bar)}$$

This value is used as an indication of the level of fouling of the membranes and when it drops below the minimum value it will trigger a clean of the membranes. Because the supply temperature remains constant no temperature correction is included in this calculation.

Rejection

The Salt Rejection for individual elements and the complete train is calculated as:

$$Rejection = \left(1.0 - \frac{Conductivity_{Permeate}}{Conductivity_{Feed}}\right) \times 100$$

LRV - Virus

Whilst the system is operating the LRV – Virus value is calculated as follows:

$$LRV_{Virus} = -\log\frac{Conductivity_{Permeate}}{Conductivity_{Feed}}$$

LRV - Bacteria

As above

LRV - Virus

Whilst the system is operating the LRV – Protozoa value is calculated as follows:

$$LRV_{Protozoa} = \log\left[\frac{0.301 \times Flow_{Permeate}}{\Delta P_{Test} \times (0.2336 \times Recovery\ Rate + 0.9764)}\right]$$

EQUIPMENT USAGE

This table details the steps of each sequence that each piece of equipment is requested to operate (run or open) in.

Equipment ID	Description	Sequence Steps																						
		0 (Offline)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	100 (Fault)
L3113	RO - Feed Pump	Stop	Stop	Stop	Stop	Run	Run	Run	Run	Run	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop	Stop
L3115	RO - CIP Supply Valve	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close	Open	Open	Close	Open	Open	Close	Open	Close
L3119	RO - Drain Valve	Close	Close	Close	Close	Close	Close	Close	Close	Close	Open	Open	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close	Open
L3148	RO - CIP Return Valve	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close	Open	Open	Close	Open	Open	Close	Open	Close
L3156	RO - Permeate to Storage/Feed Forwards Selector Valve	Storage	Storage	Storage	Storage	Storage	Forwards to UV System	Forwards to UV System	Forwards to UV System	Forwards to UV System	Storage	Storage	Storage	Storage	Storage	Storage	Storage	Storage	Storage	Storage	Storage	Storage	Storage	Storage
L3158	RO - PDT Supply Valve	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close	Open	Open	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close
L3161	RO - Membrane Flush Valve	Close	Close	Close	Close	Close	Close	Close	Close	Close	Open	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close	Close	Open
L3110_PID	RO - Mixing Tank Level – PID Control Loop	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output	Auto	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output
L3113_PID	RO - Feed Pump - PID Control Loop	Manual with 0% Output	Manual with 0% Output	Manual with 0% Output	Manual with 0% Output	Auto	Auto	Auto	Auto	Manual with 0% Output	Manual with 0% Output	Manual with 0% Output	Manual with 0% Output	Manual with 0% Output	Manual with 0% Output	Manual with 0% Output	Manual with 0% Output	Manual with 0% Output	Manual with 0% Output	Manual with 0% Output	Manual with 0% Output	Manual with 0% Output	Manual with 0% Output	Manual with 0% Output

Equipment ID	Description	Sequence Steps																					
		0 (Offline)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	100 (Fault)
L3149_ PID	RO - Back Pressure Control Valve - PID Control Loop	Manual with 0% Output	Manual with 0% Output	Manual with 0% Output	Manual with 100% Output	Manual with 100% Output	Auto	Auto/Casacde with Setpoint from L3153	Manual with 100% Output	Manual with 100% Output	Manual with 0% Output	Manual with 0% Output	Manual with 0% Output	Manual with 0% Output	Manual with 0% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output
L3151_ PID	RO - Conductivity Control Valve - PID Control Loop	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 0% Output	Auto	Auto	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output	Manual with 100% Output
L3153_ PID	RO - Permeate Flow Control Loop	Manual with L3117 as Output	Manual with L3117 as Output	Manual with L3117 as Output	Manual with L3117 as Output	Manual with L3117 as Output	Manual with L3117 as Output	Auto	Manual with L3117 as Output	Manual with L3117 as Output	Manual with L3117 as Output	Manual with L3117 as Output	Manual with L3117 as Output	Manual with L3117 as Output	Manual with L3117 as Output	Manual with L3117 as Output	Manual with L3117 as Output	Manual with L3117 as Output	Manual with L3117 as Output	Manual with L3117 as Output	Manual with L3117 as Output	Manual with L3117 as Output	Manual with L3117 as Output	Manual with L3117 as Output

RO System - Set Points

Recovery Rate

This is the desired recovery rate for the system to operate at. It directly set the percentage of feed water that is fed forwards as RO permeate.

Default Value: 70%.

Range: 50 – 80%

Operational Level in RO Mix Tank

This is the desired level in the RO Mix Tank during operation. It is also the minimum level in this tank before the system will be allowed to start. The Permeate and Brine Flow will be adjusted to maintain this level.

Default Value: 500 Litres

Range: 200 – 700 Litres

Concentrate Flow

This is the desired concentrate flow for the system, the speed of the feed pump will be adjusted to achieve this flow.

Default Value: 27 Lt/min.

Range: 15 – 40 Lt/min

Pressure Decay Test (PDT) Decay Time

This is the time that is allowed for the pressure in the filters to decay during a PDT.

Default Value: 10 Minute

Range: 1 – 60 Minutes

Pressure Decay Test Start Delay

This is the amount of time in seconds after the membranes have stopped being pressurised that the Start Pressure for the PDT test is recorded.

Default Value: 120 Seconds

Range: 0 – 1200 Seconds

First Chemical Wash Recipe Number

This is the Recipe Number (refer to the CIP System FD for Recipe details) that the CIP system will produce when the RO Cleaning cycle requests the first chemical wash.

Default Value: N.A.

Range: 1 – 7

First Chemical Wash Time

This is the time that the first chemical wash will circulate for during the First Wash Step of the RO Cleaning cycle.

Default Value: 600 Seconds

Range: 60 – 18000 Seconds

Second Wash Recipe Number

This is the Recipe Number (refer to the CIP System FD for Recipe details) that the CIP system will produce when the RO Cleaning cycle requests the second chemical wash.

Default Value: N.A.

Range: 1 – 7

Second Wash Time

This is the time that the second wash will circulate for during the Second Chemical Wash Step of the RO Cleaning cycle.

Default Value: 600 Seconds

Range: 60 – 18000 Seconds

Preservation Wash Recipe Number

This is the Recipe Number (refer to the CIP System FD for Recipe details) that the CIP system will produce when the RO Preservation cycle requests the preservation solution.

Default Value: N.A.

Range: 1 – 7

RO System - Alarms

Equipment Fault

Cause: Any piece of equipment which is required by the Sequence has either been switched to Manual Mode or has faulted. In either case the equipment is no longer available to the Sequence, therefore an Equipment fault is generated.

Check Steps: Every step except Step 0 (Offline)

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: All equipment must have any faults reset and be switched back to the Auto Mode. Once all equipment is available the fault can be reset by pressing the “Fault Reset/Continue” button.

Membranes fouled warning

Cause: The system is reaching the limits of pressure and flow to achieve the required throughput of the system. This is a result of the membranes being fouled and the Normalised Permeate Flow exceeding the Maximum Value. This alarm will trigger a clean at the end of the current batch.

Check Steps: Step 6

Effect: When this fault occurs a warning is flagged along with a request to do a cleaning cycle at the end of the current batch.

Reset Requirements: The fault can be reset by pressing the "Fault Reset/Continue" button.

Excessive High Pressure Fault

Cause: The system has detected the pressure in the system has exceeded the Hi Hi alarm point. This indicates a significant blockage of the membranes that requires an immediate shutdown to prevent system damage.

Check Steps: Step 4 – 8

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it. When it is reset it will trigger a cleaning cycle immediately.

Reset Requirements: Determine why an excessively high pressure has occurred and rectify. The fault can be reset by pressing the "Fault Reset/Continue" button.

1µm Feed Filter Blocked

Cause: The system has detected that the differential pressure across the Feed Filter has exceeded the maximum value which indicates that the filter is blocked.

Check Steps: Step 4 - 8

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it. When it is reset it will trigger a cleaning cycle immediately.

Reset Requirements: Replace the filter cartridge. The fault can be reset by pressing the "Fault Reset/Continue" button.

Feed Flow Deviation Alarm

Cause: The system has detected that it is not able to maintain the feed flow to the RO membranes within the required flow rate. This may indicate blockages, pump failure, etc.

Check Steps: Step 4 - 6

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it. When it is reset it will trigger a cleaning cycle immediately.

Reset Requirements: Determine why the pump is not able to maintain the required flow and rectify. The fault can be reset by pressing the "Fault Reset/Continue" button.

Feed Pressure Deviation Alarm

Cause: The system has detected that it is not able to maintain the feed pressure to the RO membranes within the required range. This may indicate blockages, leakages, pump failure, etc.

Check Steps: Step 4 - 6

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it. When it is reset it will trigger a cleaning cycle immediately.

Reset Requirements: Determine why the pump is not able to maintain the required pressure and rectify. The fault can be reset by pressing the “Fault Reset/Continue” button.

Permeate Flow Deviation Alarm

Cause: The system has detected that it is not able to maintain the permeate flow from the RO membranes within the required range. This may indicate blockages, fouling, leakages, pump failure, etc.

Check Steps: Step 4 - 6

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it. When it is reset it will trigger a cleaning cycle immediately.

Reset Requirements: Determine why the system is not able to maintain the required flow and rectify. The fault can be reset by pressing the “Fault Reset/Continue” button. The fault can be reset by pressing the “Fault Reset/Continue” button.

OPERATIONAL INTERLOCKS

The following is a list of interlocks which are specific to certain pieces of equipment. Each drive can have up to eight independent interlocks and some of these interlocks can be masked under certain conditions, these conditions are listed in the “Mask” column.

Equipment Interlocks

L3115 - RO - CIP Supply Valve

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.10.1 *L3119 - RO - Drain Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.10.2 *L3148 - RO - CIP Return Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.10.3 *L3156 - RO - Permeate to Storage/Feed Forwards Selector Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.10.4 *L3158 - RO - PDT Supply Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.10.5 *L3161 - RO - Membrane Flush Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.10.6 *L3149 - RO - Back Pressure Control Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.10.7 *L3151 - RO - Conductivity Control Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.10.8 *L3113 - RO - Feed Pump*

Interlock	Description	Mask
1	High High Discharge Pressure (L3117)	NA
2	Low Level in Mix Tank (L3107)	NA
3	None	NA
4	None	NA
5	None	NA
6	None	NA
7	None	NA
8	None	NA

PROCESS INTERFACES

Not Applicable

ASSUMPTIONS AND EXCLUSIONS

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CONTROL SYSTEM

Manual Control

Whilst none of the automatic sequences are running any piece of equipment can be operated in the manual mode. This means that the operator will be able to change the state of any piece of equipment provided they change the equipment to Manual Mode first as per the standard operating philosophy for equipment.

Auto Control

Whilst any of the automatic sequences are running all equipment associated with those sequences must be in the automatic mode. If any piece of equipment is switched to the manual mode during operation of an automatic sequence the sequence will stop operating and generate a fault. It is the responsibility of the operator to ensure that switching equipment to manual during automatic operation will not cause damage to equipment and/or product.

Operator Notification

Where appropriate the operator will be prompted by the system to ensure that the operator is present and aware of the current stage in the process. This system will take the form of a popup asking the operator to confirm that they are aware by clicking on an “Okay” or simular button.

ALARM DEFINITION AND MANAGMENT

In addition to the standard alarms that are generated for standard pieces of equipment the following system specific alarms will be provided.

- *Equipment Interlock:* If any piece of equipment required by this process cell faults or is switched to the manual mode whilst the sequence is running the sequence will go into the fault mode. An equipment fault alarm will be generated when this occurs.

All alarms are generated within the PLC controller and displayed and logged on the SCADA system as per the Citect User Manual, the list of alarms associated with each standard piece of equipment can also be found in this document.

POWER FAILURE

When the power is restored after a power failure, the system will be reset with all sequences stopped and in the default state. However the Batch numbers, etc will be retained such that the sequences, when restarted, will start from where they left off when the power failure occurred.

Davis Advanced Water Treatment Plant – Ultra-Violet (UV) Disinfection System

FUNCTIONAL DESCRIPTION

AUTHORS			
Author			**Institution**
Michael Packer			Australian Antarctic Division
VERSION CONTROL REVISION HISTORY			
Version	**Date revised**	**Section Revised**	**Revision**
1.0	21/3/2014	NA	First Draft – Packer
1.1	05/04/2015	All	“As Built”
1.2	28/05/2015	7.2	Added Low UV Transmissivity Alarm
APPROVAL			
Version	**Date Approved**	**Person Approving**	

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PURPOSE

This Functional Requirements Specification details the operation of the Ultra-Violet (UV) System that forms the Fifth Barrier in the Davis Advanced Water Treatment Plant (Davis AWTP). It includes a full description of the modes of operation plus the system interlocks and alarms. All the PLC and SCADA programming done for this system will be executed according to this document.

SCOPE

This Functional Requirements Specification applies to the operation of the UV System and associated equipment.

The equipment associated with the UV System includes all equipment listed in section 0 of this document.

The operation of the UV System will be completely automated in line with the expectations of the project to make a system that required minimal or no operator input and also to increase the safety and consistency of the system.

The Davis AWTP has a dedicated Alan Bradley ControlLogix 5000 PLC and this will be used to control the UV System. The Davis AWTP also has a dedicated Citect SCADA system which will be used as an interface to monitor and control the system.

DEFINITIONS

PC	Personal Computer
SCADA	Supervisory Control and Data Acquisition
MCC	Motor Control Centre
Historical Trends	A Historical Trend is a series of measurements taken at a regular interval of a field based variable.
User	A user is an individual who is using a system or piece of equipment
AWTP	Advanced Water Treatment Plant, a treatment plant that process water to a standard suitable for potable use.

REFERENCES

	Title	*Reference*
1	*Davis AWTP P&ID – Ozone and Backwash*	*27/13/07 Sheet 1 of 4*
2	*Davis AWTP P&ID – MF and BAC*	*27/13/07 Sheet 2 of 4*
3	*Davis AWTP P&ID – RO*	*27/13/07 Sheet 3 of 4*
4	*Davis AWTP P&ID – UV, Calcite and Chlorine*	*27/13/07 Sheet 4 of 4*
5	*Davis AWTP – Functional Description*	
6	*Davis AWTP – MF Functional Description*	
7	*Davis AWTP – MF Cleaning Functional Description*	
8	*Davis AWTP – BAC Functional Description*	
9	*Davis AWTP – RO Functional Description*	
10	*Davis AWTP – UV Functional Description*	
11	*Davis AWTP – CL Functional Description*	
12	*Davis AWTP – CIP Functional Description*	
13	*Davis AWTP – Citect Users Manual*	
14	*Davis AWTP – Operator Manual*	

MATERIALS AND EQUIPMENT

SCADA

The Citect SCADA system provides operators with control over, and feedback from, the UV System. The UV System will be displayed on a number of graphics pages in the Davis AWTP project of the AAD SCADA system. The Citect system will also provide alarming, trending and reporting functionality for the UV System.

PLC

The dedicated Davis AWTP ControlLogix 5000 system is used to control the UV System. This PLC is located in the Electrical Control Panel for the Davis AWWTP and is linked via Ethernet to the Davis Intranet.

Equipment – Instruments

Instrument ID	Description	Range
L3165	UV - Transmisitivity	75…100% Transmisitivity
L3167	UV - Reactor No.1 Intensity	0…300 W/m^2
L3171	UV - Reactor No.2 Intensity	0…300 W/m^2

Equipment – Drives

Equipment ID	Description
L3166	UV - Reactor No.1
L3170	UV - Reactor No.2

Equipment – Solenoid Valves

Note: It is assumed that all gates and diverters have position feedback.

Equipment ID	Description
None	N.A

1.11 Equipment – Control Valves

Equipment ID	Description
None	N.A

1.12 Equipment – PID Control Loops

Equipment ID	Description
None	N.A

OPERATIONAL DESCRIPTION

Overview

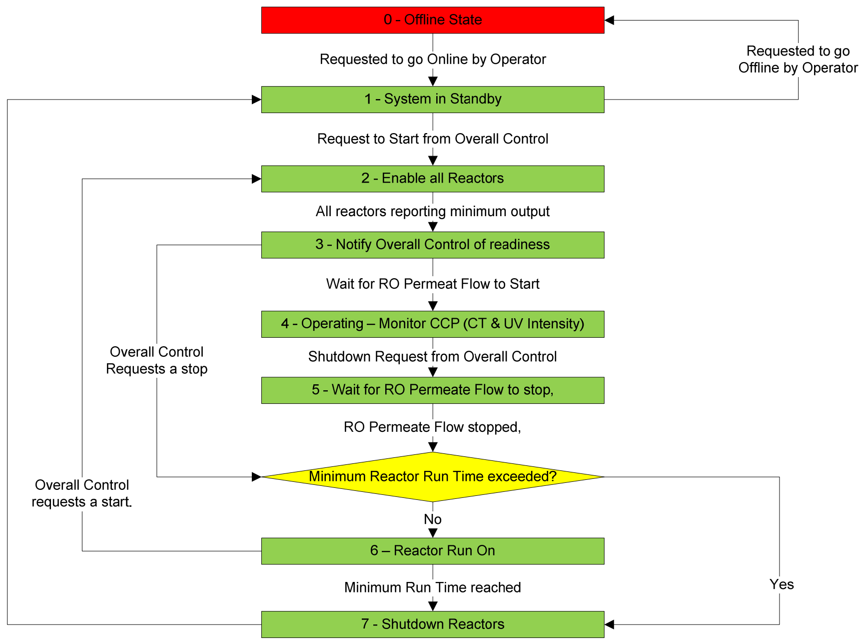
The UV System is responsible for disinfecting the process water through the use of high intensity UV-C radiation and monitoring the performance of the reactors.

The UV System contains the following key components:

- Two UV Reactors which each utilise a single low-pressure UV lamp to produce UV-C radiation.
- The two reactors are connected in series to provide redundancy. Each reactor is capable of producing considerably more UV energy that is required to achieve the required intensity to meet the LRV requirements for this barrier.
- Each reactor is fitted with an intensity monitoring system which allows online monitoring of the output of each reactor and this is used to ensure that the system is operating at all times.
- The UV Transmissivity of the incoming water is also manually measured weekly to ensure that this parameter is within the range of the certification for the reactors.

The UV System starts and stops all the associated equipment. This sequence will also monitor all alarms and interlocks to ensure that the system is always operating safely and within the design parameters.

UV System - Sequence



UV System – Sequence Notes

Dose (CT) Calculation

The UV dose being delivered to the product water is a calculated for each reactor as follows:

$$CT(mJ/cm^2) = ReactorVolume(L) \times Flow(L/sec) \times Intensity(mW/cm^2)$$

EQUIPMENT USAGE

This table details the steps of each sequence that each piece of equipment is requested to operate (run or open) in.

Equipment ID	Description	Sequence Steps								
		0 (Offline)	1	2	3	4	5	6	7	100 (Fault)
L3166	UV - Reactor No.1	Stopped	Stopped	Running	Running	Running	Running	Running	Stopped	Stopped
L3170	UV - Reactor No.2	Stopped	Stopped	Running	Running	Running	Running	Running	Stopped	Stopped

UV System - Set Points

1.12.1 *Minimum Run Time for UV Reactors*

This is the minimum time that the UV Reactors are permitted to operator for. This limits the number of times that the reactors restart and thereby increases the life of the tubes.

Default Value: 720 Minutes.

Range: 0 – 720 Minutes

UV System - Alarms

Equipment Fault

Cause: Any piece of equipment which is required by the Sequence has either been switched to the Manual Mode or has faulted. In either case the equipment is no longer available to the Sequence, therefore an Equipment fault is generated.

Check Steps: Every step except Step 0 (Offline)

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: All equipment must have any faults reset and be switched back to the Auto Mode. Once all equipment is available the fault can be reset by pressing the “Fault Reset/Continue” button.

Reactor No.1 Low UV Intensity Warning

Cause: The system has detected that the UV Intensity of Reactor No.1 has dropped below the lower limit. The most likely cause of this that the output of the UV Lamps has either failed or its output as deteriorated.

Check Steps: Step 3 and 4

Effect: When this fault occurs flag a warning.

Reset Requirements: Determine why the UV Lamp is producing insufficient output and rectify. The fault can be reset by pressing the "Fault Reset/Continue" button.

Reactor No.2 Low UV Intensity Warning

Cause: The system has detected that the UV Intensity of Reactor No.2 has dropped below the lower limit. The most likely cause of this that the output of the UV Lamps has either failed or its output as deteriorated.

Check Steps: Step 3 and 4

Effect: When this fault occurs flag a warning.

Reset Requirements: Determine why the UV Lamp is producing insufficient output and rectify. The fault can be reset by pressing the "Fault Reset/Continue" button.

Both Reactors have Low UV Intensity

Cause: The system has detected that the UV Intensity of both reactors has dropped below the lower limit meaning that that system can no longer deliver full capacity.

Check Steps: Step 3 and 4

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Determine why the UV Lamps are producing insufficient output and rectify. The fault can be reset by pressing the "Fault Reset/Continue" button.

Low UV Transmissivity

Cause: The system has detected that the UV Transmissivity of the RO permeate has dropped below the alert or alarm values and therefore the UV reactors are operating outside there certified range.

Check Steps: Step 4 and 5

Effect: The UV transmissivity is determined manually during weekly measurements. When this fault is detected, the operating is required to either stop the plant if it is below the critical UV transmittance or else investigate why the UV transmissivity is dropping. The transmissivity should be recorded and plotted every week to identify trends in the data. Slow decline of the UV transmissivity might be associated with ageing and wear of the RO membranes, so a gradual decline could signal the need to replace the RO membranes once the UV transmissivity is below the alarm value. A decrease in RO conductivity rejection would also be observed.

Reset Requirements: Determine why UV Transmissivity of the water has dropped and rectify. The fault can be reset by pressing the "Fault Reset/Continue" button.

OPERATIONAL INTERLOCKS

The following is a list of interlocks which are specific to certain pieces of equipment. Each drive can have up to eight independent interlocks and some of these interlocks can be masked under certain conditions, these conditions are listed in the "Mask" column.

Equipment Interlocks

L3166 UV - Reactor No.1

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA
5	None	NA
6	None	NA
7	None	NA
8	None	NA

1.12.2 *L3170 UV - Reactor No.2*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA
5	None	NA
6	None	NA
7	None	NA
8	None	NA

PROCESS INTERFACES

Not Applicable

ASSUMPTIONS AND EXCLUSIONS

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CONTROL SYSTEM

Manual Control

Whilst none of the automatic sequences are running, any piece of equipment can be operated in the manual mode. This means that the operator will be able to change the state of any piece of equipment provided they change the equipment to Manual Mode first as per the standard operating philosophy for equipment.

Auto Control

Whilst any of the automatic sequences are running all equipment associated with those sequences must be in automatic mode. If any piece of equipment is switched to manual mode during operation of an automatic sequence, the sequence will stop operating and generate a fault. It is the responsibility of the operator to ensure that switching equipment to manual during automatic operation will not cause damage to equipment and/or product.

Operator Notification

Where appropriate the operator will be prompted by the system to ensure that the operator is present and aware of the current stage in the process. This system will take the form of a popup asking the operator to confirm that they are aware by clicking on an “Okay” or simular button.

ALARM DEFINITION AND MANAGMENT

In addition to the standard alarms that are generated for standard pieces of equipment, the following system specific alarms will be provided.

- *Equipment Interlock:* If any piece of equipment required by this process cell faults or is switched to the manual mode whilst the sequence is running the sequence will go into the fault mode. An equipment fault alarm will be generated when this occurs.

All alarms are generated within the PLC controller and displayed and logged on the SCADA system as per the Citect User Manual. The list of alarms associated with each standard piece of equipment can also be found in this document.

POWER FAILURE

When the power is restored after a power failure, the system will be reset with all sequences stopped and in the default state. However the Batch numbers, etc will be retained such that the sequences, when restarted, will start from where they left off when the power failure occurred.

Davis Advanced Water Treatment Plant – Chlorination System

FUNCTIONAL DESCRIPTION

AUTHORS			
Author		**Institution**	
Michael Packer		Australian Antarctic Division	
VERSION CONTROL REVISION HISTORY			
Version	**Date revised**	**Section Revised**	**Revision**
1.0	21/3/2014	NA	First Draft – Packer
1.1	06/04/2015	All	"As Built"
APPROVAL			
Version	**Date Approved**	**Person Approving**	

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PURPOSE

This Functional Requirements Specification details the operation of the Chlorination (CL) System that forms the Sixth Barrier in the Davis Advanced Waste Water Treatment Plant (Davis AWWTP). It includes a full description of the modes of operation plus the system interlocks and alarms. All the PLC and SCADA programming done for this system will be executed according to this document.

SCOPE

This Functional Requirements Specification applies to the operation of the CL System and associated equipment.

The equipment associated with the CL System includes all equipment listed in section 0 of this document.

The operation of the CL System will be completely automated in line with the expectations of the project to make a system that required minimal or no operator input and also to increase the safety and consistency of the system.

The Davis AWWTP has a dedicated Alan Bradley ControlLogix 5000 PLC and this will be used to control the CL System. The Davis AWWTP also has a dedicated Citect SCADA system which will be used as an interface to monitor and control the system.

DEFINITIONS

PC	Personal Computer
SCADA	Supervisory Control and Data Acquisition
MCC	Motor Control Centre
Historical Trends	A Historical Trend is a series of measurements taken at a regular interval of a field based variable.
User	A user is an individual who is using a system or piece of equipment
AWWP	Advanced Waste Water Treatment Plant, a treatment plant that process water to a very high standard.

REFERENCES

	Title	*Reference*
1	*Davis AWTP P&ID – Ozone and Backwash*	*27/13/07 Sheet 1 of 4*
2	*Davis AWTP P&ID – MF and BAC*	*27/13/07 Sheet 2 of 4*
3	*Davis AWTP P&ID – RO*	*27/13/07 Sheet 3 of 4*
4	*Davis AWTP P&ID – UV, Calcite and Chlorine*	*27/13/07 Sheet 4 of 4*
5	*Davis AWTP – Functional Description*	
6	*Davis AWTP – MF Functional Description*	
7	*Davis AWTP – MF Cleaning Functional Description*	
8	*Davis AWTP – BAC Functional Description*	
9	*Davis AWTP – RO Functional Description*	
10	*Davis AWTP – UV Functional Description*	
11	*Davis AWTP – CL Functional Description*	
12	*Davis AWTP – CIP Functional Description*	
13	*Davis AWTP – Citect Users Manual*	
14	*Davis AWTP – Operator Manual*	

MATERIALS AND EQUIPMENT

SCADA

The Citect SCADA system provides operators with control over, and feedback from, the CL System. The CL System will be displayed on a number of graphics pages in the Davis AWWTP project of the AAD SCADA system. The Citect system will also provide alarming, trending and reporting functionality for the CL System.

PLC

The dedicated Davis AWWT ControlLogix 5000 system will be used to control the CL System. This PLC is located in the Electrical Control Panel for the Davis AWWTP and is linked via Ethernet to the Davis Intranet.

Equipment - Instruments

Instrument ID	Description	Range
L3181	Cl - Feed Water Temperature	0...100°C
L3187	Cl - Chlorine Concentration	0...20 mg/L
L3188	Cl - pH	0...14 pH
L3194	CL - Contact Tank No.1 Level	0...100 mBar
L3198	Cl - Contact Tank No.1 Chlorine Concentration	0...10 mg/L
L3201	Cl - Contact Tank No.2 Level	0...100 mBar
L3205	Cl - Contact Tank No.2 Chlorine Concentration	0...10 mg/L
L3243	Dosing - Chlorine Drum Empty	On/Off

Equipment - Drives

Equipment ID	Description
L3186	Cl - Sample Pump
L3197	Cl - Contact Tank No.1 Sample Pump
L3204	Cl - Contact Tank No.2 Sample Pump
L3242	Dosing - Chlorine to Chlorine System Pump

Equipment – Solenoid Valves

Note: It is assumed that all gates and diverters have position feedback.

Equipment ID	Description
L3190	Cl - Water to Drain or Contact Tanks Selector Valve
L3192	Cl - Contact Tank Feed Selector Valve

1.13 Equipment – Control Valves

Equipment ID	Description
	None

1.14 Equipment – PID Control Loops

Equipment ID	Description
L3242	CL - Chlorine to Chlorine System Pump Dosing Control Loop

OPERATIONAL DESCRIPTION

Overview

The CL System is responsible for disinfecting the process water by adding chlorine and monitoring the concentration to ensure that sufficient disinfection is occurring.

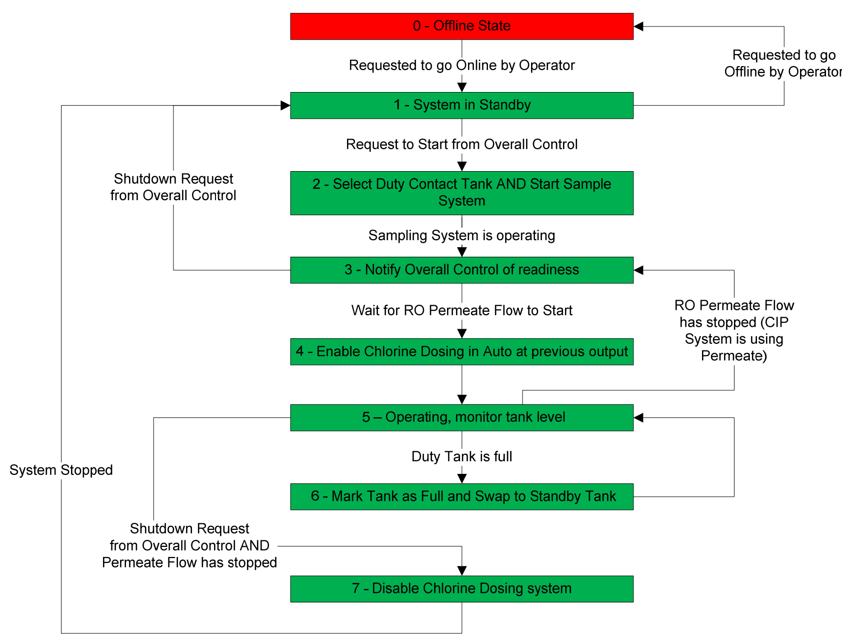
The CL System contains the following key components:

- A store of Sodium Hypochlorite and a Dosing Pump and associated plumbing to deliver it to the product water flow. The pumping rate is calculated based on the flow rate being delivered by the RO system.

- There is a free chlorine meter that measures the actual concentration of free chlorine being dosed into the product water and this value is used to trim the dosing pump speed to compensate for variations in the system.
- There are two contact tanks that are alternately filled with the chlorinated water. Once one tank is full the system switches the flow to the other tank. The first tank is then allowed to sit for the minimum contact time required to achieve the LRV.
- Each contact tank has a free chlorine monitor in that is used to confirm that the minimum CT value (based on time and concentration) is achieved before the water is ready to be discharged.

The CL System starts and stops all the associated equipment. This sequence will also monitor all alarms and interlocks to ensure that the system is always operating safely and within the design parameters.

CL System - Sequence



Chlorination System – Sequence Notes

Dosing Control

The speed for the dosing pump is calculated as follows:

$$PumpRate\left(\frac{ml}{hr}\right) = \frac{Concentration_{required}\left(\frac{mg}{mL}\right) \times Flow\left(\frac{L}{min}\right) \times 60(min)}{Concentration_{RawHypo}\left(\frac{mg}{mL}\right)}$$

The flow paced Pump Rate calculated above is trimmed with the Output of the Dosing PID Loop (Max 10%) to account for variations in the system.

EQUIPMENT USAGE

This table details the steps of each sequence that each piece of equipment is requested to operate (run or open) in.

Equipment ID	Description	Sequence Steps								
		0 (Offline)	1	2	3	4	5	6	7	100 (Fault)
L3186	Cl - Sample Pump	Stopped	Stopped	Stopped	Stopped	Stopped	Running	Running	Stopped	Stopped
L3197	Cl - Contact Tank No.1 Sample Pump	Any time the No.1 Contact Tank contains a complete Batch of Water								
		Stopped	Stopped	Running if Tank is NOT Empty	Running if Tank is NOT Empty	Running if Tank is NOT Empty	Running if Tank is NOT Empty	Running if Tank is NOT Empty	Running if Tank is NOT Empty	Stopped
L3204	Cl - Contact Tank No.2 Sample Pump	Any time the No.2 Contact Tank contains a complete Batch of Water								
		Stopped	Stopped	Running if Tank is NOT Empty	Running if Tank is NOT Empty	Running if Tank is NOT Empty	Running if Tank is NOT Empty	Running if Tank is NOT Empty	Running if Tank is NOT Empty	Stopped
L3242	Dosing - Chlorine to Chlorine System Pump	Stopped	Stopped	Stopped	Stopped	Running	Running	Running	Stopped	Stopped
L3190	Cl - Water to Drain or Contact Tanks Selector Valve	To Drain	To Drain	To Drain	To Tanks	To Tanks	To Tanks	To Tanks	To Tanks	To Drain
L3192	Cl - Contact Tank Feed Selector Valve	Closed	Closed	Open when Tank No.2 is selected to duty Closed when Tank No.1 is selected for Duty						Closed
L3242	CL - Chlorine to Chlorine System Pump Dosing Control Loop	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output	Manual with 50% Output	Auto	Auto	Auto	Manual with 50% Output	Manual with 50% Output

CL System - Set Points

Batch Size

This is the volume of water in a Contact tank that constitutes a complete batch.

Default Value: 900 litres.

Range: 2000 – 1000 litres

1.14.1 *Chlorine Dosing Concentration*

This is the desired concentration of free chorine in the product water. It is used to calculate the speed of the dosing pump.

Default Value: 0.7 mg/L.

Range: 0.1 – 3.0 mg/L

1.14.2 *Raw Hypo Solution Concentration*

This is the current strength of the Sodium Hypochlorite solutions. This needs to be measure periodically by the operator as the solution degrades over time.

Default Value: 50 mg/mL.

Range: 0 – 500 mg/mL

1.14.3 *Max Capacity of Chlorine Dosing Pump*

This is the maximum rate at which the Chlorine Dosing Pump can deliver the raw Hypo solution to the dosing point. It is used to calculate speed at which to run the dosing pump.

Default Value: 50 mL/hr.

Range: 0 – 100 mL/hr

1.14.4 *Contact Time*

This is the period of time that a complete batch of water is held in the contact tank before being identified as complete and ready for discharge. This value is set based on the required LRV for this barrier.

Default Value: 0.7 mg/L.

Range: 0.1 – 3.0 mg/L

CL System - Alarms

Equipment Fault

Cause: Any piece of equipment which is required by the Sequence has either been switched to the Manual Mode or has faulted. In either case the equipment is no longer available to the Sequence, therefore an Equipment fault is generated.

Check Steps: Every step except Step 0 (Offline)

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: All equipment must have any faults reset and be switched back to the Auto Mode. Once all equipment is available the fault can be reset by pressing the “Fault Reset/Continue” button.

Both Tanks are Full

Cause: The system has detected both Chlorine Contact Tanks are full and that it is therefore not possible to continue to operate. This indicates that there is a problem with the discharge system that pumps the water from the tanks.

Check Steps: Step 2 – 6

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Determine why the tanks have not been emptied and rectify. The fault can be reset by pressing the “Fault Reset/Continue” button.

1.14.5 *No Chlorine for Dosing System*

Cause: The system has detected there the Hypo solution has run out and needs replenishing.

Check Steps: Step 4 – 6

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Determine why the UV Lamps are producing insufficient output and rectify. The fault can be reset by pressing the “Fault Reset/Continue” button.

1.14.6 *Chlorine Dosing Deviation*

Cause: The system has detected that it is not able to maintain the required concentration of Chlorine in the product water. This may indicate blockages, pump failure, incorrect concentrations, etc.

Check Steps: Step 4 - 6

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it. When it is reset it will trigger a cleaning cycle immediately.

Reset Requirements: Determine why the pump is not able to maintain the required flow and rectify. The fault can be reset by pressing the “Fault Reset/Continue” button.

OPERATIONAL INTERLOCKS

The following is a list of interlocks which are specific to certain pieces of equipment. Each drive can have up to eight independent interlocks and some of these interlocks can be masked under certain conditions, these conditions are listed in the “Mask” column.

Equipment Interlocks

1.14.7 *L3186 - Cl - Sample Pump*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA
5	None	NA
6	None	NA
7	None	NA
8	None	NA

1.14.8 *L3197 - Cl - Contact Tank No.1 Sample Pump*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA
5	None	NA
6	None	NA
7	None	NA
8	None	NA

1.14.9 *L3204 - Cl - Contact Tank No.2 Sample Pump*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA
5	None	NA
6	None	NA
7	None	NA
8	None	NA

1.14.10

1.14.11 *L3242 - Dosing - Chlorine to Chlorine System Pump*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA
5	None	NA
6	None	NA
7	None	NA
8	None	NA

1.14.12 *L3190 - Cl - Water to Drain or Contact Tanks Selector Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

1.14.13 *L3192 - Cl - Contact Tank Feed Selector Valve*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA

PROCESS INTERFACES

Not Applicable

ASSUMPTIONS AND EXCLUSIONS

-

CONTROL SYSTEM

Manual Control

Whilst none of the automatic sequences are running any piece of equipment can be operated in the manual mode. This means that the operator will be able to change the state of any piece of equipment provided they change the equipment to Manual Mode first as per the standard operating philosophy for equipment.

Auto Control

Whilst any of the automatic sequences are running all equipment associated with those sequences must be in the automatic mode. If any piece of equipment is switched to the manual mode during operation of an automatic sequence the sequence will stop operating and generate a fault. It is the responsibility of the operator to ensure that switching equipment to manual during automatic operation will not cause damage to equipment and/or product.

Operator Notification

Where appropriate the operator will be prompted by the system to ensure that the operator is present and aware of the current stage in the process. This system will take the form of a popup asking the operator to confirm that they are aware by clicking on an “Okay” or simular button.

ALARM DEFINITION AND MANAGMENT

In addition to the standard alarms that are generated for standard pieces of equipment the following system specific alarms will be provided.

- *Equipment Interlock:* If any piece of equipment required by this process cell faults or is switched to the manual mode whilst the sequence is running the sequence will go into the fault mode. An equipment fault alarm will be generated when this occurs.

All alarms are generated within the PLC controller and displayed and logged on the SCADA system as per the Citect User Manual, the list of alarms associated with each standard piece of equipment can also be found in this document.

POWER FAILURE

When the power is restored after a power failure, the system will be reset with all sequences stopped and in the default state. However the Batch numbers, etc will be retained such that the sequences, when restarted, will start from where they left off when the power failure occurred.

Davis Advanced Water Treatment Plant – CIP System

FUNCTIONAL DESCRIPTION

AUTHORS	
Author	**Institution**
Michael Packer	Australian Antarctic Division

VERSION CONTROL REVISION HISTORY			
Version	**Date revised**	**Section Revised**	**Revision**
1.0	23/3/2014	NA	First Draft – Packer

APPROVAL		
Version	**Date Approved**	**Person Approving**

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PURPOSE

This Functional Requirements Specification details the operation of the Clean In Place (CIP) System that is part of the support systems for the Davis Advanced Waste Water Treatment Plant (Davis AWWTP). It includes a full description of the modes of operation plus the system interlocks and alarms. All the PLC and SCADA programming done for this system will be executed according to this document.

SCOPE

This Functional Requirements Specification applies to the operation of the CIP System and associated equipment.

The equipment associated with the CIP System includes all equipment listed in section 0 of this document.

The operation of the CIP System will be completely automated in line with the expectations of the project to make a system that required minimal or no operator input and also to increase the safety and consistency of the.

The Davis AWWTP has a dedicated Alan Bradley ControlLogix 5000 PLC and this will be used to control the CIP System. The Davis AWWTP also has a dedicated Citect SCADA system which will be used as an interface to monitor and control the system.

DEFINITIONS

PC	Personal Computer
SCADA	Supervisory Control and Data Acquisition
MCC	Motor Control Centre
Historical Trends	A Historical Trend is a series of measurements taken at a regular interval of a field based variable.
User	A user is an individual who is using a system or piece of equipment
AWWP	Advanced Waste Water Treatment Plant, a treatment plant that process water to a very high standard.

REFERENCES

	Title	*Reference*
1	*Davis AWTP P&ID – Ozone and Backwash*	*27/13/07 Sheet 1 of 4*
2	*Davis AWTP P&ID – MF and BAC*	*27/13/07 Sheet 2 of 4*
3	*Davis AWTP P&ID – RO*	*27/13/07 Sheet 3 of 4*
4	*Davis AWTP P&ID – UV, Calcite and Chlorine*	*27/13/07 Sheet 4 of 4*
5	*Davis AWTP – Functional Description*	
6	*Davis AWTP – MF Functional Description*	
7	*Davis AWTP – MF Cleaning Functional Description*	
8	*Davis AWTP – BAC Functional Description*	
9	*Davis AWTP – RO Functional Description*	
10	*Davis AWTP – UV Functional Description*	
11	*Davis AWTP – CL Functional Description*	
12	*Davis AWTP – CIP Functional Description*	
13	*Davis AWTP – Citect Users Manual*	
14	*Davis AWTP – Operator Manual*	

MATERIALS AND EQUIPMENT

SCADA

The Citect SCADA system provides operators with control over, and feedback from, the CIP System. The CIP System will be displayed on a number of graphics pages in the Davis AWWTP project of the AAD SCADA system. The Citect system will also provide alarming, trending and reporting functionality for the CIP System.

PLC

The dedicated Davis AWWT ControlLogix 5000 system will be used to control the CIP System. This PLC is located in the Electrical Control Panel for the Davis AWWTP and is linked via Ethernet to the Davis Intranet.

Equipment - Instruments

Instrument ID	Description	Range
L3215	CIP - Tank Temperature	-50...150 °C
L3216	CIP - Tank Level	0 – XX litres
L3217	CIP - Tank Hi Level	-1.00...10.00 bar
L3218	CIP - pH	0 – 14 pH
L3220	CIP - Conductivity	0 – 20000 mS
L3221	CIP - Flow	0 – 150 lt/Sec
L3223	CIP - Circulation Loop Pressure	-1.00...10.00 bar
L3237	Dosing - Caustic Drum Empty	On/Off
L3239	Dosing - Acid Drum Empty	On/Off

L3241	Dosing - MSBS Drum Empty	On/Off

Equipment - Drives

Equipment ID	Description
L3222	CIP - Circulation Pump
L3214	CIP - Tank Heater
L3236	Dosing - Caustic to CIP Pump
L3238	Dosing - Acid to CIP Pump
L3240	Dosing - MSBS to CIP Pump

Equipment – Solenoid Valves

Note: It is assumed that all gates and diverters have position feedback.

Equipment ID	Description
L3224	CIP - Re Circulation Loop Valve
L3226	CIP - Destination Selector Valve
L3227	CIP - Station Water Supply Valve
L3228	CIP - Permeate Supply Valve

1.15 Equipment – Control Valves

Equipment ID	Description
	None

1.16 Equipment – PID Control Loops

Equipment ID	Description
L3222_PID	CIP - Circulation Pump – Flow Control Loop

OPERATIONAL DESCRIPTION

Overview

The CIP System is responsible for providing cleaning water and chemicals to the various systems that require cleaning.

The CIP System contains the following key components:

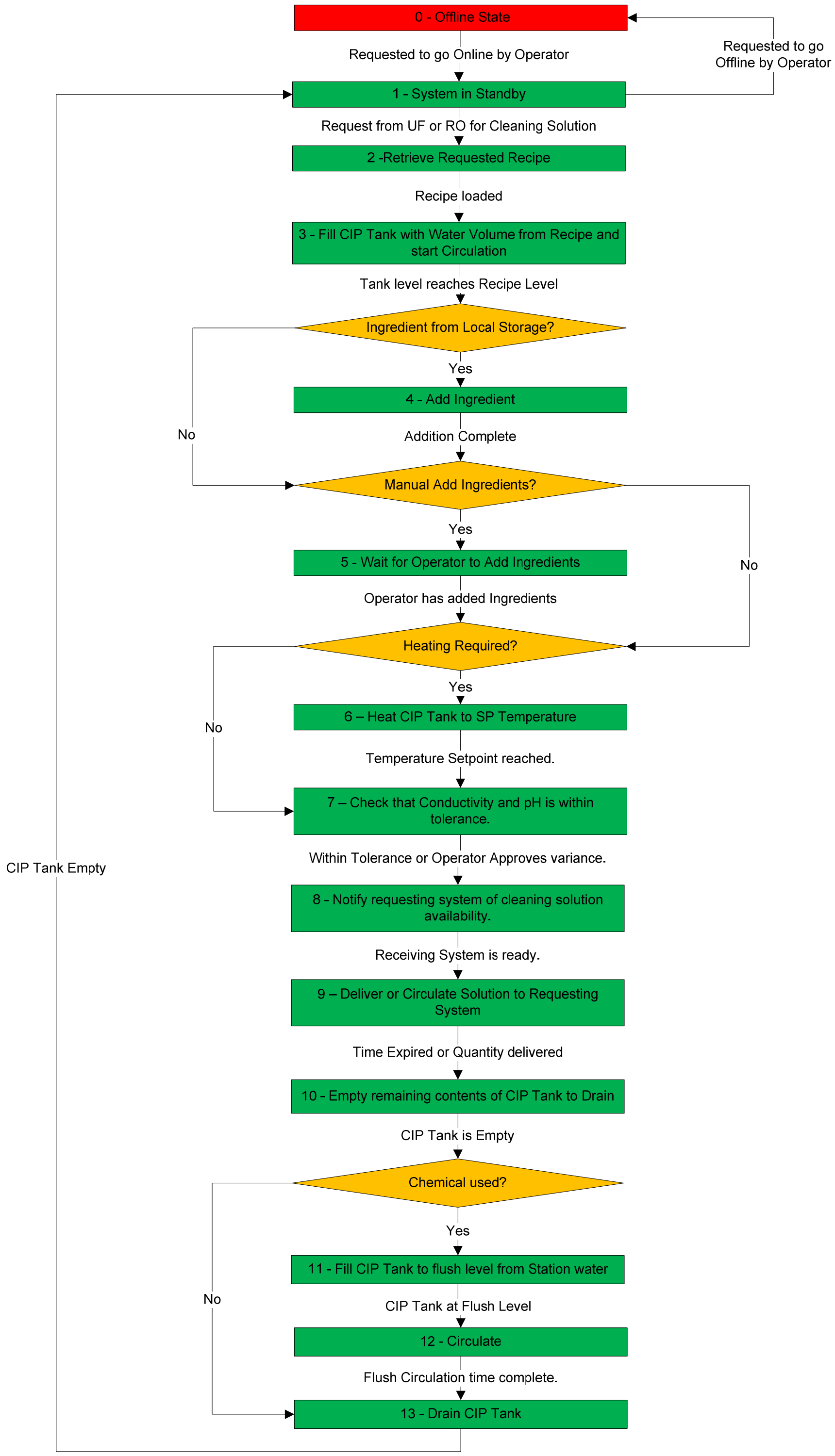
- The CIP batching tank is where cleaning solutions are mixed up prior to delivery. The Tank contains a heater and addition points for three different chemicals.
- Chemical Dosing system. There are three dosing pumps which can deliver various chemicals to the CIP Batching Tank at a metered rate. There is also manual addition point on the tank itself to allow for the addition of ingredient(s) that are not available from the dosing pumps.
- Circulations and delivery system. From the batching tank the cleaning solution can either be circulated back to the Tank during filling a washing steps or delivered to the requesting

system and then either returned to the Tank or sent to drain depending on what the requesting system requires. (For example the RO required that the cleaning solution be circulated for a period of time whereas the MF required that the solution be sent directly to drain after it has passed through the filter.)

- The conductivity, temperature and pH of the cleaning solution is measured and these values are used to confirm that the correct recipe has been prepared prior to delivery of the solution to the requesting system.
- Water Supply. The source of water for the recipes can either be RO permeate or Town Water depending on the requirements of the recipe. There is a limited supply of RO Permeate therefore there is an option to use town water when there is insufficient RO Permeate if this is acceptable.
- Recipe Management. The system has the capacity for 7 different recipes, any of which can be requested by any barrier that requires cleaning. The recipes

The CIP System starts and stops all the equipment associated with it. This sequence will also monitor all alarms and interlocks to ensure that the system is always operating safely and within the design parameters.

Sequence - CIP System



CIP System – Sequence Notes

Ingredient Dosing Quantity

The system calculates how long to run the dosing pump for based on the following equations:

$$Ingredient\ Qty(L) = Water\ Volume(L) \times \frac{RecipeQty(\frac{g}{L})}{Concentration(\frac{g}{L})}$$

$$Dosing\ Time(s) = \frac{Ingredient\ Qty(L)}{PumpRate(\frac{L}{s})}$$

EQUIPMENT USAGE

This table details the steps of each sequence that each piece of equipment is requested to operate (run or open) in.

Equipment ID	Description	Sequence Steps														
		0 (Offline)	1	2	3	4	5	6	7	8	9	10	11	12	13	100 (Fault)
L3222	CIP - Circulation Pump	Stopped	Stopped	Stopped	Running 10% IF L3216 < 40litre 100% IF L3216 ≥ 40litre			Running At L3222_PID Output				Running 10% IF L3216 < 40litre 100% IF L3216 ≥ 40litre				Stopped
L3214	CIP - Tank Heater	Stopped	Stopped	Stopped	Stopped	Stopped	Stopped	Running	Running if Heating required by Recipe On IF L3215 ≤ Temperature Setpoint			Stopped	Stopped	Stopped	Stopped	Stopped
L3236	Dosing - Caustic to CIP Pump	Stopped	Stopped	Stopped	Stopped	Running if Required by Recipe	Stopped	Stopped	Stopped	Stopped	Stopped	Stopped	Stopped	Stopped	Stopped	Stopped
L3238	Dosing - Acid to CIP Pump	Stopped	Stopped	Stopped	Stopped	Running if Required by Recipe	Stopped	Stopped	Stopped	Stopped	Stopped	Stopped	Stopped	Stopped	Stopped	Stopped
L3240	Dosing - MSBS to CIP Pump	Stopped	Stopped	Stopped	Stopped	Running if Required by Recipe	Stopped	Stopped	Stopped	Stopped	Stopped	Stopped	Stopped	Stopped	Stopped	Stopped

Equipment ID	Description	Sequence Steps														
		0 (Offline)	1	2	3	4	5	6	7	8	9	10	11	12	13	100 (Fault)
L3224	CIP - Re Circulation Loop Valve	CLosed	CLosed	CLosed	Open	Open	Open	Open	Open	Open	Open unless delivery valve to requesting System (MF or RO) is open.					CLosed
L3226	CIP - Destination Selector Valve	Recirculate	Recirculate	Recirculate	Recirculate	Recirculate	Recirculate	Recirculate	Recirculate	Recirculate	Dependant on Recipe	Drain	Recirculate	Recirculate	Drain	Recirculate
L3227	CIP - Station Water Supply Valve	CLosed	CLosed	CLosed	Open if required by Recipe	CLosed	CLosed	CLosed	CLosed	CLosed	CLosed	CLosed	Open	CLosed	CLosed	CLosed
L3228	CIP - Permeate Supply Valve	CLosed	CLosed	CLosed	Open if required by Recipe	CLosed	CLosed	CLosed	CLosed	CLosed	CLosed	CLosed	CLosed	CLosed	CLosed	CLosed
L3222_PID	CIP - Circulation Pump – Flow Control Loop	Manual with Ouput: 10% IF L3216 < 40litre 100% IF L3216 ≥ 40litre						Auto with Setpoint from Recipe				Manual with Ouput: 10% IF L3216 < 40litre 100% IF L3216 ≥ 40litre				

Set Points - CIP System

Ingredient No.1 Pump Rate

This is rate at which Ingredient No.1 is pumped by its dosing pump. This value is used to calculate how long to run the pump for to get the required concentration.

Default Value: 500 L/min

Range: 0 – 5000 L/min

1.16.1 *Ingredient No.2 Pump Rate*

This is rate at which Ingredient No.2 is pumped by its dosing pump. This value is used to calculate how long to run the pump for to get the required concentration.

Default Value: 500 L/min

Range: 0 – 5000 L/min

1.16.2 *Ingredient No.3 Pump Rate*

This is rate at which Ingredient No.3 is pumped by its dosing pump. This value is used to calculate how long to run the pump for to get the required concentration.

Default Value: 500 L/min

Range: 0 – 5000 L/min

Recipe

This is the Recipe list that contains all the possible recipes that are required by the system:

Value: Recipe Name

Description: Name of the recipe.

Default Value: “Empty”.

Range: 30 Characters

Value: Water Source

Description: Source of water to be used in the recipe.

Default Value: RO Permeate.

Range: RO Permeate OR Town Supply

Value: Use Town Water if no Permeate available?

Description: If the recipe calls for Permeate but there is none available is it okay to use Town Water instead?

Default Value: No.

Range: Yes/No

Value: Water Quantity

Description: Quantity of Water required for recipe.

Default Value: 100 Litre.

Range: 100 – 600 Litre

Value: Ingredient Source

Description: Specifies which ingredient to use or if there are manual additions to make. It is possible to select no ingredients if it is a water only recipe (i.e. MF Backwash, etc).

Default Value: No.

Range: Yes OR No

Value: Ingredient Quantity

Description: This is the required concentration of the selected ingredient in the final product.

Default Value: 0.1 g/L.

Range: 0 – 20 g/L

Value: Required Conductivity

Description: This is the expected conductivity for the cleaning solution. If the actual conductivity falls outside this value (plus the error tolerance – see below) then the system will check with the operator before proceeding.

Default Value: none.

Range: 0 – 5000 µs/cm

Value: Required pH

Description: This is the expected pH for the cleaning solution. If the actual pH falls outside this value (plus the error tolerance – see below) then the system will check with the operator before proceeding.

Default Value: none.

Range: 0 – 14 pH

Value: Error Tolerance

Description: This is the acceptable error range for the expected pH and Conductivity values, if the measured values are within these limits then the recipe is acceptable and the system will deliver it to the requesting barrier.

Default Value: 10%.

Range: 0 – 100%

Value: Manual Addition Ingredient Required

Description: This indicates whether the recipe requires manual addition of ingredients by the operator. If it is selected then the system will stop before delivering the solution and wait for the operator to add the ingredients.

Default Value: No.

Range: Yes OR No

Value: Heating Required

Description: This indicates whether the recipe requires that the solution be heated prior to delivery to the requesting barrier.

Default Value: No.

Range: Yes OR No

Value: Heating Temperature

Description: This is the temperature setpoint to heat the solution to if heating is required.

Default Value: 45 °C.

Range: 25°C – 95°C

Value: Delivery Flow Rate

Description: This is the flow rate that the solution is delivered to the requesting system. The RO for example requires that the solution be circulated through the membranes at a low flow rate whereas the MF required all the solution as quick as possible.

Default Value: 50 L/min.

Range: 20 – 100L/min

Value: Return Destination

Description: this selects where the cleaning solution goes when it returns from the requesting system. The RO for example requires that the cleaning solution is circulated for a while whereas the MF requires that the (dirty) solution is dumped directly to drain.

Default Value: Circulation.

Range: Circulation OR Drain

CIP System - Alarms

Equipment Fault

Cause: Any piece of equipment which is required by the Sequence has either been switched to the Manual Mode or has faulted. In either case the equipment is no longer available to the Sequence, therefore an Equipment fault is generated.

Check Steps: Every step except Step 0 (Offline)

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: All equipment must have any faults reset and be switched back to the Auto Mode. Once all equipment is available the fault can be reset by pressing the “Fault Reset/Continue” button.

1.16.3 *Ingredient No.1 Tank Empty Fault*

Cause: The tank containing Ingredient No.1 is empty.

Check Steps: 4

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Replace the tank with a full tank and reset the fault by pressing the “Fault Reset/Continue” button.

1.16.4 *Ingredient No.2 Tank Empty Fault*

Cause: The tank containing Ingredient No.2 is empty.

Check Steps: 4

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Replace the tank with a full tank and reset the fault by pressing the “Fault Reset/Continue” button.

1.16.5 *Ingredient No.3 Tank Empty Fault*

Cause: The tank containing Ingredient No.3 is empty.

Check Steps: 4

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Replace the tank with a full tank and reset the fault by pressing the “Fault Reset/Continue” button.

1.16.6 *CIP Tank Overfull Fault*

Cause: The CIP tank has been overfilled.

Check Steps: 3 -12

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Determine why the tank has been overfilled (valve failure?) and reset the fault by pressing the “Fault Reset/Continue” button.

1.16.7 *No Permeate Water Available*

Cause: The recipe calls for Permeate Water but the RO Header Tank is empty and the “*Use Town Water if no Permeate available”* option is not selected, therefore the system has to stop as there is no water available.

Check Steps: 3

Effect: When this fault occurs it sends the sequence to fault step (100) and waits for the operator to reset it.

Reset Requirements: Find an alternative source of water and fill the tank manually and then reset the fault by pressing the "Fault Reset/Continue" button.

OPERATIONAL INTERLOCKS

The following is a list of interlocks which are specific to certain pieces of equipment. Each drive can have up to eight independent interlocks and some of these interlocks can be masked under certain conditions, these conditions are listed in the "Mask" column.

Equipment Interlocks

L3038 Ozone System - Circulation Pump

Interlock	Description	Mask
1	L3267 - Ozone System - Ozone in Air Concentration – Hi Hi Alarm	NA
2	L3032 - Ozone System - Feed Pressure – Hi Hi Alarm	NA
3	None	NA
4	None	NA
5	None	NA
6	None	NA
7	None	NA
8	None	NA

L3042 Ozone System - Ozone Generator

Interlock	Description	Mask
1	L3267 - Ozone System - Ozone in Air Concentration – Hi Hi Alarm	NA
2	L3032 - Ozone System - Feed Pressure – Hi Hi Alarm	NA
3	L3038 – Ozone System – Circulation Pump – NOT Running	Auto Mode
4	Lxxx6 – Ozone System – Ozone Supply Valve – NOT Open	Auto Mode
5	L3266 - Ozone System - Ozone Gas Pressure Switch – No Vacuum	Auto Mode
6	L3043 – Ozone System – Oxygen Generator – NOT Running	Auto Mode
7	None	NA
8	None	NA

1.16.8 *L3043 Ozone System – Oxygen Generator*

Interlock	Description	Mask
1	None	NA
2	None	NA
3	None	NA
4	None	NA
5	None	NA
6	None	NA

7	None	NA
8	None	NA

1.16.9 *Lxxx6 Ozone System – Ozone Supply Valve*

Interlock	Description	Mask
1	L3266 - Ozone System - Ozone Gas Pressure Switch – No Vacuum	Auto Mode
2	None	NA
3	None	NA
4	None	NA

PROCESS INTERFACES

Not Applicable

ASSUMPTIONS AND EXCLUSIONS

-

CONTROL SYSTEM

Manual Control

Whilst none of the automatic sequences are running any piece of equipment can be operated in the manual mode. This means that the operator will be able to change the state of any piece of equipment provided they change the equipment to Manual Mode first as per the standard operating philosophy for equipment.

Auto Control

Whilst any of the automatic sequences are running all equipment associated with those sequences must be in the automatic mode. If any piece of equipment is switched to the manual mode during operation of an automatic sequence the sequence will stop operating and generate a fault. It is the responsibility of the operator to ensure that switching equipment to manual during automatic operation will not cause damage to equipment and/or product.

Operator Notification

Where appropriate the operator will be prompted by the system to ensure that the operator is present and aware of the current stage in the process. This system will take the form of a popup asking the operator to confirm that they are aware by clicking on an “Okay” or simular button.

ALARM DEFINITION AND MANAGMENT

In addition to the standard alarms that are generated for standard pieces of equipment the following system specific alarms will be provided.

- *Equipment Interlock:* If any piece of equipment required by this process cell faults or is switched to the manual mode whilst the sequence is running the sequence will go into the fault mode. An equipment fault alarm will be generated when this occurs.

All alarms are generated within the PLC controller and displayed and logged on the SCADA system as per the Citect User Manual, the list of alarms associated with each standard piece of equipment can also be found in this document.

POWER FAILURE

When the power is restored after a power failure, the system will be reset with all sequences stopped and in the default state. However the Batch numbers, etc will be retained such that the sequences, when restarted, will start from where they left off when the power failure occurred.