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1. INTRODUCTION

The following Process Control Narrative describes in detail the operation of the UV disinfection system and associated equipment and controls. The operating conditions and scenarios described below include but are not limited to the majority of conditions and scenarios which will be encountered.

1.1 Process Overview

System Overview
Raw water diverted from Duteau Creek is treated at the Duteau Creek Water Treatment Plant (DCWTP) using pre-treatment coagulation followed by clarification by Dissolved Air Flotation (DAF). The DCWTP consist of two treatment trains each sized to produce 81 ML/d for a total production capacity of 162 ML/d. The DAF clarified water is stored on-site in a 10 ML reservoir to provide balancing storage and primary disinfection for viruses. Treated water flows by gravity from the reservoir to the UV Disinfection Facility for primary disinfection of protozoa before entering the distribution network. Secondary disinfection is achieved by dosing hypochlorite downstream of the UV Disinfection Facility. Refer to PCN Hypochlorite Dosing System-Rev 2 for further details on the domestic hypochlorite dosing.

UV Disinfection Process

The UV system is sized to provide 3.0 log *Cryptosporidium* inactivation credit using a minimum validated UV dose of 12 mJ/cm^2 as set out in the US EPA Disinfection Guidance Manual (UVDGM). To provide a margin of safety to account for instrumentation uncertainty, changes in flow and quality, and operational UV dose set-points, the UV system is sized to deliver a “Target UV Dose” that is 30 percent greater than the validated UV dose required for *Cryptosporidium* credit specified in the UVDGM.

Water enters the UV Disinfection Facility via a common inlet pipe header which feeds three (3) UV trains. Each train has motorized inlet and outlet isolation valves, a flow meter, and a UV reactor. Each UV reactor contains nine (9) rows of 12 low-pressure, high-output (LPHO) lamps that continuously deliver a validated dose greater than the target dose. The vessels are powered from ballast cabinets mounted on the mezzanine level in the electrical room. The UV trains operate in a two duty and one standby configuration.

Flow rate is measured at the inlet of each UV reactor by ultrasonic flow meters. Water quality entering the UV reactors (i.e. leaving the reservoir) is monitored for the UV transmittance (UVT) and chlorine from a common sample line on the UV supply header. UV light intensity is measured by intensity sensors within each reactor at each row of lamps. Flow rate, UV transmittance and UV Intensity measurements are used in the UV Dose Control Algorithm to control the number of lamps that are operating and their respective power level

Sampling of the treated water downstream of the UV reactors is done using a sample line from the Treated Water Chamber. Final Treated Water sampling parameters include, pH, turbidity, and free chlorine that are continuously measured from a common sample line at Treated Water Chamber. Each reactor is controlled by a local PLC (Train PLC) that communicates with the PCS.

Clean-in-Place System
Periodic cleaning of the quartz sleeves in each reactor will be performed either 3-4 times per year or more depending on the rate of fouling found on the sleeves. Off-line UV reactors are typically drained, isolated, locked out, and the sleeves are cleaned in place using this system. The system includes the following components:

- CIP Storage Tank (TNK-830)
- CIP Supply Pump (P-831)
- CIP Return Pump (P-832)
- Common, 75mm CIP return header
- Common, 25mm CIP supply header
- Piping and valving for Clean-in-Place system
- Local control panels, instrumentation and controls

The CIP equipment is manually operated using local controls and manual valves. Cleaning solution is batched in the CIP Storage tank by the operator. The CIP Supply Pump is used to pump the cleaning solution in the CIP Storage Tank to a UV Train by inserting the cleaning wand into the UV Reactor. The CIP Return Pump returns the cleaning solution to the CIP Storage Tank when the level inside the UV Reactor reaches approximately 30% full. The pumps (supply and return) provide sufficient flow and pressure to remove residue and rinse and clean the UV Train.

Note: The UV Trains share a common CIP system. Individual UV Trains can be selected for the CIP cleaning process. Valve selections and operations for the UV Trains in the CIP system will be done manually by the operator.

1.2 Functionality of Equipment

UV Disinfection System Equipment
Where tag numbers are provided, they are for UV Train 1.

The UV disinfection equipment in each train includes the UV Reactor (UV-810), the local control cabinet (LCP-810A) and the electrical distribution panels (EDP) for power distribution, and ballast controls.

The UV system provides primary disinfection providing 3.0-log inactivation of *Cryptosporidium* using a target dose of 12 mJ/cm2, with 30% safety factor, or 15.6 mJ/cm2. There are three (3) UV trains. Each UV train includes the following components:

- One (1) UV reactor (UV810)
- One (1) inlet motorized butterfly valve (MV811)
- One (1) outlet motorized butterfly valve (MV 812).
- One (1) flow meter (FE\FIT 810)
- Related piping and valving.
- Dedicated local control panel (LCP), ballast cabinets (EDP), reactor and panel mounted instrumentation and controls.
- Dedicated local programmable logic controller (PLC) – mounted in each train LCP.

All three UV trains share the following components:

- Common, 1800mm diameter inlet header.

- Reservoir outlet water sampling with the following online analyzers:
  - Two (2) online UV transmittance monitors.
  - One (1) Free Chlorine Analyzer
- Common, UV outlet chamber;
- Post-UV water sampling from the Treated Water Chamber with the following analyzers:
  - One (1) Free Chlorine Analyzer on the outlet header;
  - One (1) pH monitor.
  - One (1) turbidity monitor
- Clean-in-place (CIP) system.
- UV drain pump.
- Related piping and valving.

UV Reactor (UV)

The three (3) Wedeco K143 12/9 reactors are supplied with nine rows of twelve 360 W amalgam low-pressure high-output UV lamps, with each row monitored by a single UV sensor; there is a total of 108 lamps per reactor. The lamps are powered by electronic ballasts supplying the power, where one ballast powers two (2) lamps at power settings that range from 50 percent to 100 percent. The ballasts are located in the electrical ballast enclosure panel in the electrical room. A PLC will control the power setting of the ballasts and the lamp status using measured UV intensity. UV dose delivery by each reactor is calculated by a UV Dose Control Algorithm programmed into the Train PLC.

The reactor has two (2) drain ports, and two (2) air release vents. Each 75mm drain port is operated by a manual butterfly valve for isolation or shut-off control. The two drains are connected to the Clean-In Place (CIP) System piping and the building drainage system; allowing flow to be directed to the CIP System and returned to the inlet of the reactor or wasted to the drain.

Draining of the reactors is done using a dedicated drain pump connected to the UV reactor drain. The UV Drain Pump discharges into the irrigation watermain inside the Treated Water Chamber.

UV Intensity Sensors (AE/AIT)

Each UV Reactor has one intensity sensor for each row of lamps. Row UV intensity sensors (AE 811 – AE 819) are installed for each row of lamps and measures the amount of UV light at each row of lamps. The LCP's HMI and PCS will display the measured UV intensity for each row of lamps and the UV intensity will be recorded by the PCS. A low level UV intensity alarm will be generated by the Train PLC.

The PCS will display the measured value for each row of lamps in each reactor (as W/m^2) and will display the trend of the measured value.

Level Switch (LSL)

There is one (1) level sensor (switch) mounted in each train reactor vessel. Since each UV reactor must be completely flooded (and normally under pressure), if the level in the vessel reaches and trips the low level switch (LSL), the Train PLC will generate a low level alarm and shut down the reactor following a programmable time delay.

Temperature Switch (TSH)
Each UV reactor has a temperature switch mounted to it to monitor the temperature of the water inside the reactor. If some plant condition were to cause the UV reactor to be on but there to be no flow through the reactor, the energy from the lamps would cause the temperature at the lamps, and of the water, to rise and potentially cause damage to the lamps. Therefore, if the temperature switch contact is reached, the Train PLC will alarm and shut down the reactor following a programmable time delay.

UV Reactor Flow Meter (FE/FIT)
Each train has one (1) dedicated flow meter (FE 810) and indicating transmitter (FIT 810) installed on the inlet piping upstream of the UV Reactor. The flow meter is an ultrasonic type. The PCS will display and record the measured flow rate for each train. The train flow rate will be communicated to the Train PLC and displayed locally at the indicating transmitter.

The PCS will display the totalized daily flow for each UV Reactor (ML/d), Total Plant Flow Rate (i.e. combined flow rate measured at each UV Train), and Total Daily Volume (ML) for the UV Disinfection Facility which will re-zero at midnight.

UV Supply Header Pressure Indication (PIT)
There is one (1) pressure transmitter (PIT 801) to continuously monitor the pressure of the UV Supply Header. The pressure monitoring is used to monitor system pressures at the UV Disinfection Facility and to compare to the pressure downstream of the UV outlet to monitor the differential pressure across UV Disinfection System.

The PCS will display the measured pressure (kPa), will record measured values in the plant historian and signal an alarm if measurements are below the low level setpoint of 50 kPa (operator adjustable).

UV Outlet Chamber Pressure Indication (PIT)
There is one (1) pressure transmitter (PIT 802) to continuously monitor the pressure of the UV Outlet Chamber. The pressure monitoring is used to monitor system pressures at the UV Disinfection Facility and to compare to the pressure in the UV Supply Header to monitor the differential pressure across UV Disinfection System. A low pressure would indicate low level in the treated water reservoir or high flows in the distribution system.

The PCS will display the measured pressure (kPa), will record measured values in the plant historian and signal an alarm if measurements are below the low level setpoint of 7 kPa (operator adjustable).

UV Reactor Inlet Motorized Valve (MV)
There is an open-close motorized valve (butterfly valve) on the 1200mm inlet piping located between the 1800mm Inlet Header Pipe and the UV Reactor. The motorized valve has an electric motorized actuator and is used to isolate the UV Train.

The valve has a HAND-OFF-AUTO (HOA) selector switch, an OPEN-STOP-CLOSE (OSC) selector switch (or OPEN, STOP, and CLOSE push-button), and open/closed indication. With the HOA in AUTO, the valve position will be controlled automatically based on logic in the PCS or controlled manually by the operator from the PCS. With the HOA in HAND, the valve will be controlled by the OSC selector switch. Status of the HOA switches will be displayed and recorded by the PCS.

The valve actuator has position limit switches at the open (ZSO) and closed (ZSC) position. The PCS will display the open and closed position of the valve based on the open and closed limit switches. The actuator will also communicate fault conditions. The PCS will alarm if the valve fails to close or open in the allowable time of 3 minutes (adjustable). The PCS will communicate the valve position and fault status to the Train PLC.

UV Reactor Outlet Motorized Valve (MV)

There will be an open-close motorized valve (butterfly valve) on the 1200mm outlet piping located between the UV reactor and the UV Outlet Chamber. The motorized valve has a motorized actuator and is used to control flow through the UV Reactor.

The valve will have a HAND-OFF-AUTO (HOA) selector switch, an OPEN-STOP-CLOSE (OSC) selector switch (or OPEN, STOP, and CLOSE push-button), and position indication. With the HOA in AUTO, the valve position will be controlled automatically based on logic in the PCS or controlled manually by the operator from the PCS. With the HOA in HAND, the valve will be controlled by the OSC selector switch. Status of the HOA switches will be displayed and recorded by the PCS.

The valve actuator has position limit switches at the open (ZSO) and closed (ZSC) position. The PCS will display the open and closed position of the valve based on the open and closed limit switches. The actuator will also communicate fault conditions to the PCS. The PCS will alarm if the valve fails to close or open in the allowable time of 3 minutes (adjustable). The PCS will communicate the valve position and fault status to the Train PLC.

Related Piping

The UV Train inlet and outlet piping is 1200mm in diameter. There are two (2) pressure indicators on the UV Train Piping. One pressure gauge is located on the UV Inlet Motorized Valve bypass piping. The other pressure sensor will be located upstream of the UV Outlet Motorized Valve.

Air inside UV Reactors can reduce the UVT and negatively impact the operation of the UV Reactors. To ensure air is not accumulated inside the UV Train piping systems each UV Train has one (1) air release valve located at the top of the UV Reactor and one (1) combination air vacuum-release valve between the UV Reactor and the UV Outlet Motorized Valve.

There are sample taps located on the adjacent to the UV Inlet and Outlet Motorized Valves to allow the operator to collect grab samples.

Water Sampling Analyzers

UV Transmittance Analyzers (AE/AIT)

The UV Transmittance is measured at the inlet to UV Train 1 using two analyzers (AE 802\803) which measure the absorbance of UV light in the water. The instruments provide analog input to the PCS which communicates a calculated value to each Train PLC equal to the minimum of the two measured values. If the two measured values deviate by more than 5 percent (adjustable), a deviation alarm will be generated.

Either instrument can be placed in an “OFF-LINE” mode, wherein the PCS will not include it in the calculations.

Each Train PLC will use either the calculated value from the PCS, or can accept values manually entered at the UV Train HMI (where the values are obtained from grab samples measured using a bench-top spectrophotometer).

The PCS will display the measured value (%T), will display the 1 hour trend of the measured value, and the value will be recorded by the plant historian.

Treated Reservoir Free Chlorine (AE/AIT)

There is one (1) free chlorine sensor (AE 804) to continuously monitor the free chlorine of the water leaving the reservoir. Free chlorine present in the reservoir outlet water is used to verify the target virus inactivation is being achieved.

Refer to PCN 10-Hypochlorite Dosing System Rev 2 for further details on the chlorine monitoring and controls.

Post-UV Free Chlorine (AE/AIT)

There is one existing (1) free chlorine sensor (AE 395) to continuously monitor the free chlorine of the water downstream of the UV Reactor from the Treated Water Chamber prior to entering the distribution system. Free chlorine present in the Treated Water Chamber Sample represents the presence of a residual disinfectant in the water entering the distribution system

The PCS will display the measured chlorine (ppm), will display the 1 hour trend of the measured value and will record measured values in the plant historian. The PCS will signal alarms if measured value is below the low level alarm of 1 ppm (operator adjustable).

pH (AE/AIT)

There is one existing (1) pH sensor (AE 396a) to continuously monitor the pH of Treated Water downstream of the UV Disinfection System. The pH level of water is used to measure the acidity or alkalinity of water, where pH of 7 is neutral and lower values are more acid and higher values are more alkaline. While the UV dose-response of pathogens is independent of pH variations between pH 6 and pH 9, chlorine dose effectiveness is influenced by minor fluctuations in pH.

The PCS will display the measured pH, will record measured values in the plant historian and signal an alarm if measurements are outside of the operating range set-points of pH 6.0 to pH 8.5 (operator adjustable).

Turbidity (AE/AIT)

There is one existing (1) turbidity sensor (AE 396) to continuously monitor the turbidity of the inlet water. Turbidity is the cloudiness or opacity of water and is measured as the quantity of light scattered in water by suspended particulate. The presence of particulate can impact the effectiveness of UV disinfection by particles shielding pathogens from UV light. The turbidity of the inlet water is to remain below 1 NTU to ensure UV disinfection effectiveness and comply with the 4-3-2-**1**-0 guidelines set out by Interior Health Authority (IHA).

The PCS will display the measured turbidity (NTU), will display the four (4) hour trend of the measured value, and the value will be recorded by the plant historian.

CIP Components

CIP Storage Tank (TNK)

One (1) storage tank (TNK-830) is provided for the CIP cleaning solution. The storage tank has a drain line controlled by a normally closed ball valve. The storage tank also has an overflow drain line, where the overflow empties to the containment are.

CIP Storage Tank Level Instrumentation (LSH and LSL)

Two (2) level sensors (switches) will be mounted in the storage tank. If the level in the tank falls and trips the low level switch (LSL830), the PCS will generate a low level alarm. The low level alarm will also shut down operation of the CIP Supply Pump. A high level float (LSH830) will alarm the PCS that the CIP tank has been overfilled. The high level alarm will also shut down operation of the CIP Return Pump. If the level in the tank overflows and trips the high level switch (LSH832) in the containment area, the PCS will generate and overflow alarm.

CIP Supply Pump (P-831)

The CIP Supply Pump (P831) is used to pump the CIP storage tank cleaning solution to a UV Train. The Supply Pump has a Start-Stop selector switch and a low discharge thermal dispersion type flow switch (FSL-831) interlocked with the associated motor starter in the Motor Control Center (MCC). With the switch in start, the pump will run continuously, subject only to local interlocks. The emergency Stop push button on the local control station and the CIP tank low level switch will shut off the pump regardless of control mode. The CIP Supply Pump is sized only to clean one UV Train at one time.

CIP Return Pump (P-832)

The CIP Return Pump (P832) is used to pump (or return) the cleaning solution from a UV Train to the CIP storage tank. The Return Pump has a selector switch and a low discharge thermal dispersion type flow switch (FSL-832) interlocked with the associated motor starter in the MCC. With the switch in start, the pump will run continuously, subject only to local interlocks. The emergency Stop push button on the local control station and the CIP tank low level switch will shut off the pump regardless of control mode. The CIP Return Pump is sized only to clean one UV Train at one time.

UV Drain Pump (P-833)

The UV Drain Pump (P832) is used to empty the UV Reactor and connected piping between the Inlet and Outlet isolation valves prior to cleaning or maintenance of the reactor. The UV Drain Pumps has a selector switch and a low discharge thermal dispersion type flow switch (FSL-833) interlocked with the associated motor starter in the MCC. With the switch in start, the pump will run continuously, subject only to local interlocks. The emergency Stop push button on the local control station will shut off the pump regardless of control mode. The UV Drain Pump is sized to drain one UV Train in 60 minutes.

CIP Piping and Valving

Ball valves are used for isolation or shut-off on the CIP piping system. Each control valve must be manually operated. Two (2) strainers are located on the CIP piping system, where one (1) strainer is located upstream of each of the CIP Supply and CIP Return Pumps. Pressure on the discharge each pump is display used a liquid filled pressure gauge.

2. CONTROLS

2.1 Vendor Supplied PLC

There is one local control panel (LCP) for each UV Reactor, each housing a PLC controller which communicates with the PCS. The UV Train PLC is factory programmed with a UV Dose Control Algorithm developed during validation of the UV Reactor. The algorithm is as follows:

$$\log i = 10^{A} \times UVA^{B} \times \left(\frac{S/S_0}{Q \times D_L} \right)^{C + D\times UVA + E\times UVA^2} \times R^{F + G\times UVA + H\times UVA^2} \qquad \textbf{Equation 1}$$

where log *i* is the log inactivation of the microbe, D_L is the UV sensitivity of the microbe, UVA is the UV absorbance of the water calculated from the UVT measured by the online monitor, Q is the flow rate through the reactor measured by the flow meter, R is the number of operating rows of lamps, S is the UV intensity measured by the UV sensors, and S_0 is the UV intensity expected with new lamps operating at 100 percent power within clean sleeves. The terms A through H are constants that are determined by fitting the equation to data collected during UV validation testing. To obtain disinfection credit, the UV reactor must deliver a validated dose, D_{val} that is equal to or greater than the required dose specified by the LT2. The validated dose is related to the UV Dose Control Algorithm using:

$$D_{val} = \frac{\log i \times D_L}{VF}$$ **Equation 2**

where VF is the validation factor and D_L is the UV sensitivity of the target microorganism (mJ/cm^2/log inactivation. Further details on the UV Dose Control Algorithm are set out in the UV Vendor Control Philosophy contained in the Operation and Maintenance Manual.

There is an HMI panel at each LCP which allows local display of train status and set-point, as well as control of the UV Reactor using a three position, MANUAL-OFF-AUTO switch for each panel. In MANUAL, control will be via the HMI, all rows operating. In AUTO, the Train PLC controls the power levels to deliver the validated dose. In OFF, the ballast power is turned off. An Ethernet interface connection is provided between the PCS and the Train PLC to allow remote viewing and control of the Train PLC HMI screens.

The PLC cycles the start of rows within each reactor to evenly distribute the number of starts required by a single lamp row and prevent frequent repeated starts of a single lamp. Lamp row cycles down sequentially flowing each successive lamp start.

The local HMI at each UV Train will display the following (as a minimum):

UV Train LCP-HMI
UV Train o In-Auto Status o Run Status o Flow Rate o UVT o Level Alarm o Power Rate, kilowatts o Current Rate, amperage o Inlet Motorized Valve Position o Outlet Motorized Valve Position o Temperature Alarm o Enclosure Temperature Alarm
Lamp Status (Typical of 9 Rows) o Lamp On o Lamp Hours o UV High Intensity Alarm o UV Low Intensity Alarm o Lamp Hours (typical of 12 lamps) o Lamp Fail (typical of 12 lamps)

2.2 Remote-Auto

Control Strategy for UV Trains
Selection of online UV Trains will be controlled by the PCS wherein the number of operating UV Trains is selected based on the flow rate, water quality and number of available UV Reactors.

Passive flow splitting between operating UV Trains is achieved by maintaining low velocities within the inlet header piping.

The PCS will manage the start-up and shut-down sequencing of each UV reactor based on the Total Rows Operating to achieve the Target UV Dose and number of available UV Trains. The PCS will calculate the Total Rows Operating based on the status (On/Off) of lamp rows sent from the Train PLC.

Table 1 outlines the Total Rows Operating set-points used by the PCS to determine the number of operating UV Trains.

Table 1 UV Train Selection

Total Operating Rows	# of Operating UV Trains		
	1 Train Available	2 Trains Available	3 Trains Available
2 – 5	1	1	1
6 – 9	1	2	2
9 – 18	OFF-SPEC	2	2
> 18	OFF-SPEC	OFF-SPEC	3

The three UV Trains will operate in a Duty-Assist-Standby configuration, where the duty train always runs and the assist train runs when additional lamp rows are needed based on the Total Rows Operating. Duty-Assist-Standby cycling is controlled by the PCS and will be initiated based on the following conditions:

- Duty UV Train timer elapsed (operator adjustable between 0 and 48 hours. Cycling needs to occur to prevent stagnant water in offline trains).
- Duty UV Train failure
- Operator initiated change in lead assignment

The operator is able to manually select the number of operating UV Trains by selecting a “Manual/Auto” selector button at the Operator Work Station.

Control of each UV Train will be by the Train PLC using the Dose Control Algorithm wherein the number of operating rows and ballast power setting will be adjusted to deliver the Target UV Dose.

UV Reactor Operation
Train LCP HOA in “AUTO”. PCS in “AUTO”.

In this mode, set-point control is available via any Operator Workstation and the PCS is able to change set-points in the Train PLC. The UV Reactor(s) waits for a start command from the PCS.

The PCS controls the number of reactors on-line to ensure the reactors are operating within their validation envelope. In “AUTO” mode, the PCS will send a signal to the UV Train to start or stop the UV Reactor based on the Total Lamp Rows Operating. The PCS logs and records any off-specification event recorded by the UV Train PLC and totalized flow for that event. Off-specification will be an alarm generated by each Train PLC. Off-specification related flow below validated flow range will be logged separately by the PCS.

Each Train PLC adjusts ballast power and number of rows operating to achieve the Target UV Dose according to UVT, Train Flow and the measured UV intensity.

In the event of a flow meter failure, the maximum design flow rate will be used (as an entered value), and all lamps will be powered to 100 percent. The PCS would then start up a stand-by reactor. Once the standby reactor receiving flow, the PCS shuts down the UV Train with the failed flow meter.

In the event of a UVT analyzers failure, the UVT will be input manually by the operator based on grab samples results collected at 4 hour intervals.

CIP System
PLC alarms if the tank is in an overflow condition. PCS has no control over the CIP pumps.

2.3 Local Auto

Requires Train LCP in “AUTO”. PCS in “LOCAL”. PCS monitors but has no control. Flow, UVT and Inlet/Outlet Motorized Valve position status are monitored by the Train PLC.

Via the Train LCP, set-points can be manually entered (including UVT and measured flow rate) and train set-points can be modified (such as minimum number of operating rows). The operator controls the number of operating trains by selecting the UV Trains to start at the respective Train LCPs.

The Train PLC adjusts the number of rows in service and the power output of the lamps based on the UV Dose Control Algorithm. The Train PLC monitors the Inlet and Outlet Motorized Valve positions. On start-up, the Train PLC energizes all lamps to 100% power for 15 minutes (Warm-up Period). Once the reactor is confirmed to be fully operational, the Train PLC adjusts the number and power output to each row to achieve the Target UV Dose.

Maintenance Mode
Maintenance Mode is a sub-function of AUTO mode and can be selected on the Train LCP. In Maintenance Mode, the Train PLC loses automatic control of the lamps and the PCS indicates the UV Train as “Out-of-Service”. The operator is able to control the lamp power and the number of lamp rows operating. The operator adjusts the Outlet Motorized Valve position from the motorized valve operator to control flow through the UV Reactor.

Contactor permissive interlocks for cabinet high temperature, UV Reactor low level, UV Reactor high temperature alarms are still in effect. In Maintenance Mode, UV dose is not controlled by the Train PLC.

Exiting Maintenance Mode is only permitted if the Outlet Motorized Valve is closed or the Outlet Motorized Valve is open and the UV Reactor is achieving the Target UV Dose.

2.4 Local Manual

UV System

Train LCP in “MANUAL”. PCS in “LOCAL”.

To run the UV Reactor, the operator selects “Manual Override” button to ON. In Manual Override, the Train PLC energizes all rows to 100% power. Prior to selecting “Manual Override” to ON, the operator shall ensure the UV Reactor is filled with water and the Inlet Motorized Valve is open. The Train PLC is not controlling the UV Reactor in Manual Override and the operator is responsible for controlling flow through the UV Reactor to prevent overheating.

CIP System

Local control is present at the LCP operating stations. Control status will be sent to the PLC for display and record.

2.5 Local Off

In OFF mode, all PCS and Train PLC controls are disabled and the PCS indicates the UV Train “Out-of-Service” until the operating mode is changed.

In this mode, the equipment is off-line for maintenance of the equipment or calibration of related instruments. Normal practice is to perform electrical disconnect using lock out/tag out procedures.

3. START-UP & SHUTDOWN SEQUENCE

The start-up sequence for a UV Train is as follows:

3.1 Normal Start-up

Start-up of the UV Reactor is controlled by the Train PLC to prevent off-specification water from entering the distribution system. The following conditions are to be met before the PCS will start-up the UV Reactor in automatic mode:

- Upstream and Downstream Motorized Control Valves for offline trains are in the closed position;
- All rows of lamps are off;
- Check and resolve any system alarms being displayed;
- All online analyzers are operating within calibration; and
- Reactors are full of water.

On a request for UV Reactor start, either from the PCS or manually at the LCP, the PCS calculates the expected flowrate based on the Total Plant Flow Rate and the number of operating reactors and then the Train PLC proceeds with the following sequence:

- PCS sends “Start” command to UV Train, along with the number of rows to start up and the calculated anticipated flow rate. The calculated anticipated flow rate will be determined by the PCS based on equal flow splitting between operating UV Trains or the last operating flow rate if only one UV Train is required to operate.
- Train PLC confirms system is in AUTO, PLC communications are healthy, and outlet valve is in the closed position.
- PCS opens the Inlet Motorized Valve.

- Train PLC energizes requested number of startup rows to 100% and initiates warm-up period (10 minutes – adjustable and pre-set by Xylem).
    - Check all internal UV Train PLC software interlocks are cleared for the UV Train.
    - Check the UV Validated Dose based on anticipated flow rate, measured UVT, and actual UV intensity exceeds the Target UV Dose.
- PCS opens the Outlet Motorized Valve when warm-up timer expires.
- The Train PLC starts a preset 15 minute timer to allow the UV Reactor to establish stable flow through the UV Reactor. If the flow is still below the no flow setpoint value of 1 ML/d (adjustable) then the start will be aborted, the reactor shuts down and a “Start-up failed” alarm is raised by the Train PLC.

3.2 Normal Shutdown

The following sequence occurs during a normal shutdown:

- The reactor receives a stop request from the PCS
- PCS verifies that one train will still be in operation – i.e. that its outlet and inlet valve are both be open.
- The Train PLC initiates “Stop In-Progress” flag and resets the run request.
- PCS closes the Outlet Motorized Valve.
- When the Outlet Motorized Valve reaches the closed position, the Train PLC de-energizes the lamps and flags are reset.
-
- PCS closes the Inlet Motorized Valve.
- UV Train remains in available state.

3.3 Emergency Shutdown and Power Failure

Emergency Shutdown
The following sequence occurs during an emergency shutdown:

- PCS sends an Emergency Shutdown signal to the Train PLC.
- PCS closes the Outlet Motorized Valve and the Train PLC de-energizes the lamps simultaneously.
- LCP run request is reset.
- Alarm Message “Emergency Shutdown” is displayed by the PCS and the Train PLC.
- PCS closes the Inlet Motorized Valve.

Power Failure
In the event of a power failure, the inline UPS will maintain continuous power to the UV reactors to prevent the equipment shutdown for a period of 10 minutes until the standby power systems are operational and energizing the WTP.

In the event of a prolonged power outage or failure of the UPS equipment, the standby diesel generator with automatic transfer switch (ATS) will energize the main power distribution panel and supply power to the UV reactors. ATS is normally in "AUTO" mode.

Refer to existing Process Control Narratives for further details on the standby power operation.

Communication Failure

If there is a loss of communication between the Train PLC and the PCS, the Train PLC will continue operating using the last value for UVT and UV Train Flow.

If there is a PCS PLC failure when the UV Reactor is operating, the ballast power setting will default to 100 percent power.

If there is a LCP PLC failure then when the UV Reactor is operating, the UV Train will be shut down and the standby UV Train called to start.

4. CONTROL SYSTEM DETAILS

4.1 Equipment Interlocks and Alarms

Hardware Interlocks

The following hardware (hard-wired) interlocks are present for this system:

- LSL at each reactor will shut the reactor down.
- TSH at each reactor will shut the reactor down.
- FSL at each pump will shut down the respective pump.

Software Interlocks

The following software interlocks are defined:

- Failure of flowmeter (FE/FIT 810) will signal an alarm, energize the reactor to 100% lamp power, start-up the standby reactor, and shut the duty reactor down once the standby reactor reaches 100% power for the lamps.
- Failure of Inlet or Outlet Motorized Valves will trigger:
  - UV Train Operating – signal an alarm
  - UV Operating and called to stop - signal an alarm.
  - UV Offline and called to Start - signal an alarm and start-up the standby reactor.
  - UV Train Offline or in Fault Mode - alarm
- Flowrate measurement with Outlet Motorized Valve in the closed position will shut down the UV Reactor and signal an alarm.
- Flow measured is below preset value (operator adjustable in the Train PLC) for a preset 15 minute time period during UV Train Startup with Outlet Motorized Valve in the Open position will shutdown the UV Reactor, send a "Start up Failed" alarm to the PCS.
- Exiting Maintenance Mode on the Train LCP is not permitted unless:
  - Outlet Motorized Valve is closed or,

  - o Outlet Motorized Valve is open and the UV Reactor is achieving the Target UV Dose.
- Closed position switch at the UV Train Outlet Motorized Valve and Inlet Motorized Valve provides derived no flow condition which will shut the reactor down if it is operating.
- At least one UV train to remain open at all times (both inlet and outlet valves).
- Low level switch at the supply tank will shut off the Supply Pump
- High level switch at the supply tank will shut off the Return Pump

Local Alarm Annunciation

There is no local alarm annunciation.

5. CONTROL SYSTEM DETAILS

5.1 Description

The Control System Details provides planning for the SCADA programming requirements related to derived or calculated values, alarms, or other information which will be displayed at an Operator Workstation, trended, or logged as an event. Reference should be made to the related Reference P&ID's, related instrument datasheets, and related equipment specifications. Not all I/O data shown on the P&ID's will be displayed.

The UV system operation will be defined by both the Dose-Control Algorithm and by set-point values that are entered into the PCS via SCADA or Train PLC by the operator. Refer to the Vendor Control Philosophy for all setpoints and alarms for the Train PLC.

5.2 System Set Points, Status and Alarms

Legend:

1. D – Display on a screen
2. S – Display and operator input on a screen
3. I – Physical I/O
4. R- Internal Register
5. Alarm Level Priority 1 – High Priority Dial Out
6. Alarm Level Priority 2 – High Priority – Immediate Action - No Dial Out
7. Alarm Level Priority 3 – Low Priority
8. L – Logged to database
9. T – Display on trend

The following list may not contain all required plant control system tags and signals. The contractor is to do a detailed take-off from all drawings and specifications and determine all required tags and signals.

5.3 Operator Workstation Display & Function Summary

The following table lists the information to be handled in PCS.

/1/ In PCS: Operator Workstation	
	• Number of rows operating – for each UV Reactor (with operating rows identified) • Total Rows Operating (calculated as sum of lamps rows operating in each reactor) • Flow Rate through each Reactor (ML/d) • Total Treated Water Flow Rate (calculated as sum of each train flow meter) • Totalized “off-specification” volume (from Train PLC) • UV Reactor Duty-Assist-Standby assignment • UV Reactor operating – for each UV Reactor • UV Reactor HOA status – for each UV Reactor • Duty UV Reactor timer • UV Reactor available – for each reactor • Number of UV Reactor starts per day. • UV target dose set-point (mJ/cm2) • Calculated validated UV dose delivered (mJ/cm2) – for each UV Reactor • UV intensity – for each row of lamps at each reactor • UV transmittance (percent) per analyzer • UV transmittance maximum variance (1-2%) • UV transmitter operating – for each transmitter • UV transmittance monitoring Offline mode – each transmitter • UV transmittance input auto-manual status • UV transmittance value – manual input value • UV transmittance off specification delay timer (0 – 1440 minutes) • Motorized Valve status (Hand/Off/Auto) • Motorized valve position – for each automated valve • Motorized Valve fail to close timer – each motorized valve • Motorized Valve fail to open timer – each motorized valve • Totalized volume per day • pH measurement • pH Alarm setpoint • Free chlorine measurement (ppm) • Turbidity measurement (NTU) • WTP Turbidity (NTU) • Conductivity measurement (S/cm) • Sample line pressure (kPA) • Calibration period for UV transmittance analyzer – timer per analyzer • CIP Supply Pump (P831) running • CIP Return Pump (P832) running • UV Drain Pump (P833) running
/2/ In PCS: Event/Data Log	
	• UV Reactor on/off - for each UV Reactor • UV target dose set-point (mJ/cm^2) • Input UV transmittance • Inlet Motorized Valve position • Outlet Motorized Valve position • Lamp row on/off – for each row of each UV Reactor • Lamp on/off – for each row of each UV Reactor • UV sensor verification error • Off specification event • Off specification time • All alarms and faults

	• CIP Supply Pump (P831) running • CIP Return Pump (P832) running • UV Drain Pump (P832) running
/3/ In PCS: Historian/Trend	
	• Flow Rate (MLD) - for each UV Reactor • Total Plant Flow • UV intensity – for each row of lamps at each reactor • Ballast Power Output – for each lamp row at each reactor • S/So for each row • Off specification percent • Off specification volume • Operating time (for reactor) • Operating time (for ballast) • Operating time (for intensity sensors) • Operating time (for each row of lamps) • Measured UV transmittance • Measured pH • Measured conductivity • Measured turbidity • Measured free chlorine • Sample pressure (kPa) • Calculated actual delivered validated UV dose (RED) mJ/cm^2 (for each UV Reactor)
/4/ Alarm Level 1 – High Priority Dial-out	
	• UV Train Shutdown • Emergency Stop button engaged • Power Failure • Off-specification Water (Train PLC) • Flow Meter Failure • Low System Dose Alarm (Train PLC) • Valve Fault • Low chlorine alarm – 0.5 ppm (operator adjustable) • High turbidity alarm – 1 NTU (operator adjustable) • Generator Fault • UV Train Communication Fault (Train PLC Watchdog Timer) • Low UVT Alarm – 74% UVT (operator adjustable) • High Level Alarm (Containment Tank)
/5/ Alarm Level 2 – High Priority No Dial-out outside working hours	
	• UV Transmittance High Variance • UV Train Failed to Shutdown • UV System Failed to Start • Low Water Level (Train PLC) • Cabinet High Temperature (Train PLC) • Maximum design flow exceeded (Train PLC) • Low System Dose Warning (Train PLC) • Multiple Lamp Failure (Train PLC) • Lamp Failure (Train PLC) • 24 V Power Loss (Train PLC) • Low UVT Warning – 76% UVT (operator adjustable) • Low Row UV Intensity S/So (Train PLC) • High Ballast Temperature (Train PLC)

	• Low Reactor Intensity S/So (Train PLC) • CIP tank containment area level high • Off Specification Volume Exceeded (Train PLC)
/6/ Alarm Level 3 – Low Priority	
	• UVT High (Train PLC) • Flow less than validated flow (Train PLC) • System not in auto (Train PLC) • Intensity Sensor Check (Train PLC) • pH High/Low • UV Train surge suppression operated • Plant Surge Suppression Operated • Row hours timer complete • Low Sample Pressure • CIP Supply Pump (P831) low flow (while running) • Low CIP tank level • CIP Return Pump (P832) low flow (while running) • CIP tank level high