APPENDIX C

Process Narrative

North End Water Pollution Control Centre
Rehabilitation of Digester 11 and Sludge Holding Tank No. 5 and 7
Process Controls Narrative

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Water & Waste department

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Definitions

There are a number of abbreviations, terminologies and acronyms used throughout the document. These are defined below:

OWS: Operator workstation computer interface located in the main digester control room.

DCS: Distributed Control System – Existing programmable control system in the North End Water Pollution Control Centre

DGC: Digester Gallery programmable logic controller, part of the central control system, connected to the plant DCS network and OWS via Modbus TCP protocol. Controller used to monitor and control various aspects of the existing leachate storage and handling facilities as well as the new digester No.11 mixing system.

DGCP: Control panel located in the Digester Control Room. Panel contains the DGC, input and output cards, communication hardware

In Service/Out of Service: Available modes for equipment used in the process control system such as control valves, pumps, gates etc. The equipment can be manually switched between modes at the OWS. If there is an equipment failure, that piece of equipment will be automatically placed in the Out of Service mode and will require the operator to place the system back to In Service mode at the OWS once the fail condition has been reset.

Automatic Mode: Equipment is under control of the control system and will respond to various changes in the process environment.

Manual Mode: Equipment is under manual control – changes to equipment state can be made at the OWS. The system will not automatically respond to changes in the process environment. This situation should be avoided when possible, and equipment left in Automatic Mode.

VFD: Variable Frequency Drive – used to control motors at variables speeds as required by the control system.

1.0 Digester No. 11 Mixing System Overview

1.1 PURPOSE

Digester No. 11 is one of six (6)completely mixed, single stage anaerobic digesters at the North End Water Pollution Control Centre (NEWPCC). The purpose of anaerobic digestion is to stabilize the co-thickened primary and waste activated sludge (WAS) by converting the organic material to methane and carbon dioxide. The purpose of mixing in the digestion process is to:

- Ensure contact of digested sludge with incoming sludge;
- Optimize volatile solids reduction;
- Optimize gas production;
- Prevent settlement of grit;
- Ensure uniform temperature throughout the digester;
- Minimize foaming inside the digester.

1.2 SYSTEM DESCRIPTION

This document is intended to be read in conjunction with drawings and specifications in the City of Winnipeg Bid Opportunity No. 573-2012. The mixing system for Digester No. 11 is comprised of mixing pumps, discharge nozzles, foam buster nozzles, instrumentation and instrumentation flushing water.

1.2.1 Mixing System

Duty mixing pump (with installed standby mixing pump) provide a mixing flow to re-circulate digested sludge through a series of nozzles inside the anaerobic digester and thereby mix the contents of the tank.

The mixing pumps are operated by variable speed motors. When in operation the digested sludge is discharged through a series of nozzles strategically located inside the tank to provide mixing. A Foambuster nozzle is located above the liquid level to discharge a small portion of the sludge mixing flow over the sludge surface to suppress foam. A wall-mounted scum nozzle is located below the liquid surface and just below the Foambuster nozzle to help break up any possible scum blanket and to assure that the upper surface rotates beneath the Foambuster for more complete foam suppression.

The mixing system is anticipated to be operated continuously via the VFD at an operator-selected speed between 75% and 100%. The lower operational mixing pump speeds will save

on power usage but will also provide reduced mixing. Mixing directly affects the digester reaction rate for improved volatile solids destruction as well as methane generation. If there is any potential for foaming, the VFD controller allows the operators to “tune” the mixing system and digester reactor rate to the characteristics of media. The control system for the mixing system allows the operators significant flexibility to also operate the duty mixing pump on an operator selectable timed cycle of intermittent ON/OFF operation. Ideally, however, continuous mixing should provide more stable digester operation. Intermittent mixing could allow new feedstock to accumulate in the digester until the mixing system is again operating, possibly resulting in bursts of biogas leading to foaming. For this reason, if intermittent mixing is used, mixing pumps should be operated at least one half hour before co-thickened sludge is added to the digester and for one half hour after sludge addition is secured.

A pressure transmitter is provided to monitor the pressure in the mixer discharge header and a flow meter is provided to measure the flow of digested sludge returned to the digester. An increase in pressure to an operator selectable pressure setting will result in an alarm and disable the mixing pumps. A decrease in pressure to an operator selectable pressure setting will also result in an alarm, but the mixing pump will not be disabled.

Flushing water is provided to the pressure transmitter line to prevent plugging of the pressure transmitter. Under normal operation a normally open solenoid and a manually throttled valve will result in a trickle of flushing water into the pressure transmitter line. Periodically (based on an operator selectable timed cycle) a second solenoid valve will open for an operator selectable duration to provide a greater flush of the pressure transmitter line. During the flush cycle, the PLC will continue to monitor the pressure, however, all pressure alarms will be disabled during the flush cycle.

1.2.2 Automatic Mode

The system and equipment should normally be operated in automatic mode, with adjustments to the automatic settings as required. This will ensure that interlocks and process control loops are allowed to act on the system as designed to achieve effective mixing and foam control in a safe effective manner.

1.2.3 Manual Mode

Provisions have been made to operate the equipment in manual mode. This mode can be used by maintenance personnel for troubleshooting or as an aid in commissioning. Great care and continuous monitoring by plant personnel should be utilized any time any equipment is placed in manual mode, as system or equipment damage could result from running the equipment when ancillary equipment or systems are not in a safe mode to do so. Additionally human safety is a factor and should be considered using appropriate protocols when running equipment manually.

In the transition from Automatic to Manual mode for any equipment, the initial manual commanded state shall match the last automatic commanded state. For example, if a valve is

commanded open in automatic mode, and the operator then switches the valve to manual mode, the valve shall remain open in manual mode until the operator changes the command. A similar philosophy will apply to analog signals. For example, if a VFD is commanded to run at 90% in automatic mode, the transition to manual will continue to command the VFD to run at 90% speed in manual mode until the control is changed manually by the operator.

1.2.4 Local Mode

Provisions have been made to operate the equipment in local mode. This mode can be used by maintenance personnel for troubleshooting or as an aid in commissioning. Great care and continuous monitoring by plant personnel should be utilized any time any equipment is placed in local mode, as system or equipment damage could result from running the equipment when ancillary equipment or systems are not in a safe mode to do so. Additionally human safety is a factor and should be considered using appropriate protocols when running equipment manually.

In local mode, the operators have the ability to start and stop the VFD/pump in the digester gallery west electrical room at the VFD control panel using the HMI module mounted on the VFD cabinet door. The control valves will also have manual control wheels. This will provide an option to run the equipment locally in the event of a DCS or PLC system failure. There is no provision for operation of the pump itself in local mode.

2.0 Process Description – Mixing mode

2.1.1 Mixing Pumps – Duty/Standby Operation

The two mixing pumps will operate in a duty/standby arrangement. Mixing pump D376-P will normally be designated as the duty pump for Digester No.11. Mixing pump D375-P will normally be designated as the standby pump for Digester 11, and provision is made that it can also be the standby pump for Digester No.12 in the future. The selection of duty/standby will be available at the OWS, and will be manually selected by the operator. There is no provision for automatic changeover or automatic starting of the standby pump if the lead pump should fail. While the discharge valves are automated and the control system will ensure that the pump discharge valve is open prior to starting the pump, the operator should also verify that the manual valves on the inlet side of the pump are open prior to switching the duty/standby arrangement.

2.1.2 Mixing Pumps – Continuous Operation Mode

The plant operators will be able to set the mixing system to continuous mode operation via the OWS. In the continuous mode of operation the duty mixing pump will run at a fixed speed between 75-100% as set by the operator.

2.1.3 Mixing Pumps – Duty Cycle Operation Mode

The plant operators will be able to set the mixing system to duty cycle mode operation via the OWS. In the duty cycle mode of operation the duty mixing pump will run at a fixed speed between 75-100% as set by the operator for an adjustable number of hours, then at a secondary fixed speed between 75-100% for an adjustable number of hours. Additionally the system will also allow an entry of 0% in the duty cycle mode, which will turn the duty pump off during its time period. Speed entries greater than 0% and less than 75% will not be permitted.

As a starting point for obtaining minimum intermittent mixing, the Rotamix mixing system from Vaughan should be started 30 minutes before adding new sludge and maintained for at least 30 minutes after stopping the addition of new sludge. This schedule may be adjusted over the course of (approximately) the first 6 months of operation as the digester stability increases and lab results are evaluated.

2.1.4 Mixing Pump D376-P – Interlocks and Alarms

The mixing pump VFD is connected to the DGC via Modbus TCP Ethernet connection. The controller monitors and controls the VFD through the Ethernet connection. The PLC logic shall prevent the VFD from running below 75% speed in automatic mode to prevent the mixing nozzles from plugging.

The control system will monitor the following signals and prevent the pump from operating in automatic mixing mode unless all conditions are satisfied:

- Discharge Valve D380-XV Open
- Discharge Valve D379-XV Closed
- Pump D376-P E-stop not pressed
- Pump D376-P Local Disconnect Closed
- Pump D376-P VFD Ready
- Pump D376-P Auto Mode Active
- Digester No.11 Pressure Normal (not high pressure alarm)
- Flow Meter D382-FIT Low flow alarm
- Discharge Header Pressure D386-PIT High Pressure Alarm

The control system will monitor the VFD and generate alarms in the PLC and OWS in the following conditions:

- VFD Fail to Run Alarm
- VFD Fault
- VFD Communication Failure
- Duty Pump Not in Auto (generated if D376P is designated as Duty Pump and is not in Auto Mode)

The control system will allow the VFD to be placed in Manual mode at either the OWS or at the VFD itself. In Manual mode, the VFD speed can be adjusted over its entire range of 0-100% and interlocks will not be in effect.

2.1.5 Mixing Pump D376-P Discharge Isolation Valve D380-XV

The mixing pump discharge pneumatically operated valve is controlled by the PLC system.

In automatic mode, the valve is programmed to open any time mixing pump D376-P is commanded to operate via the automatic sequence, and closed when the mixing pump is commanded off, and the speed feedback has confirmed that the pump has been shut down.

The valve can be manually opened/closed at the OWS in the control room by placing the valve in Manual mode and commanding the valve open or closed. Additionally, a local control station will provide control near the valve. The system must be placed in local mode at the local station, and then the valve can be either opened or closed locally. The control system monitors the local/remote mode status and provides feedback on the OWS when the valve is in local mode.

The control system will monitor the valve and generate alarms in the PLC and OWS when the valve is not in local control mode:

- Valve Fail to Open
- Valve Fail to Close

2.1.6 Mixing Pump D375-P – Interlocks and Alarms

The mixing pump VFD is connected to the DGC via Modbus TCP Ethernet connection. The controller monitors and controls the VFD through the Ethernet connection. The PLC logic shall prevent the VFD from running below 75% speed in automatic mode to prevent the mixing system nozzles from plugging.

The control system will monitor the following signals and prevent the pump from operating in automatic mixing mode unless all conditions are satisfied:

- Discharge Valve D379-XV Open
- Discharge Valve D380-XV Closed
- Pump D375-P E-stop not pressed
- Pump D375-P Local Disconnect Closed
- Pump D375-P VFD Ready
- Pump D375-P Auto Mode Active
- Digester No.11 Pressure Normal (not high pressure alarm)
- Flow Meter D382-FIT Low flow alarm
- Discharge Header Pressure D386-PIT High Pressure Alarm

The control system will monitor the VFD and generate alarms in the PLC and OWS in the following conditions:

- VFD Fail to Run Alarm
- VFD Fault
- VFD Communication Failure
- Duty Pump Not in Auto (generated if D375P is designated as Duty Pump and is not in Auto Mode

The control system will allow the VFD to be placed in Manual mode at either the OWS or at the VFD itself. In Manual mode, the VFD speed can be adjusted over its entire range of 0-100% and interlocks will not be in effect.

2.1.7 Mixing Pump D375-P Discharge Isolation Valve D379-XV

The mixing pump discharge pneumatically operated valve is controlled by the PLC system.

In automatic mode, the valve is programmed to open any time mixing pump D375-P is commanded to operate via the automatic sequence, and closed when the mixing pump is commanded off, and the speed feedback has confirmed that the pump has been shut down.

The valve can be manually opened/closed at the OWS in the control room by placing the valve in Manual mode and commanding the valve open or closed. Additionally, a local control station will provide control near the valve. The system must be placed in local mode at the local station, and then the valve can be either opened or closed locally. The control system monitors the local/remote mode status and provides feedback on the OWS when the valve is in local mode.

The control system will monitor the valve and generate alarms in the PLC and OWS when the valve is not in local control mode:

- Valve Fail to Open
- Valve Fail to Close

2.1.8 Flow Meter D382-FIT

The control system will continuously monitor the return flow to Digester No.11 via flow meter D382-FIT. The system will record daily flow totals and record the totals in the system database.

Once one of the mixing pumps has been started and the speed feedback indicates that the pump is running at 75% or greater speed for 5 seconds, the system will begin to monitor flow condition for a low flow alarm. If a flow condition below 1300 m^3/hour occurs a low flow alarm will be generated in the PLC and displayed on the OWS. The low flow condition setpoint can be adjusted lower if the media is unexpectedly viscous, causing the pumped flow to be lower than expected at a given pump RPM. The low flow alarm condition will require a manual alarm reset

at the OWS. The corresponding mixing pump will be shut down and both pumps locked out until the alarm condition is reset.

2.1.9 Pump Discharge Header Pressure D386-PIT

The control system will monitor the pump discharge header pressure via pressure transmitter D386-PIT.

The pressures sensor face is fed with a trickle of flushing water through normally open solenoid valve D384-VX1 and throttling hand valve D384-HV1. This trickle water will be enabled anytime the duty pump is running in automatic mode and will remain energized for an additional 60 seconds when the pump is confirmed to be stopped. A high volume normally closed flush solenoid valve D384-VX2 is plumbed in parallel to hand valve D384-HV1. A flush cycle will be periodically executed by opening D384-VX2 when the duty pump is operating and also an additional 60 seconds when the pump is confirmed to be stopped. The high volume flushing duty cycle is adjustable at the OWS.

If the discharge pressure should rise above 130kPA for five seconds, when solenoid valve D384-VX2 is closed, an alarm will be generated in the PLC and displayed on the OWS. The high pressure alarm condition will require a manual alarm reset at the OWS. The corresponding mixing pump will be shut down and both pumps locked out until the alarm condition is reset.

If the discharge pressure drops below 59kPA for five seconds, when either duty pump is running at minimum speed (75%), an alarm will be generated in the PLC and displayed on the OWS. The low pressure alarm condition will automatically reset when the pressure rises above 65kPa.

2.1.10 Digester No.11 Headspace Pressure – High Pressure Alarm

The DCS system will send a signal to the PLC control system indicating the digester headspace pressure from pressure sensor DXXX-PIT is in alarm condition. If a high pressure alarm exists, the corresponding mixing pump will be shut down and both pumps locked out until the alarm condition is cleared.

2.1.11 Digester No.11 Headspace Foam Level D130-LIT

The control system will monitor the headspace foam level in the digester continuously.

If a high foam level condition is detected when the mixing system is in full operation, an alarm will be generated at the OWS. The mixing pump Auto VFD speed setting will be reduced in a stepped manner by first reducing the speed to 90%, then 85% and finally to a minimum speed of 75% until the foam level drops below the alarm reset level and remains below the reset level for at least 30 minutes (operator adjustable). The mixing pump will then be allowed to return to its normal operating speed.

If a high foam level condition is detected when the pump system is not running and the duty pump is in automatic mode, an alarm will be generated at the OWS and an indicator will appear next to the pumps on the process overview graphic indicating “Automatic Foam Suppression Mode Active”. The duty mixing pump will be started and VFD speed setting will be set to minimum speed (75%) until the foam level drops below the alarm reset level and remains below the reset level for 30 minutes. The mixing pump system will operate for a minimum of 30 minutes after the foam level alarm has been reset prior to shutting down.