

	<b>Automation Design Guide</b>	Revision: 00	Page 1 of 107
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**The City of Winnipeg**  
**Water & Waste Department**

**Wastewater Treatment Facilities**  
**Automation Design Guide**

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 Winnipeg	<b>Automation Design Guide</b>	Revision: 00	Page 4 of 107
		Document Code: 612620-0013-40ER-0001	

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## TABLE OF CONTENTS

<b>1</b>	<b>Introduction .....</b>	<b>9</b>
1.1	Scope of the Guide .....	9
1.2	Application .....	9
1.3	Definitions .....	10
<b>2</b>	<b>General.....</b>	<b>13</b>
2.1	References .....	13
2.1.1	General.....	13
2.1.2	City of Winnipeg Standards.....	13
2.1.3	Codes and Standards.....	13
2.1.4	Local Codes and Bylaws .....	13
2.2	Units of Measure .....	14
<b>3</b>	<b>Process Control System.....</b>	<b>15</b>
3.1	General.....	15
3.2	Existing DCS .....	15
3.3	Architecture Overview .....	16
3.4	Communication Networks.....	17
3.4.1	General.....	17
3.4.2	Facility-Wide Network Upgrades .....	17
3.4.3	Process Control System Network.....	18
3.4.4	Network Routing .....	22
3.4.5	Network Equipment and Cabling.....	22
3.4.6	Wireless Networking.....	23
3.5	HMI, Historian, and Information Server Systems .....	23
3.5.1	General.....	23
3.5.2	HMI Servers.....	23
3.5.3	HMI Clients .....	24
3.5.4	HMI Terminal Servers.....	24
3.5.5	Historian Server.....	24
3.5.6	Information Server .....	25
3.6	Modification of HMI Systems .....	25
3.7	Domain Controller.....	25
3.8	Server Virtualization .....	25
3.9	Programming/Maintenance Workstations .....	26
3.10	Programmable Logic Controllers .....	26
3.10.1	PLC to Replace an Existing DCS PCU .....	27
3.10.2	PLCs for New Wastewater Treatment Process Equipment or Independent Critical Equipment .....	28
3.10.3	PLCs for a Minor Process Train or Auxiliary Equipment .....	28
3.10.4	Packaged PLC from Equipment Vendor .....	29
3.11	Standardized PLC Hardware.....	29
3.12	Standard Architectures.....	33
3.13	PLC Programs .....	39
3.13.1	Program Language.....	39

	3.13.2 PLC Configurations and Program Logic.....	39
	3.13.3 Program Structure .....	39
	3.13.4 Program Documentation .....	40
	3.13.5 Variable Data Types .....	40
3.14	Control Modes .....	40
3.15	Cyber Security .....	41
<b>4</b>	<b>Identification.....</b>	<b>44</b>
<b>5</b>	<b>Environmental Requirements .....</b>	<b>45</b>
5.1	Ingress Protection.....	45
5.2	Temperature and Humidity Ratings.....	45
5.3	Cold Environment Requirements .....	45
<b>6</b>	<b>Wiring, Cabling, and Conduit.....</b>	<b>46</b>
6.1	Standard Colours.....	46
	6.1.1 Control Wiring – Wire Colour.....	46
	6.1.2 Network Cable – Jacket Colour.....	46
	6.1.3 Profibus Cable – Conductor Colour.....	46
	6.1.4 Conduit Colour Coding .....	47
6.2	Cable Types and Ratings .....	47
6.3	Use of Conduits vs. Cables .....	47
6.4	Conduit Materials and Sizes.....	47
6.5	Junction Boxes .....	48
6.6	Cable Trays .....	48
6.7	Shield Termination and Grounding.....	49
6.8	Signal Noise Prevention .....	50
<b>7</b>	<b>HMI Systems.....</b>	<b>51</b>
7.1	Typical Information and Control Points on HMI Systems.....	51
7.2	HMI Standards and Reference Material .....	52
<b>8</b>	<b>Local User Interface.....</b>	<b>53</b>
8.1	General.....	53
8.2	Pilot Device Colours .....	53
8.3	Touchscreen HMIs .....	54
8.4	Typical Manual Controls.....	54
<b>9</b>	<b>Control Panels.....</b>	<b>55</b>
9.1	Heating, Ventilation, and Cooling .....	55
9.2	Spare Space.....	55
9.3	Wireways .....	55
9.4	Cable Entry.....	56
9.5	Power Supply Voltage .....	56
9.6	Control Voltage.....	56
9.7	Grounding and Bonding.....	56
9.8	Terminals.....	57
9.9	Terminals for Hardwired I/O Terminations .....	59
9.10	Lighting .....	59
9.11	Shelves.....	59
9.12	Laptop Receptacle.....	60

9.13	Ethernet Port .....	60
<b>10</b>	<b>Motor Control .....</b>	<b>61</b>
10.1	Standard Equipment.....	61
10.2	Control and Monitoring .....	61
10.2.1	General.....	61
10.2.2	Low Voltage Motor Control Centres .....	61
10.2.3	Low Voltage Variable Frequency Drives .....	63
10.2.4	Medium Voltage Motors.....	65
10.2.5	Automatic Restart .....	65
<b>11</b>	<b>Valve Control .....</b>	<b>66</b>
11.1	General.....	66
11.2	Control and Monitoring .....	66
<b>12</b>	<b>Field Instrumentation.....</b>	<b>69</b>
12.1	Typical Practices .....	69
12.1.1	Fail-Safe Implementation .....	69
12.1.2	Routing of Signal Cabling .....	69
12.1.3	Instrument Redundancy .....	69
12.1.4	Installation and Removal .....	69
12.1.5	Instrument Displays .....	70
12.1.6	Instrument Manifolds .....	70
12.2	Selection Criteria .....	70
12.2.1	Standardized Manufacturers .....	70
12.2.2	Instrument Accuracy.....	70
12.2.3	Transmitter Output.....	70
12.2.4	Switches vs. Transmitters.....	71
12.2.5	Instrument Power Supply .....	72
12.2.6	Materials .....	72
12.2.7	Flow Measurement Instruments .....	72
12.2.8	Level Measurement Instruments .....	73
12.2.9	Pressure Measurement Instruments .....	73
12.2.10	Temperature Measurement Instruments.....	73
<b>13</b>	<b>Power Supply .....</b>	<b>74</b>
13.1	General Requirements .....	74
13.2	24 Vdc Power Supplies .....	74
13.3	UPS Power .....	74
<b>14</b>	<b>Hazardous Locations .....</b>	<b>76</b>
14.1	General.....	76
14.2	References .....	76
14.3	Design Requirements .....	77
14.3.1	General.....	77
14.3.2	Intrinsically Safe Systems .....	77
14.4	Preferred Methods of Protection .....	78
14.4.1	General.....	78
14.4.2	Zone 0 Locations .....	78
14.4.3	Zone 1 Locations .....	78
14.4.4	Zone 2 Locations .....	78
<b>15</b>	<b>Safety Instrumented Systems .....</b>	<b>79</b>

15.1	General .....	79
15.2	Documentation Requirements .....	80
15.3	General Design Principles .....	80
<b>16</b>	<b>Grounding .....</b>	<b>82</b>
16.1	General .....	82
16.2	Implementation of Automation Equipment Grounding .....	83
	16.2.1 Installations in Existing Buildings .....	83
	16.2.2 Installations in New Buildings .....	83
	16.2.3 Typical Configurations .....	83
16.3	Minimum Requirements .....	85
16.4	Good Practices .....	86
<b>17</b>	<b>Engineering Design Team Responsibility .....</b>	<b>87</b>
17.1	General .....	87
17.2	Drawings .....	88
	17.2.1 Loop Drawings .....	88
	17.2.2 Instrument Segment Drawings .....	89
	17.2.3 Instrument Location Plan Drawings .....	89
	17.2.4 Instrument Installation Details .....	90
	17.2.5 Control Panel Layouts .....	91
	17.2.6 Control Panel Power Distribution Schematics .....	91
	17.2.7 I/O Module Wiring Diagrams .....	92
	17.2.8 Network Diagrams .....	92
	17.2.9 Automation Conduit Riser Diagrams .....	93
	17.2.10 Process and Instrumentation Diagrams .....	93
17.3	Other Documents .....	94
	17.3.1 Instrument List .....	94
	17.3.2 Loop Numbering List .....	95
	17.3.3 I/O List .....	96
	17.3.4 Interface Maps .....	97
	17.3.5 Automation Cable Schedule .....	97
	17.3.6 Lamacoid Schedule .....	98
	17.3.7 Process Control Narrative .....	99
	17.3.8 Functional Requirements Specifications .....	99
17.4	Construction and Commissioning Documents .....	100
	17.4.1 Instrument Test Forms .....	100
	17.4.2 I/O Module Test Forms .....	102
	17.4.3 PLC System Commissioning Checklist .....	102
	17.4.4 Valve Actuator Commissioning Checklist .....	103
17.5	Design Calculations and Studies .....	104
<b>18</b>	<b>Sample Drawings .....</b>	<b>106</b>
<b>19</b>	<b>Sample Documents .....</b>	<b>107</b>



	<b>Automation Design Guide</b>	Revision: 00	Page 9 of 107
		Document Code: 612620-0013-40ER-0001	

# 1 INTRODUCTION

This Wastewater Department Automation Design Guide is intended to serve as a reference for consistent design of new automation systems for City of Winnipeg owned wastewater facilities. This document provides guidance to department personnel, as well as external consultants, in the design of automation systems for the Winnipeg Sewage Treatment Program (WSTP), and also indicates the expectations and responsibilities of the designers.

## 1.1 Scope of the Guide

These design requirements will apply to the following facilities:

1. North End Water Pollution Control Centre (NEWPCC),
2. South End Water Pollution Control Centre (SEWPCC),
3. West End Water Pollution Control Centre (WEWPCC).

These design requirements will also be applied to the collection system where relevant and useful.

## 1.2 Application

The scope and intent of this document is to convey general design guidance regarding automation systems at wastewater facilities. This document addresses specifics related to equipment type, selection, and configuration, however the guidance is presented without knowledge of the specific process implementation. It is not within the scope of this document to provide detailed design direction, and it will be the responsibility of the respective system designers to fully develop the automation design details with general conformance, as appropriate, for the concepts presented herein. This guide shall not be construed as comprehensive engineering design requirements or negate the requirement for professional engineering involvement. Any design must be executed under the responsibility and seal of the respective engineer in each instance, and must be performed in conformance with all applicable codes and standards, as well as good engineering practice, with due consideration for other relevant issues such as equipment warranties, statutory certifications, and the like.

Where significant deviations from this guide are deemed to be appropriate by the design engineer, these shall be subject to further review and acceptance by all stake holders.

Existing facilities do not necessarily comply with this guide. The expectations regarding application of this guide to new designs at existing facilities must be assessed on a case-by-case basis, however general guidelines for application are presented as follows:

1. All new designs, not related to an existing facility, are expected to be subject to the utilization of this guideline.
2. All major upgrades to a facility, or a larger facility's process area, are expected to be subject to the utilization of this guideline, however in some cases compromise with the configuration of the existing facility design may be required.
3. All minor upgrades should use this guide as far as practical for new equipment, however in some cases compromise with the configuration of the existing facility design and installation which will be retained after an upgrade will be required.
4. This document shall be reviewed and updated as required on an annual basis by the City of Winnipeg Water and Waste department to ensure that the document remains relevant and accurate.

### 1.3 Definitions

A	Amperes
ACIC	Armoured Control and Instrumentation Cable
BPCS	Basic Process Control System
CIC	Control and Instrumentation Cable (Non-Armoured)
CPT	Control Power Transformer
CPU	Central Processing Unit
CSA	Canadian Standards Association
CV	Control Variable (PID Control)
d	Flame-proof
DCS	Distributed Control System
DIO	Distributed I/O
DMZ	Demilitarized Zone
DP	Decentralized Periphery (PROFIBUS DP protocol)
DRS	Dual Ring Switch (Ethernet Switch)
EMT	Electrical Metallic Tubing
FAT	Factory Acceptance Test
JB	Junction Box
HMI	Human Machine Interface
HOA	Hand - Off - Auto (switch)
HOR	Hand - Off - Remote (switch)
HP, hp	Horsepower
HVAC	Heating Ventilation and Cooling
I/O	Input / Output
ia	Intrinsic Safety Level, Zone 0
ib	Intrinsic Safety Level, Zone 1
ic	Intrinsic Safety Level, Zone 2
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IS	Intrinsically Safe
IT	Information Technology
LHMI	Local HMI (dedicated to a specific piece of equipment)
LOR	Local - Off - Remote (switch)
MCC	Motor Control Centre
MOA	Manual - Off - Auto (switch)
MRP	Media Redundancy Protocol

MTBF	Mean Time Between Failure
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
PA	Process Automation (PROFIBUS PA protocol)
PB	Pull Box
PCS	Process Control System
PCU	Process Control Unit
PCV	Process Control View (DCS HMI software)
PDF	Portable Document Format
PE	Potential Earth
PID	Proportional Integral Derivative
PLC	Programmable Logic Controller
PRM	Profibus Remote Master (by Schneider Electric)
PV	Process Variable (PID Control)
Q-EIO	Quantum Ethernet I/O
RFI	Request for Information
RIO	Remote I/O
RRF	Risk Reduction Factor
RSTP	Rapid Spanning Tree Protocol
RTU	Remote Terminal Unit
SCCR	Short Circuit Current Rating
SIS	Safety Instrumented System
SIF	Safety Instrumented Function
SIL	Safety Integrity Level
SP	Setpoint
TC	Tray Cable
TU	Termination Unit
UPS	Uninterruptible Power Supply
V	Volts
VCSEL	Vertical Cavity Surface Emitting Laser
WAN	Wide Area Network
WSTP	Winnipeg Sewage Treatment Program
VFD	Variable Frequency Drive
VM	Virtual Machine

 Winnipeg	<b>Automation Design Guide</b>	Revision: 00	Page 12 of 107
		Document Code: 612620-0013-40ER-0001	

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	<b>Automation Design Guide</b>	Revision: 00	Page 13 of 107
		Document Code: 612620-0013-40ER-0001	

## 2 GENERAL

### 2.1 References

#### 2.1.1 General

Where this document, codes, standards, and other referenced documents differ in content, the most stringent shall generally apply.

#### 2.1.2 City of Winnipeg Standards

The following City of Winnipeg standards shall be used where applicable:

1. Water and Waste Department Identification Standard, document number 510276-0000-40ER-0002.
2. Wastewater Treatment Electrical Design Guide, document number 510276-0000-40ER-0002.
3. Tagname Identification Standard, document number 612620-0014-40ER-0001.
4. HMI Layout and Animation Plan, document number 612620-0015-40ER-0001.
5. Historical Data Retention Standard, document number 612620-0016-40ER-0001.

#### 2.1.3 Codes and Standards

ANSI	American National Standards Institute
ASTM	American Society for Testing and Materials
ATEX	Atmospheres Explosives
CSA	Canadian Standards Association
CEC	Canadian Electrical Code (modified by Winnipeg Electrical Bylaw)
IEEE	Institute of Electrical and Electronic Engineers
IEC	International Electro-technical Commission
ISA	International Society of Automation
NFPA	National Fire Protection Association
NEMA	National Electrical Manufacturers Association
PI	PROFIBUS International
ULC	Underwriters Laboratories of Canada
WSHA	The Workplace Safety and Health Act (Manitoba)

#### 2.1.4 Local Codes and Bylaws

The latest editions of the following local codes and bylaws, together with any bulletins or addenda thereto, shall be referenced when performing automation designs for the City of Winnipeg.

1. Canadian Electrical Code
2. Winnipeg Electrical Bylaw

 Winnipeg	<b>Automation Design Guide</b>	Revision: 00	Page 14 of 107
		Document Code: 612620-0013-40ER-0001	

## 2.2 Units of Measure

All drawings and documentation, including design calculations, and field instruments shall use the International System of Units (SI units). Imperial units on drawings and documentation will be provided in parenthesis after the metric unit, where requested or appropriate.

	<b>Automation Design Guide</b>	Revision: 00	Page 15 of 107
		Document Code: 612620-0013-40ER-0001	

## 3 PROCESS CONTROL SYSTEM

### 3.1 General

The Process Control System (PCS) at the wastewater treatment facilities provides monitoring and control of the wastewater treatment process and ancillary systems.

The original process control system installed at each wastewater treatment facility was based on an ABB/Bailey Infi90 Distributed Control System (DCS). The City has initiated a program to replace the DCS with a Process Control System (PCS) based upon distributed Programmable Logic Controllers (PLCs) along with a new HMI and historian system.

The City underwent a standardization process to standardize on the make and model of new control system equipment including PLCs, HMI software, historian software, information server software, process instruments, gas detection systems, motor control equipment, and valve actuators. All new designs utilizing such components shall make use of the City's standardized components to ensure consistency in the operation and maintenance of the treatment facilities.

The following sections provide guidance on the design and implementation of new process control systems at the wastewater treatment facilities utilizing the City's standardized components.

### 3.2 Existing DCS

A brief summary of the existing DCS is provided to facilitate an understanding of its implementation, since portions of the existing DCS hardware may be re-used when upgrading to a PLC system.

The original ABB/Bailey Infi90 DCS installations are composed of one or more Process Control Units (PCUs) in each major process area, and an HMI system utilizing ABB/Bailey Process Control View (PCV) software.

A PCU consists of one or more rack type industrial cabinets containing the DCS programmable controller, I/O modules, communication modules, power supply, and field wiring Termination Units (TUs). The processor and I/O modules are typically located in the front-half of the main cabinet, and the TUs are located in the rear-half of the same cabinet. Additional TUs may be located in adjacent cabinets as required.

A TU provides the physical connection points for discrete and analog I/O field wiring, and often contains DIP switches, relays, and other components for customizing the operation of the TU for the associated I/O module and/or field device. One TU is typically provided for each I/O module, and are individually connected together using pre-fabricated cordsets. Note that the existing TUs are generally in acceptable condition and do not require replacement.

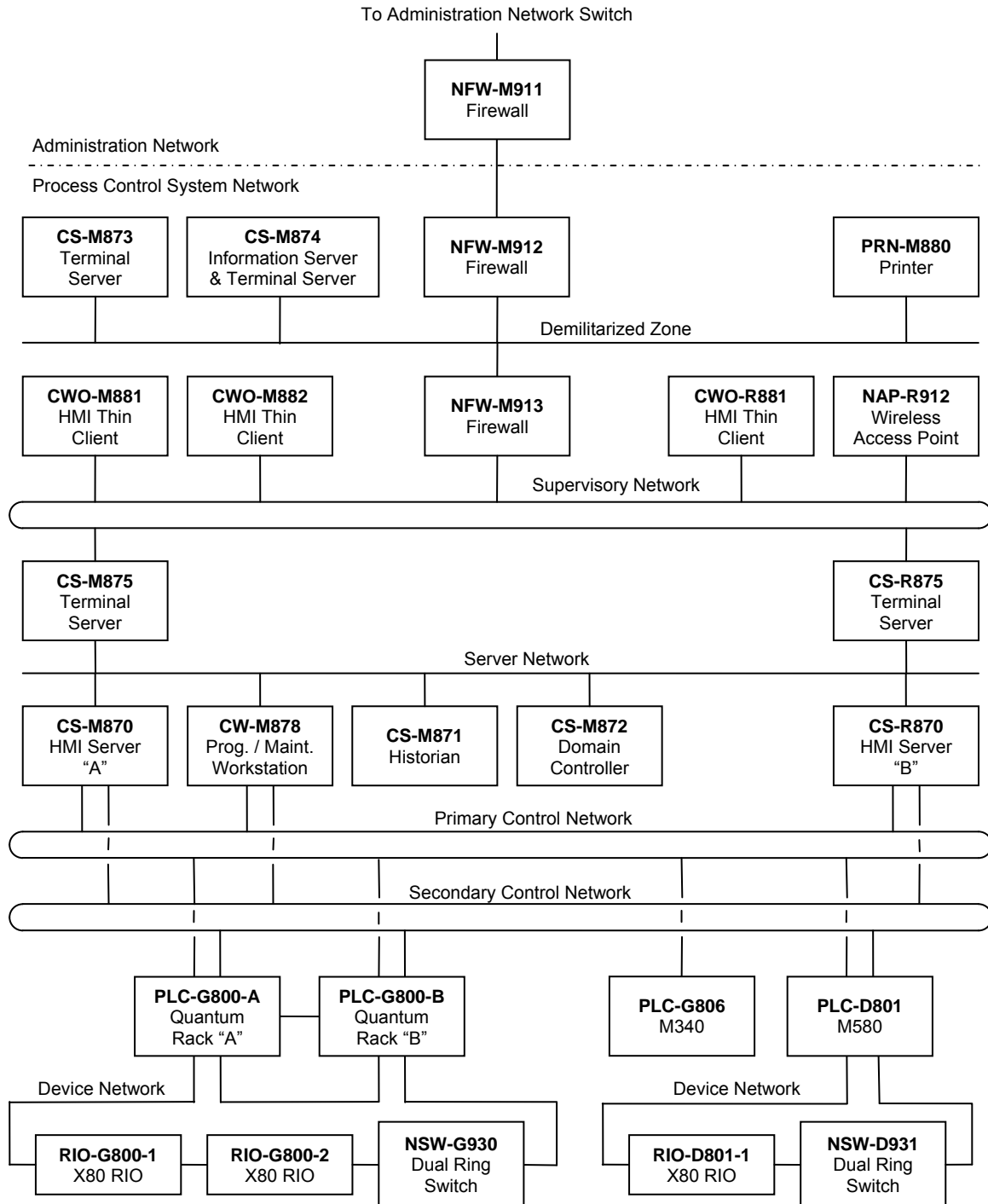
The City typically uses 120 Vac discrete input modules and 24 Vdc discrete output modules. Note that the TUs for the discrete output modules contain interposing relays to transition the 24 Vdc signal coming from the discrete output modules to 120 Vac signals for the field devices.

While the DCS has served the City well, the functionality and maintainability of an older system is limited and therefore the City has initiated a program to replace the DCS with distributed PLCs.

As the existing DCS is in the process of being replaced, the Automation Design Guide does not provide details regarding DCS component upgrades, nor the means of integrating new process equipment into the DCS. However, Section 3.10.1 provides details on the replacement of a DCS PCU with a new PLC-based system.

### 3.3 Architecture Overview

A high-level overview of the upgraded process control system architecture is provided in Figure 3-1, which shall be used as the basis for design of all new PLC-based process control system installations.



**Figure 3-1: Facility PLC-based Process Control System Architecture**



	<b>Automation Design Guide</b>	Revision: 00	Page 17 of 107
		Document Code: 612620-0013-40ER-0001	

Notes regarding Figure 3-1:

1. *The figure does is not comprehensive in that it does not show typical quantities of programmable controllers, remote I/O racks, HMI clients, etc., that would be installed at a wastewater treatment facility.*
2. *All network switches and patch panels are not shown.*
3. *Field equipment such as instruments, motor starters, VFDs, etc., are not shown.*
4. *Refer to Section 3.4.3.5 for additional details on the device networks for connecting field equipment.*

Implementation details for the communication network, HMI system, programmable logic controllers, and field devices are provided in the following sections.

## 3.4 Communication Networks

### 3.4.1 General

The standard communication network implementation at the wastewater treatment facilities consists of three primary networks, as follows:

1. **Process Control System Network** – a multi-tier network for communication between process control system equipment including programmable controllers, HMI servers, HMI clients, historian servers, and field devices. The network is composed of a mix of Ethernet and fieldbus technologies.
2. **Administration Network** – an Ethernet network for communication between administration systems including office and laboratory computers, printers, computer servers, and the corporate WAN.
3. **Security Network** – an Ethernet network for security systems equipment including video surveillance cameras and recorders.

Only the Process Control System Network is shown in Figure 3-1, with the exception that firewall NFW-M911 is also shown, which is part of the Administration Network. Note that the Administration Network and Security Network typically fall under the responsibility of the City's Information Technology (IT) group and therefore standard topologies for these networks are not provided.

### 3.4.2 Facility-Wide Network Upgrades

The replacement of the DCS will include the installation of a new facility-wide fibre ring that will act as the backbone for the new Process Control System Network. Typically a 24-strand fibre cable would be used between major process areas. Six of the strands in the fibre cable would be dedicated to the Process Control System Network, two strands for the Administration Network, and another two strands for Security Network. The remaining strands in the cable will be spare.

The fibre backbone shall span the entire facility and pass through each major process area. Install a fibre patch panel and a networking panel in each major process area for connection to the fibre ring.

Networking equipment associated with the Administration and Security Networks is the responsibility of the City, and will be physically separated at all levels from the Process Control System Network (other than sharing a common fibre cable).

	<b>Automation Design Guide</b>	Revision: 00	Page 18 of 107
		Document Code: 612620-0013-40ER-0001	

### 3.4.3 Process Control System Network

The Process Control System Network is segregated into multiple tiers for the sake of performance and security as follows:

1. **Demilitarized Zone (DMZ)** – a sub-network between the Administration Network and the Process Control Network for locating devices that are accessed from both of these networks. The demilitarized zone typically contains the Information Server, a read-only terminal server, and a printer.
2. **Supervisory Network** – a facility-wide fibre/copper Ethernet, and wireless 802.11 sub-network for communication between HMI terminal servers, HMI thin clients, and portable HMI clients.
3. **Server Network** – a fibre/copper Ethernet sub-network for communication between HMI servers, HMI terminal servers, historian server(s), and domain controller(s).
4. **Control Network** – a facility-wide redundant fibre/copper Ethernet sub-network for communication between HMI servers and programmable controllers, and for controller-to-controller communication.
5. **Device Networks** – multiple independent copper sub-networks within each process area for communication between the programmable controllers, remote I/O, and field devices. The network is implemented using a combination of Ethernet/IP, Modbus/TCP, and PROFIBUS.

Each of these network tiers are further described in the following sections.

#### 3.4.3.1 Demilitarized Zone (DMZ)

The Demilitarized Zone (DMZ) is a sub-network that contains computer servers and other networked equipment that will be accessed from both the Administration Network and the Process Control System Network. The DMZ would typically contain an Information Server, a terminal server for read-only access to the HMI system, and a printer.

Firewalls are used on either side of the DMZ to control access in and out of the DMZ. Two firewalls shall be installed between the Administration Network and the DMZ, and shall be different brands to reduce the likelihood that an attack can penetrate both firewalls. The firewall nearest the Administration network (NFW-M911 in Figure 3-1) shall be installed and maintained by the City's I.T. group, and the downstream firewall (NFW-M912 in Figure 3-1) nearest the DMZ shall be owned and maintained by City Wastewater Services. Between the DMZ and the Process Control System Network, a single firewall shall be installed (NFW-M913 in Figure 3-1), which is to be owned and maintained by City Wastewater Services.

The DMZ network shall be located in the Administration Building of a wastewater treatment facility, and does not typically extend to other plant areas. For this reason, the DMZ is implemented using CAT6 cabling in a star topology. Devices in the DMZ operate at 100 Mbps or 1 Gbps network speed as required.

Install a dedicated DMZ network switch for connection of the devices in the DMZ, such as computer servers and a printer.

#### 3.4.3.2 Supervisory Network

The Supervisory Network is a facility-wide sub-network used for communication between the HMI thin clients and HMI terminal servers.

Implement the Supervisory Network using a combination of fibre and CAT6 Ethernet cabling in a ring/star topology. Use fibre cabling in a ring topology between major process areas and CAT6

	<b>Automation Design Guide</b>	Revision: 00	Page 19 of 107
		Document Code: 612620-0013-40ER-0001	

cabling in a ring topology to feed minor process areas from adjacent major process areas. Connect HMI thin clients and HMI terminal servers to the network using CAT6 cabling in a star topology.

Install a dedicated network switch for the Supervisory Network inside a networking panel in each major process area. The network switch shall be equipped with both fibre and copper ports for connection to the supervisory fibre ring and copper-connected devices.

The main ring shall operate at 1 Gbps network speed. The HMI terminal servers shall operate at 1 Gbps, and the HMI clients that are connected via CAT6 cabling shall operate at 100 Mbps.

### 3.4.3.3 Server Network

The Server Network is an Ethernet sub-network used for communication between computer servers including the HMI servers, HMI terminal servers, historian server, and domain controller. Programming/maintenance workstations are also connected to the Server Network to facilitate server administration.

Redundant computer servers (eg. the HMI Terminal Servers and HMI Servers) are to be located in two separate areas of the facility, therefore a fibre cable is used to connect the two areas where the computers are located.

The fibre cable for the Server Network would typically be a separate fibre cable from that of the main fibre ring, but two strands in the main fibre ring may be used for the Server Network if it is practical to do so (i.e. if the routing is similar).

Provide dedicated network switches at each end of the server network for connection of the servers and programming/maintenance workstations.

The server network and the computer servers shall operate at 1 Gbps network speed.

### 3.4.3.4 Control Network

The control network is a redundant facility-wide Ethernet sub-network for communication between the HMI servers and programmable logic controllers, and for controller-to-controller communication. The network is to be implemented using a combination of CAT6 and fibre media in a redundant (parallel) ring and star topology. Fibre cabling in a redundant ring topology is used between major process areas, and CAT6 cabling in a redundant ring topology is used to feed minor process areas from adjacent major process areas. Connect the HMI servers and programmable logic controllers to the network using CAT6 cabling in a star topology.

As the Control Network is implemented in a redundant fashion, the two control networks are identified as “Primary” and “Secondary”. The Primary Control Network shall be a separate subnet and act independently of one-another. This is to mitigate the effect of broadcast storms or similar events that can take down an Ethernet network.

The Primary network is for critical process equipment and all other network connected equipment such as HVAC, electrical distribution, etc. The Secondary network is reserved for critical equipment only. For example, a PLC used for process control will be connected to both the Primary and Secondary network, whereas a PLC used for HVAC control is typically only connected to the Primary network.

Provide dedicated network switches in major process areas for each control network. The network switches shall be equipped with both fibre and copper ports for connection to the facility fibre ring and the copper-connected devices. Control network switches shall be located in networking panels.

Programming/maintenance workstations are also connected to the Control Network for programming and maintenance of the PLCs. These workstations will require two network adapters for connection to the Primary and Secondary Control Networks, in addition to the network adapter for the server network.

	<b>Automation Design Guide</b>	Revision: 00	Page 20 of 107
		Document Code: 612620-0013-40ER-0001	

The control network rings shall operate at 1 Gbps network speed. The HMI servers and engineering workstations shall operate at 1 Gbps, and the PLCs shall operate at 100 Mbps.

### 3.4.3.5 Device Networks

Install one or more independent device networks in each process area to allow for data exchange between programmable controllers and field equipment.

Device networks are implemented using a combination of Ethernet and fieldbus technologies including Q-EIO (Quantum Ethernet I/O), Modbus/TCP, and PROFIBUS DP/PA. The Q-EIO network provides high-speed connectivity to field devices such as remote I/O racks, VFDs, and MCCs, while the PROFIBUS network provides connectivity to PROFIBUS-enabled devices.

Ethernet-based field devices shall be connected using a ring topology to the greatest extent practicable. All field devices in an Ethernet ring must support the Rapid Spanning Tree Protocol (RSTP). Ethernet-based field devices that do not support the ring topology can be connected to an in-rack Ethernet module or to a network switch in the main ring using a star or daisy-chain topology, rather than a ring topology.

Remote I/O racks on the Q-EIO network are considered RIO devices, and all other Ethernet devices such as MCC intelligent overloads, VFDs, and soft-starters are considered DIO (Distributed I/O) devices. Under the Q-EIO architecture, RIO devices and DIO devices cannot reside within the same Ethernet ring. DIO devices must be connected in a “DIO sub-ring” or in a “DIO cloud” off the main ring, or placed in an independent network from the RIO devices (eg. by connecting the DIO devices directly to a DIO Ethernet module that is not interlinked with an RIO Ethernet module). A DIO cloud is a collection of DIO devices connected using a star or daisy-chain topology rather than a ring topology. Schneider Electric manufactures specific “Dual Ring Switches” (DRSs) to facilitate dual ring network architectures and for connection of DIO devices to the RIO ring. Part numbers for Dual Ring Switches are provided in Table 3-1.

Note that a maximum of 31 RIO drops plus 128 DIO devices are supported in a single Q-EIO network.

Ethernet networks should be designed such that no more than 10 Ethernet devices are connected to a single point of failure (eg. a network switch). This can be achieved by providing additional PLC networking modules, network switches, or connecting the devices in a ring topology.

Where equipment redundancy (eg. Duty/Duty or Duty/Assist) is provided in the field, the associated networked devices (eg. motor controllers) should be connected to separate network switches to prevent both pieces of equipment from being taken out of service upon a single network device failure.

Minimize the number of Ethernet network switches in process networks by connecting Ethernet cabling directly to field devices where practicable. Network switches are a point of failure, therefore network switches shall only be installed within device networks if absolutely required (eg. to support a DIO sub-ring or DIO cloud).

A PROFIBUS network may be added to a device network if communication to PROFIBUS devices is required. It is recommended to use PROFIBUS instruments as opposed to hard-wired 4-20 mA instruments due to the reduced cabling and availability of additional diagnostics information. A PROFIBUS network is created by connecting a Schneider Electric PROFIBUS Remote Master (PRM) module to an in-rack Ethernet module or a dual-ring switch in the device network. The PROFIBUS network provided by PRM module is a PROFIBUS DP network, therefore a DP/PA coupler is also required for connection of PROFIBUS PA devices.

PROFIBUS DP networks shall be designed for operation at 1.5 Mbps and operated at 500 kbps. PROFIBUS PA networks shall be designed for and operated at 31.25 kbps.

	<b>Automation Design Guide</b>	Revision: 00	Page 21 of 107
		Document Code: 612620-0013-40ER-0001	

Each PROFIBUS DP and PA segment shall have at least one point of connection for a programming device or bus analyzer. For Profibus DP segments, this is typically provided by a 9-pin D-shell connector that has a PG socket. For Profibus PA segments, a set of feed-through terminals with parallel points of connection may be provided.

Ensure that all PROFIBUS installations facilitate removal of the field devices from the network without adversely affecting the process. If equipment is daisy-chained on the network, removal of one device from the mid-point of the network may cause all downstream devices, or the entire network segment, to stop working. Some equipment, such as Rotork valve actuators, have provisions for isolating the equipment from the network without affecting the network. Where such provisions are not provided by the equipment vendor, and disconnection of a particular device from the network will negatively affect the process, then external provisions are typically required. One method is to provide multi-channel repeaters or segment protectors and segregate the devices to independent network segments. Another method is to provide external terminations on the network. These methods may be used independently, or in conjunction, as required.

If multi-channel repeaters or segment protectors are used then it is best to group devices that are associated with one control loop on a common segment. That way, it won't matter if removal of a device takes down the network segment since failure of the device would have prevented the control loop from operating in the first place. Where equipment redundancy is provided in the field, group all devices associated with the duty equipment on one segment, and all instruments associated with the standby equipment on another segment.

If a field device (eg. instrument or valve actuator) is providing the end-of-line termination, removal of the device will generally take down the network, since the termination will be lost. For this reason, it is often required to install external end-of-line terminations, even if the field devices are capable of terminating the network. As previously indicated, PROFIBUS DP networks require an active termination, so if an external terminator is used it will typically require 24 Vdc power to it. For PROFIBUS PA networks, the terminating capacitor and resistor could be installed in a small enclosure at the end of the network.

PROFIBUS repeaters often incorporate automatic termination at the "beginning" of the network, so only a terminator and the "end" of the network is required if they are used.

When designing PROFIBUS networks, follow all design and implementation rules indicated by PROFIBUS International with respect to network speed, cable lengths, installation of equipotential bonding conductors, cable routing, and terminations.

Use of insulation displacement connectors on PROFIBUS networks should generally be avoided as their use in practice has shown that they are not reusable. After disconnecting an insulation displacement connector from the cabling they typically cannot be properly reconnected due to malformation of the contacts within connector.

PROFIBUS field devices (instruments, valve actuators, etc.) shall be assigned an address in the range of 2 to 125. Address 0 is reserved for the Class 2 master (configuration and diagnostics tool), and address 1 is reserved for the Class 1 master (the Schneider Electric PRM module). Address 126 is the default address used for new devices on the network, so it should not be assigned to a device, otherwise an address conflict may arise when adding a new device to the network. Address 127 is the broadcast address, so this address shall not be assigned to any device.

For connection of HART devices, Schneider Electric produces in-rack HART modules that are available for the X80 platform. Where HART modules are used, they must be installed in an appropriate slot within a BME Ethernet backplane. HART modules must be used in conjunction with an M580 processor, as opposed to an M340 processor. If HART modules are installed in a remote rack, then the BME XBP and BME CRA drop adapters must be used.

If wireless instruments are required, install an appropriate gateway on the associated device network to facilitate communication with the instruments. Wireless instruments shall not be connected to the

Control Networks. Refer to Section 12.2.3 for additional information on use and selection of wireless instruments.

### 3.4.4 Network Routing

Network routing between the control networks and the device networks should be provided so that the programming/maintenance workstations are able to connect to devices in the device networks.

Routing functionality can be provided by the Quantum Ethernet Control Network Head Adapter, catalog number 140 NOC 781 00. Install one Control Network Head Adapter module in each Quantum rack where it is required to route down to an associated device network. Note that static routes will need to be configured on the programming/maintenance workstations, which is described in the Schneider Electric documentation.

For non-Quantum PLCs (eg. M340 and M580), routing between the control network and the device network would be provided via an external router. The decision to include a router to provide connectivity to an M340 or M580 device network should be based on the quantity and type of devices in the device network. For example, if the only Ethernet device in an M340 device network is a variable frequency drive, which doesn't often require maintenance, then the router may be omitted.

Where routing capability is not provided to a particular device network, maintenance personnel would bring a laptop into the field and connect to devices or the device network directly.

One or more Layer 3 network switches shall be installed with the Process Control System Network to provide routing between the Supervisory Network, Server Network, and Control Networks.

### 3.4.5 Network Equipment and Cabling

Table 3-1 provides standard catalog numbers for typical Schneider Electric network hardware used in the Process Control System Network.

**Table 3-1: Standardized Networking Components**

Purpose	Port Specifications	Model Number
Dual Ring Switch in Device Network	8 x 100Base-TX	TCSESM083F23F1
PROFIBUS Remote Master	2 x 100Base-TX	TCSEGPA23F14F

Use laser-optimized 50/125 μm, multimode, OM3 cable for all new fibre installations. All fibre network switches shall use VCSEL transmitters.

Cabling associated with ring networks shall be routed such that no two points of the ring are adjacent to each-another within the same duct or cable-tray.

Where CAT6 cable is routed near sources of electromagnetic noise, such as in MCCs, VFD cabinets, or near power cabling, use shielded CAT6 cable and ground the shield at one end. Shielded RJ45 connectors that are plugged into appropriately grounded RJ45 ports may be used for grounding the cable shield.

CAT6 cable located within equipment containing 600V shall have an insulation rating of 600V.

CAT6 cabling entering or leaving a networking panel shall be terminated on patch panels. Do not connect fibre or CAT6 field cables directly to the network switches within network panels; only patch cables are permitted to be connected to network switches in networking panels. It is generally preferred to connect CAT6 cabling directly to equipment in the field, where patch panels are not provided.

	<b>Automation Design Guide</b>	Revision: 00	Page 23 of 107
		Document Code: 612620-0013-40ER-0001	

For CAT6 cabling operated at 100/1000 Mbps network speed, the maximum allowable length is 100 meters. However, to allow for cabling between patch panels and network switches, and between network jacks and end devices, permanent cabling shall be limited to 80 meters in length. This allows for the installation of patch cables and incorporates some level of contingency.

### 3.4.6 Wireless Networking

Wi-Fi (IEEE 802.11) wireless networking should be provided for access to the HMI system from mobile devices such as laptops, smart-phones, and tablets. Wi-Fi access points should be provided throughout wastewater treatment facilities in electrical and control rooms, and in the field where useful.

Wi-Fi access points shall be connected to the facility Administration Network, and be fully managed by the City's Information Technology (IT) group.

Access to the HMI system for wireless devices is provided by a read-only HMI terminal server that is located in the DMZ Network.

## 3.5 HMI, Historian, and Information Server Systems

### 3.5.1 General

When a wastewater treatment facility is upgraded with a PLC based control system, provide new HMI, historian, and information server systems based on the City's standardized components, which consists of a Schneider Electric Vijeo Citect HMI, Wonderware Historian, and Ampla Information Server. The following sections apply to new HMI system installations at wastewater treatment facilities.

### 3.5.2 HMI Servers

Each HMI server consists of multiple individual software services that operate on a common hardware server. Such services include the I/O server, alarms server, trends server, and report server. The primary purpose of the HMI servers is to communicate with the PLCs to obtain tag data and make the data available to HMI clients.

Provide redundant HMI servers at each facility and locate the servers in separate process areas. The primary HMI server shall be located in the main process control system server room (typically within the Administration Building), and the secondary HMI server shall be located inside an automation room or server room in a different major process area. The purpose of locating the HMI servers in different areas is to prevent both servers from being damaged in the event of a fire or similar catastrophic event that is localized to the process control system server room. The HMI servers shall be installed in non-floodable areas that don't have any pipes with liquids above the area.

Install Schneider Electric Vijeo Citect server software and the facility HMI application on each HMI server.

Implement hardware virtualization on the HMI server computers with VMWare ESXi. Refer to Section 3.8 for additional information on server virtualization.

Each HMI server shall be connected via Ethernet to both the Primary and Secondary Control Networks, as well as the server network, as shown in Figure 3-1. Each HMI server therefore requires three Ethernet adapters.

	<b>Automation Design Guide</b>	Revision: 00	Page 24 of 107
		Document Code: 612620-0013-40ER-0001	

### 3.5.3 HMI Clients

Vijeo Citect HMI clients will use thin client technology based on Microsoft Remote Desktop Protocol (RDP), also known as Terminal Services. Use of thin client technology allows for rapid replacement of HMI clients in the event of failure, and reduces the maintenance requirements of HMI client computers.

Connect the HMI clients to the Supervisory Network for communication with the HMI terminal servers. HMI clients communicate with the HMI terminal servers only, and do not directly communicate with the HMI servers.

Configure Vijeo Citect HMI thin clients to automatically open a remote desktop (terminal services) session with the HMI terminal server upon boot-up.

Use of hardware virtualization on HMI clients is not required since they will not have a user-installed operating system and application software.

### 3.5.4 HMI Terminal Servers

Four (4) HMI terminal server instances will typically be provided at a wastewater treatment facility for hosting the facility HMI runtime software. As the HMI clients use thin client technology, they will connect to the HMI terminal servers for access to the HMI system. Note that Terminal Services is also known as Remote Desktop Protocol (RDP).

Two (2) of the HMI terminal server instances are installed on dedicated terminal server computers, which connect between the Supervisory Network and the Server Network. These terminal servers will be used as the main terminal servers for the facility HMI system and will operate in a redundant manner. The HMI runtime software on these HMI terminal servers shall be configured read/write, thereby giving operations personnel the ability to view equipment status and control the process via the HMI. Each HMI terminal server computer shall be located in a separate area of the facility, typically in the same locations as the HMI servers.

An additional two (2) HMI terminal server instances shall be provided in the DMZ network for access to the HMI from the office computers on the Administration Network, from mobile devices such as smart-phones and tablets, and from other facilities (eg. viewing SEWPCC from NEWPCC). One terminal server instance is installed on a dedicated terminal server computer in the DMZ, and will be considered the primary DMZ HMI terminal server. A second terminal server instance is installed on the same computer hosting the Ampla Information Server software, and will be considered the secondary DMZ HMI terminal server. The HMI runtime software on these DMZ HMI terminal servers shall be configured read-only to prevent unauthorized control of the HMI system.

Install the Vijeo Citect HMI runtime client software on all four (4) computers hosting the HMI terminal server instances. The Vijeo Citect HMI server software is not required on these computers.

Create a user-login script that automatically opens the Vijeo Citect HMI runtime client upon logging into the terminal services session.

Implement hardware virtualization on the HMI terminal server computers using VMWare ESXi. Refer to Section 3.8 for additional information on server virtualization.

### 3.5.5 Historian Server

Provide a single historian server at the facility. Only one historian server is required as the HMI servers are able to buffer data in the event that the historian server is out of service.

Install Schneider Electric Wonderware Historian software on the historian server.



	<b>Automation Design Guide</b>	Revision: 00	Page 25 of 107
		Document Code: 612620-0013-40ER-0001	

Separate server hardware shall be provided for the historian server. Do not use the HMI server hardware, domain controller hardware, or HMI terminal server hardware for hosting the historian server instance.

Locate the historian server in the main process control system server room (typically within the Administration Building at the facility).

Implement hardware virtualization on the historian server computer with VMWare ESXi. Refer to Section 3.8 for additional information on server virtualization.

The period of data retention on the historian system shall be consistent with the Historical Data Retention Standard, document 612620-0016-40ER-0001. Ensure the hard drives are sized to meet the data retention requirements.

### 3.5.6 Information Server

Provide an information server using the Schneider Electric Ampla software at each facility for collection and reporting of process and equipment statistics.

Install the information server software on a computer in the De-militarized Zone (DMZ) network so that computers on the Process Control System Network and Administration Network are able to access the information server. The information server computer shall physically be located within the process control system server room within Administration Building of a facility.

Implement hardware virtualization on the Information server computer with VMWare ESXi. Refer to Section 3.8 for additional information on server virtualization.

The configuration and implementation of the information server software, including configuration of reports and key performance indicators, etc., will typically be performed by the City.

## 3.6 Modification of HMI Systems

All HMI system configurations and HMI applications shall be fully accessible and editable by the City of Winnipeg. HMI hardware or software applications that are password protected, or inaccessible for modification by the City for any reason, will not be accepted under any circumstance. This applies to HMIs used for any application, including process and HVAC applications.

## 3.7 Domain Controller

Provide a domain controller at each facility for security authentication (user login, permissions, etc.). Use domain based security on all computers associated with the process control system, which includes the HMI servers, HMI terminal servers, historian, HMI clients, programming/maintenance workstations, and laptops as applicable.

The domain controller server instance may be located on one of the HMI terminal server computers since the resource utilization by the domain controller is low. A second domain controller may be installed on the second HMI terminal server computer for domain server redundancy.

If a stand-alone domain controller is provided, locate the computer in the main process control system server room (typically within the Administration Building at the facility).

## 3.8 Server Virtualization

Computers hosting process control system server software shall use virtual machine (VM) technology to facilitate rapid recovery following a hardware or software failure. VMWare ESXi is the preferred

	<b>Automation Design Guide</b>	Revision: 00	Page 26 of 107
		Document Code: 612620-0013-40ER-0001	

server virtualization software since Schneider Electric has verified compatibility of their HMI software with VMWare ESXi.

VMWare ESXi is a Type 1 hypervisor, also known as a bare metal hypervisor, which means the server virtualization software is installed directly on a bare computer, not within an operating system such as Microsoft Windows. The server virtualization software then mimics the existence of virtual hardware, which an instance of Microsoft Windows is installed upon. Since the hardware seen by the operating system (Microsoft Windows) is virtual hardware, it is possible to replace the physical computer with a new computer and reinstate the software without having to repair the operating system installation or update the drivers. The benefit of using a Type 1 hypervisor as opposed to a Type 2 hypervisor is that it is not required to install an operating system prior to installing the server virtualization software.

Snapshots of the VM's disk file will be taken by the City at periodic intervals and will be used to restore a server after a hardware or software failure.

It is not expected that any individual computer will be running more than one VM instance – the computers will have a single operating system

### 3.9 Programming/Maintenance Workstations

Provide programming/maintenance workstations to facilitate remote programming and management of process control system equipment including the PLCs, HMI servers, historian, motor control equipment, and field instruments. A typical facility would require at minimum two (2) programming/maintenance workstations.

Install the following software applications on the programming/maintenance workstations:

1. Schneider Electric Vijeo Citect HMI development software,
2. Schneider Electric Vijeo Designer touchscreen HMI software,
3. Schneider Electric Unity Pro XL PLC programming software,
4. Schneider Electric Wonderware Historian client,
5. Schneider Electric SoMove motor control equipment configuration software,
6. MDT AutoSave change management software, and
7. MiMiC software acceptance testing (SAT) and operating training system (OST) software.

Locate one of the programming/maintenance workstations in the Administration Building. A second workstation should generally be located in the same room as the secondary HMI server and secondary HMI terminal server.

Connect the programming/maintenance workstations to both control networks and the server network. As such, each workstation requires three network adapters.

### 3.10 Programmable Logic Controllers

The City has standardized on the use of Schneider Electric Modicon PLCs for all new PLC installations at the wastewater treatment facilities. The exact model and configuration of the PLC is dependent on its application, but will generally fall into one of the four following categories:

1. **PLC to Replace an Existing DCS PCU** – a high-end redundant PLC system installed within an existing DCS cabinet or in an adjacent cabinet, that is used for control of existing equipment via the existing field wiring.

	<b>Automation Design Guide</b>	Revision: 00	Page 27 of 107
		Document Code: 612620-0013-40ER-0001	

2. **PLC for New Process Equipment or Independent Critical Equipment** – a high-end redundant PLC system that is used for control of new wastewater treatment process equipment or for control of independent critical equipment.
3. **PLC for a Minor Process Train or Auxiliary Equipment** – a mid-grade, non-redundant PLC for control of non-critical equipment.
4. **Packaged PLC from Equipment Vendor** – a mid-grade, non-redundant PLC supplied with packaged equipment having non-customizable control.

Each of these applications are described further in the following sections.

### 3.10.1 PLC to Replace an Existing DCS PCU

New PLC installations that replace existing DCS PCUs shall use Schneider Electric Modicon Quantum controllers in a hot-standby configuration with X80 series Remote I/O (RIO). Note that this configuration is valid until the year 2018, at which point it should be reviewed as Schneider Electric may release a new redundant solution that supersedes the Quantum platform.

The Quantum hot-standby configuration requires that each processor be installed in an independent chassis, therefore two Quantum chassis are required. Each Quantum rack (chassis and modules) must be identical, and must only contain a power supply module, processor module, and communication modules. I/O modules are located in separate RIO racks.

Table 3-2 and Table 3-4 in Section 3.11 list the standard part numbers for the Quantum hot-standby racks and X80 remote I/O racks.

RIO racks are connected to the main racks via a fault-tolerant Ethernet RIO ring network. Distributed I/O (DIO) devices such as intelligent MCCs, VFDs, and soft-starters connect to a Schneider Electric Dual-Ring Switch (DRS) off the main RIO ring. DIO devices can be connected in a ring topology (if the devices support ring networks), or a star topology.

A sample architecture diagram of a Quantum hot-standby system with remote I/O, VFDs, and smart overloads is shown in Figure 3-2 in Section 3.12.

It is recommended to re-use the existing termination units in the DCS cabinets to facilitate the reuse of the existing field wiring. This will significantly reduce downtime and costs associated with the new PLC installation. The Termination Units (TUs) can be connected to the new PLC system using custom cordsets that are available from Schneider Electric Winnipeg Inc.

If mounting the new PLC hardware in an existing DCS cabinet, the installation may be expedited by pre-mounting and pre-wiring all the new components onto one or more back-panels that can be installed into the DCS cabinet as an assembly.

In some instances it may be more expedient to install the new PLC hardware in separate independent control cabinets. This will allow parallel operation of the PLC and DCS during the integration process. The new I/O would likely be part of a separate control panel installation if insufficient room exists in the existing DCS termination cabinets.

Prior to decommissioning any DCS PCU, coordinate with the City to have them back-up the DCS run-time application.

Do not damage the DCS PCU and other components in the removal process as they will be turned over to City personnel.

Minimize interruptions to the process and coordinate activities with plant Operations. Each outage must be scheduled and approved by the City prior to commencement of the work.

The existing DCS implementation uses 120 Vac discrete input modules and 24 Vdc discrete output modules. The signals from the discrete output modules drive interposing relays on the termination units to change the 24 Vdc signals from the output modules to voltage free contacts. In general,

	<b>Automation Design Guide</b>	Revision: 00	Page 28 of 107
		Document Code: 612620-0013-40ER-0001	

these contacts are field powered by 120 Vac. For the new PLC system, use 120 Vac discrete input modules and 24 Vdc discrete output modules to ensure compatibility with the existing TUs and field devices. For new I/O that was not previously connected to the DCS, use 24 Vdc input and 24 Vdc output modules. New I/O will require the installation of new terminals for termination of the field and I/O module wiring, along with the appropriate Schneider Electric preformed cordset (eg. BMX FCW 303 for the BMX DDI 3202 K input module).

### 3.10.2 PLCs for New Wastewater Treatment Process Equipment or Independent Critical Equipment

New PLC systems for control and monitoring of new wastewater treatment process equipment or independent critical equipment shall use Schneider Electric Modicon Quantum controllers in a hot-standby configuration with X80 series Remote I/O (RIO). Note that this configuration is valid until the year 2018, at which point it should be reviewed as Schneider Electric may release a new redundant solution that supersedes the Quantum platform.

The Quantum hot-standby configuration requires that each processor be installed in an independent chassis, therefore two Quantum chassis are required. Each Quantum rack (chassis and modules) must be identical, and must only contain a power supply module, processor module, and communication modules. I/O modules are located in separate RIO racks.

Table 3-2 and Table 3-4 in Section 3.11 list the standard part numbers for the redundant Quantum racks and X80 remote I/O racks.

RIO racks are connected to the main racks via a fault-tolerant Ethernet RIO ring network. Distributed I/O (DIO) devices such as intelligent MCCs, VFDs, and soft-starters connect to a Schneider Electric Dual-Ring Switch (DRS) off the main RIO ring. DIO devices can be connected in a ring topology (if the devices support ring networks), or a star topology.

An sample architecture diagram of a Quantum hot-standby system with remote I/O, VFDs, and smart overloads is shown in Figure 3-2 in Section 3.12.

New control panels associated with wastewater treatment process equipment should be located in dedicated control/automation rooms, or electrical rooms. The control panels should be located at an elevation such that they are not subject to flooding. Additionally, the control panels should not be located below any piping that may be subject to leaks of any kind.

The 24 Vdc power supplies associated with each control panel should be located in a separate "Power Supply Panel".

Network switches and gateways should be located in dedicated "Networking Panels" rather than inside the control panel, but there are exceptions and in some cases installation of a network switch in a control panel may be appropriate. Networking panels should be provided in each major process area for housing the fibre switches.

### 3.10.3 PLCs for a Minor Process Train or Auxiliary Equipment

PLC systems for minor process trains or auxiliary equipment are not required to use redundant processors because the criticality of the equipment is low, unless failure of the minor system will in turn directly prevent another critical system from running. For non-redundant applications, use a mid-grade PLC processor, such as the Modicon M340 or Modicon M580. I/O modules are typically located in the same chassis as the processor, but may be in a remote I/O rack if required.

For applications where the I/O modules are installed in the local rack or an extension rack, an M340 processor is sufficient. If remote I/O is required, use the M580 processor since the M340 does not support remote I/O. Modules with a part number beginning in "BME", such as the HART analog I/O modules, require the M580 processor and the "BME" Ethernet backplane.

	<b>Automation Design Guide</b>	Revision: 00	Page 29 of 107
		Document Code: 612620-0013-40ER-0001	

Where remote I/O (RIO) racks are required, connect them to the main rack using a fault tolerant Ethernet RIO ring network. DIO devices, such as MCCs and VFDs, may be connected to a Dual Ring Switch (DRS) as a DIO sub-ring or DIO cloud, to the service port of the processor as a DIO cloud, or to an Ethernet module as a DIO cloud.

Instruments may be connected to the PLC via hard-wired cabling, but use of PROFIBUS is encouraged. Hard-wired instruments are typical for most HVAC applications, as PROFIBUS instruments are typically higher cost.

Table 3-3 in Section 3.11 lists the standard Schneider Electric part numbers associated with a mid-grade PLC system. The part numbers for X80 remote I/O racks, if required, are listed in Table 3-4 in Section 3.11.

Sample architecture diagrams of mid-grade PLC systems are shown in Figure 3-3 and Figure 3-4 in Section 3.12. Figure 3-3 illustrates a single PLC rack that is connected to the Primary Control Network, which uses local I/O. Figure 3-4 illustrates a slightly more critical application, which makes use of an M580 processor that connects to both the Primary and Secondary Control Networks, and uses remote I/O.

### 3.10.4 Packaged PLC from Equipment Vendor

Packaged PLC systems from equipment vendors may come in a variety of implementations with various brands of hardware if not specified. If possible, specify a Schneider Electric Modicon M340 or M580 PLC, which will allow for straightforward integration with the plant process control system.

If the vendor is unable to provide a Schneider Electric Modicon PLC, ensure that their PLC system incorporates a Modbus/TCP interface so that the City's Process Control System (PCS) can communicate with it. If a third-party product is required for the Modbus/TCP interface, the preference is to use an in-rack solution as opposed to an out-of-rack (eg. DIN rail mounted) solution.

Regarding the program within the packaged PLC, the preferred approach is to have the vendor program the PLC based on the City's standard function block classes. If the vendor is unable or unwilling to program the PLC based on the City's standards, request that they provide a control narrative with a detailed functional requirements specification based on the City's standard function block classes. These would then be issued to the systems integrator for programming the PLC. Failing this, the vendor should at minimum provide a control narrative, and the design engineer would develop the functional requirements specification, which would be issued to the systems integrator or the City for programming.

Due to warranty issues, some vendors may not approve that another party program the PLC supplied by the vendor. If the vendor requires that they program the PLC, have the vendor supply a PLC interface map so that the process control system PLCs and HMI system can interface with the vendor PLC. Refer to Section 17.3.4 for further information on Interface Maps. Request that the vendor supply a copy of the PLC program to the City, and that the program not be locked or password protected.

It is desired that all integration and configuration software and hardware tools and documentation are provided to the City for packaged equipment with intelligent controls, with password access to the levels and registers used by manufacturer service technicians.

## 3.11 Standardized PLC Hardware

This section provides standard Schneider Electric part numbers for PLC system hardware, including processors, I/O modules, backplanes, power supply modules, and ancillary components.

Additional products, beyond those listed below, may be used in the design if required.

Schneider Electric also has “harsh environment” versions of many of their products, which may be used in corrosive or damp locations. Harsh environment versions have a catalog number ending in “H”.

Standard part numbers for Quantum hot-standby racks are listed in Table 3-2. Standard part numbers for mid-grade PLC racks are listed in Table 3-3. Standard part numbers for X80 remote I/O racks are listed in Table 3-4.

**Table 3-2: Quantum Hot-Standby Racks**

Description	Catalog Number	Notes
Chassis, 6 slot	140 XBP 006 00	
Chassis, 10 slot	140 XBP 010 00	Recommended for most installations
Power Supply Module, 24 Vdc	140 CPS 214 00	
Power Supply Module, 120 Vac	140 CPS 124 20	
Processor	140 CPU 672 60	
Ethernet Remote I/O (RIO) Head Adaptor	140 CRP 312 00	
Ethernet Control Network Head Adaptor	140 NOC 781 00	Integrated router
Ethernet Distributed I/O (DIO) Head Adaptor	140 NOC 780 00	
Empty Slot Filler	140 XCP 510 00	

**Table 3-3: Mid-Grade PLC Racks**

Description	Catalog Number	Notes
Chassis	BMX XBP ●●00	X-Bus Backplane
	BME XBP ●●00	X-Bus + Ethernet Backplane
Power Supply, 24 Vdc	BMX CPS 2010	
	BMX CPS 3020	
Power Supply, 120 Vac	BMX CPS 2000	
	BMX CPS 3500	
Processor	BMX P34 2020	M340 series. Compatible with BMX backplanes only.
	BME P58 ●●●●	M580 series. Compatible with BMX or BME backplanes.
Ethernet Communication Module	BMX NOC 0401	Use with M340 processor
	BMX NOC 0402	Use with M580 processor
	BME NOC 0311	Requires BME Backplane and M580 processor
Discrete Input Module, 32 channel, 24 Vdc	BMX DDI 3202 K	
Discrete Output Module, 32 channel, 24 Vdc	BMX DDO 3202 K	
Discrete Output Module, 16 channel, Relay	BMX DRA 1605	
Analog Input Module, 8 channel, Isolated	BMX AMI 0810	
HART Analog Input Module, 8 channel, Isolated	BME AHI 0812	Requires BME Backplane
Analog Output Module, 4 channel, Isolated	BMX AMO 0410	
Analog Output Module, 8 channel, Non-Isolated	BMX AMO 0802	
HART Analog Output Module, 4 channel, Isolated	BME AHO 0412	Requires BME Backplane
Empty Slot Filler	BMX XEM 010	As required
Rack Extension Kit	BMX XBE 2005	As required

**Notes:**

1. Part numbers starting with “BMX” can be installed into “BME” backplanes.
2. On some BME backplanes, only specific slot numbers on the backplane support “BME” modules. Refer to Schneider Electric documentation.

**Table 3-4: X80 Remote I/O Racks**

Description	Catalog Number	Notes
Chassis	BMX XBP ●●00	X-Bus Backplane
	BME XBP ●●00	X-Bus + Ethernet Backplane
Power Supply Module, 24 Vdc	BMX CPS 2010	
Power Supply Module, 120 Vac	BMX CPS 2000	
X80 Ethernet Drop Adapter	BMX CRA 312 10	Use with BMX I/O modules only
	BME CRA 312 10	Use with BME or BMX I/O modules
Discrete Input Module, 16 channel, 120 Vac	BMX DAI 1604	Use for existing I/O
Discrete Input Module, 32 channel, 24 Vdc	BMX DDI 3202 K	Use for new I/O
Discrete Output Module, 16 channel, 24 Vdc	BMX DDO 1602	
Analog Input Module, 8 channel, Isolated	BMX AMI 0810	
HART Analog Input Module, 8 channel, Isolated	BME AHI 0812	Requires BME Backplane
Analog Output Module, 4 channel, Isolated	BMX AMO 0410	
Analog Output Module, 8 channel, Non-Isolated	BMX AMO 0802	
HART Analog Output Module, 4 channel, Isolated	BME AHO 0412	Requires BME Backplane
Empty Slot Filler	BMX XEM 010	As required
Rack Extension Kit	BMX XBE 2005	As required

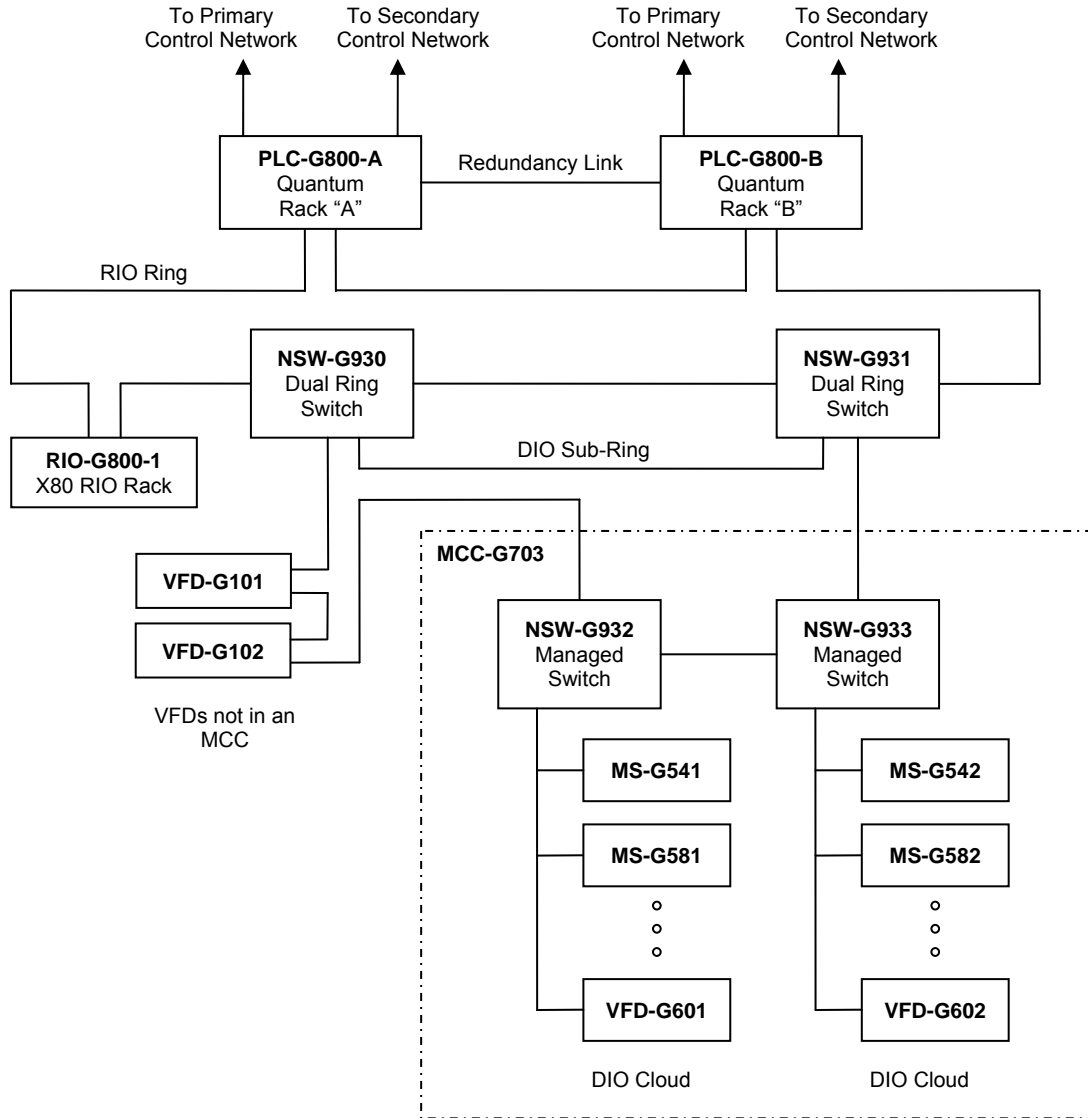
*Notes:*

1. Part numbers starting with "BMX" can be installed into "BME" backplanes.
2. On some "BME" backplanes, only specific slot numbers on the backplane support "BME" modules. Refer to Schneider Electric documentation.



### 3.12 Standard Architectures

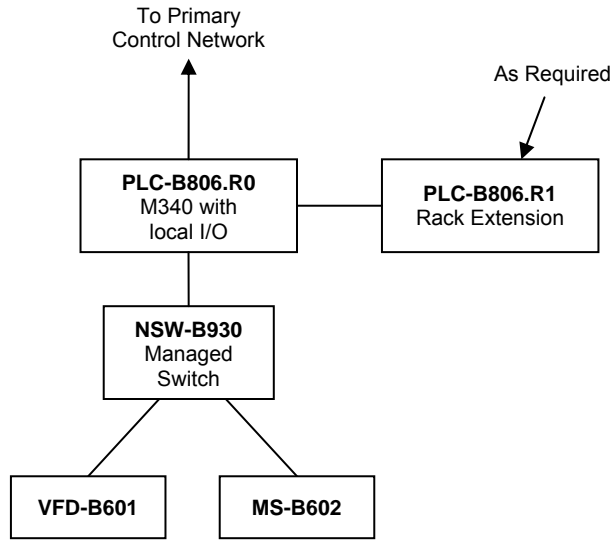
Standard architectures are shown in the following figures to illustrate the method for connecting process control system equipment using the City's preferred methods.



**Figure 3-2: Quantum Hot-Standby Architecture**

**Notes:**

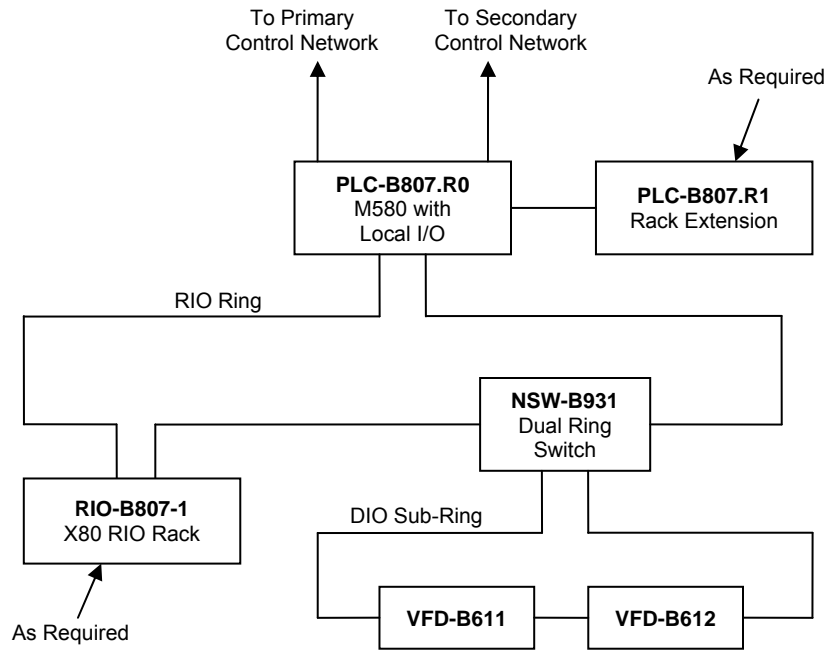
1. All I/O modules are located in separate remote I/O (RIO) racks.
2. Where process equipment redundancy is provided, the associated motor controllers should be connected to separate network switches to improve availability. In this figure, the starters in the MCC are divided to separate switches, but could also be placed in separate MCCs.
3. The DIO sub-ring for the VFDs and MCC is shown connected to two dual ring switches to improve reliability.



**Figure 3-3: Mid-grade PLC System Architecture with M340 Processor**

**Notes:**

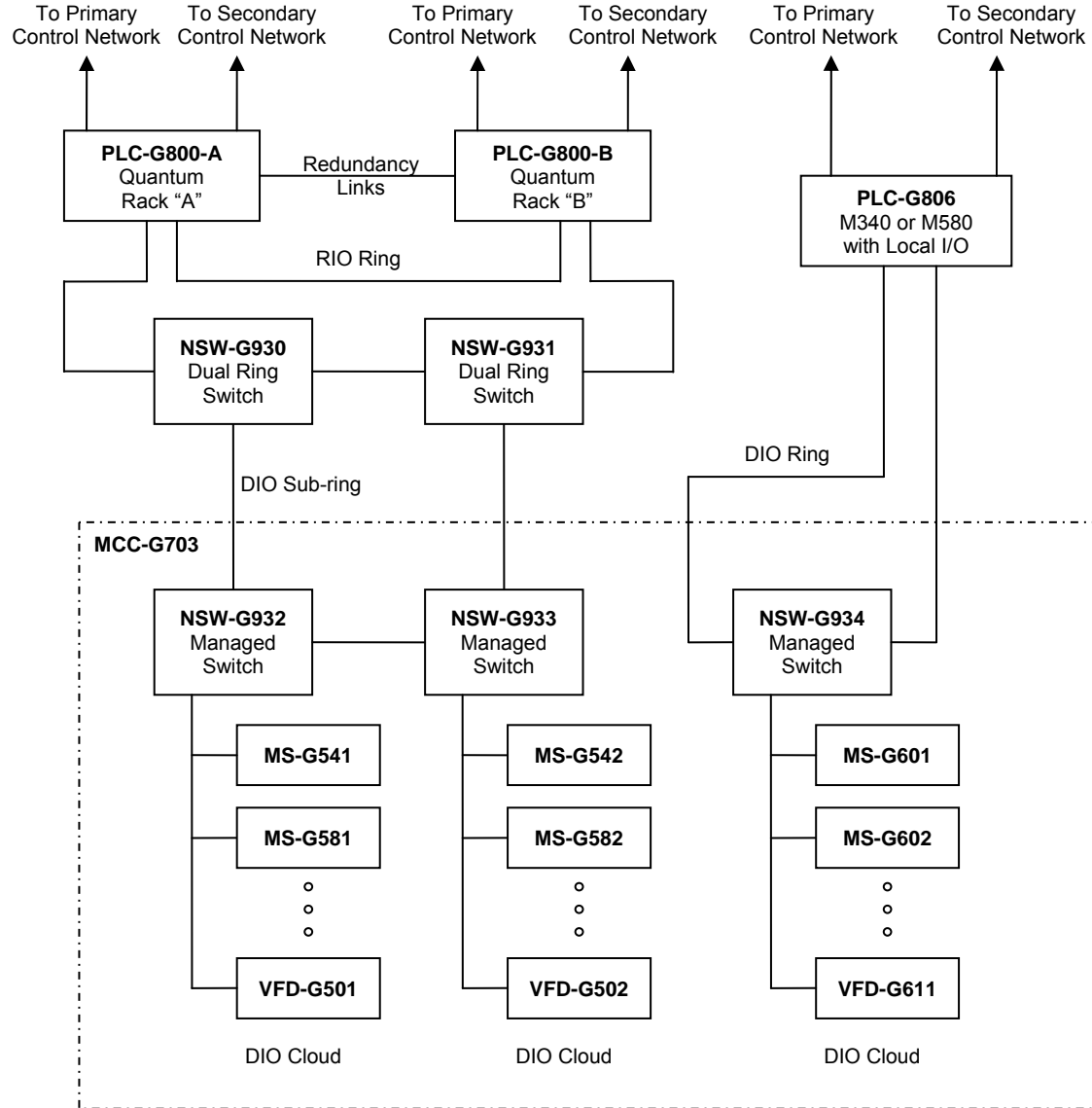
1. *Non-redundant PLCs typically connect to one control network via the processor service port or an in-rack Ethernet modules. An additional in-rack Ethernet module may be installed if connection to the Secondary Control Network is required.*
2. *Rack extensions may be added to the main rack for additional I/O if required. The M340 processor does not support Remote I/O (RIO) racks.*
3. *Instruments are typically hardwired to in-rack I/O modules.*
4. *Distributed I/O (DIO) devices such as MCCs and VFDs are connected to the service port of the processor or to an Ethernet module. If the field devices support Rapid Spanning Tree Protocol (RSTP) then they may be connected in a ring topology to a BMXNOC0401 in-rack Ethernet module.*



**Figure 3-4: Mid-grade PLC System Architecture with M580 Processor**

**Notes:**

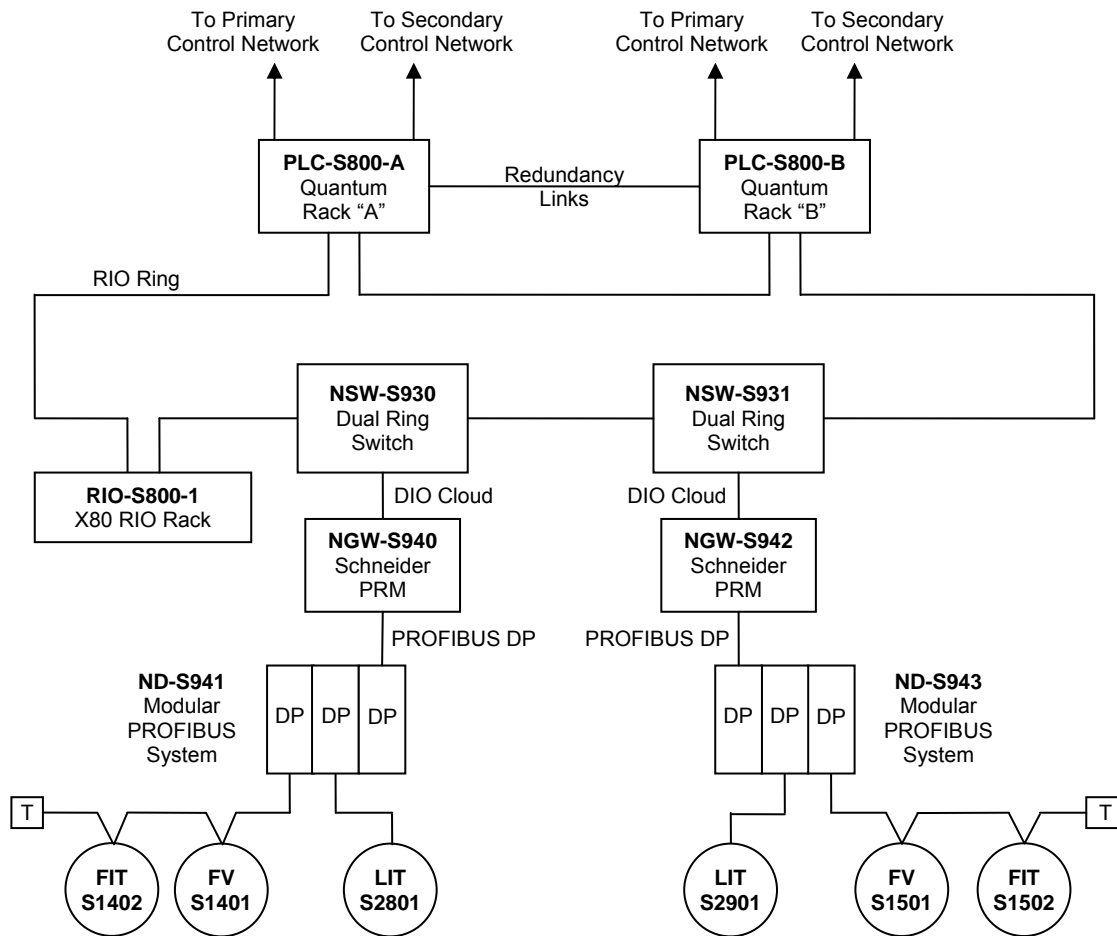
1. Non-redundant PLCs connect to one or both control networks via the processor service port and/or an in-rack Ethernet modules.
2. The M580 processor may use in-rack I/O or Remote I/O (RIO).
3. Instruments are typically hardwired to in-rack I/O modules.
4. Distributed I/O (DIO) devices such as MCCs and VFDs are connected in a DIO sub-ring (preferred) or as a DIO cloud. DIO devices connected as a DIO cloud may connect to a dual ring switch (DRS), to the service port of the processor, or to an Ethernet module.



**Figure 3-5: Multiple PLCs controlling a single MCC**

**Notes:**

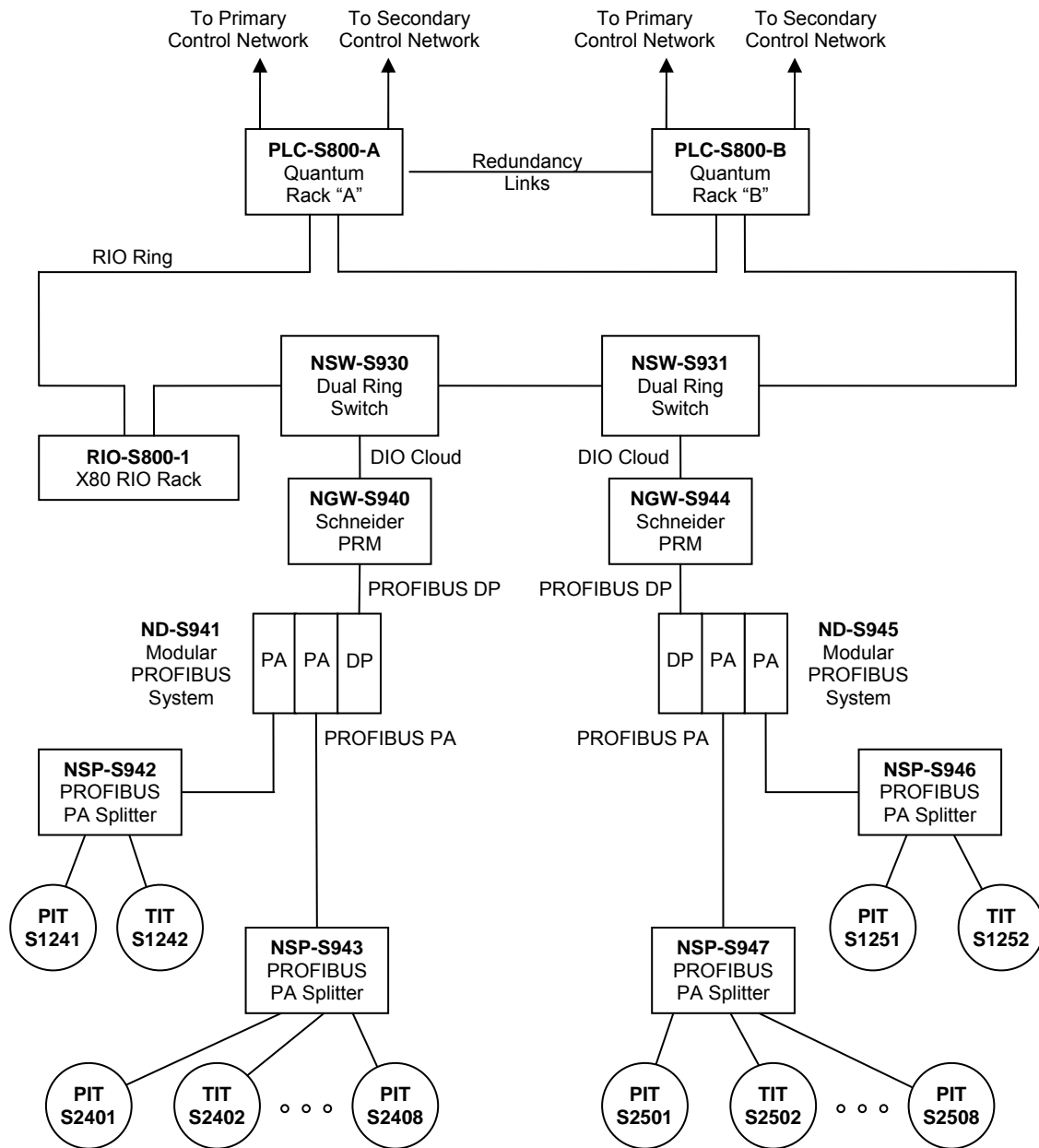
1. Multiple PLCs cannot connect to the same RIO ring. As such, if an MCC must be controlled by separate PLCs, separate networks must be provided to the MCC.
2. An X80 remote I/O rack could be connected in the RIO ring associated with the Quantum pair, but this is not shown.
3. PLC-G806 is connected to network switch NSW-G934 in the MCC using a ring topology. This requires the use of an in-rack Ethernet module such as the BMXNOC0401. Alternatively, a single (non-ring) connection to NSW-G934 can be implemented, but it will not have the same fault-tolerance as a ring topology.



**Figure 3-6: Connection of PROFIBUS DP Devices**

**Notes:**

1. The Schneider PRM (Profibus Remote Master) module provides conversion between Modbus/TCP and PROFIBUS DP, and is connected as a DIO cloud to the PLC system.
2. The Schneider PRM may connect directly to the PLC, or to a dual ring switch. In the case of redundant Quantum PLCs, the PRM would be connected to a dual ring switch.
3. A modular PROFIBUS system is shown for connection of PROFIBUS devices. This facilitates replacement of PROFIBUS DP devices without affecting the entire PROFIBUS DP network.
4. External terminations are shown at the ends of the PROFIBUS DP segments with more than one instrument, to facilitate replacement of the last device without affecting the segment. Note that if all the instruments on one segment are in the same loop then external terminations may not be required.
5. Group together devices of one process loop on a common PROFIBUS DP segment. FV-S1401 and FIT-S1402 are in the same process loop and therefore share the same PROFIBUS DP segment.
6. Where process equipment and/or instrumentation redundancy is provided, it is encouraged to connect the redundant devices to separate PRM modules, as shown.



**Figure 3-7: Connection of PROFIBUS PA Devices**

**Notes:**

1. PROFIBUS PA splitters (or “segment protectors”) are used in the field to provide spur connections for PROFIBUS PA devices, rather than connecting the devices in a daisy-chain fashion. This allows for easy replacement of individual devices, and prevents an electrical short on one spur from affecting other spurs.
2. Provide multiple splitters (or “segment protectors”) in the field as required to minimize spur lengths.

### 3.13 PLC Programs

#### 3.13.1 Program Language

The Schneider Electric Modicon PLCs support all five languages defined by IEC 61131-3. However, the specific language used for an application must be selected as per Table 3-5. Note that more than one programming language may be used within a single PLC program.

**Table 3-5: Permitted PLC Programming Languages**

Language	Permitted	Notes
Function Block Diagram	Yes	Preferred for most general applications.
Ladder Diagram (Ladder Logic)	Yes	Permitted for specific logic applications with minimal analog control.
Instruction List	Generally Not	May be considered for a very specific subroutine requiring high performance.
Structured Text	Yes	Appropriate for certain math and logic applications.
Sequential Function Chart	Generally Not	May be considered for complex sequencing applications when difficult to implement in a different language.

#### 3.13.2 PLC Configurations and Program Logic

- All PLC configurations and program logic shall be fully accessible and editable by the City of Winnipeg. PLC systems that are password protected, or inaccessible for modification by the City for any reason, will not be accepted under any circumstance. This applies to PLC systems used in any application, including process and HVAC applications.
- A standard library of function block classes are in development for the wastewater treatment program, and it is expected that new PLC programs be implemented with these function block classes. Where an existing function block class does not provide the required functionality, develop a new function block class and add it to the library for re-use.
- Programs are to be implemented using an object-oriented approach, utilizing user-defined data types and encapsulation where possible.
- Programs are to be implemented using positive logic, meaning that discrete variables are to be named based on the function they perform in the 1 State (True State).
- Use state machine logic for state-based and sequencing applications.
- Refer to the City of Winnipeg Tagname Identification Standard, document code 612620-0014-40ER-0001, for standards regarding naming of tags and function block classes.

#### 3.13.3 Program Structure

- Segregate programs into multiple tasks and routines to improve readability and maintenance of the program.
- The name (identifier) of all tasks and routines shall contain the identifiers of the equipment they are associated with. Exceptions to this rule include system tasks that cannot be

	<b>Automation Design Guide</b>	Revision: 00	Page 40 of 107
		Document Code: 612620-0013-40ER-0001	

renamed, and routines that are not directly associated with equipment such as input/output mapping routines. When using periodic tasks, the priority number and scan rate of the task shall be included in the name of the task.

3. The name for each X80 RIO adapter in the configuration shall include the physical rack identifier and the assigned drop number per the rotary switches on the front of the module.
4. The name for each X80 I/O module in the configuration shall include the rack identifier and slot number in which the module is installed.

### 3.13.4 Program Documentation

1. Provide complete documentation within PLC programs to aid in full understanding of the logic. Note that the level of documentation expected is greater than what an experienced programmer would need, since the programs may be viewed and maintained by personnel who may not have substantial programming experience, or may not be fully familiar with “class based” function block programming.
2. Where documentation is provided for specific logic, avoid creating documentation that simply repeats the logic. Documentation should describe the functionality of the logic. For example, avoid saying “the A bit turns off the B bit after 10 seconds”. Instead, say “the discharge pressure sensor turns off the motor after it indicates low pressure for 10 seconds”.
3. All routines shall contain a documentation header containing the authoring company name, the date the routine was created, the current revision number of the routine, date of the latest revision, and the document number of the associated Functional Requirements Specification if applicable.

### 3.13.5 Variable Data Types

1. For each variable tag, use a data type that results in the least amount of memory usage while still providing the required number of significant figures.
2. For all digital (On/Off or True/False) variables, use the BOOL or EBOOL data types.
3. For analog integer variables in the range of -32768 to +32767, use the INT data type (16 bits).
4. For analog integer variables in the range of -2147483648 to +2147483647 and that exceed the range of the INT data type, use the DINT data type (32 bits).
5. Use of UINT or UDINT is to be avoided to ensure that the data is not misconstrued as being signed data by an ancillary system (eg. Microsoft Excel).
6. For non-integer analog data, use the REAL data type. Do not use the INT or DINT data types with an implied decimal for storing non-integer data.

## 3.14 Control Modes

Process equipment may be controlled from a number of sources including the PLC system, panel instruments, and manual pilot devices. Operator controls shall be provided on the HMI system and/or in the field for selection of the active control source.

The following equipment operating modes have been defined:

1. PLC Only – The equipment is always controlled by the PLC, although may be switched between *Manual* and *Auto* modes via the HMI. Manual controls are provided on the HMI.



	<b>Automation Design Guide</b>	Revision: 00	Page 41 of 107
		Document Code: 612620-0013-40ER-0001	

2. Local/Off/Remote – A Local/Off/Remote switch is provided at the equipment or at the motor controller (eg. MCC, or VFD). When in *Local* mode, the equipment is controlled via the local pilot devices. When in *Remote* mode, the equipment is controlled from the PLC system.
3. Hand/Off/Remote – A Hand/Off/Remote switch is provided at the equipment or at the motor controller. When in *Hand* mode, the equipment runs continuously. When in *Remote* mode, the equipment is controlled from the PLC system.
4. Hand/Off/Auto – A Hand/Off/Auto switch is provided, with the *Auto* mode providing automatic equipment control via a controller other than the PLC system.

Using the “Auto” designation for PLC system control is not recommended as this designation can conflict with the HMI Auto/Manual modes that may be provided on the HMI/PLC system.

Where Local/Off/Remote or Hand/Off/Remote switches are provided, connect one of the “Remote” position contacts to a PLC input and program the PLC such that its outputs associated with the equipment are only enabled when in *Remote* mode.

Refer to Section 8 for further details on local controls.

### 3.15 Cyber Security

Security controls and safeguards shall be provided with all new PLC system and network installations to prevent internal and external threats from affecting plant assets through system vulnerabilities.

Security controls and safeguards are divided into the several categories including:

1. Corrective – Controls that minimize the effect of an attack and the degree of resulting damage.
2. Detective – Controls that determine if an attack has occurred, or is in the process of occurring, and initiate corrective controls.
3. Deterrent – Controls that reduce the ease in which an external threat can affect assets.
4. Preventative – Controls that prevent external threats from affecting assets.

Controls and safeguards shall be provided to protect against the various types of attacks which include:

1. Passive – Monitoring, capture, and analysis of communication, and decrypting weakly encrypted data.
2. Active – Attempts to circumvent or break encryption, modify information, and introduce malicious code.
3. Close-In – Attaining close proximity to system components to learn about the implementation and modify, gather, or deny access to information.
4. Spoof – Modification of the source address of packets the attacker is sending so that they appear to be originating from someone or something else.
5. Buffer Overflow – Sending more data to a system than is expected, causing complete failure or unexpected operation of the system.
6. Hijack – Taking over a session between two systems and disconnecting one of the systems from communication.

Network firewalls, gateways, and encryption shall be used at appropriate points within the networks to inspect and control network traffic as a means to mitigate attacks. Firewalls shall use techniques such as packet filtering, stateful inspection, deep-packet inspection, and rate limiting.

	<b>Automation Design Guide</b>	Revision: 00	Page 42 of 107
		Document Code: 612620-0013-40ER-0001	

Firewalls used in the process control system network shall be purpose-built for process control systems, and shall be able to perform packet inspection on common industrial Ethernet protocols such as Ethernet/IP and Modbus/TCP. For example, the following mechanisms shall be provided for Modbus/TCP enforcement:

1. User-definable lists of allowed Modbus unit IDs, commands, registers, and coils.
2. Protocol “sanity check” blocks any traffic not conforming to the Modbus standard.
3. Automatic blocking and reporting of traffic that does not match the rules.

Firewalls shall also incorporate a logging mechanism to allow for routine inspection of event messages to determine if attacks have been attempted, have occurred, or are in progress. In addition to internal logging, the device shall be capable of logging to an external (syslog) monitoring system.

Encryption shall be used for all wireless communication and any inter-plant communication that uses the Internet. Wireless (Wi-Fi) networks shall not use Wired Equivalent Privacy (WEP) as it is easily breakable even when configured correctly. Wi-Fi networks shall use WPA or WPA2 encryption. At minimum, Virtual Private Networking (VPN) shall be used for inter-plant communication or anywhere the Internet is required for transmission of data associated with the process control system.

All Ethernet network switches shall be managed switches and have all unused ports disabled. Network switches shall be password protected.

All process control system devices that incorporate password protection shall be configured with a password other than the default password. The same password should not be used on multiple devices.

Field devices that incorporate physical DIP switches or jumpers to prevent write access to the device and do not require frequent configuration changes should be set read-only to prevent unauthorized or accidental change.

Demilitarized zones with upstream and downstream firewalls should be used for access to such systems as an Information Server and a read-only HMI terminal server. These systems shall still incorporate authentication mechanisms and credentials to prevent access by unauthorized users. Systems in demilitarized zones shall be configured read-only.

Restrict physical access to process control system equipment, including programmable controllers, network switches, and field devices. This may be achieved via a lock on the enclosure containing the devices, or placing the devices in a locked room.

Disable unused services on computer servers to improve security and performance.

Configure user and group security appropriately; do not grant unnecessary privileges.

Avoid use of personal or commercial grade hardware and software components (eg. virus scanning and firewall software) that may be incompatible with process control system components. For example, some firewall software may block network packets that are required for redundant HMI server synchronization and may prevent failover of the HMI server. Be aware of such issues, and properly configure and test all components.

Computers associated with the process control system shall not be directly connected to the Administration or Security networks. Similarly, computers on the Administration or Security networks shall not be directly connected to the Process Control System Network. Where connections between networks are required, they shall occur through firewalls.

Components providing system security shall be implemented in a manner that failure of the component acts to disable system functionality rather than disable system security.

Use the following standards and guidelines when implementing system security:

1. NIST Special Publication 800-82, Guide to Industrial Control Systems (ICS) Security,

	<b>Automation Design Guide</b>	Revision: 00	Page 43 of 107
		Document Code: 612620-0013-40ER-0001	

2. ISA-62443 (formerly ANSI/ISA-99.00.01): Security for Industrial Automation and Control Systems,
3. North American Electric Reliability Corporation (NERC), Critical Infrastructure Protection (CIP) Cybersecurity Standards,
4. NIST Special Publication 800-53, Recommended Security Controls for Federal Information Systems,
5. Department of Homeland Security, Catalog of Control Systems Security: Recommendations for Standards Developers,
6. AMI-SEC Task Force, AMI System Security Requirements,
7. DOD Instruction 8500.2, Information Assurance (IA) Implementation.

 Winnipeg	<b>Automation Design Guide</b>	Revision: 00	Page 44 of 107
		Document Code: 612620-0013-40ER-0001	

## 4 IDENTIFICATION

All equipment, including but not limited to automation panels, networking panels, junction boxes, instruments, and cables, shall be given an identifier that conforms to the City of Winnipeg Identification Standard, document number 510276-0000-40ER-0002. All equipment shall be identified on the drawings and in the field with the same identifier.

Provide identification of equipment, components, and cabling as per the City of Winnipeg Sewage Treatment Program Standard Specifications, Section 26 05 01, Common Work Results – Electrical.

## 5 ENVIRONMENTAL REQUIREMENTS

### 5.1 Ingress Protection

All instruments and enclosures shall have ingress protection against liquids, gasses, and dust for the environmental conditions in which they are used. So far as feasible, control panels should not be located outdoors.

Table 5-1 lists the minimum ingress protection for various environmental conditions.

**Table 5-1: Minimum Ingress Protection for Instruments and Enclosures**

Environment	NEMA
Clean indoor air conditioned area (control, electrical room)	1
Indoor non-corrosive area subjected to dripping	12
Indoor non-corrosive area subjected to wash-down	4
Outdoor non-corrosive area	4
Indoor corrosive area	4X
Outdoor corrosive area	4X

### 5.2 Temperature and Humidity Ratings

All equipment and instruments located outdoors shall have a minimum operating temperature range of -40°C to 40°C. Equipment exposed to direct sunlight shall be suitable for operation at up to 60 °C.

Where instrumentation and panels are exposed to direct sunlight, a suitable stainless steel sunshade or cooler shall be provided. Pneumatic instruments (actuators), gauges, switches, etc., generally do not require a sunshade.

All equipment and instruments shall be suitable for high humidity (95% non-condensing) conditions unless installed in a climate controlled room.

### 5.3 Cold Environment Requirements

Instrumentation subjected to freezing conditions colder than their minimum operating temperature shall be enclosed within a heated enclosure. Soft covers are not acceptable.

Impulse lines subject to process liquid freezing shall be heat traced and covered.

## 6 WIRING, CABLING, AND CONDUIT

### 6.1 Standard Colours

#### 6.1.1 Control Wiring – Wire Colour

Wires shall be colour coded as per Table 6-1.

**Table 6-1: Wire Colour Codes**

Conductor Purpose	Colour
Power – 120/240 Vac Supply	Black
Power – 120/240 Vac Neutral	White
Power – 24 Vdc Supply (+)	Blue
Power – 24 Vdc Common (–, or 0 Vdc)	Brown
Discrete Control – ac	Red
Discrete Control – dc	Blue
Intrinsically Safe (IS)	IS (light) Blue
Protective Earth (PE)	Green
Signal Ground / Instrumentation Earth (IE)	Green/Yellow

#### 6.1.2 Network Cable – Jacket Colour

Network cables shall be colour coded as per Table 6-2.

**Table 6-2: Network Cable Jacket Colour Codes**

Cable Purpose	Colour
Ethernet, CAT5e or CAT6	Blue
PROFIBUS DP	Purple
PROFIBUS PA, Non-Intrinsically Safe	Black
PROFIBUS PA, Intrinsically Safe	Light Blue
Modbus/RTU (serial)	Grey

#### 6.1.3 Profibus Cable – Conductor Colour

Use the colour scheme indicated in Table 6-3 for all Profibus cable connections.

**Table 6-3: Profibus Cable Conductor Colours**

Profibus DP	Profibus PA	Colour
Line A (Rx/D/TxD-N)	PA-	Green
Line B (Rx/D/TxD-P)	PA+	Red

### 6.1.4 Conduit Colour Coding

Apply colour coded bands to all conduits at points where they enter walls, ceilings, or floors, and at 5 meter intervals. Colour coding shall be as per Table 6-4.

**Table 6-4: Conduit Colour Codes**

System	Prime Band	Aux. Band
Power, 120/208/240 Vac	Black	
UPS Power, 120/208/240 Vac	Black	Green
Control Wiring, 120 Vac	Black	Orange
Fire Alarm	Red	
Low Voltage Communication/General	Blue	
Low Voltage Control Wiring, < 50 V	Blue	Orange
Intrinsically Safe	Blue	White

Use a 38 mm wide prime band and a 19 mm wide auxiliary band.

## 6.2 Cable Types and Ratings

Multi-conductor automation cables are to be of the CIC (Control and Instrumentation Cable) or ACIC (Armoured Control and Instrumentation Cable) type, meeting CSA C22.2 No. 239-09.

Where single-conductor wiring is used, use of RW90 in conduit is acceptable.

The voltage rating of automation cables shall meet or exceed the highest voltage present in the control panel or equipment in which the cable is used.

Refer to the City's Sewage Treatment Program standard equipment specifications for further details on cable specifications.

## 6.3 Use of Conduits vs. Cables

In general, the decision to use conduits or cables should be based on the specific details of the application. In general, cables in cable tray is preferred for new installations, however there are cases where the use of conduits is appropriate. It is acceptable for a facility to have a mixture of conduits and cables.

Conduits should be considered in the following applications:

1. Where the existing installation is conduit based.
2. Fire alarm systems.
3. Where aesthetics are a concern.
4. Where there is potential for physical abuse or damage.
5. Where the specific cables required do not have an FT4 rating.

## 6.4 Conduit Materials and Sizes

Use rigid conduit, except where flexible conduits are required for maintenance of equipment or in areas where the equipment is subject to vibrations during operation (compressors, motors, etc.), to

reduce the effect on connections. EMT may be used within office areas if there are no environmental issues.

Rigid galvanized steel conduit is not acceptable for use within wastewater facilities. See Table 6-5.

Conduit boxes to be aluminum with cast covers. Use spring door covers for areas with circulating dust and contamination.

**Table 6-5 : Facility Conduit Application**

<b>Application</b>	<b>Type</b>
In poured concrete walls and floors	PVC
Underground	PVC
General Use	Rigid Aluminum
Locations with presence of agents that cause corrosion of aluminum	PVC
Exterior	Rigid Aluminum
Hazardous Locations	Rigid Aluminum
Office and similar locations, without environmental contamination.	EMT

## 6.5 Junction Boxes

Junction boxes with terminals shall be used for automation cable connections. Joints or splices to automation wires within junction boxes without the use of terminals are not acceptable.

Junction boxes shall have an area to one side of the terminal strip reserved for the homerun cable(s). If there are two terminal strips the area between the two strips shall be reserved for the homerun cable(s).

Sufficient space for the homerun cable gland(s) must be allowed for in junction boxes. Holes for the homerun cable glands are to be punched on site unless they are explosion proof boxes.

All cables and conduits should enter the bottom of the junction box. Cables should not enter the top of the enclosure in order to avoid the issue of liquid ingress.

All junction boxes installed outside shall be supplied with an air breather/drain approved for the area classification.

Physical separation of cabling within junction boxes shall be provided for each type or category of signal, as follows:

1. Low level analog milliVolt signal cables (TC, strain-gauge),
2. 12 to 24 VDC discrete signals and high level analog DC signals (4-20 mA, 0-5 V, etc.),
3. 120/240 VAC discrete signals,
4. Intrinsically Safe (IS) signals.

## 6.6 Cable Trays

1. A side rail height of 152 mm (6") is preferred. Use 102 mm (4") side rail height where vertical space is limited.



	<b>Automation Design Guide</b>	Revision: 00	Page 49 of 107
		Document Code: 612620-0013-40ER-0001	

2. Size cable tray to meet current and future cable requirements. Minimum tray width is 152 mm (6").
3. Tray to be CSA, cUL listed.
4. The rungs of the ladder shall typically be at 229 mm (9") spacing.
5. Cable tray load ratings shall be sufficient for the cables installed and any additional loads such as snow, ice and wind, where applicable.
6. Allow for spare cables in cable tray loading calculations.
  - a. Minimum load rating for indoor tray: CSA Class C1
  - b. Minimum load rating for outdoor tray: CSA Class D
7. Use tray covers for mechanical protection in dusty areas, outdoors, and for trays passing under walkways or where there is a risk of falling debris.
8. Use aluminum cable tray in wastewater treatment facilities.
  - a. Consider the use of fibreglass cable tray in corrosive locations. Fibreglass tray shall not be exposed to sunlight unless confirmed by the manufacturer that it is sunlight/UV resistant.

## 6.7 Shield Termination and Grounding

1. Instrument cable overall shields and individual shields are to be grounded at one end only to avoid ground loops.
  - 1.1 For non-intrinsically safe wiring, where an incoming shielded cable and an outgoing shielded cable connect at a set of terminals and one of the cable shields is grounded elsewhere, use insulated feed-through terminals to connect the shields of the incoming and outgoing cables.
2. Instrument overall and individual cable shields should typically be grounded at the control panel or I/O marshalling cabinet.
  - 2.1 RTDs embedded in windings of medium and high voltage (> 1 kV) motors shall be bonded to ground in a junction box to avoid fault currents from propagating into control panels or I/O marshalling cabinets.
3. Except for grounded thermocouples, all of the shield drain wires shall be cut and taped in the field near the instrument.
4. Exposed parts of the drain wires should be inside insertion jackets. Drain wires for different loops should not touch each other within the junction boxes, I/O or marshalling cabinets.
5. PROFIBUS cable shields should be grounded at both ends to improve noise rejection, unless ground loop currents prevent proper operation of the communication cables, in which case the cables may be grounded at one end only. Provide an insulated, 12 AWG, equipotential bonding conductor along with all PROFIBUS cabling to minimize currents in the cable shields.
6. If intrinsic safety is required, the intrinsic safety ground system shall have a dedicated ground conductor that is isolated from the safety ground, except for at the final connection to the building electrode ground, to prevent ground fault currents from entering the intrinsically safe system.

 Winnipeg	<b>Automation Design Guide</b>	Revision: 00	Page 50 of 107
		Document Code: 612620-0013-40ER-0001	

## 6.8 Signal Noise Prevention

1. Analog signals such as 4-20 mA, RTD, thermocouple, pulses, and milli-Volts shall use individually shielded twisted pairs or triads.
2. Where practicable, 24 Vdc discrete signals such as relay contacts, process switches, solenoids, and limit switches should use twisted pairs or triads with overall shield but individual shielding is not required.
3. Analog and discrete signals shall not share the same multi-pair/triad cable.
4. Each signal shall have its own return wire extending from the source to the destination to protect against common impedance coupling.
5. It may be useful to ground spare wiring in marshalling cabinets and junction boxes to minimize potential noise pickup.
6. Use isolated analog PLC I/O modules to provide a separate common reference for each I/O signal.
7. Signal isolators may be installed to prevent ground loops, prevent passage of noise between cables via the common reference, or split a signal for multiple pieces of equipment. Signal isolators shall not to be used on communications cabling.

	<b>Automation Design Guide</b>	Revision: 00	Page 51 of 107
		Document Code: 612620-0013-40ER-0001	

## 7 HMI SYSTEMS

### 7.1 Typical Information and Control Points on HMI Systems

The following information shall be provided on HMI systems for display of automation equipment status and facilitate control. The following is not comprehensive in nature, but represents the minimum requirements.

1. HMI system equipment:
  - a. Primary and secondary HMI server operational status,
  - b. Indication of which HMI server is acting as primary, secondary,
  - c. Manual controls for switching between primary and secondary HMI servers,
  - d. HMI server resource utilization,
  - e. Historian server status,
  - f. Historian server resource utilization,
  - g. HMI client license usage.
2. Programmable Logic Controller (PLC) equipment:
  - a. PLC operating mode (Run / Remote / Program),
  - b. PLC fault status,
  - c. For redundant PLCs:
    - Indication of which controller is primary, secondary,
    - Manual controls shall be provided to facilitate switching between the primary and secondary controllers,
  - d. Resource utilization,
3. Networking equipment:
  - a. Network switch status,
  - b. Firewall status and alarms,
  - c. Communication gateway (PROFIBUS / Modbus / etc.) status,
  - d. Network Time Protocol server status,
4. Plant process:
  - a. Equipment mode (eg. Hand, Off, Remote, etc.),
  - b. Equipment operating status (eg. Not Ready, Running, Faulted, etc.),
  - c. Equipment manual controls,
  - d. Duty assignments for redundant equipment,
  - e. Instrument readings in engineering units,
  - f. Process control setpoints and modes,
  - g. PID controller PV, SP, CV (read-only on HMI systems),

	<b>Automation Design Guide</b>	Revision: 00	Page 52 of 107
		Document Code: 612620-0013-40ER-0001	

- h. Equipment and plant operating limits to allow operators to react before an alarm is generated,
  - i. Adjustable alarm setpoints,
  - j. Plant statistics (daily/monthly flow totals, etc.)
5. General:
- a. Alarm management system,
  - b. Screen navigation buttons,
  - c. Date and time,
  - d. Currently logged-in user,
  - e. Links to help system / plant operating manuals, if available, and
  - f. Mathematical constants page.

## 7.2 HMI Standards and Reference Material

Use the following City of Winnipeg documents in the development of HMI system applications:

1. Tagname Identification Standard, document code 612620-0014-40ER-0001,
2. HMI Layout and Animation Plan, document code 612620-0015-40ER-0001,
3. Historical Data Retention Standard, document code 612620-0016-40ER-0001.

The following guidelines may be referenced as required:

1. ASM Consortium Guidelines, Effective Operator Display Design,
2. ASM Consortium Guidelines, Effective Alarm Management Principles.

## 8 LOCAL USER INTERFACE

### 8.1 General

The local user interface for equipment may be composed of physical pilot devices, a touchscreen HMI terminal, or a combination of the two. Where both pilot devices and a touchscreen HMI are used, the pilot devices shall be associated with essential and/or safety functions only.

Pilot devices, including push buttons, selector switches, and pilot lights are to be of the heavy-duty, dust and oil-tight type, rated for the area in which they are used.

### 8.2 Pilot Device Colours

Where pilot devices are use, the color convention shall be as follows:

**Table 8-1: Standard Pilot Device Colours**

Purpose	Pilot Device Colour
Running Status Light	Green
Stopped Status Light (not normally provided)	Blue
Position Open Status Light	Green
Position Closed Status Light	Blue
Alarm Status Light – Major or Safety	Red
Warning or Minor Alarm Status Light	Amber
Ready Status Light	Blue
Operating Mode Light – Normal Mode	Blue
Operating Mode Light – Alternate Mode	Amber
Start Pushbutton	Green or Black
Stop Pushbutton	Red or Black
Test Pushbutton	Black
Reset Pushbutton	Black
E-Stop Pushbutton	Red <sup>(Note 3)</sup>
Overload Reset Pushbutton	Blue with White “R”
Selector Switch	Black with White Insert

Notes:

- The pilot light colours used are selected from an operations perspective.*
- Use of white or clear lens pilot lights is not permitted as it is difficult to discern whether they are illuminated in brightly lit areas.*
- Emergency stop pushbuttons to be push-pull maintained operators with red mushroom cap.*

	<b>Automation Design Guide</b>	Revision: 00	Page 54 of 107
		Document Code: 612620-0013-40ER-0001	

### 8.3 Touchscreen HMIs

Touchscreen HMIs can provide more functionality than pilot devices but come at a higher installed cost due to the labour involved with software configuration and testing. Use a touchscreen HMI rather than pilot devices if the equipment requires more than approximately eight pilot devices to facilitate local control, or requires operator input or indication of analog values.

HMI (software) Auto/Manual modes may be provided on the HMI/PLC system to facilitate manual control of equipment via the PLC.

### 8.4 Typical Manual Controls

Manual controls in the form of physical pilot devices may be provided for equipment to facilitate maintenance activities or for control of the equipment during PLC system failure. Manual controls should be located adjacent to the equipment but may be located elsewhere on a control panel or on a Motor Control Centre (MCC) if mounting adjacent to the equipment is not practicable.

Refer to the standard control modes defined in Section 3.14. Where manual controls are provided for equipment, selector switches are typically provided in the field for selecting between the available control modes.

The City has standardized on the following control mode switch configurations:

1. Local/Off/Remote (L/O/R) selector switch with local pilot devices for manual control, and local pilot lights to indicate status.
2. Hand/Off/Remote (H/O/R) selector switch with pilot lights to indicate status. No additional manual controls are typically provided.
3. Hand/Off/Auto (H/O/A) selector switch with pilot lights to indicate status. No additional manual controls are typically provided.

*Remote* mode implies equipment control is from the PLC system, and *Auto* mode implies equipment control is from some automatic controller, other than the PLC system. When equipment is in *Hand* mode, the equipment is run continuously.

Lock-Off-Stop (LOS) pushbuttons are generally prohibited as they do not provide the required level of electrical isolation for maintenance activities. Use a local disconnect switch if electrical isolation is required.

Emergency stop pushbuttons (e-stops) shall be provided for equipment that presents a safety hazard to personnel (eg. unguarded rotating machinery). Design the emergency stop circuit such that the equipment requires a fresh start command to restart upon releasing the e-stop pushbutton.

Typical manual control requirements are indicated in Section 7.8 of the Electrical Design Guide, document 510276-0000-47ER-0001, the following for single speed and VFD controlled motor driven equipment.

	<b>Automation Design Guide</b>	Revision: 00	Page 55 of 107
		Document Code: 612620-0013-40ER-0001	

## 9 CONTROL PANELS

### 9.1 Heating, Ventilation, and Cooling

Control panels shall be provided with heating, ventilation, and/or cooling as required to ensure the internal temperature and humidity are maintained at acceptable levels for the components within.

Perform a heat-load analysis for all control panels containing heat-generating components. Determine if the thermal dissipation via the enclosure walls is sufficient, or if additional cooling is required. If additional cooling is required, consider installing filtered louvers at opposite corners of the control panel to provide cooling through natural convection. If natural convection is insufficient, install a filtered fan unit to provide forced air flow through the panel.

Where fans are provided on control panels, ensure that the fans positively pressurize the cabinet to prevent ingress of contaminants through small openings.

Panels installed in cold or outdoor locations may require an internal heater and thermostat to maintain the temperature above the minimum required for the internal components.

A cabinet dryer or heater may be required for control panels installed in humid locations to prevent build-up of moisture within the panel, and to prevent corrosion of internal components.

Provide the mandatory ventilation clearances around heat-generating components as specified by the component manufacturer. Indicate mandatory component clearances on the panel layout drawings.

### 9.2 Spare Space

Control panels are to be provided with at minimum 20% spare space to facilitate installation of additional terminals, relays, and other components in the future. Spare space shall be logically distributed throughout the panel rather than concentrated to one area, and dimensioned on the control panel layout drawing.

The mandatory ventilation clearances around equipment shall not be considered as spare space.

For chassis based PLCs, a minimum of 20% spare space shall be provided within the chassis for the future addition of modules. Alternatively, space could be provided within the control panel for the addition of another PLC chassis in the future.

### 9.3 Wireways

Provide narrow-slot, ventilated wireways complete with snap-on covers within all control panels to contain both the internal panel wiring and incoming/outgoing field wiring.

Size wireways such that they are not more than 40% full once the wiring is installed.

Provide a minimum of 50 mm spacing between wireways and adjacent devices such as terminals and relays. This is to facilitate clear viewing of the wire identification marking, and for insertion and removal of the wiring to the device.

Provide a minimum of 19 mm separation between ventilated wireways containing intrinsically safe wiring and ventilated wireways containing non-intrinsically safe wiring.

Use grey wireways for normal (non-intrinsically safe) wiring and light blue wireways for intrinsically safe wiring.

Wiring run to the door of the control panel shall be appropriately grouped, tied together at short intervals with nylon cable ties, and secured to the door using adhesive backed cable tie mounts in a manner that minimizes stress on the wires.

Categorize and group conductors based on their application. Provide separate wireways for conductors of each category in order to minimize electromagnetic interference. Categories 3 and 4 may be combined if space is limited. Wiring categories are provided in Table 9-1.

**Table 9-1: Wiring Categories**

Category	Description	Examples
1	AC Power and Control	<ul style="list-style-type: none"> <li>• AC power for power supplies</li> <li>• 120 Vac control wiring</li> <li>• 24 Vac control wiring to HVAC devices</li> </ul>
2	DC Power and Control	<ul style="list-style-type: none"> <li>• DC power</li> <li>• DC control wiring</li> </ul>
3	Analog Signals	<ul style="list-style-type: none"> <li>• Analog I/O</li> </ul>
4	Communications	<ul style="list-style-type: none"> <li>• Communication cables</li> </ul>

## 9.4 Cable Entry

The location of cable entry into the panel should be determined prior to designing the layout of the control panel as component layout can affect the routing of field cabling.

Recommended point of cable entry for control panels is at the bottom of the enclosure. Top entry of cables is only permitted in dry locations.

## 9.5 Power Supply Voltage

PLC control panels in control/automation rooms should be powered by 24 Vdc from an external power supply panel adjacent to the control panel. However, for a DCS replacement where the PLC is installed within an existing DCS cabinet, the 24 Vdc power supplies may be located in a DCS cabinet.

Small control panels and remote I/O panels in the field may be powered by 120 Vac.

## 9.6 Control Voltage

Use 24 Vdc signalling for discrete I/O rather than 120 Vac where possible in order to reduce shock and arc flash hazards.

## 9.7 Grounding and Bonding

Control panels with I/O, 24 Vdc power supplies, or shielded network cabling shall be provided with both a non-isolated electrical (safety) ground bar and an isolated instrumentation ground bar. The non-isolated electrical (safety) ground bar shall be used for bonding components such as the enclosure wall, enclosure door, back-panel, PLC chassis, and 120 Vac powered equipment to the building electrical (safety) ground. The isolated instrumentation ground bar shall be used for bonding



	<b>Automation Design Guide</b>	Revision: 00	Page 57 of 107
		Document Code: 612620-0013-40ER-0001	

instrumentation cable shields, the DC supply common, shielded network cabling, and other sensitive components to the building instrumentation ground.

Locate the isolated and non-isolated ground bars at logical and convenient locations within the control panel to minimize the length of bonding conductors. Generally, the ground bars are to be located at the point of cable entry into the panel.

Provide a lamacoid or label adjacent to the isolated instrumentation ground bar reading "Isolated Ground".

All components requiring grounding to the non-isolated electrical (safety) ground shall be bonded to the non-isolated ground bar regardless of whether the component is seemingly bonded via the enclosure wall or back-panel.

Ensure that any paint or other such insulating materials are scraped off of components at the point where bonding conductors attach. Use star washers at the mating surface to ensure a proper bonding connection.

Where a control panel is powered from a 120 Vac source, the bonding connection associated with the 120 Vac supply shall be connected to the electrical (safety) ground bar within the control panel (either directly or via a feed-through terminal).

Instrumentation cable overall and individual shield drain wires shall connect to insulated feed-through terminals on the terminal block DIN rail. These feed-through terminals shall then be connected together via insulated jumpers (either on the side or down the centre of the terminals), and the first or last terminal be bonded to the isolated instrumentation ground bar. In this way, the instrumentation cable shields are not connected directly to the electrical (safety) ground. Provide insulation on bare drain wires as required to prevent accidental bonding to electrical (safety) ground. For smaller panels, drain wires may be directly connected to the isolated ground bar rather than through feed through terminals, but the drain wire must be insulated to prevent contact with the electrical (safety) ground.

All bonding conductors shall be connected in a star, and not be daisy chained. Bonding conductors shall be insulated, stranded copper, 14 AWG or larger. Use green insulation on bonding conductors associated with the electrical (safety) ground, and green/yellow insulation on bonding conductors associated with the instrumentation ground.

Existing buildings may not be equipped with both an electrical (safety) ground and instrumentation ground. In this situation, the isolated instrumentation ground bar within the control panel should be connected to the building star ground, or as close to the building electrode ground as possible. If these options are not feasible, a single bonding link would be provided between the non-isolated electrical (safety) ground bar and the isolated instrumentation ground bar within the control panel, in order to bond the isolated instrumentation ground bar to ground. If at a later time the building is provided with an instrumentation ground, remove the bonding link in the panel and bond the panel's isolated instrumentation ground bar to the instrumentation ground.

Refer to Section 16 for further information on grounding.

## 9.8 Terminals

Terminals are to be provided for termination of field wiring and internal panel wiring.

All terminals are to be of the screw connection type.

Where possible, use plug-in bridges rather than wire jumpers to connect terminals together within a terminal block.

Table 9-2 lists the preferred terminals and accessories for use within control panels.

**Table 9-2: Preferred Control Panel Terminals**

Type	Manufacturer	Catalog Number	Notes
Feed-Through Terminal	Phoenix Contact	3046184	57.8 mm length to match fused and disconnect terminals.
Fused Terminal		3046142	Requires Fuse Connector.
Fuse Connector		3036806	For use with 5x20 mm fuses and terminals 3046142 or 3044720.
Disconnect Terminal		3046139	
Terminal End Plate		3047141	
Potential-Earth (PE) Terminal		3046207	Does not require terminal end plate.
Double-Level Feed-Through Terminal		3044814	
Double-Level Fused Terminal		3044720	
Double-Level Disconnect Terminal		3044775	
Double-Level PE Terminal		3044759	
Double-Level Terminal End Plate		3047293	
Terminal End Clamp		1201442	
Terminal Block Marker		1004348	
Plug-in Bridge		FBS ●●-6	Various lengths are available.

## 9.9 Terminals for Hardwired I/O Terminations

The terminals listed in Table 9-3 are the preferred terminals for termination of hardwired I/O signals and for connection to PLC I/O modules.

**Table 9-3: Hardwired I/O Terminations**

Application	Function	Terminal Type
Analog Input/Output, 2-wire Transmitters	24 Vdc Loop Power	Fused Terminal
	4-20 mA Signal	Disconnect Terminal
	24 Vdc Common	Feed-Through Terminal
	Shield Drain	Feed-Through Terminal ( <i>Note 1</i> )
Analog Input/Output, 4-wire Transmitters	4-20 mA Signal	Disconnect Terminal
	4-20 mA Common	Feed-Through Terminal
	Shield Drain	Feed-Through Terminal ( <i>Note 1</i> )
Discrete Input	24 Vdc / 120 Vac Supply to Field	Double-Level Fused Terminal
	Discrete Input Signal	
Discrete Output	Discrete Output Signal	Double-Level Fused Terminal
	24 Vdc Common / Neutral	

Notes:

1. *Feed-through terminals are used for terminating analog shields in the case where the associated DIN rail is bonded to the enclosure's electrical (safety) ground. If an isolated DIN rail is provided, which is only connected to the isolated instrumentation ground bus in the enclosure, potential earth terminals may be used instead of feed-through terminals.*

It is recommended to use Schneider Electric cordsets to connect high-density discrete I/O modules to the field terminals. These cordsets are available with flying leads for termination to standard screw-connection terminals.

The use of Schneider Electric TeleFast blocks is not typically recommended and use of them requires special approval from the City.

## 9.10 Lighting

Interior lighting should be provided for all floor-standing automation control panels, and all wall-mount automation control panels 762mm (30") wide by 914mm (36") tall or larger.

Control panels that contain 120 Vac I/O may contain a 120 Vac powered interior light fixture. Use a 24 Vdc LED lighting strip for control panels operating at 24 Vdc.

Provide a door-actuated switch for control of the control panel interior light.

## 9.11 Shelves

Provide an externally-mounted shelf on automation control panels that contain a programmable logic controller. The shelf is to provide support for a laptop computer used for local PLC programming and maintenance.

 Winnipeg	<b>Automation Design Guide</b>	Revision: 00	Page 60 of 107
		Document Code: 612620-0013-40ER-0001	

## 9.12 Laptop Receptacle

A GFCI protected 120 Vac receptacle may be provided with control panels that contain a PLC and 120 Vac power or control wiring. Clearly label the receptacle “For Laptop Use Only” and indicate the upstream fuse or circuit breaker rating on the label. Receptacles for laptop use should typically be fused at 5 Amps. The receptacle should be located on the enclosure door, but may be located inside the panel.

Control panels that operate at 24 Vdc (with no 120 Vac present in the panel) should not contain a laptop receptacle. Instead, a receptacle should be installed outside of and adjacent to the control panel.

## 9.13 Ethernet Port

Provide a door-mounted Ethernet port on automation control panels that contain a programmable logic controller. The port may be used by maintenance personnel for connection to the programmable logic controller. Connect the Ethernet port to the service port on the PLC processor or in-rack Ethernet networking module.

	<b>Automation Design Guide</b>	Revision: 00	Page 61 of 107
		Document Code: 612620-0013-40ER-0001	

## 10 MOTOR CONTROL

### 10.1 Standard Equipment

The City of Winnipeg has standardized on the use of Schneider Electric motor control centres (MCCs), variable frequency drives (VFDs), and soft-starters for motor control applications operating at 600V and below. Where such motor control equipment is required, specification of the equipment from the chosen manufacturer is mandatory for all new installations.

### 10.2 Control and Monitoring

#### 10.2.1 General

Control and monitoring of MCCs, VFDs, and soft starters may be implemented in multiple ways, as follows:

1. **Hardwired control and monitoring** – all control signals are hardwired to the controlling device (eg. the PLC system or a field instrument) and monitoring signals are hardwired to the PLC system. This method typically has highest reliability but also has highest installation costs due to the requirement for installing and terminating significant amounts of field cabling.
2. **Hardwired control, network monitoring** – all control signals are hardwired to the controlling device and all monitoring signals are obtained through a network connection. This method has acceptable reliability and often lower installed cost than a fully hardwired system, but control may be affected by a network failure. This method has the advantage that significant monitoring information can be obtained from network-connected motor controllers. Note that inclusion of network-based monitoring will increase the cost of the components.
3. **Network control and monitoring** – all control and monitoring signals are conveyed through a network connection. This method has acceptable reliability if the network is properly implemented, and typically has the lowest installed cost due to the elimination of all hardwired automation cabling. The increased component cost is offset by the elimination of the hardwired cabling. Significant monitoring information can be obtained from the motor controller.

The City of Winnipeg has standardized on the use of network control and monitoring for most motor control applications utilizing MCCs, VFDs, and soft starters. The primary reasons are the reduced installed costs due to the lack of hardwired cabling, and the increased diagnostics information available from network-connected motor controllers.

Hardwired control may be used for simple applications where there is little financial or operational benefit from using network control and monitoring, or where equipment configuration or system requirements may govern. Cases where hardwired methods would be used may include VFDs used for an HVAC application, a motor starter that is not controlled by the PLC system, packaged system applications, or other configurations identified by the designer.

Hardwired control and monitoring would typically be used for very critical applications, but should generally be limited to critical applications having insufficient process equipment redundancy to mitigate against network failures.

#### 10.2.2 Low Voltage Motor Control Centres

The City's standard MCC for use in wastewater treatment facilities is the Schneider Electric Model 6 intelligent MCC with TeSys T motor management relays. The TeSys T motor management relays

may be ordered with various communication interfaces, logic input voltage ratings, and with an optional extension module, as discussed in the following.

Use the Ethernet TCP/IP communications interface on all TeSys T motor management relays. The Ethernet TCP/IP interface allows for control and monitoring of the motor controller by the PLC system utilizing the Modbus/TCP protocol. Note that the Ethernet TCP/IP interface also incorporates a device webpage on HTTP port 80.

For the logic inputs on the TeSys T, the City typically uses the 100-240 Vac option, with the power source for the inputs being the control power transformer in the MCC unit compartment. The logic inputs are commonly used for control interlocking with motor disconnect switches and process instruments in the field.

The extension module has a part number beginning with “LTM E” and incorporates 3-phase voltage monitoring. It allows for undervoltage and overvoltage functions to be incorporated into the protection scheme, and allows for computation of power factor, power, and energy usage. Provide the extension module for all motors larger than 74.6 kW (100 HP) since the additional monitoring and diagnostics information may be useful for future maintenance activities. It is not required to provide the extension module for motors less than 74.6 kW (100 HP), but may be provided if desired.

Motor soft starters are typically installed in MCCs, unless the size and/or cooling requirements are prohibitive. Where soft starters are used in an MCC, they are installed in the unit compartment with a TeSys T motor management relay to provide network control and monitoring.

Typical control and monitoring points for intelligent MCCs with the TeSys T motor protection relay are listed in Table 10-1.

**Table 10-1: Low Voltage, Intelligent MCC Starter – Typical Control and Monitoring Points**

Motor Size	Typical Control Points	Typical Monitoring Points
All motors	<ul style="list-style-type: none"> <li>• Run command</li> <li>• Reset command</li> </ul>	<ul style="list-style-type: none"> <li>• Local/Remote, Hand/Off/Remote, or Manual/Off/Remote switch</li> <li>• Ready</li> <li>• Running</li> <li>• Fault</li> <li>• Average motor current</li> <li>• Accumulated run time</li> <li>• Out of service (eg. a communication failure)</li> </ul>
≥ 37.3 kW (50 HP)		<ul style="list-style-type: none"> <li>• 3-phase motor currents</li> </ul>
≥ 74.6 kW (100 HP)		<ul style="list-style-type: none"> <li>• 3-phase motor voltages</li> <li>• Power factor</li> <li>• Power</li> <li>• Energy</li> </ul>

**Notes:**

1. Refer to the *Electrical Design Guide*, document 510276-0000-47ER-0001, for typical motor protection requirements, which should be monitored by the process control system.

Where hardwired control is used with non-intelligent MCCs, provide the control and monitoring points indicated in Table 10-2.

**Table 10-2: Low Voltage, Hardwired MCC Starter – Typical Control and Monitoring Points**

Motor Size	Typical Control Points	Typical Monitoring Points
All motors	<ul style="list-style-type: none"> <li>Run command</li> </ul>	<ul style="list-style-type: none"> <li>Local/Remote, Hand/Off/Remote, or Manual/Off/Remote switch</li> <li>Ready</li> <li>Running</li> <li>Overload tripped</li> </ul>
≥ 37.3 kW (50 HP)		<ul style="list-style-type: none"> <li>Motor current (single phase)</li> <li>Accumulated run time</li> <li>Starts per hour</li> </ul>
≥ 187 kW (250 hp)		<ul style="list-style-type: none"> <li>3-phase motor current</li> </ul>

Notes:

1. Refer to the *Electrical Design Guide*, document 510276-0000-47ER-0001, for typical motor protection requirements, which should be monitored by the process control system.

### 10.2.3 Low Voltage Variable Frequency Drives

The City has standardized on Schneider Electric Altivar 61 variable frequency drives for low voltage applications in the sewage treatment program.

Smaller VFDs should be located within MCCs, however, installation of VFDs within vendor supplied equipment is also permitted provided that the equipment is not on the roof (heating issue) and not in a location with any potential for corrosive gases. Larger VFDs with significant space or cooling requirements shall be located outside of MCCs.

The Altivar 61 VFD is available with one or two Ethernet communications interfaces and supports star and ring network topologies. Where the VFD is installed in an MCC, use a single Ethernet connection to the VFD to facilitate easy removal of the MCC bucket without disturbing other networked devices. However, if the VFD is installed in a separate cabinet (not in an MCC), connect the VFD using a ring topology for better network fault tolerance.

Where a VFD is used with critical process equipment but equipment redundancy is not provided, it is recommended to provide a bypass starter in parallel with the VFD to allow for motor starting in the event of VFD failure. If a bypass starter is provided, it is recommended to also provide an isolation contactor upstream and downstream of the VFD to fully isolate the VFD from the circuit when starting from the bypass starter.

Typical network control and monitoring points for networked and hardwired low voltage VFDs are provided in Table 10-3 and Table 10-4, respectively.

**Table 10-3: Low Voltage, Networked VFDs – Typical Control and Monitoring Points**

Motor Size	Typical Control Points	Typical Monitoring Points
All motors	<ul style="list-style-type: none"> <li>• Run command</li> <li>• Speed command</li> <li>• Reset command</li> </ul>	<ul style="list-style-type: none"> <li>• Local/Remote, Hand/Off/Remote, or Manual/Off/Remote switch</li> <li>• Ready</li> <li>• Running</li> <li>• Motor speed</li> <li>• Motor current (3-phase average)</li> <li>• Accumulated run time</li> <li>• Last protection fault</li> <li>• Starts per hour</li> <li>• Out of service (eg. a communication failure)</li> </ul>

*Notes:*

1. Refer to the *Electrical Design Guide*, document 510276-0000-47ER-0001, for typical motor protection requirements, which should be monitored by the process control system.

**Table 10-4: Low Voltage, Hardwired VFDs – Typical Control and Monitoring Points**

Motor size	Typical Control Points	Typical Monitoring Points
All motors	<ul style="list-style-type: none"> <li>• Run command</li> <li>• Speed command</li> </ul>	<ul style="list-style-type: none"> <li>• Local/Remote, Hand/Off/Remote, or Manual/Off/Remote switch</li> <li>• Ready</li> <li>• Running</li> <li>• Motor speed</li> <li>• Motor current (3-phase average)</li> <li>• Accumulated run time</li> <li>• VFD faulted</li> <li>• Starts per hour</li> </ul>

*Notes:*

1. Refer to the *Electrical Design Guide*, document 510276-0000-47ER-0001, for typical motor protection requirements, which should be monitored by the process control system.



## 10.2.4 Medium Voltage Motors

The City does not currently have an official standard for medium voltage motor controllers.

The typical control and monitoring points applicable to medium voltage motors are indicated in Table 10-5.

**Table 10-5: Medium Voltage Motors – Typical Control and Monitoring Points**

Motor size	Typical Control Points	Typical Monitoring Points
All motors	<ul style="list-style-type: none"> <li>• Run command</li> <li>• Speed command (VFD applications only)</li> </ul>	<ul style="list-style-type: none"> <li>• Local/Remote, Hand/Off/Remote, or Manual/Off/Remote switch</li> <li>• Ready</li> <li>• Running</li> <li>• Motor speed (VFD applications only)</li> <li>• 3-phase motor current</li> <li>• Accumulated run time</li> <li>• Starts per Hour</li> </ul>

*Notes:*

1. Refer to the *Electrical Design Guide*, document 510276-0000-47ER-0001, for typical motor protection requirements, which should be monitored by the process control system.

## 10.2.5 Automatic Restart

Motor driven equipment that is controlled from the process control system shall be configured to restart after a delay following control system failure or a power failure event. Starting many motors at once can cause significant loading of the electrical distribution system and may cause unintentional tripping of circuit breakers.

The City's standardized PLC function blocks incorporate a timer to delay automatic restarting of motors. This functionality, along with the equipment restart delay, shall be specified in the project's functional requirements specification.

	<b>Automation Design Guide</b>	Revision: 00	Page 66 of 107
		Document Code: 612620-0013-40ER-0001	

## 11 VALVE CONTROL

### 11.1 General

Use electric actuators, as opposed to pneumatic actuators, where practicable for applications requiring power actuation of valves.

The type of electric actuator used is dependent on the type of valve. For small open/close valves that do not require position feedback, a solenoid actuator may be used. For applications requiring position feedback, electric motor-operated actuators should be used.

The City has standardized on the use of Rotork quarter-turn and multi-turn electric valve actuators with an on-off torque requirement above approximately 250 Nm and modulating torques above approximately 150 Nm. Where actuators are required for these applications, specification of the valve actuators from the chosen manufacturer is mandatory for all new installations. For applications other than these, no standard currently exists.

Refer to Rotork Inc. documentation for actuator specifications and selection criteria. The valve actuator standardization was established through City of Winnipeg RFP 331-2014 and was awarded to:

Company: Rotork Inc.  
Address: #6, 820 – 28<sup>th</sup> Street North East, Calgary, AB, T2A 6K1

### 11.2 Control and Monitoring

For solenoid operated valves, use hard-wired control from the PLC system in the form of a discrete output. Use an external interposing relay to energize the solenoid valve, rather than energizing the solenoid directly from the PLC output. Monitoring of valve position is typically not provided for solenoid operated valves.

Small electric actuators used for process or HVAC control are typically hardwired and controlled via discrete 120 Vac or analog 4-20 mA signals. Provide feedback to the control system as required.

HVAC damper actuators are typically hardwired, and position feedback to the controlling device is usually required for interlocking and/or alarming.

Electric actuators from Rotork Inc. may be ordered with a PROFIBUS communications interface. The decision to include a PROFIBUS interface on Rotork electric actuators is primarily based on the cost and application of the actuator. For small applications or applications where accuracy is not of great importance, it may be more cost effective and simpler to use hardwired control and monitoring. For larger valves, or where accuracy is of concern, use PROFIBUS communication.

The typical control and monitoring points for various valve actuator applications are provided in Table 11-1.

**Table 11-1: Typical Valve Control and Monitoring Points**

<b>Valve and Actuator Characteristics</b>	<b>Typical Control Points</b>	<b>Typical Monitoring Points</b>
Open/Close Valve, Solenoid Actuated, Hardwired	<ul style="list-style-type: none"> <li>Open Command</li> </ul>	N/A
Small valves (≤ 102 mm), Open/Close, Electric Actuator, Hardwired	<ul style="list-style-type: none"> <li>Open and Close Command</li> </ul>	<ul style="list-style-type: none"> <li>Open and Closed Limit (as required)</li> </ul>
Small valves (≤ 102 mm), Modulating, Electric Actuator, Hardwired	<ul style="list-style-type: none"> <li>Position Command (4-20 mA)</li> </ul>	<ul style="list-style-type: none"> <li>Position Feedback (4-20 mA)</li> </ul>
Medium/Large (> 102 mm) Open/Close, Electric Actuator, Hardwired	<ul style="list-style-type: none"> <li>Open Command</li> <li>Close Command</li> </ul>	<ul style="list-style-type: none"> <li>Remote Selected</li> <li>Open Limit</li> <li>Closed Limit</li> <li>Fault</li> </ul>
Medium/Large (> 102 mm) Modulating, Electric Actuator, Hardwired	<ul style="list-style-type: none"> <li>Position Command (4-20 mA)</li> <li>Stop/Maintain Command</li> </ul>	<ul style="list-style-type: none"> <li>Remote Selected</li> <li>Position Feedback (4-20 mA)</li> <li>Open Limit (optional)</li> <li>Closed Limit (optional)</li> <li>Fault</li> </ul>
Open/Close Valve, Electric Actuator, PROFIBUS Communication (See Note 1)	<ul style="list-style-type: none"> <li>Open command</li> <li>Close command</li> </ul>	<ul style="list-style-type: none"> <li>Actuator Moving</li> <li>Closed Limit</li> <li>Open Limit</li> <li>Running Closed</li> <li>Running Open</li> <li>Remote Selected</li> <li>Local Stop Selected</li> <li>Local Selected</li> <li>Thermostat Tripped</li> <li>Monitor Relay</li> <li>Valve Obstructed</li> <li>Valve Jammed</li> <li>Valve Moving by Hand</li> <li>Moving Inhibited</li> <li>Position Control Enabled</li> <li>Watchdog Recovery</li> <li>Battery Low</li> <li>Control Contention</li> </ul>

Valve and Actuator Characteristics	Typical Control Points	Typical Monitoring Points
Modulating Valve, Electric Actuator, PROFIBUS Communication (See Note 1)	<ul style="list-style-type: none"> <li>Position command</li> </ul>	<ul style="list-style-type: none"> <li>Valve Position</li> <li>Actuator Torque</li> <li>Actuator Moving</li> <li>Closed Limit</li> <li>Open Limit</li> <li>Running Closed</li> <li>Running Open</li> <li>Remote Selected</li> <li>Local Stop Selected</li> <li>Local Selected</li> <li>Thermostat Tripped</li> <li>Monitor Relay</li> <li>Valve Obstructed</li> <li>Valve Jammed</li> <li>Valve Moving by Hand</li> <li>Moving Inhibited</li> <li>Position Control Enabled</li> <li>Watchdog Recovery</li> <li>Battery Low</li> <li>Control Contention</li> </ul>
On/Off Valve, Pneumatic Control	<ul style="list-style-type: none"> <li>Open Command</li> <li>Close Command</li> </ul>	<ul style="list-style-type: none"> <li>Closed Limit</li> <li>Open Limit</li> </ul>
Modulating Valve, Pneumatic Control	<ul style="list-style-type: none"> <li>Position Command</li> </ul>	<ul style="list-style-type: none"> <li>Valve Position</li> </ul>

**Note:**

1. Not all of the monitoring points from PROFIBUS-connected valves are required to be displayed on the HMI system. Several of these monitoring points will be used in the control strategy only, or used in combination for indicating higher level alarms on the HMI.

	<b>Automation Design Guide</b>	Revision: 00	Page 69 of 107
		Document Code: 612620-0013-40ER-0001	

## 12 FIELD INSTRUMENTATION

### 12.1 Typical Practices

#### 12.1.1 Fail-Safe Implementation

Where hardwired methods are used for connection of switches used for alarming purposes, the switches shall be wired in a fail-safe implementation, meaning that the switch is closed during normal operation and opens upon an alarm condition.

Failure of any instrument shall cause the system to react in a way that will not cause damage to equipment, injury to personnel, or leave operation of equipment in an unsafe condition.

#### 12.1.2 Routing of Signal Cabling

Where remote transmitters are used, careful consideration is required in the routing of the signal cabling between the sensor and transmitter, especially near high sources of noise such as VFD cabling. Use of dedicated conduits for such cabling is recommended.

#### 12.1.3 Instrument Redundancy

Where failure or inaccuracy of a single instrument has unacceptable consequences, instrument redundancy may be required. Instrument redundancy can be provided by either an identical instrument or an alternative (less expensive) instrument technology that provides an acceptable response.

Where instrument redundancy is provided for analog instruments (eg. pressure transmitters), the process control system would typically operate on an average of the readings from the instruments. Selections should be provided on the HMI system to select which instrument(s) are actively used. For example, if two instruments are provided, the HMI would allow for selection of the first instrument, the second instrument, or an average of both instruments, for use by the control system.

While instrument redundancy may be provided using two instruments, it may be difficult to determine which of the two signals is correct if they do not match. For this reason, consider implementing triple redundancy for critical applications and implement a voting scheme in the PLC. Under this scenario, the PLC would compare the readings from all three instruments and if one signal did not match the other two then it would be ignored, and an alarm would be generated on the HMI system.

If an instrument in a redundant application fails, the process control system shall immediately ignore that instrument (i.e. not use it in the calculation of the average), and generate an alarm on the HMI system.

#### 12.1.4 Installation and Removal

Instruments shall not be mounted on equipment or piping subject to vibration.

Field instruments (unless in-line) shall be mounted on a 51 mm (2") hot dipped galvanized or aluminum pipe support (as appropriate for the location), or wall mounted. The instrument stands shall have a height of 1,500 mm to allow an easy access for process observation or maintenance. Where mounted on a catwalk/platform the preferred location shall be on the outside of the hand railing.

Removal of process instruments must be possible without stopping the process. This is achieved by installing appropriate isolation and/or bypass systems such as thermowells, valve manifolds, or software overrides.

	<b>Automation Design Guide</b>	Revision: 00	Page 70 of 107
		Document Code: 612620-0013-40ER-0001	

### 12.1.5 Instrument Displays

Readings on instrument displays shall be in SI (metric) units and the units of measure shown shall match that specified in the project functional requirements specification.

### 12.1.6 Instrument Manifolds

All pressure instruments for process applications shall be supplied with block-and-bleed valves or three-way manifolds.

Differential pressure instruments for process applications shall be supplied with a five-way manifold.

## 12.2 Selection Criteria

### 12.2.1 Standardized Manufacturers

The City has standardized on Siemens electromagnetic flowmeters, ultrasonic level transmitters, RTD-based temperature transmitters, and pressure transmitters. This standardization was established under City of Winnipeg RFP 449-2014 and was awarded to:

Company: Trans-West Inc.  
Address: 126 Bannister Rd., Winnipeg, MB, R2R 0S3

For gas detection equipment, the City has standardized on Mine Safety Appliance Company (MSA) equipment under City of Winnipeg RFP 123-2014, which was awarded to:

Company: CB Engineering Ltd.  
Address: 5040 – 12A Street SE, Calgary, AB, T2G 5K9

Refer to the City of Winnipeg Sewage Treatment Program standard specifications for additional details. Specification of instruments from the chosen manufacturer is mandatory for all new installations.

### 12.2.2 Instrument Accuracy

The accuracy of all instruments shall be better than the application requirements.

Instrument scales/ranges should be selected such that the normal operating point will be at approximately 50% of the full scale/range for pressure, temperature and density, and at 75% for flow rate and level. The design engineer should take a common-sense approach on systems that have large variability to ensure that instruments are operating at accurate points along their curve.

### 12.2.3 Transmitter Output

The preferred method to connect process instrument transmitters to the process control system is via a PROFIBUS network. PROFIBUS instruments have the advantage that they can be configured remotely, they can transmit one or more process variables to the process control system using a digital communication link, and can provide additional diagnostics information. Note, however, that PROFIBUS instruments typically are more expensive than traditional 4-20 mA based instruments.

Transmitters for process applications without a PROFIBUS output should incorporate a 4-20mA output with HART. Switches on process systems will typically be hardwired I/O. However, PROFIBUS should be considered if maintenance diagnostic information would be of value. Instruments used for HVAC applications shall be connected via hardwired methods, to minimize the cost of the instruments.

Use of DeviceNet, CANopen, or ControlNet instruments for new installations is not approved under any circumstance. Use of AS-i should be reviewed with the City prior to implementation.

Wireless instruments should generally not be used for process-related applications, but if they are required then select instruments that communicate using industry standard WirelessHART or ANSI/ISA 100.11a technology. Note that the wireless versions of Siemens instruments use WirelessHART. Install and connect an appropriate wireless gateway (or multiple gateways) to the associated Device Network for communication with the instruments. Wireless instruments should only be used where hard wiring is cost-prohibitive or infeasible, and only be used for non-critical monitoring applications. If use of wireless instruments is required for critical monitoring and control, employ redundant instruments and ensure that contingencies are in place to prevent process downtime resulting from wireless system failure. All wireless instrumentation applications shall be reviewed with and approved by the City prior to implementation.

### 12.2.4 Switches vs. Transmitters

The selection of discrete instruments compared with transmitters (either networked or not) should be considered in all cases. The primary advantages of switches over transmitters are simplicity and cost. Transmitters have the advantage that they can be part of an analog control scheme, such as PID control, and in the case of most PROFIBUS instruments, can be configured with internal alarm setpoints for use by the process control system. General application guidelines are provided in Table 12-1.

**Table 12-1: Guidelines for Selection of Switches vs. Transmitters**

Application	Instrument	Notes
Critical and safety applications	Consider Transmitter	Careful review is required. Codes may apply.
HVAC low temperature (Freeze-stat)	Switch	Simple, cost effective solution requiring hard-wired interlock.
Wet Well Level	Transmitter	Redundancy should be provided for control
Wet Well Low/High Level	Switch	Backup to level transmitter.
Room High Temperature	Transmitter	Can be used in control strategy as well.
	Switch	Partial testing with pump on/off cycling provided.
Pump Low Flow Detection	Transmitter	Where there is use as part of process measurement.
	Switch	On/off fans. Partial testing with fan on/off cycling provided.
Ventilation Low Airflow Detection	Transmitter	Variable speed fans
	Switch	On/off fans. Partial testing with fan on/off cycling provided.
Instrument Air Low Pressure	Transmitter	Continuous indication of operation.

## 12.2.5 Instrument Power Supply

Instruments requiring external power should be powered from 24 Vdc unless it is not an option for a specific instrument, in which case 120 Vac would typically be used. For HVAC applications, 24 Vac is acceptable.

## 12.2.6 Materials

Materials for the wetted parts of all off-line instruments and instrument process connections shall be, as a minimum, 316 SS or per the corresponding piping specification and suitable for the handled process fluid.

Materials not in contact with the process fluid shall be suitable for the environment in which instruments are installed. In general, epoxy coated aluminum enclosures shall be used. For ingress protection requirements see Section 5.1. All instrumentation accessories and mounting hardware shall be stainless steel.

## 12.2.7 Flow Measurement Instruments

Electromagnetic flowmeters shall be used for measurement of the flow rate of liquids, however consideration should be given to alternate technologies where requirements dictate.

Table 12-2 lists acceptable electromagnetic flowmeter liner materials for various types of media.

**Table 12-2: Acceptable Electromagnetic Flowmeter Liner Materials**

Media	Acceptable Liner Materials
Liquid Polymer	PFA, PTFE (Teflon), Ceramic
Water with up to 20 mg/l of organic solids, Chloraminated	PFA, PTFE (Teflon), Ceramic, EPDM, ETFE, Rubber – Ebonite.
Primary Clarifier Scum	PFA, PTFE (Teflon), Ceramic
Activated Sludge	PFA, PTFE (Teflon), Polyurethane, Neoprene.
Raw Sewage	PFA, PTFE (Teflon), Polyurethane, Neoprene.

Provide grounding rings for all electromagnetic flowmeter installations in accordance with the flowmeter manufacturer's recommendations for the specific application.



	<b>Automation Design Guide</b>	Revision: 00	Page 73 of 107
		Document Code: 612620-0013-40ER-0001	

For all flow meter installations, ensure that the required upstream and downstream pipe diameters are met.

### **12.2.8 Level Measurement Instruments**

Where practicable, use ultrasonic level instruments for measurement of liquid level in process-related tanks and wet wells. Use of radar technology is to be avoided unless prior approval is obtained from the City.

Where ultrasonic level instruments are used for critical applications, provide discrete level switches (eg. float switches) as a backup to the ultrasonic level instrument.

Use float switches for level control of small sump pits. The standard of acceptance is Flygt ENM-10 float switches for latched relay control and PIL-1 – PIL-15D for single float switch with hysteresis.

### **12.2.9 Pressure Measurement Instruments**

The Siemens pressure transmitters may be used for measurement of gauge pressure, differential pressure, volumetric flow, liquid level, or liquid volume level.

### **12.2.10 Temperature Measurement Instruments**

Field mounted RTDs are to connect to field mounted transmitters and be connected to the process control system via PROFIBUS or hardwired (4-20 mA) cabling. Use of PLC in-rack RTD input modules with direct connection to field mounted RTDs is not approved.

Use of thermocouples for temperature measurement in the wastewater treatment process is to be avoided; RTDs are to be used instead of thermocouples for process applications. Note that thermocouples may be required for non-process, high temperature applications. Use of thermocouples should be reviewed and approved by the City before being incorporated into a design.

All in-line sensors used for process and liquid temperature measurement instruments shall use thermowells. HVAC temperature measurement instruments in clean air typically do not require thermowells.

	<b>Automation Design Guide</b>	Revision: 00	Page 74 of 107
		Document Code: 612620-0013-40ER-0001	

## 13 POWER SUPPLY

### 13.1 General Requirements

Provide redundant 24 Vdc power supplies for all PLC system installations. Where the power supplies are associated with a PLC installation that replaced an existing DCS PCU, the 24 Vdc power supplies may be located inside the existing DCS cabinet. For PLC installations not meant to replace an existing DCS PCU, provide a separate “power supply panel” containing the redundant 24 Vdc power supplies.

Provide power supply panels to supply 24 Vdc power to neighbouring control panels, networking panels, and other process control system panels or devices that require 24 Vdc power.

Remote I/O panels in the field may contain 24 Vdc power supplies if they are not in close proximity to a power supply panel.

### 13.2 24 Vdc Power Supplies

Where a facility is equipped with an instrumentation ground, connect the common terminal on the output of each 24 Vdc power supply to the instrumentation ground. Otherwise, connect the common terminal of each 24 Vdc power supply to the electrical (safety) ground.

Provide monitoring of the 24 Vdc power supplies by the process control system via the dry contact outputs on the power supplies and/or redundancy module.

Power each 24 Vdc power supply from a separate 120 Vac source to improve availability. Power the first power supply from a 120 Vac UPS panelboard (i.e. a panelboard that is powered from a UPS), and the second power supply from a 120 Vac non-UPS panelboard (i.e. a panelboard that is not fed from a UPS, which may or may not have standby generator backup).

Provide individual fusing within power supply panels for each connected load. A fuse schedule shall be shown on the power distribution schematics, showing the fuse type and rating for each fuse.

Indicate the 24 Vdc power supply loading on the power supply distribution schematics so that it is clear how much spare capacity is available for future loads.

### 13.3 UPS Power

Critical automation equipment shall be powered from an uninterruptible power supply, either directly from a small individual UPS, or from a UPS panelboard. The decision to use a small individual UPS is appropriate where the number of UPS loads within a given physical area is limited and/or widely distributed. For remote locations it is often more appropriate to install a small individual or distributed UPS rather than extend UPS from a large centralized UPS. Typically, UPS power in a wastewater treatment facility will be centralized with distribution through a dedicated panelboard. Where small individual UPS units are used, the UPS shall be industrial-grade rather than commercial-grade. Direct current (dc) UPS units with a 24 Vdc output are acceptable for small loads, such as a single control panel.

For the most critical systems and where standby generation is not available, consideration should be given to utilization of two UPS systems with separate power supplies and separate distribution, feeding loads that are dual sourced (eg. computer servers with dual power supplies). Note that the use of paralleled UPS units with a synchronized common distribution system is not a preferred redundancy solution.

Table 13-1 indicates the requirement for UPS power for various types of process control system equipment.

**Table 13-1: Equipment Requiring UPS Power**

Equipment	UPS Powered
HMI Servers	Yes
Historian Servers	Yes
HMI Operator Workstations and Monitors	Yes
Process Related Network Equipment	Yes
HMI Touchscreens, Field Mounted	No
Process Related PLCs and I/O	Yes
Non-Process Related PLCs and I/O	Optional
Process Related Instruments	Yes
Non-Process Related Instruments	Optional
Emergency Shutdown Systems	Yes
Programming/Maintenance Workstations and Monitors	Optional

The design battery duration rating of the UPS is dependent on the criticality of the load and degree of backup within the power supply system. Battery run time calculations shall be performed for all designs.

**Table 13-2: UPS Design Battery Life**

UPS Type	Backup Generator	Time	
		Low / Medium Reliability Requirement	High Reliability Requirement
Centralized (Large)	None	60 minute	120 minute
	Single Standby	30 minute	60 minute
	Redundant Standby	15 minute	30 minute
Distributed (Small, Individual)	None	45 minute	120 minute
	Single Standby	20 minute	60 minute
	Redundant Standby	10 minute	30 minute

Motor starters within MCCs will be powered by dedicated local 120 Vac control power transformers associated with each motor starter. Ensure that manual control capability, where provided, is not compromised due to the loss of any other power source, including the loss of UPS power.

	<b>Automation Design Guide</b>	Revision: 00	Page 76 of 107
		Document Code: 612620-0013-40ER-0001	

## 14 HAZARDOUS LOCATIONS

### 14.1 General

Wastewater facilities typically have some hazardous locations due to the presence of combustible gas and liquids (Zone 0/1/2, previously known as Class I). Hazardous locations due to presence of combustible dust (Zone 20/21/22, previously known as Class II), or fibres or flyings (Zone 20/21/22, previously known as Class III) are generally not found within wastewater treatment facilities.

Design, installation, selection of equipment and materials shall be based on the hazardous location drawings produced for the facility.

### 14.2 References

All installations shall comply with the latest codes regarding installations associated with hazardous locations, including but not limited to:

1. CSA C22.1, Section 18 – Hazardous locations.
2. CSA C22.1, Appendix F – Recommended installation practice for intrinsically safe and non-incendive electrical equipment and wiring.
3. Winnipeg Electrical Bylaw.

Use the following standards, along with sound engineering judgement, in the design of automation equipment installations associated with hazardous locations:

1. Definitions and Information Pertaining to Electrical Equipment in Hazardous (Classified) Locations, ANSI/ISA-12.01.01-2013.
2. Recommendations for the Preparation, Content, and Organization of Intrinsic Safety Control Drawings, ANSI/ISA-12.02.02-2014.
3. Recommended Practice for Wiring Methods For Hazardous (Classified) Locations, Instrumentation Part 1: Intrinsic Safety, ANSI/ISA-RP12.06.01.
4. NFPA 820.

Equipment associated with hazardous locations shall meet the applicable codes as follows:

1. Explosionproof enclosures used within hazardous (classified) locations shall meet CSA C22.2, No. 30.
2. Motors and generators used within hazardous (classified) locations shall meet CSA C22.2, No. 145.
3. Combustible gas detection equipment used within hazardous (classified) locations shall meet CSA C22.2, No. 152.
4. Intrinsically safe equipment used for hazardous (classified) locations shall meet CSA C22.2, No 157.
5. Cables and cable glands used within hazardous (classified) locations shall meet CSA C22.2, No. 174.
6. Non-incendive electrical equipment installed within Class I, Division 2 hazardous (classified) locations shall meet CSA C22.2, No. 213.

MTL TP1121-1, A definitive guide to earthing and bonding in hazardous areas, may also be used.

	<b>Automation Design Guide</b>	Revision: 00	Page 77 of 107
		Document Code: 612620-0013-40ER-0001	

## 14.3 Design Requirements

### 14.3.1 General

All equipment shall have the appropriate Class, Division or Zone, Group, and Temperature Class ratings for the area in which they are installed. Exceptions to this include simple apparatus, which are field devices that will neither generate nor store more than 1.2 Volts, 0.1 Amps, 25 mW, or 20  $\mu$ J. Examples of simple apparatus include simple contacts, thermocouples, RTDs, LEDs, and non-inductive potentiometers and resistors.

### 14.3.2 Intrinsically Safe Systems

An intrinsically safe (IS) circuit is one which is incapable of causing ignition of the prescribed flammable gas, vapour, or dust upon the occurrence of any spark or thermal effect during normal use, or any conditions of fault likely to occur in practice.

An intrinsically safe system generally consists of three components:

1. The field device, referred to as the intrinsically safe apparatus,
2. The field cabling, and
3. The energy limiting device or barrier, referred to as the intrinsically safe associated apparatus.

For all designs incorporating intrinsically safe systems, the designer shall perform all entity parameter calculations to ensure that the complete installation meets the requirements of the intrinsically safe apparatus and associated apparatus, and is a safe installation. Specific manufacturers and model numbers, and the entity parameters, shall be indicated on the associated loop drawing.

Where associated apparatus are used, they shall be located as close as possible to the hazardous area to minimize cable length, thereby minimizing capacitance in the circuit.

Grounded associated apparatus that contain one or more shunt diode devices (eg. Zener diodes) shall be grounded to a ground electrode and have a ground path resistance to the grounding electrode of less than 1 Ohm. Where it is not possible to achieve a ground path resistance of less than 1 Ohm, consideration should be given to using isolated repeater barriers, which do not require grounding, as opposed to the grounded type.

Where grounded associated apparatus are used, duplicate grounding conductors shall be provided to connect the associated apparatus to the designated ground electrode. The grounding conductors shall be minimum 12 AWG each. The grounding system shall be insulated from ground at all places except at the point of connection to the designated ground electrode.

Grounded associated apparatus may be connected directly to a ground electrode, but if multiple grounded associated apparatus are used then it is often beneficial to install intermediary grounding points (eg. copper bus bars) to reduce the number of individual grounded conductors.

Where multiple grounded associated apparatus are installed in an enclosure, provide a copper barrier bus within the enclosure for grounding each barrier. Ground each barrier to the barrier bus using duplicate 12 AWG, insulated conductors.

Where multiple enclosures containing grounded associated apparatus are installed in the field, an IS master ground bus bar may also be provided in the building for grounding the enclosures. Installing an IS master ground bus also facilitates grounding of new IS enclosures that may be added in the future. Where an IS master ground bus bar is employed, it shall be isolated from structural steel and connected directly to the building star ground or electrode ground, or as close as practicable. Provide duplicate bonding connections between the IS enclosures and the IS master ground bus using larger,

	<b>Automation Design Guide</b>	Revision: 00	Page 78 of 107
		Document Code: 612620-0013-40ER-0001	

insulated conductors, such as with two (2) 4 AWG or 6 AWG conductors. Provide duplicate grounding conductors between the IS master ground bus and the final grounding connection using two (2) insulated copper conductors that are at minimum 2/0 AWG each. As previously stated, the ground path resistance between any grounded associated apparatus and the ground electrode shall be less than 1 Ohm.

All bonding and grounding connections shall be secure, permanent, visible, and accessible for routine inspection.

Refer to Section 16 for additional information on grounding.

Review the recommended practices for bonding of cable shields indicated in ANSI/ISA-RP12.06.01.

## **14.4 Preferred Methods of Protection**

### **14.4.1 General**

If possible, avoid locating equipment in hazardous locations to eliminate the additional installation requirements associated with hazardous locations. Where equipment must be located in a hazardous area, the preferred method of protection depends on the classification of the area.

Equipment utilizing isolation techniques such as pressurization, purging, and continuous dilution generally require frequent maintenance and inspections. For this reason, pressurization, purging, and continuous dilution shall only be used if they are deemed the only option for protection.

The preferred methods of protection are provided in the following sections.

### **14.4.2 Zone 0 Locations**

The preferred method of protection in Zone 0 (previously known as Class I, Zone 0) locations is the intrinsically safe “ia” method.

### **14.4.3 Zone 1 Locations**

The preferred method of protection in Zone 1 (previously known as Class I, Zone 1) locations is the intrinsically safe “ia” or “ib” method as this is typically the lowest cost solution and allows live work to be done in the hazardous area. If the intrinsically safe method is not an option, then the flameproof (d) method is preferred. Other methods may be acceptable but should be discussed with the City before use.

### **14.4.4 Zone 2 Locations**

The preferred method of protection in Zone 2 (previously known as Class I, Zone 2) locations is the non-sparking, non-arcing “n” method as this is typically the lowest cost solution and allows for the simplest installation. If this method is not an option then the intrinsically safe “ia” or “ib” method or the flameproof “d” method is preferred. Other methods may be acceptable but should be discussed with the City before use.

	<b>Automation Design Guide</b>	Revision: 00	Page 79 of 107
		Document Code: 612620-0013-40ER-0001	

## 15 SAFETY INSTRUMENTED SYSTEMS

### 15.1 General

A Safety Instrumented System (SIS) is engineered to perform safety function(s) that are intended to achieve or maintain a safe state for the equipment under control, in respect of a specific hazardous event. Examples of safety functions include functions that are required to be carried out as positive actions to avoid hazardous situations (for example switching off a motor) and functions that prevent actions being taken (for example preventing a motor starting).

A safety instrumented system is required when, after performing a Hazard and Risk analysis, the risk reduction provided by external risk reduction and other technology based systems is not enough to meet the target risk. External risk reduction examples include shielding, emergency management and containment system. Other technology-based systems include relief valves and credible basic process control system functions.

Each “external risk reduction” and “other technology” can be credited with risk reduction as an independent protection layer if:

1. They are effective in preventing the consequence,
2. They are independent of the initiated event,
3. They are independent of other credited independent protection layers for a given scenario, and
4. They can be audited.

After all of the risk reduction and mitigation impacts from the basic process control system and other layers of protection are taken into account, a user must compare the residual risk against their risk tolerance. If there is still an unacceptably high level of risk, a Risk Reduction Factor (RRF) is determined and a Safety Integrity Level (SIL) requirement is calculated. The RRF is the inverse of the Probability of Failure on Demand for the Safety Instrumented Function (SIF). A multidisciplinary approach is usually required to determine SIL and SIF.

Safety Integrity Level (SIL) is a discrete level (one out of a possible four), corresponding to a range of safety integrity values, where SIL 4 has the highest level of safety integrity and SIL 1 has the lowest.

A Safety Integrity Level (SIL) is not a property of a system, subsystem, element or component. The correct interpretation of the phrase “SIL n safety-related system” (where n is 1, 2, 3 or 4) is that the system is potentially capable of supporting safety functions with a safety integrity level up to n.

Safety integrity levels are used for specifying the safety integrity requirements of the safety functions to be allocated to the safety systems.

When a SIL 1 or higher electrical/electronic/programmable electronic safety related system is required, the design, implementation, and commissioning, and all documentation deliverables shall comply with ANSI/ISA-84.00.01-2001 (IEC 61511-1 Mod).

The process and documentation must be carried out with the participation of a functional safety engineer, F.S. Eng (TÜV Rheinland).

In general, the requirement for design and implementation of safety instrumented systems would be identified in the project scope of work.

	<b>Automation Design Guide</b>	Revision: 00	Page 80 of 107
		Document Code: 612620-0013-40ER-0001	

## 15.2 Documentation Requirements

Documentation deliverables shall be provided for all safety instrumented systems and shall include at minimum the following:

1. Indication of the hazards or hazardous events that are being mitigated, and associated probability and consequences of the events occurring.
2. The allocation of safety functions to protection layers.
3. Indication of the safety target, safety functions required, and the tolerable risk.
4. Identification of the external risk reduction facilities, if any.
5. Identification of applicable regulatory requirements, if any.
6. The safety requirements specification, including the functional requirements and safety integrity requirements of the safety instrumented system, and its required safety integrity level.
7. The type of safety function of the safety instrumented system, be it continuous mode or demand mode, and for the demand mode case whether the system is used for prevention functions or mitigation functions.
8. Sealed engineered drawings indicating the make and model number of each hardware and software component used in the design, and allowable substitutions where applicable.
9. The safety instrument system supporting data (eg. hardware MTBF, etc.)
10. Requirements for the installation, testing, and commissioning of the safety instrumented system. A complete and detailed commissioning procedure shall be provided.
11. Required routine testing and maintenance procedures of the implemented safety instrumented system, including identification of department(s) involved and qualifications or certifications required.
12. Identification of the stages in the safety lifecycle at which point additional functional safety assessment activities are to be carried out. (eg. after changes to the associated process system, or upon identification of new hazards not previously considered, etc.).
13. Decommissioning procedures of the safety instrumented system.
14. Certifications of the safety instrumented system designer.

All documentation provided shall be accurate, easy to understand, suit the purpose for which it is intended, and be available in an accessible and maintainable form. Each piece of documentation shall have unique identification so it is possible to reference, shall have a revision index to allow for identification of different revisions, and be structured to make it possible to search for relevant information.

All documentation shall be revised, amended, reviewed, approved, and be under the control of an appropriate documentation control scheme.

## 15.3 General Design Principles

The SIS shall be separate from the basic process control system (BPCS) to ensure that a failure of a single device does not corrupt the control function and interlock system.

The SIS shall not be used for basic process control where a failure of the SIS results in a failure of basic process control function and places demand on the SIS.



	<b>Automation Design Guide</b>	Revision: 00	Page 81 of 107
		Document Code: 612620-0013-40ER-0001	

Where an SIS is used for both safety and non-safety functions then all hardware and software that can negatively affect any safety instrumented function, under any condition, shall be treated as part of the SIS and comply with the requirements for the highest SIL.

Where an SIS is used to implemented safety instrumented functions at various safety integrity levels, the shared components shall meet the highest safety integrity level.

Methods for performing maintenance and testing shall be incorporated into the design of all safety instrumented systems.

The design of the SIS shall account for human capabilities and limitations and be suitable for the related tasks assigned to operators and maintenance personnel.

The SIS shall be designed in such a way that once it has placed the process in a safe state that the process shall remain in a safe state until a manually initiated reset is performed, unless otherwise dictated by the requirements of the system.

Manual means shall be provided to actuate the SIS final elements, unless otherwise dictated by the requirements of the system.

Safety instrumented functions with a safety integrity level higher than that associated with SIL 4 shall not be allocated to a safety instrumented system.

Applications which require the use of a single safety instrumented function of safety integrity level 4 are rare in the process industry, and such applications shall be avoided where reasonably practicable because of the difficulty of achieving and maintaining such high levels of performance throughout the safety life cycle. If analysis results in a SIL 4 being assigned to a safety instrumented function, the process design shall be changed in a way that makes it more safe, or additional layers of protection shall be added. These changes could perhaps then reduce SIL requirements for the safety instrumented system.

Components as part of the SIS for SIL 1 to SIL 3 shall be either in accordance with IEC 61508 or shall meet the minimum requirements for hardware fault tolerance and be suitable based on prior use as per that defined in ANSI/ISA-84.00.01-2004.

Design and implement safety instrumented systems such that they are not likely to experience common cause failure, which is the result of one or more events ultimately leading to system failure.

Design all safety instrumented systems in a fail-safe manner such that failure of the system results in a safe and orderly shutdown or mode of operation of the associated process equipment.

Field devices shall be selected and installed in a manner so as to minimize failures or inaccuracies. This includes but is not limited to affects due to process or environmental conditions such as corrosion, freezing, high temperature and pressures, suspended solids, and condensation.

Each field device shall have its own dedicated wiring to the system inputs/outputs, except where sensors are wired in series or multiple final elements are connected to a single output.

	<b>Automation Design Guide</b>	Revision: 00	Page 82 of 107
		Document Code: 612620-0013-40ER-0001	

## 16 GROUNDING

### 16.1 General

Automation equipment is generally more sensitive to noise and voltage spikes on the grounding system than electrical equipment such as MCCs, VFDs, and motors. For this reason, grounding of automation equipment often requires extra care to ensure the equipment does not fail as a result of continuous or momentary issues on the grounding system.

Automation equipment that is powered from a 120 Vac supply shall have the enclosure or chassis bonded to the electrical (safety) grounding system. This is to allow ground fault currents that are sourced from the 120 Vac supply to return to the source, which would trip the protective device (fuse or circuit breaker) feeding the equipment. Automation equipment that is powered from 24Vdc and below should be connected to an isolated instrumentation ground, which is segregated from the electrical (safety) ground to the greatest extent possible. As discussed in Section 9.7, if automation equipment is powered from 120 Vac and also contains PLC I/O, 24 Vdc power supplies, or shielded network cabling, the equipment shall be provided with both an electrical (safety) ground for grounding the enclosure, and an isolated instrumentation ground for grounding the 24 Vdc common and the cable shields.

The grounded conductor associated with an isolated instrumentation ground should be connected as close as possible to a ground electrode so that noise and voltage spikes, as seen by the automation equipment, are kept to a minimum. If multiple pieces of automation equipment are being installed, it is typically not cost effective to install dedicated ground conductors between each piece of automation equipment and the ground electrode. Instead, it is more sensible to install an automation equipment grounding point (eg. an isolated ground bus bar within an automation room), which allows for bonding multiple pieces of automation equipment to ground. The grounding point would be connected as close as practicable to a ground electrode with a single, insulated conductor. Where automation equipment groundings points are provided, they shall be isolated from building structural steel.

Where multiple types of automation equipment are being installed, multiple grounding points may be required for each type of equipment. Some automation equipment is more sensitive than others with respect to noise or voltage on the grounding system, and some types of automation equipment (eg. computers with switch-mode power supplies) may induce additional noise on the grounding system. For these reasons, separate grounding points should be provided for each of the following types of equipment:

1. Instrumentation (cable shields, DC supply common, etc.),
2. Intrinsically safe equipment (IS barriers, etc.),
3. Computer systems, and
4. Communications equipment (wireless radios, etc.).

As per the electrical code, separate grounding systems may not be provided for a single building and therefore the above automation equipment grounding points are not completely independent from one other or the electrical (safety) ground, but are segregated to the greatest extent possible. The only common point of connection should be at the final connection point to the grounding system, near a ground electrode.

Where multiple grounding points for various types of automation equipment are provided, they shall independently be connected as close as practicable to a ground electrode, and not be connected in series with one-another.

If only one or two PLCs or HMI clients are being installed in a building, installation of dedicated grounding points for these would generally not be required due to the additional costs involved. In this case, the equipment may be connected to the electrical (safety) ground system if deemed acceptable.

	<b>Automation Design Guide</b>	Revision: 00	Page 83 of 107
		Document Code: 612620-0013-40ER-0001	

Further discussion on the implementation of automation equipment grounding is provided in Section 16.2.

## 16.2 Implementation of Automation Equipment Grounding

### 16.2.1 Installations in Existing Buildings

The existing wastewater treatment facilities typically employ a single electrical (safety) ground within each building, and dedicated grounding points for automation equipment may or may not be provided.

Where new automation equipment is installed into an existing building with only an electrical (safety) ground, and it is not within the scope of work to provide dedicated automation grounding points, the automation equipment should be bonded as close as practicable to an existing ground electrode.

If a significant amount of new automation equipment is being installed into a building, new automation grounding points (eg. isolated ground bus bars) should be installed for bonding the new automation equipment to ground. Multiple automation grounding points may be provided for serving equipment in separate areas of the building to minimize cable length, or for serving different types of automation equipment.

### 16.2.2 Installations in New Buildings

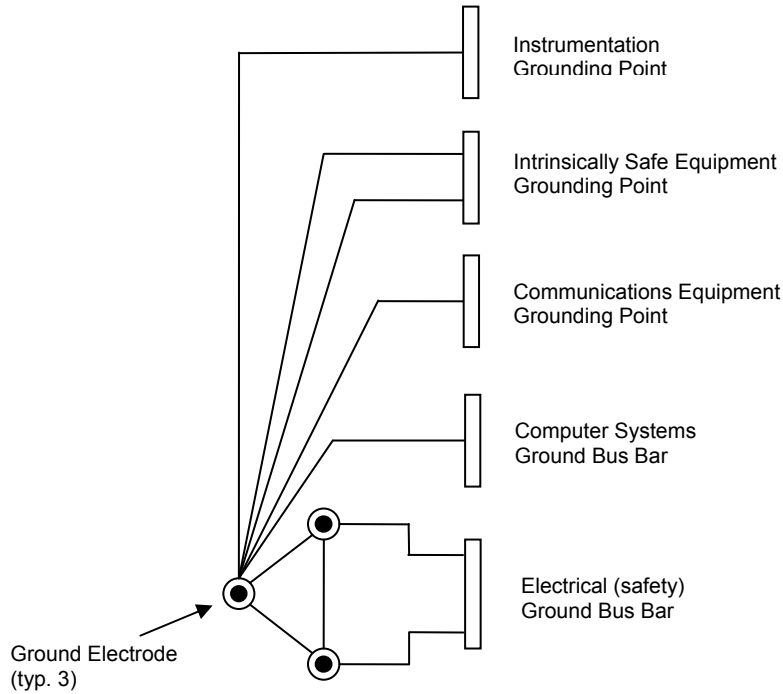
New buildings shall be constructed with dedicated automation grounding points for the various types of automation equipment within. Multiple automation grounding points should be provided for serving equipment in separate areas of the building to minimize cable length, or for serving different types of automation equipment.

### 16.2.3 Typical Configurations

A typical building ground system is composed of two or more ground electrodes in close proximity, or a building perimeter ground with several ground electrodes distributed at regular intervals. When connecting automation equipment to a ground electrode, it is preferred to use an electrode that is not directly used by the electrical (safety) ground in order to reduce the potential rise, as seen by the automation equipment, during an electrical ground fault.

Insulated, 2/0 AWG conductors are typically used to ground equipment grounding points (eg. ground bus bars) to ground. Intrinsically safe grounding points and electrical (safety) grounding points are grounded using duplicate grounding conductors for redundancy.

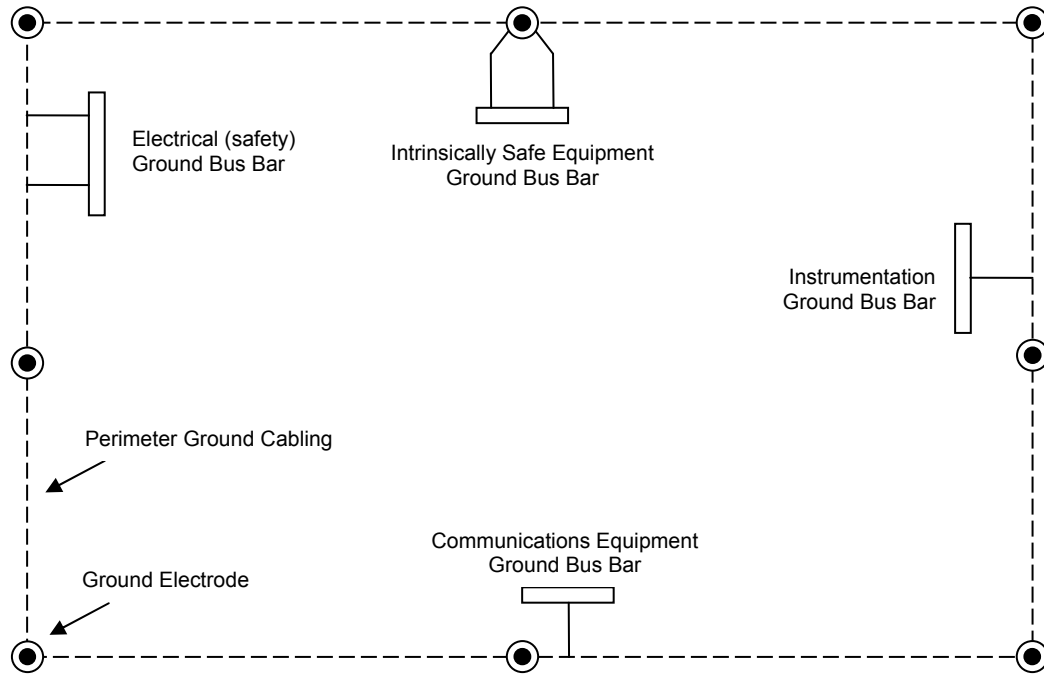
Typical grounding system implementations are provided in the following figures. Figure 16-1 illustrates a grounding system with three ground rods in close proximity, and the preferred method to connect the electrical and automation grounding points to the ground rods. Figure 16-2 illustrates a grounding system using a perimeter ground, with ground rods distributed at regular intervals, and the preferred method to connect the electrical and automation grounding points to the perimeter ground cabling.



**Figure 16-1: Typical Grounding System Implementation with Three Grounding Electrodes**

*Notes:*

1. *The electrical (safety) ground bus bar is grounded to two ground electrodes to ensure proper connectivity to ground.*
2. *The ground bus bars other than the electrical (safety) ground bus bar are grounded to a different ground electrode than those used by the electrical (safety) ground. This is done to minimize potential rise on these ground buses during an electrical ground fault. The negative effects resulting from electrical noise are also minimized.*
3. *Duplicate grounded conductors are provided for the Intrinsically Safe ground bus bar for safety reasons.*



**Figure 16-2: Typical Grounding System Implementation with a Perimeter Ground**

*Notes:*

1. *The electrical (safety) ground bus bar is grounded using two ground conductors to ensure proper connectivity to ground. Ideally these are connected directly to two ground electrodes, but connection to the perimeter ground cabling, as shown, is also acceptable.*
2. *The grounding points for the instrumentation and communications equipment are shown connected to the perimeter ground cabling rather than directly to a ground electrode. This is acceptable provided that electrical equipment is not grounded at a point between them and the nearest ground electrode. It is preferred to have direct connections to a ground electrode.*
3. *The grounding point for the intrinsically safe equipment is shown connected directly to a ground electrode, which is the preferred method due to the sensitivity of intrinsically safe equipment. If this is not feasible, it may be connected to the perimeter ground cabling provided that no electrical equipment is grounded at a point on the perimeter ground between it and the nearest ground electrode.*
4. *Duplicate grounded conductors are provided for the Intrinsically Safe ground bus bar for safety reasons.*

### 16.3 Minimum Requirements

Panels containing I/O, 24 Vdc power supplies, and/or shielded network cabling shall be grounded as per the requirements indicated in Section 9.7.

	<b>Automation Design Guide</b>	Revision: 00	Page 86 of 107
		Document Code: 612620-0013-40ER-0001	

Automation panels that are grounded to an instrumentation grounding point shall each have an independent bonding conductor to the grounding point, and not be connected in series with one-another.

Panels containing grounded intrinsically safe associated apparatus (IS barriers) shall have duplicate (redundant) bonding conductors between the IS panel and the grounding point, and not be connected in series with one-another.

Automation junction boxes and panels without I/O, 24 Vdc power supplies, or shielded network cabling shall be grounded to the building electrical (safety) ground only.

## 16.4 Good Practices

New buildings should be provided with an instrumentation grounding point, and if required, an IS master grounding point if practicable. Note that it may not be feasible to unearth the existing grounding electrodes for direct connection of new instrumentation and/or IS ground buses. In this case, these grounding points would be connected as close as possible to the ground electrodes.

Grounded associated apparatus (Zener barriers) should be connected directly to an intrinsic safety (IS) master ground bus or a building ground electrode. Refer to Section 14.3.2 for further information on grounded associated apparatus.

	<b>Automation Design Guide</b>	Revision: 00	Page 87 of 107
		Document Code: 612620-0013-40ER-0001	

## 17 ENGINEERING DESIGN TEAM RESPONSIBILITY

### 17.1 General

1. Responsibility for deliverables:
  - 1.1 All drawings and other deliverables related to a design are the responsibility of the design engineer.
2. All automation deliverables are to be sealed by a qualified professional engineer.
3. Completeness of drawings:
  - 3.1 All drawings shall be comprehensive in nature to allow for effective use in construction and maintenance.
4. Update of existing drawings:
  - 4.1 If the project is an addition, expansion, upgrade, or modification to an existing site or facility, existing drawings may require up-dating.
    - 4.1.1 Loop drawings, motor schematics, and wiring diagrams must always be updated.
    - 4.1.2 PLC system I/O schematic drawings must always be updated.
    - 4.1.3 Updates to or superseding existing P&ID drawings is mandatory. Partial P&ID diagrams showing a small portion of the process modifications are not acceptable.
    - 4.1.4 The update of existing instrument plan drawings to reflect new work is not typical, and is not required unless specifically identified by the City.
    - 4.1.5 The update of other existing automation drawings is dependent upon the design engineer's scope.
5. As-Built Drawings:
  - 5.1 All automation deliverables shall be updated to "as-built" status at the end of the project. The "as-built" documents shall incorporate contractor mark-ups, inspections performed by the design team, change orders, RFIs, and other communication between the Contractor and Design Team.
  - 5.2 Unless otherwise specified by the City and agreed to by the Design Team, as-built drawings will not be sealed (otherwise known as record drawings).
6. Site Visits:
  - 6.1 The design team is responsible for ensuring that a sufficient number of site visits occur to facilitate the understanding of specific field conditions or status of existing facilities and equipment.
7. Demolition Requirements:
  - 7.1 It is generally required that the design engineer is responsible for associated demolition works required to implement the scope of work. Clearly indicate all demolition requirements on the drawings and in the specifications.
  - 7.2 Where demolition requirements are significant, create dedicated demolition drawings.

	<b>Automation Design Guide</b>	Revision: 00	Page 88 of 107
		Document Code: 612620-0013-40ER-0001	

- 7.3 Generally, abandoned equipment, wiring, etc. shall be removed unless specifically requested by the City that the equipment/wiring be retained, or removal is not practicable.
- 8. Acceptance Testing:
  - 8.1 Acceptance testing requirements shall be defined for every project. Acceptance tests shall use industry approved methods.
  - 8.2 Acceptance testing forms shall be completed for every project and included with the O&M manuals.
  - 8.3 The Design Team is responsible for reviewing the completed acceptance test forms to ensure that the installation complies with the specifications.

## 17.2 Drawings

The drawing requirements in this section are not exhaustive, but indicate general requirements for all projects, as applicable to the scope of work in the project. The automation drawings produced shall be comprehensive to cover the scope of the project, and shall be detailed to an “industrial” level of detail. “Commercial-grade” drawings that have excessive use of “typical” and general lack of detail are not acceptable.

All drawings that are converted to PDF must be searchable.

### 17.2.1 Loop Drawings

- 1. Requirement:
  - 1.1 Loop Drawings are required for all field instruments that connect to a local control panel or programmable automation controller.
- 2. Content:
  - 2.1 Divide the drawing into columns such that each column represents a physical location. Title each column with the physical location it represents.
  - 2.2 Clearly show all instruments, terminals, devices, and wiring interconnections in each instrument loop.
  - 2.3 Provide all instrument and/or device settings on the loop drawing, such as dip switch settings, dial settings, etc.
  - 2.4 For analog loops, such as 4-20 mA and 0-20 mA loops, indicate the impedance of each device in each loop on the drawing.
  - 2.5 Provide an appropriate symbol within each special terminal to indicate the type of terminal:
    - 2.5.1 Indicate fused terminals with a small fuse symbol inside the terminal. Provide the fuse rating below the terminal.
    - 2.5.2 Indicate disconnect terminals with a small disconnect symbol inside the terminal.
    - 2.5.3 Indicate potential earth terminals with a small ground symbol inside the terminal.
  - 2.6 Show the instrument identifier within an instrument bubble symbol adjacent to and pointing at the instrument.
  - 2.7 Show all field instrument and control panel device part numbers on loop drawings.



	<b>Automation Design Guide</b>	Revision: 00	Page 89 of 107
		Document Code: 612620-0013-40ER-0001	

- 2.8 For intrinsically safe wiring, indicate the following:
  - 2.8.1 The classification of the hazardous location (eg. Class I, Zone 1, Group IIC),
  - 2.8.2 For intrinsically safe apparatuses (field devices) other than simple devices, the manufacturer, model, and entity parameters of the apparatus,
  - 2.8.3 Manufacturer/model and/or permissible entity parameters of the associated apparatus (eg. IS barrier),
  - 2.8.4 Maximum entity values for the cabling.
- 3. Format:
  - 3.1 All loop drawings are to be produced on a standard B size drawing.
  - 3.2 Drawing Scale: NTS
- 4. Standard of acceptance:
  - 4.1 Refer to sample Instrument Loop Diagram, drawing SK-A103.

### 17.2.2 Instrument Segment Drawings

- 1. Requirement:
  - 1.1 Instrument Segment Drawings shall be prepared for every project utilizing PROFIBUS instruments.
- 2. Content:
  - 2.1 All new PROFIBUS instruments shall be shown on the instrument segment drawings.
  - 2.2 Indicate all instrument and networking equipment identifiers.
  - 2.3 Indicate the cable identifier and cable type for each cable on the drawing.
  - 2.4 Indicate the estimated length for all cables on the drawing.
  - 2.5 Indicate allowable minimum and/or maximum cable lengths on the drawing where applicable.
  - 2.6 Indicate the network speed(s) on the drawing.
  - 2.7 Indicate the location and type of terminations on the drawing.
  - 2.8 Indicate the network address number of each device on the drawing.
  - 2.9 Provide a Segment Schedule on the drawing, showing the number of devices, total length, and maximum spur length for each segment.
- 3. Format:
  - 3.1 All instrument segment drawings are to be produced on a standard B size drawing.
  - 3.2 Drawing Scale: NTS
- 4. Standard of acceptance:
  - 4.1 Refer to sample Instrument Segment Diagram, drawing SK-A105.

### 17.2.3 Instrument Location Plan Drawings

- 1. Requirement:
  - 1.1 Instrument Location Plan Drawings shall be prepared for every project.

	<b>Automation Design Guide</b>	Revision: 00	Page 90 of 107
		Document Code: 612620-0013-40ER-0001	

2. Content:
  - 2.1 All new instruments shall be shown on instrument location plan drawings.
  - 2.2 Provide instrument elevation drawings for instruments that are to be installed at a specific elevation and where sufficient detail cannot be provided in plan view.
  - 2.3 All instrument identifiers are to appear on the drawings.
  - 2.4 All mechanical equipment, if applicable, shall be shown with a lighter lineweight.
3. Format:
  - 3.1 All instrument plan and elevation drawings are to be produced on a standard A1 size drawing.
  - 3.2 Drawing Scale:
    - 3.2.1 Recommended: 1:30

#### **17.2.4 Instrument Installation Details**

1. Requirement:
  - 1.1 Instrument installation details shall be provided for all instruments that require a specific means of installation.
  - 1.2 Specific (non-typical) installation details are required for all magnetic flow meter installations where the flow-tube is 350 mm (14") or larger, where remote transmitters are used, or where specific site constraints must be addressed. Typical installation details may be used for flow meter installations where the flow-tube is 300 mm (12") or smaller, with an integral transmitter, and without any site constraints.
  - 1.3 Typical installation details may be provided for ultrasonic level transducer installations unless a specific site constraint must be addressed.
  - 1.4 Specific installation details shall be provided for all differential pressure based level transmitter installations.
2. Content:
  - 2.1 Show all installation details including instrument orientation, mounting bracketry, cables, conduits, strain reliefs, pull boxes, and junction boxes as applicable.
  - 2.2 For magnetic flow meter installations, show grounding ring installation and connection details.
  - 2.3 All structural and mechanical equipment, if applicable, shall be shown with a lighter lineweight.
3. Format:
  - 3.1 Instrument installation details are typically shown as a detail on a standard A1 size drawing.
  - 3.2 Drawing Scale:
    - 3.2.1 Recommended: 1:10
    - 3.2.2 Maximum: 1:20

	<b>Automation Design Guide</b>	Revision: 00	Page 91 of 107
		Document Code: 612620-0013-40ER-0001	

### 17.2.5 Control Panel Layouts

1. Requirement:
  - 1.1 Provide control panel layout drawings for all control panels that are to be constructed by a Contractor or where included in the project scope.
2. Content:
  - 2.1 Provide a bill of materials, indicating the quantities, manufacturer name, model name, and a description for each component.
  - 2.2 Show exterior panel dimensions.
  - 2.3 Show the exterior (typically the front door only) elevation of the control panel with all components to scale.
  - 2.4 Show the interior elevation panel layout of all components to scale. The only component not shown on the layout shall be the wires.
  - 2.5 Where dedicated wireways are required, indicate the type or category of wiring that may be installed in each wireway.
  - 2.6 For each terminal block, indicate which side is for field wiring side and which side is for internal wiring.
  - 2.7 Provide construction notes indicating specific construction details.
3. Format:
  - 3.1 All control panel layout drawings are to be produced on a standard A1 size drawing.
  - 3.2 Drawing Scale:
    - 3.2.1 Recommended: 1:4
    - 3.2.2 Maximum: 1:10
4. Standard of acceptance:
  - 4.1 Refer to sample Control Panel Layout, drawing SK-A101.

### 17.2.6 Control Panel Power Distribution Schematics

1. Requirement:
  - 1.1 Control panel power distribution schematics shall be provided for all control panels.
2. Content:
  - 2.1 Show the complete schematic for the power distribution, including component identifiers, terminals, terminal numbers, wires, and wire tags.
  - 2.2 Show where the source of power terminates to the control panel, and include the name and details of the power source (eg. "120 VAC from PNL-R731, CCT 12").
  - 2.3 Provide a fuse schedule on the drawing which lists the identifier, type, and rating of each fuse.
  - 2.4 Provide a power consumption schedule for each major voltage level used within the control panel that summarizes the current consumption from each device, including PLC inputs and outputs. The total current consumption shall be provided at the bottom of the table.

	<b>Automation Design Guide</b>	Revision: 00	Page 92 of 107
		Document Code: 612620-0013-40ER-0001	

- 2.5 Provide a terminal layout (arrangement) on the drawing for terminal blocks associated with power distribution.
- 3. Format:
  - 3.1 All control panel power distribution schematics shall be produced on a standard A1 size drawing.
- 4. Standard of acceptance:
  - 4.1 Refer to sample PLC Power Schematic, drawing SK-A102 (Sheets 001 and 002).

### 17.2.7 I/O Module Wiring Diagrams

- 1. Requirement:
  - 1.1 I/O module wiring diagrams shall be provided for all programmable automation controller I/O modules.
- 2. Content:
  - 2.1 Show the I/O modules and their connections to the I/O (field) terminals. The field instruments and associated wiring to the I/O (field) terminals shall not be shown on I/O module wiring diagrams. The field wiring details must be shown on loop drawings or other automation / electrical diagrams.
  - 2.2 Provide the I/O signal name and drawing reference beside each set of I/O (field) terminals associated with each I/O point.
  - 2.3 Where fused I/O (field) terminals are used, provide a fuse schedule which lists the identifier, type, and rating of each fuse.
- 3. Format:
  - 3.1 All I/O module wiring diagrams shall be produced on a standard A1 size drawing.

### 17.2.8 Network Diagrams

- 1. Requirement:
  - 1.1 Network diagrams shall be provided for all new network equipment installations.
  - 1.2 Use an Instrument Segment Drawing for all PROFIBUS instrumentation network drawings. See Section 17.2.2.
  - 1.3 Existing network diagrams shall be updated where changes are made to an existing network.
- 2. Content:
  - 2.1 Network diagrams shall show all networking equipment, including patch panels, network switches, routers, media converts, wireless devices, and cabling.
  - 2.2 The port type (RJ45, FC, LC, ST, SC, etc.) shall be identified on the drawing using a specific symbol.
  - 2.3 All port labels and/or port numbers for networking devices shall be indicated on the drawing in a manner that is consistent with the physical port labelling on the device.
  - 2.4 All cable identifiers are to be shown on the drawing along with the cable types:
    - 2.4.1 For copper network cables, indicate the number of conductors, conductor size, and type of cable. Example: "4 PR, 24 AWG, CAT 6".

	<b>Automation Design Guide</b>	Revision: 00	Page 93 of 107
		Document Code: 612620-0013-40ER-0001	

- 2.4.2 For fibre cables, indicate the type of fibre (single-mode, multi-mode, hybrid, etc.) number of strands, core diameter, cladding diameter, and signal compatibility.
- 2.5 For long runs of fibre or CAT5e/CAT6 Ethernet cabling, indicate the estimate length of the cabling on the drawing.
- 2.6 For Ethernet Networks, indicate the IP addresses of the devices on the drawing.
- 2.7 For Modbus/TCP, Modbus/RTU (serial), or other networks utilizing “Node” numbers, indicate all device node numbers on the drawing.
- 2.8 For outdoor wireless systems, show all antennae and lightning surge arrestors.
- 2.9 Provide a symbol legend on the drawing or on a standard legend sheet.
- 3. Format:
  - 3.1 All network diagrams shall be produced on a standard A1 size drawing.
- 4. Reference:
  - 4.1 Standard of acceptance: sample network diagram, SK-A104.

## 17.2.9 Automation Conduit Riser Diagrams

- 1. Requirement:
  - 1.1 Where conduit sizing for the provision for future wiring is required, an automation conduit riser diagram shall be provided so that conduits are installed with the required spare capacity, and not sized by the installation contractor to the minimum size required by Code.
- 2. Content:
  - 2.1 Show the conduit type and size for each conduit.
  - 2.2 Show pull boxes, junction boxes, and panels as required.
  - 2.3 Show area boundaries using boundary lines and show each pull box, junction box, and panel within the appropriate boundaries.
  - 2.4 Provide a legend on the drawing or a standard legend sheet indicating the acronyms used. Examples:
    - ARC Aluminum Rigid Conduit
    - LFMC Liquidtight Flexible Metallic Conduit
    - PB Pull Box
    - PVC Polyvinyl Chloride
- 3. Format:
  - 3.1 All automation conduit riser diagrams are to be produced on a standard A1 size drawing.

## 17.2.10 Process and Instrumentation Diagrams

*Note: Process and Instrumentation Diagrams are officially categorized under the Process discipline, but rely heavily on input from automation engineers.*

- 1. Requirement:
  - 1.1 Process and Instrumentation Diagrams shall be provided for all processes including HVAC and Building Services.

	<b>Automation Design Guide</b>	Revision: 00	Page 94 of 107
		Document Code: 612620-0013-40ER-0001	

2. Content:
  - 2.1 Show the following automation details on P&IDs:
    - 2.1.1 Instrument balloons for all discrete instruments (i.e. those that are not a subcomponent to a parent piece of equipment).
    - 2.1.2 Alarm switch setpoints for all instruments used for alarming (eg. temperature alarm setpoint for a TSH).
    - 2.1.3 Manual control devices (pushbuttons, switches, pilot lights, etc.) associated with each piece of equipment. Type clarifications (eg. HOA, HOR, L/O/R, E/S), shall be shown above Hand/Off/Auto, Hand/Off/Remote, Local/Off/Remote, and Emergency Stop switches.
    - 2.1.4 Physical I/O (represented by triangle symbol) associated with process control system or automatic controller, along with functional signal designations.
    - 2.1.5 Software control function blocks associated with equipment, which logically represent the control functionality provided by the PLC system or automatic controller. The major control loops shall be shown, however the level of detail shall be managed such that the process is not lost in excessive automation detail. Note that the Control Narratives (Section 17.3.7) together with the Functional Requirements Specifications (Section 17.3.8) provide the complete control strategy.
    - 2.1.6 Major software interlocks and control signals between software control function blocks, as required. Where multiple PLCs or controllers provide control for one piece of equipment, indicate the controller identifier above each software control function block.
    - 2.1.7 Hardwired interlocks and control signals.
    - 2.1.8 Critical operating and alarm setpoints for major equipment.
    - 2.1.9 Indication of communication protocol (eg. PB-DP, PB-PA, MB-E) for communications cabling.
3. Format:
  - 3.1 All process and instrumentation diagrams are to be produced on a standard A1 size drawing.
4. Design Responsibility:
  - 4.1 Where appropriate, P&IDs should be sealed by both the appropriate process engineer and the automation engineer.

## 17.3 Other Documents

The documentation requirements in this section are not exhaustive, but indicate general requirements for all projects, as applicable to the scope of work in the project. The automation documents produced shall be comprehensive and shall be detailed to an “industrial” level of detail.

All documents converted to PDF format shall be searchable.

### 17.3.1 Instrument List

1. Requirement:
  - 1.1 An instrument list is required for every project where new instruments are installed.

	<b>Automation Design Guide</b>	Revision: 00	Page 95 of 107
		Document Code: 612620-0013-40ER-0001	

2. Content:
  - 2.1 Provide an overall cover page, indicating client name, project title, document code, and document revisions. The cover page shall be sealed by the Design Engineer.
  - 2.2 The instrument list shall include the following fields:
    - 2.2.1 Instrument Tag (identifier)
    - 2.2.2 Description
    - 2.2.3 Communication (4-20mA, HART, PB DP, etc.)
    - 2.2.4 File name and version of associated EDDL/GSD/DTM, if applicable.
    - 2.2.5 Plan Drawing (reference to drawing number)
    - 2.2.6 P&ID Drawing (reference to drawing number)
    - 2.2.7 Schematic / Loop Drawing (reference to drawing number)
    - 2.2.8 Installation Detail Drawing (reference to drawing number)
    - 2.2.9 Mounting Method
    - 2.2.10 Supplied By (indicate which sub-trade should supply the instrument)
    - 2.2.11 Notes
    - 2.2.12 Revision of last change
3. Format:
  - 3.1 An instrument list shall be prepared in Microsoft Excel, but other formats may be accepted by the City with approval.
4. Standard of acceptance:
  - 4.1 Refer to sample Instrument List, document SD-A101.

### **17.3.2 Loop Numbering List**

1. Requirement:
  - 1.1 A Loop Numbering List lists all of the loop numbers used at each facility to prevent inadvertent duplication of loop numbers and equipment identifiers.
  - 1.2 A Loop Numbering List is required for all projects where new equipment is installed.
  - 1.3 The Loop Numbering List shall be divided by process area.
2. Content:
  - 2.1 The Loop Numbering List shall include the following fields:
    - 2.1.1 Loop Number
    - 2.1.2 Loop/Equipment Description
    - 2.1.3 Reference Drawings (eg. loop drawings, P&ID drawings)
    - 2.1.4 Notes
    - 2.1.5 Revision of last change

	<b>Automation Design Guide</b>	Revision: 00	Page 96 of 107
		Document Code: 612620-0013-40ER-0001	

### 17.3.3 I/O List

1. Requirement:
  - 1.1 An I/O list is required for every project where changes to PLC system I/O are made.
  - 1.2 Where possible, update an existing facility I/O list rather than creating a new I/O list. Alternatively, update the existing facility I/O list upon completion of the project.
2. Content:
  - 2.1 Provide an overall cover page, indicating client name, project title, document code, and document revisions. The cover page shall be sealed by the Design Engineer.
  - 2.2 I/O lists shall include the following fields:
    - 2.2.1 I/O Module Address (eg. rack number and/or slot number)
    - 2.2.2 Module Point (I/O point number or channel number on module)
    - 2.2.3 Tag (instrument or signal tagname)
    - 2.2.4 Description
    - 2.2.5 For discrete I/O:
      - 2.2.5.1 "0 State" Description (description of signal when FALSE)
      - 2.2.5.2 "1 State" Description (description of signal when TRUE)
    - 2.2.6 For analog I/O:
      - 2.2.6.1 Type (4-20mA, 0-5 VDC, 0-10 VDC, etc.)
      - 2.2.6.2 EU Range (engineering units range)
    - 2.2.7 P&ID drawing (reference to applicable P&ID drawing)
    - 2.2.8 Loop/wiring drawing (reference to applicable loop/wiring drawing)
  - 2.3 The list shall be grouped by I/O signal type:
    - 2.3.1 Discrete Input
    - 2.3.2 Discrete Output
    - 2.3.3 Analog Input
    - 2.3.4 Analog Output
    - 2.3.5 HART Input
    - 2.3.6 HART Output
3. Format:
  - 3.1 An I/O list will typically be prepared in Microsoft Excel, but other formats may be accepted by the City with approval.
4. Standard of acceptance:
  - 4.1 Refer to sample I/O List, document SD-A012.



	<b>Automation Design Guide</b>	Revision: 00	Page 97 of 107
		Document Code: 612620-0013-40ER-0001	

### 17.3.4 Interface Maps

1. Requirement:
  - 1.1 Interface maps are required for projects where a new customizable controller is installed and makes data available to other controllers via a communication link. For example, a new standalone PLC is installed for an HVAC system, which is monitored by the facility PLC system using Modbus TCP.
2. Preparation and Completion:
  - 2.1 For non-packaged systems, preparation of interface maps falls under the responsibility of the Systems Integrator. The Design Engineer may provide templates to the Systems Integrator for completion.
  - 2.2 For packaged systems including equipment and a programmable controller or HMI, preparation of interface maps falls under the responsibility of the vendor.
3. Content:
  - 3.1 Interface maps shall include an overall cover page, indicating client name, project title, document code, and document revisions.
  - 3.2 Interface maps shall include the following fields:
    - 3.2.1 PLC Register or PLC Tagname,
    - 3.2.2 Protocol Address (eg. Modbus address),
    - 3.2.3 Description,
    - 3.2.4 Analog Range – Raw,
    - 3.2.5 Analog Range – Engineering Units,
    - 3.2.6 Read/Write,
    - 3.2.7 Notes.
4. Format:
  - 4.1 An interface map will typically be prepared in Microsoft Excel, but other formats may be accepted by the City with approval.
5. Standard of acceptance:
  - 5.1 Refer to sample Interface Map, document SD-A103.

### 17.3.5 Automation Cable Schedule

1. Requirement:
  - 1.1 An automation cable schedule is required for every project.
2. Content:
  - 2.1 Provide an overall cover page, indicating client name, project title, document code, and document revisions. The cover page shall be sealed by the Design Engineer.
  - 2.2 All control cables shall be uniquely identified on the cable schedule. Cables shall not be entered as typical.
  - 2.3 Where individual wires are routed in conduit, the wires shall be identified as an item in the cable schedule. This is not applicable to power wiring for minor circuits, such as lighting, receptacles, etc.

	<b>Automation Design Guide</b>	Revision: 00	Page 98 of 107
		Document Code: 612620-0013-40ER-0001	

- 2.4 Cable schedules shall include the following fields:
  - 2.4.1 Cable Identifier
  - 2.4.2 Cable Type
  - 2.4.3 From (Source)
  - 2.4.4 To (Destination)
  - 2.4.5 Spacing (typically not applicable to automation cabling)
  - 2.4.6 Length (estimate)
  - 2.4.7 Routing (brief description)
  - 2.4.8 Notes
  - 2.4.9 Revision of last change.
- 2.5 The length for each cable shall be estimated at design time to within ~10% accuracy for purposes of pre-bid cost estimating.
- 3. Format:
  - 3.1 A cable schedule will typically be prepared in Microsoft Excel, but other formats may be accepted by the City with approval.
- 4. Standard of acceptance:
  - 4.1 Refer to sample Automation Cable Schedule, document SD-A104.

### **17.3.6 Lamacoid Schedule**

- 1. Requirement:
  - 1.1 A lamacoid schedule is a requirement for every project.
  - 1.2 Note that the creation of a lamacoid schedule at design time greatly assists the Contractor, helps provide a higher quality of identification lamacoids for maintenance personnel, and can be created for a minimum effort above that required to thoroughly review a Contractor-produced lamacoid schedule.
- 2. Content:
  - 2.1 Provide an overall cover page, indicating client name, project title, document code, and document revisions.
  - 2.2 All automation lamacoids shall be uniquely identified on the lamacoid schedule, except as follows:
    - 2.2.1 Lamacoids for cables may reference the cable schedule.
  - 2.3 Lamacoid schedules shall at minimum include the following fields:
    - 2.3.1 Item
    - 2.3.2 Line 1 (text to appear on row 1)
    - 2.3.3 Line 2 (text to appear on row 2)
    - 2.3.4 Line 3 (text to appear on row 3)
    - 2.3.5 Text size
    - 2.3.6 Notes
    - 2.3.7 Revision of last change.

	<b>Automation Design Guide</b>	Revision: 00	Page 99 of 107
		Document Code: 612620-0013-40ER-0001	

3. Format:
  - 3.1 A lamacoid schedule will typically be prepared in Microsoft Excel, but other formats may be accepted by the City with approval.
4. Standard of acceptance:
  - 4.1 Refer to sample Lamacoid Schedule, document SD-A105.

### **17.3.7 Process Control Narrative**

1. Requirement:
  - 1.1 Provide a Process Control Narrative for all projects where new process equipment is installed.
  - 1.2 While this document is primarily written by process engineers, the automation engineers should review and provide input.
2. Content:
  - 2.1 Provide an overall cover page, indicating client name, project title, document code, and document revisions.
  - 2.2 Provide a listing of reference drawings (typically P&IDs).
  - 2.3 Provide an equipment and instrument listing, complete with identifiers (tag numbers) and descriptions.
  - 2.4 Provide a detailed textual description of all the control modes of the process.
  - 2.5 Indicate general arrangement details, such as equipment physical locale and configuration where required to clarify the process control.
  - 2.6 For each operating mode describe the normal operation of each piece of equipment.
  - 2.7 Describe the operation of equipment under abnormal circumstances (eg. instrument failure, mechanical failure, etc.), where possible.
  - 2.8 Indicate special requirements of the automation system to accommodate maintenance activities, as required.
  - 2.9 Indicate operating setpoints for each operating mode.
  - 2.10 Indicate process interlocks and major equipment protection interlocks. Standard interlocks (i.e. motor overload) can be detailed in the Functional Requirements Specification (Section 17.3.8).
  - 2.11 Indicate required major alarms. The complete set of alarms will be in the Functional Requirements Specification.
3. Format:
  - 3.1 A process control narrative will typically be prepared in Microsoft Word, but other formats may be accepted by the City with approval.

### **17.3.8 Functional Requirements Specifications**

1. Requirement:
  - 1.1 Provide a Functional Requirements Specification (FRS) for all projects where programming of a PLC or similar system is required.
2. Content:

	<b>Automation Design Guide</b>	Revision: 00	Page 100 of 107
		Document Code: 612620-0013-40ER-0001	

- 2.1 Specific functional requirements for each piece of equipment in the design that is controlled by the programmable controller.
  - 2.2 Provide textual descriptions, cause-effect matrices, or high-level function block logic diagrams of the required equipment functionality as required.
    - 2.2.1 Use pseudo-code and function block logic diagrams only when necessary, i.e. when it is not possible to convey functionality using alternate means.
    - 2.2.2 Textual descriptions should be used to provide a general understanding where required, but should not be used alone to describe detailed logic.
  - 2.3 Logic in functional requirements specifications are to be based on the City's standard library of function blocks.
    - 2.3.1 Create additional standard function blocks that can be imported into the City's function block library as required.
3. Format:
- 3.1 Functional requirements specifications are typically prepared in Microsoft Word, and may reference external documents such as cause-effect matrices that were generated using Microsoft Excel.
  - 3.2 Functional Requirements Specifications are split into multiple documents as follows:
    - 3.2.1 A Standard Function Block Class FRS – contains the standard set of function block classes that are used within the process control system associated with the City's Sewage Treatment Program. Standard function block classes provide high-level functionality for equipment monitoring and control and can be saved into a repository for re-use. The City is in the process of developing standard function block classes. Contact the City for information on the availability of the standard classes and the Standard Function Block Class FRS document.
    - 3.2.2 One or more Process Area FRSs – specific functional requirements specifications for the equipment controlled by the PLC system. The specific FRSs are broken down by process area so that they are manageable in size. If the work associated with the project is all within one process area then only one Process Area FRS would be provided. If the work spans multiple process areas then one FRS would be provided for each process area. These FRSs reference the standard classes defined in the Standard Function Block Class FRS.
4. Standard of acceptance:
- 4.1 Refer to the included sample Functional Requirements Specifications:
    - 4.1.1 Sample document SD-A106: Area "A" – Standard Function Block Classes.
    - 4.1.2 Sample document SD-A107: Area "S" – Secondary Clarifiers.

## **17.4 Construction and Commissioning Documents**

### **17.4.1 Instrument Test Forms**

1. Requirement:
  - 1.1 Instrument test forms shall be provided with projects where new instruments will be installed.

	<b>Automation Design Guide</b>	Revision: 00	Page 101 of 107
		Document Code: 612620-0013-40ER-0001	

2. Preparation and Completion:
  - 2.1 Instrument test forms shall be prepared by the Design Engineer and filled in by the installation contractor.
  - 2.2 Use standard City forms where available.
3. Content:
  - 3.1 Provide a header section at the top of the test form with the following fields, to be filled in by the contractor:
    - 3.1.1 Facility
    - 3.1.2 Project Name
    - 3.1.3 Plant Area
    - 3.1.4 Bid Opportunity number
    - 3.1.5 Document number
  - 3.2 Provide a sign-off section at the bottom. Test forms are to be signed and dated by the tester and a witness, where the witness is a person designated by the Contract Administrator.
  - 3.3 Provide sections for filling in the following:
    - 3.3.1 Sensor / element and transmitter details indicating at minimum:
      - a. Units,
      - b. Design range,
      - c. Configured range,
    - 3.3.2 Inspection of instrument and installation.
    - 3.3.3 For discrete instruments:
      - a. The setpoint trip point,
      - b. The actual trip point,
      - c. The setpoint time delay,
      - d. The actual time delay, and
      - e. Verification of the signal for each discrete state.
    - 3.3.4 For analog instruments, verification of the signal under various process or test conditions.
    - 3.3.5 For PROFIBUS instruments, the communication is functioning without error, the transmitter alarms are configured (as required), and the transmitter configuration is complete and saved.
4. Format:
  - 4.1 Instrument test forms will typically be prepared in Microsoft Word, but other formats may be accepted by the City with approval.

	<b>Automation Design Guide</b>	Revision: 00	Page 102 of 107
		Document Code: 612620-0013-40ER-0001	

## 17.4.2 I/O Module Test Forms

1. Requirement:
  - 1.1 I/O module test forms shall be provided for new PLC installations for verification that each I/O point and associated HMI object(s) are configured correctly.
2. Preparation and Completion:
  - 2.1 I/O module test forms shall be prepared by the Design Engineer and filled in by the Systems Integrator as part of the FAT documentation.
  - 2.2 Use City standard forms where available.
3. Content:
  - 3.1 Provide a header section at the top with the following fields, to be filled in by the contractor:
    - 3.1.1 Facility
    - 3.1.2 Project Name
    - 3.1.3 Plant Area
    - 3.1.4 Bid Opportunity number
    - 3.1.5 Document number
  - 3.2 Provide a sign-off section at the bottom. Forms are to be signed and dated by the tester and a witness, where the witness is a person designated by the Contract Administrator.
  - 3.3 Provide a section for filling in the associated PLC identifier, PLC description, rack number, slot number, and module type.
  - 3.4 Provide separate forms for each type of module (discrete input, discrete output, analog input, analog output, thermocouple input, RTD input, etc.).
  - 3.5 Provide columns within the forms for the I/O point number, I/O point tagname, I/O point description, 0 State (False state) description, 1 State (True state) description, and checkboxes for indicating that each state has been verified:
    - 3.5.1 at the PLC Input/Output module,
    - 3.5.2 on the HMI graphic display, and
    - 3.5.3 on the HMI alarm system.
4. Format:
  - 4.1 I/O module test forms will typically be prepared in Microsoft Word, but other formats may be accepted by the City with approval.

## 17.4.3 PLC System Commissioning Checklist

1. Requirement:
  - 1.1 PLC system commissioning checklists shall be provided for new PLC installations for verification that each PLC system is installed and operating correctly.
2. Preparation and Completion:
  - 2.1 PLC system commissioning checklists shall be prepared by the Design Engineer and filled in by the Systems Integrator.

	<b>Automation Design Guide</b>	Revision: 00	Page 103 of 107
		Document Code: 612620-0013-40ER-0001	

3. Content:
  - 3.1 Provide a header section at the top with the following fields, to be filled in by the contractor:
    - 3.1.1 Facility
    - 3.1.2 Project Name
    - 3.1.3 Plant Area
    - 3.1.4 Bid Opportunity number
    - 3.1.5 Document number
  - 3.2 Provide a sign-off section at the bottom. Checklists are to be signed and dated by the tester and a witness, where the witness is a person designated by the Contract Administrator.
  - 3.3 Provide a section for filling in the PLC identifier, PLC description, processor and network adapter module numbers, and rack number.
  - 3.4 Provide a section indicating that the following has been inspected:
    - 3.4.1 PLC cabinet is completely clean and there are no loose papers inside.
    - 3.4.2 Ventilation openings are not covered.
    - 3.4.3 Drawings are marked up as-built.
    - 3.4.4 Communications between PLC and HMI system is acceptable.
    - 3.4.5 Communications between PLC and remote racks is acceptable, as applicable.
    - 3.4.6 For redundant PLC applications, failover functionality from primary rack to secondary (standby) rack, then back to primary, is operational.
    - 3.4.7 Memory card(s) are installed and program has been transferred to the memory card(s), as applicable.
  - 3.5 Provide a section for filling in the following run-time information:
    - 3.5.1 Percentage processor (CPU) utilization.
    - 3.5.2 Percentage memory utilization.
    - 3.5.3 Program scan time.
4. Format:
  - 4.1 PLC system commissioning checklists will typically be prepared in Microsoft Word, but other formats may be accepted by the City with approval.

#### **17.4.4 Valve Actuator Commissioning Checklist**

1. Requirement:
  - 1.1 Valve actuator commissioning checklists shall be provided for all new valve actuator installations for verification that the valve actuator is correctly installed and configured.
2. Preparation and Completion:
  - 2.1 Valve actuator commissioning checklists shall be prepared by the Design Engineer and filled in by the installation contractor.

	<b>Automation Design Guide</b>	Revision: 00	Page 104 of 107
		Document Code: 612620-0013-40ER-0001	

3. Content:
  - 3.1 Provide a header section at the top with the following fields, to be filled in by the contractor:
    - 3.1.1 Facility
    - 3.1.2 Project Name
    - 3.1.3 Plant Area
    - 3.1.4 Bid Opportunity number
    - 3.1.5 Document number
  - 3.2 Provide a sign-off section at the bottom. Checklists are to be signed and dated by the tester and a witness, where the witness is a person designated by the Contract Administrator.
  - 3.3 Provide a section for filling in the valve actuator details:
    - 3.3.1 Identifier (tag)
    - 3.3.2 Description
    - 3.3.3 Manufacturer
    - 3.3.4 Model
    - 3.3.5 Serial Number
    - 3.3.6 Design Range
    - 3.3.7 PROFIBUS network address
  - 3.4 Provide a section indicating that the following has been inspected:
    - 3.4.1 Actuator type and materials matches the P&ID and actuator data sheet
    - 3.4.2 Installation of actuator is correct
    - 3.4.3 Equipment tag is correct
    - 3.4.4 Configuration matches valve actuator settings sheet
    - 3.4.5 Open/close/position command from process control system is functioning
    - 3.4.6 Status monitoring by process control system is functioning
    - 3.4.7 Drawings are marked up as-built
    - 3.4.8 HMI graphic symbol, tag, and units are correct
4. Format:
  - 4.1 Valve actuator commissioning checklists will typically be prepared in Microsoft Word, but other formats may be accepted by the City with approval.

## 17.5 Design Calculations and Studies

1. All design decisions leading to important design activities, must be supported by an appropriate calculation, which may be required for verification and justification. The Design Engineer shall prepare design calculations as required. It shall be the responsibility of the Design Team to collect, verify, and file all such calculations.
2. The software tools or vendor PLC packages used for the required calculations must be approved by the Lead Engineer for each specific project.



	<b>Automation Design Guide</b>	Revision: 00	Page 105 of 107
		Document Code: 612620-0013-40ER-0001	

3. Calculations done by subcontractors, contractors or vendors will be permitted if the calculation requires specialized knowledge or experience that a typical automation design engineer would not possess. In these cases, it is the responsibility of the design engineer to ensure that the calculations follow all City standards and guidelines.
4. The calculations and studies shall only be deferred to the Contractor after review and agreement with the City.
5. The following are potential calculations that may be required by the design engineer depending on the size and complexity of the design:
  - 5.1 New control panels, power supply panels, networking panels:
    - 5.1.1 Wireway sizing / fill calculations, where there are a significant number of wires in the wireways and the percent fill is non-trivial,
    - 5.1.2 Heat load calculations,
    - 5.1.3 Power supply loading calculations,
  - 5.2 New junction boxes:
    - 5.2.1 Wireway sizing / fill calculations, where there are a significant number of wires in the wireways and the percent fill is non-trivial.
  - 5.3 Intrinsically safe installations:
    - 5.3.1 Indication of manufacturer, model number, and entity parameters of the intrinsically safe apparatus as they apply to the specific set(s) of terminals to be connected.
    - 5.3.2 Indication of manufacturer, model number, and entity parameters of the associated apparatus as they apply to the specific set(s) of terminals to be connected.
    - 5.3.3 Calculation of maximum allowable interconnecting cable entity parameters.
  - 5.4 Cable tray installations:
    - 5.4.1 Cable tray sizing (volume) and loading (weight) calculations.
  - 5.5 Conduit installations:
    - 5.5.1 Conduit fill calculations.
  - 5.6 Safety Integrity Calculations as per Section 15.
  - 5.7 Profibus installations:
    - 5.7.1 Bus voltage drop calculations.
    - 5.7.2 Bus current (loading) calculations.
    - 5.7.3 Max bus cable length (trunk and spur) calculations based on network speed and topology.
6. All design calculations relating to process control system performance and utilization should be included in the Operation and Maintenance Manuals for the associated areas.

	<b>Automation Design Guide</b>	Revision: 00	Page 106 of 107
		Document Code: 612620-0013-40ER-0001	

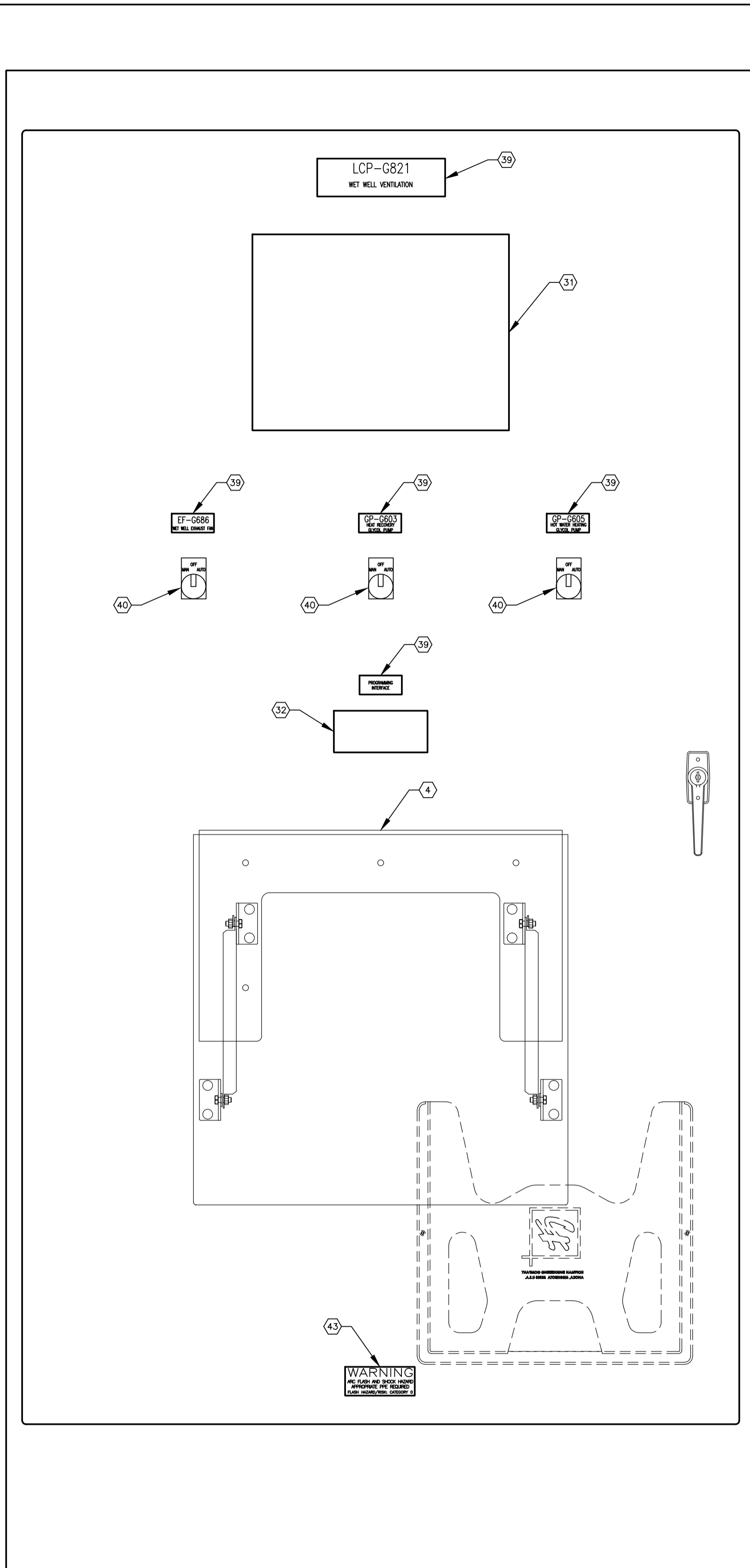
## 18 SAMPLE DRAWINGS

SK-A101	Control Panel Layout
SK-A102	PLC Power Schematic
SK-A103	Instrument Loop Diagram
SK-A104	Network Diagram
SK-A105	Instrument Segment Diagram

	<b>Automation Design Guide</b>	Revision: 00	Page 107 of 107
		Document Code: 612620-0013-40ER-0001	

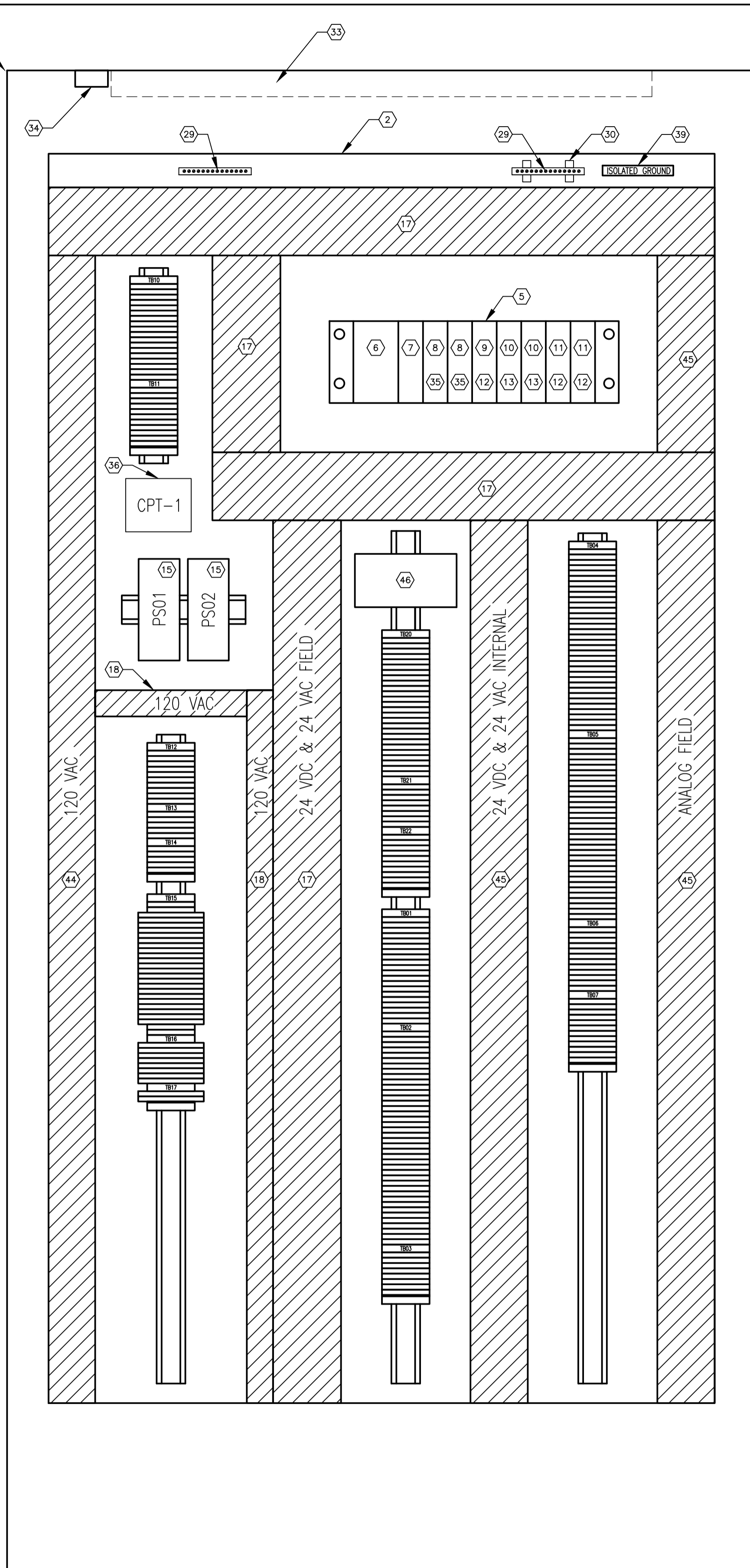
## 19 SAMPLE DOCUMENTS

SD-A101	Instrument List
SD-A102	I/O List
SD-A103	Interface Map
SD-A104	Automation Cable Schedule
SD-A105	Lamacoid Schedule
SD-A106	Functional Requirements Specification: Area "A" – Standard Function Block Classes
SD-A107	Functional Requirements Specification: Area "S" – Secondary Clarifiers



**EXTERIOR PANEL VIEW**  
SCALE: 1 : 4

NOTE: THIS DRAWING IS A SAMPLE DRAWING THAT INDICATES THE TYPICAL REQUIREMENTS FOR CONTROL PANEL LAYOUTS. REFER TO AUTOMATION DESIGN GUIDE (612620-0013-40ER-0001) FOR FURTHER DETAILS.



**INTERIOR PANEL VIEW**  
SCALE: 1 : 4

**BILL OF MATERIAL**

ITEM	QTY	DESCRIPTION	MANUFACTURER	CATALOG NUMBER
1	1	ENCLOSURE, FREE STAND, SINGLE DOOR, NEMA 12	HAMMOND	1418Y18
2	1	BACKPAN FOR ITEM 1	HAMMOND	72YFN
3	-	NOT USED		
4	1	FOLDING SHELF, GREY	HOFFMAN	AASHLF1818
5	1	8 SLOT RACK	SCHNEIDER ELECTRIC	BMX XBP 0800
6	1	RACK POWER SUPPLY, 17 W	SCHNEIDER ELECTRIC	BMX CPS 2010
7	1	PROCESSOR	SCHNEIDER ELECTRIC	BMX P34 2020
8	2	32-POINT DIGITAL INPUT	SCHNEIDER ELECTRIC	BMX DDI 3202K
9	1	16-POINT DIGITAL OUTPUT	SCHNEIDER ELECTRIC	BMX DDO 1602
10	2	8-CHANNEL ANALOG INPUT	SCHNEIDER ELECTRIC	BMX AMI 0810
11	2	4-CHANNEL ANALOG OUTPUT	SCHNEIDER ELECTRIC	BMX AMO 0410
12	3	SCREW CLAMP TERMINAL BLOCK	SCHNEIDER ELECTRIC	BMX FTB 2010
13	2	SPRING CLAMP TERMINAL BLOCK	SCHNEIDER ELECTRIC	BMX FTB 2810
14	-	NOT USED		
15	2	24 VDC POWER SUPPLY	SOLA	SDN 5-24-100C
16	AS REQ'D	35mm DIN RAIL	PHOENIX CONTACT	0801733
17	AS REQ'D	NARROW SLOT WIRING DUCT, 3.25" x 3.12"	PANDUIT	
18	AS REQ'D	NARROW SLOT WIRING DUCT, 1.26" x 3.12"	PANDUIT	
19	AS REQ'D	FEED-THROUGH TERMINAL	PHOENIX CONTACT	3046184
20	AS REQ'D	FUSED TERMINAL	PHOENIX CONTACT	3046142
21	AS REQ'D	FUSE CONNECTOR	PHOENIX CONTACT	3036806
22	AS REQ'D	KNIFE-DISCONNECT TERMINAL	PHOENIX CONTACT	3046139
23	AS REQ'D	POTENTIAL-EARTH TERMINAL	PHOENIX CONTACT	3046207
24	AS REQ'D	TERMINAL END PLATE	PHOENIX CONTACT	3047141
25	AS REQ'D	TERMINAL END CLAMP	PHOENIX CONTACT	1201442
26	AS REQ'D	DOUBLE LEVEL FUSED TERMINAL	PHOENIX CONTACT	3044720
27	AS REQ'D	DOUBLE LEVEL TERMINAL END PLATE	PHOENIX CONTACT	3047293
28	AS REQ'D	PLUG-IN BRIDGE	PHOENIX CONTACT	3030365
29	2	GROUND BAR, 12 TAPS	PANDUIT	UGB2/0-414-12
30	1	GROUND BAR ISOLATION STAND-OFFS	PANDUIT	UGB-IN-S0
31	1	12" TOUCHSCREEN HMI	SCHNEIDER ELECTRIC	XBT GT6330
32	1	POWER & DATA ACCESS PORT	HUBBELL	P155E
33	1	PANEL LIGHT	-	-
34	1	DOOR SWITCH, METAL ENCLOSED	-	-
35	2	PREFORMED CORSET	SCHNEIDER ELECTRIC	BMX FCW 303
36	1	120:24 VAC TRANSFORMER, 100 VA	-	-
37	-	NOT USED		
38	-	NOT USED		
39	AS REQ'D	LAMACOID, WHITE BACKGROUND, BLACK TEXT	-	-
40	3	SWITCH, 3 POSITION, MAINTAINED	ALLEN BRADLEY	800T
41	AS REQ'D	RELAY TERMINAL BLOCK, 120 VAC	PHOENIX CONTACT	2966197
42	AS REQ'D	RELAY TERMINAL BLOCK, 24 VDC	PHOENIX CONTACT	2966171
43	1	ARC FLASH LAMACOID	-	-
44	AS REQ'D	NARROW SLOT WIRING DUCT, 2.25" x 3.12"	PANDUIT	-
45	AS REQ'D	NARROW SLOT WIRING DUCT, 2.75" x 3.12"	PANDUIT	-
46	1	ETHERNET SWITCH, 5 PORT	MOXA	EDS-305

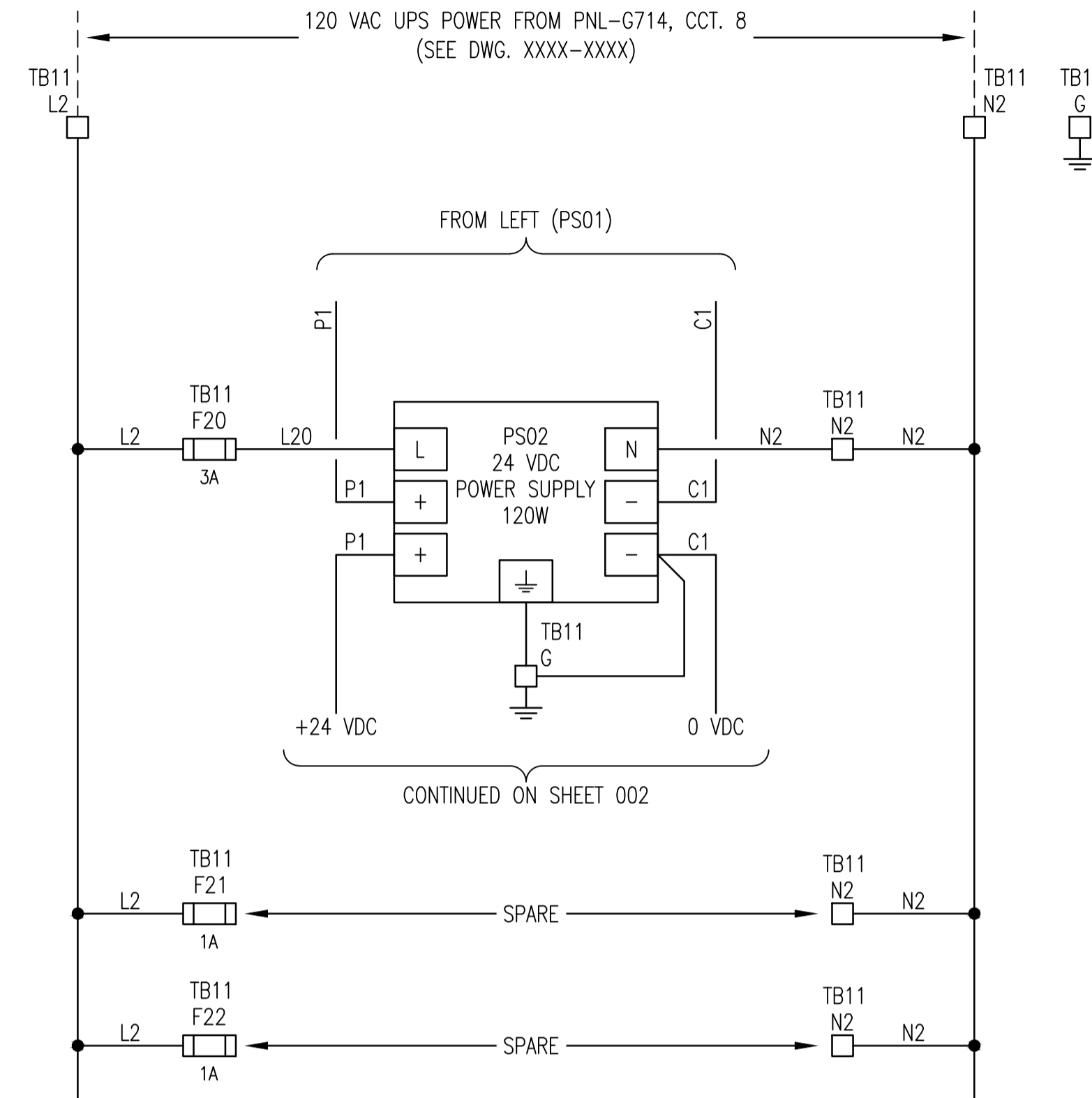
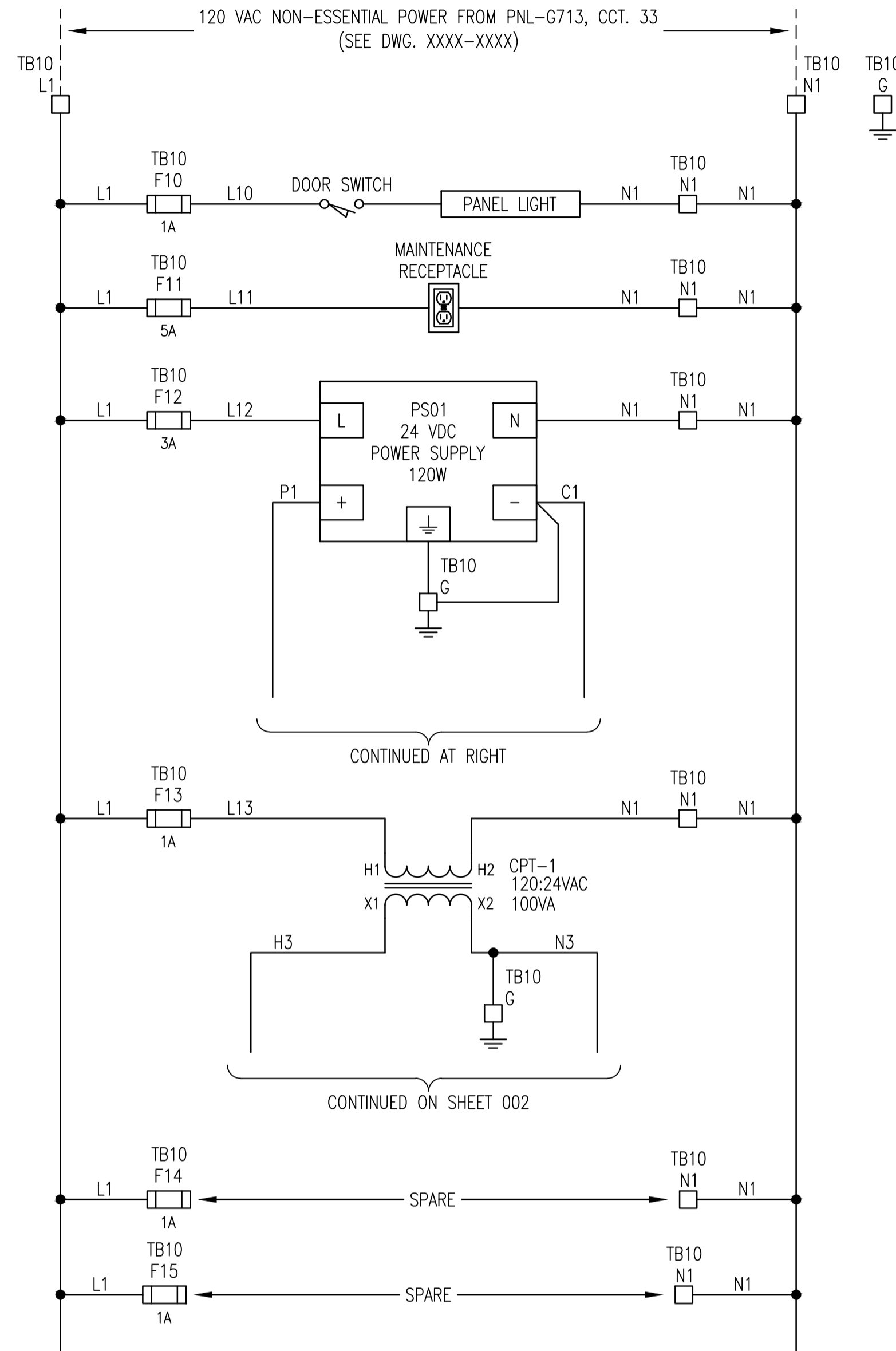
**GENERAL NOTES:**

- ALL POWER WIRING TO BE TEW/MTW 600V, 105°C INSULATION, STRANDED COPPER, 12 AWG OR LARGER WHERE CURRENT REQUIREMENTS DICTATE AS PER CEC REQUIREMENTS.
- ALL CONTROL WIRING TO BE TEW/MTW 300V, 105°C INSULATION, STRANDED COPPER, 16 AWG.
- ALL ANALOG WIRING TO BE 18 AWG SHIELDED TWISTED PAIR, WITH INSULATION RATED AT 300V.
- EXTERNAL COMPONENTS ARE TO BE LABELED AS SHOWN ON THE DRAWINGS.
- ALL FUSES ARE TO BE PROVIDED. IN ADDITION, TWO SPARES OF EACH FUSE SIZE ARE TO BE PROVIDED.
- TEST ALL WIRING AND COMPONENTS FOR FUNCTIONAL OPERATION, CORRECT CONNECTION, CONTINUITY AND INSULATION INTEGRITY. THREE COPIES OF CERTIFIED TEST DOCUMENTATION ARE TO BE PROVIDED.
- ALL MAJOR COMPONENTS INSIDE THE PANEL ARE TO BE LABELED WITH LAMACOIDS IN ACCORDANCE WITH MAJOR DESCRIPTIONS ON THE DRAWINGS.
- PROVIDE WIRE BARREL FERULES FOR ALL WIRING.
- ALL TERMINAL BLOCKS SHALL BE NUMBERED AS SHOWN IN THE DRAWINGS, COMPLETE WITH GROUP LABELING.
- ALL WIRES SHALL BE MARKED AS INDICATED ON THE DRAWINGS.
- ROUTE ALL 24VDC WIRING SEPARATE FROM 120VAC WIRING.
- ALL ETHERNET CABLING IS TO BE ATTACHED TO THE SIDE WALLS OF THE ENCLOSURE AND KEPT AS FAR AS POSSIBLE FROM 120VAC WIRING.
- CLEARLY LABEL DEVICE IDENTIFIERS ON THE DOOR INTERIOR USING LAMACOIDS.
- DOOR CLAMP BLOCKS TO BE REMOVED.
- JUMPER BARS SHALL BE USED INSTEAD OF WIRE JUMPERS WHERE POSSIBLE.

		<b>SNC-LAVALIN INC.</b> 148 Nature Park Way Winnipeg, MB, Canada R3P 0X7 204-786-8080		ENGINEER'S SEAL	
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DRAWN BY:		APPROVED BY:			
SCALE:		ISSUED FOR CONSTRUCTION BY:			
DATE:		DATE:			
ISSUED WITH AUTOMATION DESIGN GUIDE	2015/08/19	-	-	CONSULTANT NO.:	
NO. REVISIONS	DATE	DESIGN	CHECK	CITY DRAWING NUMBER	SK-A101
				SHEET	001
				REV.	00
				SIZE	A1

FUSE SCHEDULE			
TB	IDENTIFIER	SIZE	RATED CURRENT
TB10	F10	5x20mm	1A
	F11	5x20mm	5A
	F12	5x20mm	3A
	F13	5x20mm	1A
	F14	5x20mm	1A
TB11	F20	5x20mm	3A
	F21	5x20mm	1A
	F22	5x20mm	1A

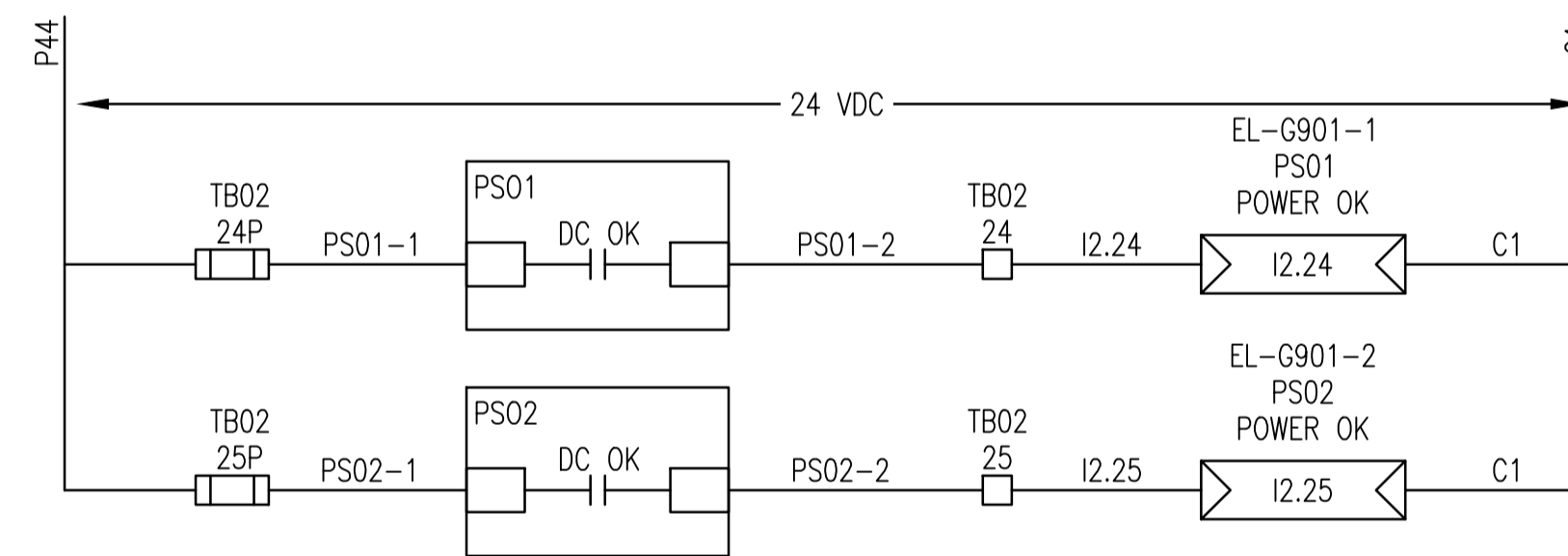
TERMINAL LAYOUT TB10	
L1	
N1	
G	
F10	
F11	
F12	
F13	
F14	
F15	
N1	
N1	
N1	
N1	
N1	
N1	



**GENERAL NOTES:**

- 24VDC POWER SUPPLIES TO BE CAPABLE OF PARALLEL OPERATION.

TERMINAL LAYOUT TB11	
L2	
N2	
G	
F20	
F21	
F22	
N2	
N2	
N2	



NOTE: THIS DRAWING IS A SAMPLE DRAWING THAT INDICATES THE TYPICAL REQUIREMENTS FOR POWER DISTRIBUTION SCHEMATICS. REFER TO AUTOMATION DESIGN GUIDE (612620-0013-40ER-0001) FOR FURTHER DETAILS.

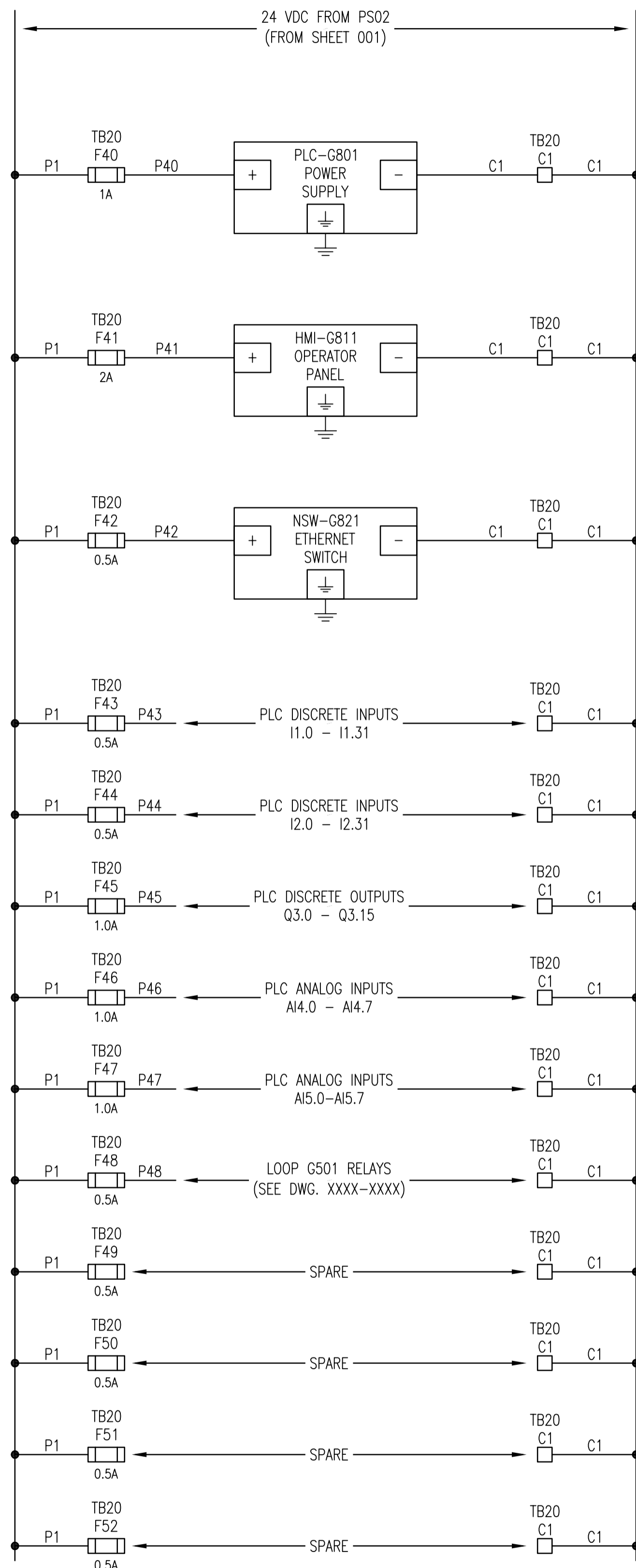
<p>SNC-LAVALIN INC.                  148 Nature Park Way                  Winnipeg, MB, Canada R3P 0X7                  204-786-8080</p>		ENGINEER'S SEAL			
		<p><b>THE CITY OF WINNIPEG</b>                  WATER AND WASTE DEPARTMENT</p> <p>DESIGN STANDARD DRAWINGS                  WINNIPEG SEWAGE TREATMENT PROGRAM                  POWER DISTRIBUTION SCHEMATIC                  LCP-G821</p>			
				<p>CITY DRAWING NUMBER: SK-A102</p>	
				<p>SHEET: 001 REV: 00 SIZE: A1</p>	
<p>DESIGNED BY: _____ CHECKED BY: _____</p>		<p><b>SAMPLE</b></p>			
<p>DRAWN BY: _____ APPROVED BY: _____</p>					
<p>SCALE: _____ ISSUED FOR CONSTRUCTION BY: _____ DATE: _____</p>					
<p>DATE: _____</p>		<p>CONSULTANT NO.:</p>			
<p>00 ISSUED WITH AUTOMATION DESIGN GUIDE 2015/08/19 - -</p>		<p>NO. REVISIONS DATE DESIGN CHECK</p>			

### FUSE SCHEDULE

M	IDENTIFIER	SIZE	RATED CURRENT
TB20	F40	5x20mm	1A
	F41	5x20mm	2A
	F42	5x20mm	0.5A
	F43	5x20mm	0.5A
	F44	5x20mm	0.5A
	F45	5x20mm	1.0A
	F46	5x20mm	1.0A
	F47	5x20mm	1.0A
	F48	5x20mm	0.5A
	F49	5x20mm	0.5A
	F50	5x20mm	0.5A
	F51	5x20mm	0.5A
TB21	F30	5x20mm	1.0A
	F31	5x20mm	1.0A

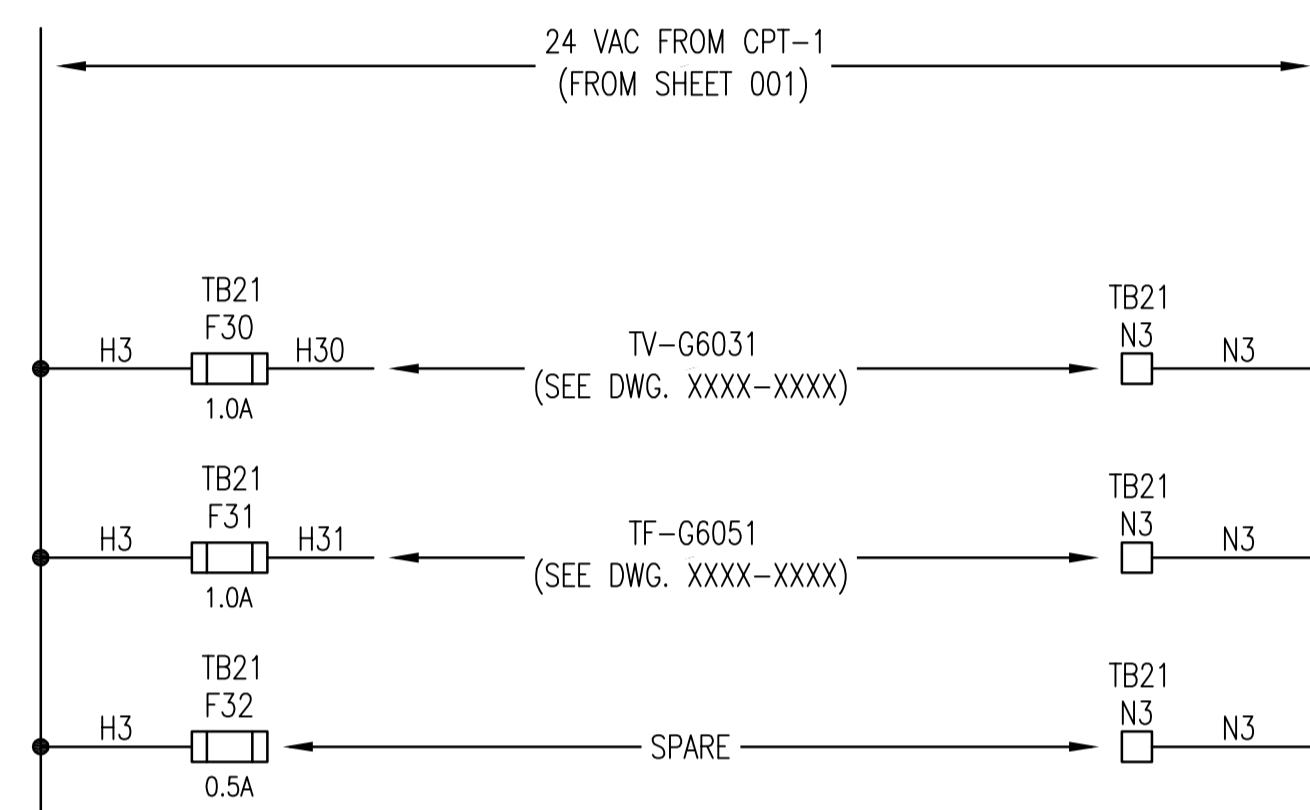
### POWER CONSUMPTION SCHEDULE AT 24 VDC

LOAD	QTY.	CURRENT (mA)	SUBTOTAL (mA)
DISCRETE INPUTS	64	3.5	224
DISCRETE OUTPUTS	8	9	72
DISCRETE OUTPUTS	8	50	400
ANALOG INPUTS	16	20	320
PLC-G10	1	708	708
HMI-G1	1	1250	1250
NSW-LCP-G1	1	92	92
MISC RELAYS	2	38	76
FLOW METERS	2	250	500
<b>TOTAL</b>			<b>3642</b>



### TERMINAL LAYOUT TB20

F40
F41
F42
F43
F44
F45
F46
F47
F48
F49
F50
F51
F52
C1
C1
C1
C1
C1
C1
C1
C1
C1
C1
C1
C1



### TERMINAL LAYOUT TB21

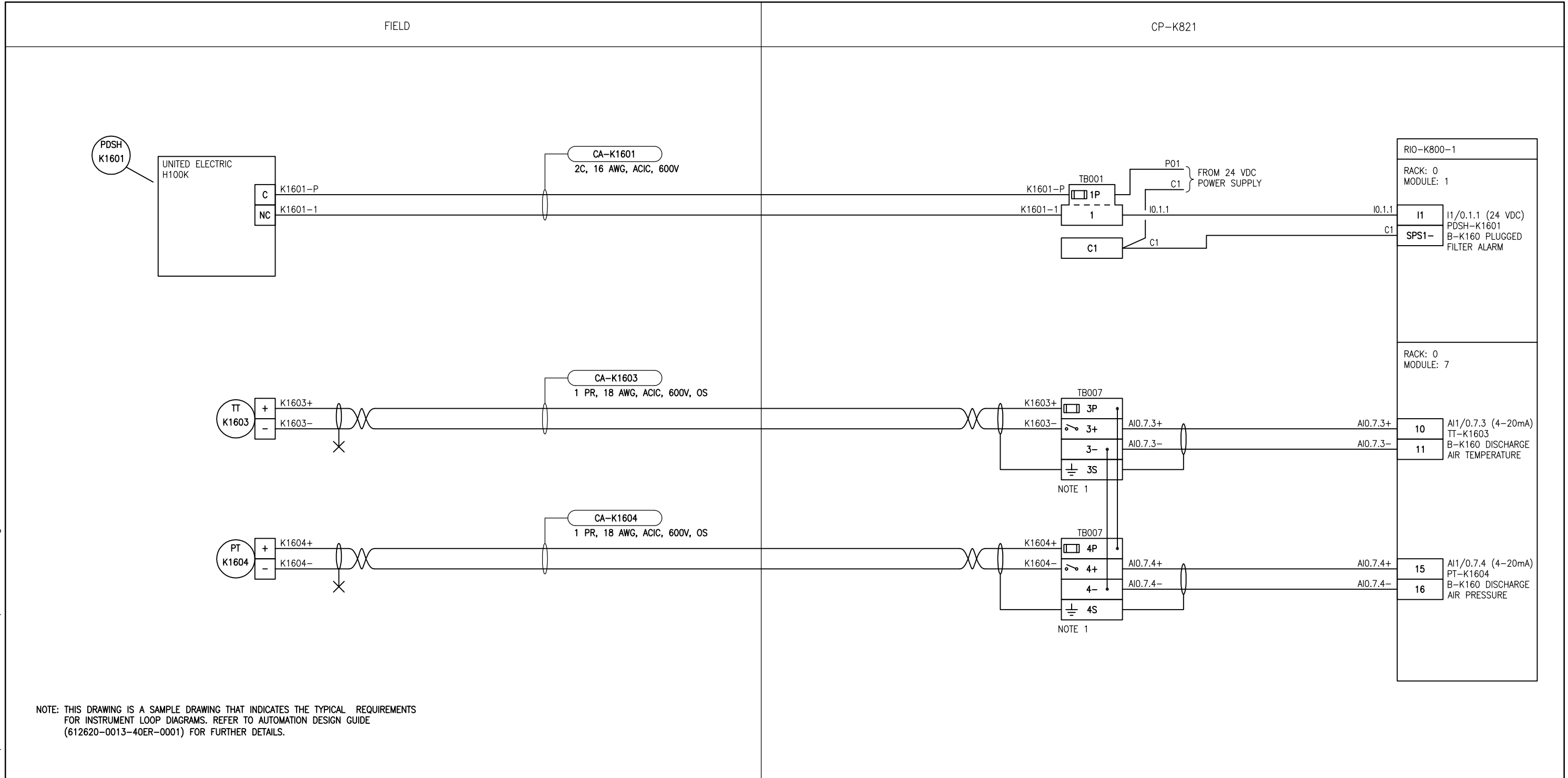
F30
N3
S
F31
N3
F32
N3
S

NOTE: THIS DRAWING IS A SAMPLE DRAWING THAT INDICATES THE TYPICAL REQUIREMENTS FOR POWER DISTRIBUTION SCHEMATICS. REFER TO AUTOMATION DESIGN GUIDE (612620-0013-40ER-0001) FOR FURTHER DETAILS.

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	NO.	REVISIONS	DATE	DESIGN	CHECK									
	00	ISSUED WITH AUTOMATION DESIGN GUIDE	2015/08/19	-	-									
	DESIGNED BY:	CHECKED BY:												
DRAWN BY:	APPROVED BY:													
SCALE:	ISSUED FOR CONSTRUCTION BY:													
DATE:	DATE:	CONSULTANT NO.:	SAMPLE	CITY DRAWING NUMBER										
NO.	REVISIONS	DATE		DESIGN	CHECK									
SK-A102		SHEET		REV.	SIZE									
002		00		A1										

B SIZE - 279mm x 432mm

LAST SAVE: 2015/08/19 - 11:30am  
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NOTE: THIS DRAWING IS A SAMPLE DRAWING THAT INDICATES THE TYPICAL REQUIREMENTS FOR INSTRUMENT LOOP DIAGRAMS. REFER TO AUTOMATION DESIGN GUIDE (612620-0013-40ER-0001) FOR FURTHER DETAILS.

**GENERAL NOTES:**  
 1. GROUNDED TERMINALS CONNECTED TO ISOLATED GROUND THROUGH DIN RAIL.

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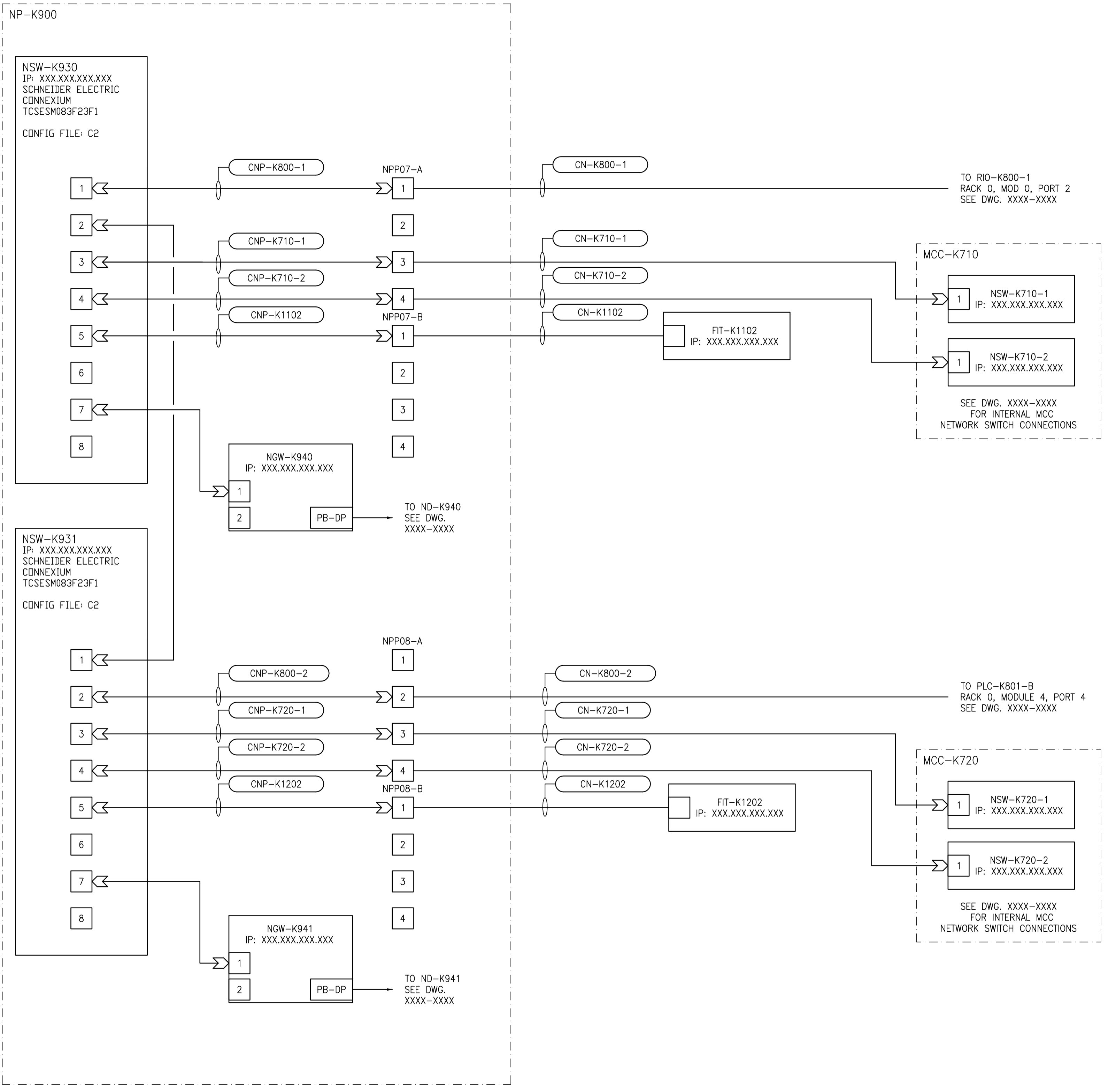
ENGINEER'S SEAL

SAMPLE

**THE CITY OF WINNIPEG**  
 WATER AND WASTE DEPARTMENT

DESIGN STANDARD DRAWINGS  
 WINNIPEG SEWAGE TREATMENT PROGRAM  
 LOOP DIAGRAM  
 PDSH-K1601, TT-K1603, PT-K1604  
 BLOWER B-K160 INSTRUMENTS

CITY DRAWING NUMBER	SHEET	REV.	SIZE
SK-A103	001	00	B



- LEGEND**
- X RJ45 PORT OR PATCH PANEL
  - FIBRE PORT OR PATCH PANEL
  - WALL PLATE RJ45 JACK
  - CAT 6 CABLE, SHIELDED
  - - - FIBRE CABLE
  - FIBRE CONNECTOR
  - >> RJ45 CONNECTOR UNSHIELDED
  - > RJ45 CONNECTOR SHIELDED

**GENERAL NOTES:**

- FIELD RUN COPPER NETWORK CABLES TO BE ARMoured UNLESS OTHERWISE NOTED.

NOTE: THIS DRAWING IS A SAMPLE DRAWING THAT INDICATES THE TYPICAL REQUIREMENTS FOR NETWORK DIAGRAMS. REFER TO AUTOMATION DESIGN GUIDE (612620-0013-40ER-0001) FOR FURTHER DETAILS.

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				SAMPLE				THE CITY OF WINNIPEG WATER AND WASTE DEPARTMENT	
DESIGNED BY:				CHECKED BY:		DESIGN STANDARD DRAWINGS WINNIPEG SEWAGE TREATMENT PROGRAM NETWORK DIAGRAM DEVICE NETWORK			
DRAWN BY:				APPROVED BY:					
SCALE:				ISSUED FOR CONSTRUCTION					
DATE:				DATE:					
ISSUED WITH AUTOMATION DESIGN GUIDE				2015/08/19		- -		CONSULTANT NO.:	
NO. REVISIONS				DATE		DESIGN		CHECK	
CITY DRAWING NUMBER				SHEET		REV.		SIZE	
SK-A104				001		00		A1	



B SIZE - 279mm x 432mm

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FIELD

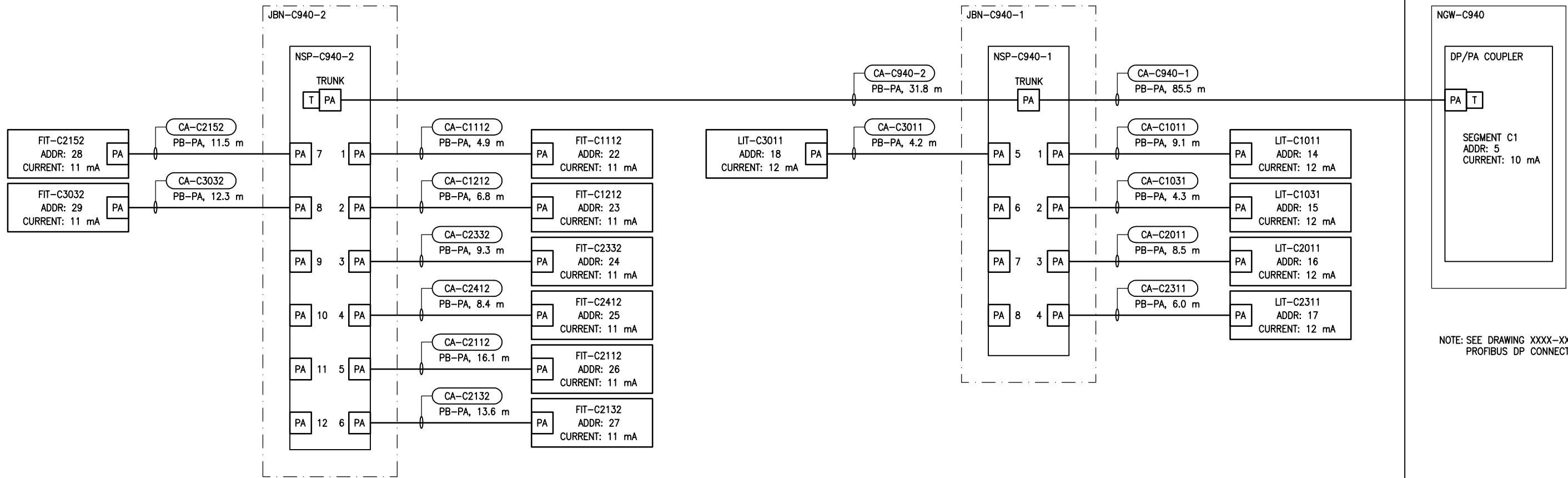
NP-C900

SEGMENT C1 - DESIGN INFORMATION

NO. OF DEVICES	BAUD RATE	MAX LENGTH (m)	TOTAL LENGTH (m)	MAX SPUR LENGTH (m)	LONGEST SPUR (m)	TOTAL CURRENT MAX. (mA)	TOTAL CURRENT USED (mA)
13	31.25 kbps	1900.0	232.3	90.0	16.1	500.0	158.0

GENERAL NOTES

1. ALL CABLE SHIELDS TO BE GROUNDED AT BOTH ENDS.
2. AN EQUIPOTENTIAL BONDING LINE (GROUND CABLE) TO BE RUN WITH EACH PROFIBUS CABLE.



NOTE: SEE DRAWING XXXX-XXXX FOR PROFIBUS DP CONNECTION.

NOTES:

1. THIS DRAWING IS A SAMPLE DRAWING THAT INDICATES THE TYPICAL REQUIREMENTS FOR INSTRUMENT SEGMENT DIAGRAMS. REFER TO AUTOMATION DESIGN GUIDE (612620-0013-40ER-0001) FOR FURTHER DETAILS.



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ENGINEER'S SEAL

DESIGNED BY:	CHECKED BY:
DRAWN BY:	APPROVED BY:
SCALE:	DATE:
ISSUED FOR CONSTRUCTION BY:	DATE:
CONSULTANT NO.:	

**SAMPLE**




THE CITY OF WINNIPEG  
 WATER AND WASTE DEPARTMENT

DESIGN STANDARD DRAWINGS  
 WINNIPEG SEWAGE TREATMENT PROGRAM  
 INSTRUMENT SEGMENT DIAGRAM

NO.	REVISIONS	DATE	DESIGN	CHECK
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CITY DRAWING NUMBER	SHEET	REV.	SIZE
SK-A105	001	00	B


	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> Company Logo </div>	<b>INSTRUMENT LIST</b>	Document Code	SD-A101
			Revision	00
Client City of Winnipeg				
Project SAMPLE				
Package / Area				
Prepared By	Name	Signature	Date	
Checked By	Name	Signature	Date	
Approved By	Name	Signature	Date	
Notes / Comments			Seal	

Revisions					
Rev	Description	Date	By	Checked	Approved
00	Issued with Automation Design Guide	2015-08-19	B. Cleven	T. Church	T. Church

Tag	Description	P&ID Drawing	Plan Drawing	Segment/Schem./ Loop Drawing	Datasheet	Installation Detail	Mounting	Supplied By	Notes
LT-B5801	P-B580 Boiler Room Flood Level Transmitter	1-0102B-A0024	1-0102B-E0012	1-0102B-A0030		1-0102B-E0012	Suspended	Contractor - I&C	
FT-G6013	SF-G601 Flow Transmitter	1-0102G-A0094	1-0102G-A0097	1-0102G-A0114	112577-0116-48ED-0001	1-0102G-A0128	Duct	Contractor - I&C	
PDS-G6012	SF-G601 Filter Differential Pressure Switch	1-0102G-A0094	1-0102G-A0097	1-0102G-A0118			Wall	Contractor - I&C	
TT-G6011	SF-G601 Outside Air Temperature Transmitter	1-0102G-A0094	1-0102G-A0097	1-0102G-A0114	112577-0116-48ED-0003	1-0102G-A0128	Duct	Contractor - I&C	with immersion stem
XV-G6011	SF-G601 Intake Damper	1-0102G-A0094	1-0102G-A0097	1-0102G-E0036			Damper	Contractor - HVAC	
XV-G6014	SF-G601 Discharge Damper	1-0102G-A0094	1-0102G-A0097	1-0102G-E0036			Damper	Contractor - HVAC	
FT-G6023	SF-G602 Flow Transmitter	1-0102G-A0095	1-0102G-A0097	1-0102G-A0115	112577-0116-48ED-0002	1-0102G-A0128	Duct	Contractor - I&C	
XV-G6021	SF-G602 Intake Damper	1-0102G-A0095	1-0102G-A0097	1-0102G-E0037			Damper	Contractor - HVAC	
XV-G6022	SF-G602 Discharge Damper	1-0102G-A0095	1-0102G-A0097	1-0102G-E0037			Damper	Contractor - HVAC	
FSL-G6031	P-G603 Flushing Water Glycol Flow Switch	1-0102G-A0094	1-0102G-A0097	1-0102G-A0118		1-0102G-A0128	Pipe - Inline	Contractor - I&C	
TT-G6032	SF-G601 Intermediate Air Temperature Transmitter	1-0102G-A0094	1-0102G-A0097	1-0102G-A0116	112577-0116-48ED-0004	1-0102G-A0128	Duct	Contractor - I&C	with immersion stem
TT-G6033	HE-G603 Flushing Water Inlet Temperature	1-0102G-A0094	1-0102G-A0097	1-0102G-A0116	112577-0116-48ED-0005		Pipe - Inline	Contractor - I&C	with thermowell
TT-G6034	HE-G603 Flushing Water Outlet Temperature	1-0102G-A0094	1-0102G-A0097	1-0102G-A0116	112577-0116-48ED-0006		Pipe - Inline	Contractor - I&C	with thermowell
TV-G6032	HE-G603 Flushing Water Valve	1-0102G-A0094	1-0102G-A0097	1-0102G-A0116			Pipe - Inline	Contractor - HVAC	
FSL-G6051	P-G605 Hot Water Heating Glycol Flow Switch	1-0102G-A0094	1-0102G-A0097	1-0102G-A0118		1-0102G-A0128	Pipe - Inline	Contractor - I&C	
TT-G6052	SF-G601 Discharge Air Temperature Transmitter	1-0102G-A0094	1-0102G-A0097	1-0102G-A0117	112577-0116-48ED-0007	1-0102G-A0128	Duct	Contractor - I&C	with immersion stem
TV-G6052	HE-G605 Hot Water Valve	1-0102G-A0094	1-0102G-A0097	1-0102G-A0117			Pipe - Inline	Contractor - HVAC	
HS-G6061	Wet Well Entry Station Switch	1-0102G-A0093	1-0102G-A0098	1-0102G-A0090			Wall	N/A	Existing
YL-G6061-1	"Do Not Enter" Lamp	1-0102G-A0093	1-0102G-A0098	1-0102G-A0090			In Enclosure	Contractor - I&C	
YL-G6061-2	"Enter" Lamp	1-0102G-A0093	1-0102G-A0098	1-0102G-A0090			In Enclosure	Contractor - I&C	
PDT-G6081	Wet Well Differential Pressure	1-0102G-A0093	1-0102G-A0097	1-0102G-A0119			Wall	Contractor - I&C	
FSL-G6827	G682-AHU Supply Air Flow Switch	1-0102G-A0026	1-0102G-A0099	1-0102G-A0125			Duct	Contractor - I&C	
PDT-G6825	Electrical Room Differential Pressure	1-0102G-A0026	1-0102G-E0007	1-0102G-A0124			Wall	Contractor - I&C	
TV-G6821-1	AHU-G682.SF Outside Air Intake Damper	1-0102G-A0026	1-0102G-A0099	1-0102G-A0121			Damper	Contractor - HVAC	
TV-G6821-2	AHU-G682.SF Return Air Damper	1-0102G-A0026	1-0102G-A0099	1-0102G-A0121			Damper	Contractor - HVAC	
PV-G6825	AHU-G682.SF Outside Air Relief Damper	1-0102G-A0026	1-0102G-A0099	1-0102G-A0121			Damper	Contractor - HVAC	
TSL-G6826	AHU-G682.SF Low Temperature Switch	1-0102G-A0026	1-0102G-A0099	1-0102G-E0043			Duct	Contractor - I&C	
TT-G6823	AHU-G682.SF Outside Air Temperature Transmitter	1-0102G-A0026	1-0102G-A0099	1-0102G-A0120	112577-0116-48ED-0008	1-0102G-A0128	Duct	Contractor - I&C	with immersion stem
TT-G6824-1	AHU-G682.SF Discharge Air Temperature Transmitter	1-0102G-A0026	1-0102G-A0099	1-0102G-A0120	112577-0116-48ED-0009	1-0102G-A0128	Duct	Contractor - I&C	with immersion stem
TT-G6824-2	AHU-G682.SF Return Air Temperature Transmitter	1-0102G-A0026	1-0102G-A0099	1-0102G-A0120	112577-0116-48ED-0010	1-0102G-A0128	Duct	Contractor - I&C	with immersion stem
TV-G6824-1	AHU-G682.SF Hot Water Control Valve	1-0102G-A0026	1-0102G-A0099	1-0102G-A0122			Pipe - Inline	Contractor - HVAC	
TV-G6824-2	AHU-G682.SF Chilled Water Control Valve	1-0102G-A0026	1-0102G-A0099	1-0102G-A0123			Pipe - Inline	Contractor - HVAC	
XV-G6861	EF-G686 Discharge Damper	1-0102G-A0095	1-0102G-A0099	1-0102G-E0039			Damper	Contractor - HVAC	
XV-G6871	EF-G687 Discharge Damper	1-0102G-A0095	1-0102G-A0099	1-0102G-E0038			Damper	Contractor - HVAC	
TT-G6922	Electrical Room Temperature Transmitter - Above VFDs	1-0102G-A0096	1-0102G-E0007	1-0102G-A0126			Wall	Contractor - I&C	
XV-G6921	EF-G692 Discharge Damper	1-0102G-A0096	1-0102G-E0007	1-0102G-E0042			Damper	Contractor - HVAC	

**Notes:**

1. This instrument list is provided for reference only, and is not necessarily comprehensive.
2. The specific division (Mechanical, HVAC, Electrical, I&C) indicated in the "Supplied By" column is a suggestion only. The Contractor may divide the supply of the instruments between subtrades as required.

	<div style="border: 1px solid black; padding: 5px; width: fit-content;"> Company Logo </div>	<b>I/O LIST - PLC-G801</b>	Document Code	SD-A102
			Revision	00
Client City of Winnipeg				
Project SAMPLE				
Package / Area				
Prepared By	Name	Signature	Date	
Checked By	Name	Signature	Date	
Approved By	Name	Signature	Date	
Notes / Comments			Seal	

Revisions					
Rev	Description	Date	By	Checked	Approved
00	Issued with Automation Design Guide	2015-08-19	B. Cleven	T. Church	T. Church

## Discrete Inputs

PLC	Slot	Point	Tag	Description	0 State	1 State	Notes
PLC-G801	1	0	P-G603.Rdy	P-G603 Ready	Not Ready	Ready	120 VAC relay in CP
PLC-G801	1	1	P-G603.Run	P-G603 Running	Not Running	Running	120 VAC relay in CP
PLC-G801	1	2	P-G605.Rdy	P-G605 Ready	Not Ready	Ready	120 VAC relay in CP
PLC-G801	1	3	P-G605.Run	P-G605 Running	Not Running	Running	120 VAC relay in CP
PLC-G801	1	4	EF-G686.Rdy	EF-G686 Ready	Not Ready	Ready	120 VAC relay in CP
PLC-G801	1	5	EF-G686.Run	EF-G686 Running	Not Running	Running	120 VAC relay in CP
PLC-G801	1	6	XV-G6861.ZSC	EF-G686 Damper Closed	Not Closed	Closed	120 VAC relay in CP
PLC-G801	1	7	XV-G6861.ZSO	EF-G686 Damper Open	Not Open	Open	120 VAC relay in CP
PLC-G801	1	8	EF-G686.IS	EF-G686 Motor Loaded	Not Loaded	Loaded	120 VAC relay in CP
PLC-G801	1	9		SPARE			120 VAC relay in CP
PLC-G801	1	10		SPARE			120 VAC relay in CP
PLC-G801	1	11		SPARE			120 VAC relay in CP
PLC-G801	1	12		SPARE			120 VAC relay in CP
PLC-G801	1	13		SPARE			120 VAC relay in CP
PLC-G801	1	14		SPARE			120 VAC relay in CP
PLC-G801	1	15		SPARE			120 VAC relay in CP
PLC-G801	1	16	P-G603.Rem	P-G603 Auto Mode	Not Auto	Auto	
PLC-G801	1	17	FSL-G6031	P-G603 No Flow	No Flow	Flow	
PLC-G801	1	18	P-G605.Rem	P-G605 Auto Mode	Not Auto	Auto	
PLC-G801	1	19	FSL-G6051	P-G605 No Flow	No Flow	Flow	
PLC-G801	1	20	EF-G686.Rem	EF-G686 Auto Mode	Not Auto	Auto	
PLC-G801	1	21		SPARE			
PLC-G801	1	22		SPARE			
PLC-G801	1	23		SPARE			
PLC-G801	1	24		SPARE			
PLC-G801	1	25		SPARE			
PLC-G801	1	26		SPARE			
PLC-G801	1	27		SPARE			
PLC-G801	1	28		SPARE			
PLC-G801	1	29		SPARE			
PLC-G801	1	30		SPARE			
PLC-G801	1	31		SPARE			
PLC-G801	2	0	VFD-G601.Rem	SF-G601 Auto Mode	Not Auto	Auto	
PLC-G801	2	1	VFD-G601.Rdy	SF-G601 Ready	Not Ready	Ready	
PLC-G801	2	2	VFD-G601.Run	SF-G601 Running	Stopped	Running	
PLC-G801	2	3	XV-G6011.ZSC	SF-G601 Inlet Damper Closed	Not Closed	Closed	
PLC-G801	2	4	XV-G6011.ZSO	SF-G601 Inlet Damper Fully Open	Not Fully Open	Fully Open	
PLC-G801	2	5	XV-G6014.ZSC	SF-G601 Outlet Damper Closed	Not Closed	Closed	
PLC-G801	2	6	XV-G6014.ZSO	SF-G601 Outlet Damper Fully Open	Not Fully Open	Fully Open	
PLC-G801	2	7	PDS-G6012	SF-G601 Outdoor Air Filter Plugged	Not Plugged	Plugged	
PLC-G801	2	8	VFD-G602.Rem	SF-G602 Auto Mode	Not Auto	Auto	
PLC-G801	2	9	VFD-G602.Rdy	SF-G602 Ready	Not Ready	Ready	
PLC-G801	2	10	VFD-G602.Run	SF-G602 Running	Stopped	Running	
PLC-G801	2	11	XV-G6021.ZSC	SF-G602 Inlet Damper Closed	Not Closed	Closed	
PLC-G801	2	12	XV-G6021.ZSO	SF-G602 Inlet Damper Fully Open	Not Fully Open	Fully Open	
PLC-G801	2	13	XV-G6022.ZSC	SF-G602 Discharge Damper Closed	Not Closed	Closed	
PLC-G801	2	14	XV-G6022.ZSO	SF-G602 Discharge Damper Fully Open	Not Fully Open	Fully Open	
PLC-G801	2	15		SPARE			
PLC-G801	2	16		SPARE			
PLC-G801	2	17	VFD-G687.Rem	EF-G687 Auto Mode	Not Auto	Auto	
PLC-G801	2	18	VFD-G687.Rdy	EF-G687 Ready	Not Ready	Ready	
PLC-G801	2	19	VFD-G687.Run	EF-G687 Running	Stopped	Running	
PLC-G801	2	20	XV-G6871.ZSC	EF-G687 Damper Closed	Not Closed	Closed	
PLC-G801	2	21	XV-G6871.ZSO	EF-G687 Damper Fully Open	Not Fully Open	Fully Open	
PLC-G801	2	22	HS-G6061.Occ	Wet Well Occupied Switch	Unoccupied	Occupied	
PLC-G801	2	23	AA-G5015	Gas Detection Alarm	Okay	Alarm	
PLC-G801	2	24	LCP-G1.EA-1	LCP-G1 PS01 Power OK	Fail	Okay	
PLC-G801	2	25	LCP-G1.EA-2	LCP-G1 PS02 Power OK	Fail	Okay	
PLC-G801	2	26		SPARE			
PLC-G801	2	27		SPARE			
PLC-G801	2	28		SPARE			
PLC-G801	2	29		SPARE			
PLC-G801	2	30		SPARE			
PLC-G801	2	31		SPARE			

## Discrete Outputs


PLC	Slot	Point	Tag	Description	0 State	1 State	Notes
PLC-G801	3	0	P-G603.CmdRun	P-G603 Run Command	Stop	Run	Relay in CP
PLC-G801	3	1	P-G605.CmdRun	P-G605 Run Command	Stop	Run	Relay in CP
PLC-G801	3	2	EF-G686.CmdRun	EF-G686 Run Command	Stop	Run	Relay in CP
PLC-G801	3	3		SPARE			Relay in CP
PLC-G801	3	4		SPARE			Relay in CP
PLC-G801	3	5		SPARE			Relay in CP
PLC-G801	3	6		SPARE			Relay in CP
PLC-G801	3	7		SPARE			Relay in CP
PLC-G801	3	8	VFD-G601.CmdRun	SF-G601 Run Command	Stop	Run	
PLC-G801	3	9	VFD-G602.CmdRun	SF-G602 Run Command	Stop	Run	
PLC-G801	3	10	VFD-G687.CmdRun	EF-G687 Run Command	Stop	Run	
PLC-G801	3	11	YL-G6061-1.CmdOn	Wet Well "Do Not Enter" Lamp	Off	On	
PLC-G801	3	12	YL-G6061-2.CmdOn	Wet Well "Enter" Lamp	Off	On	
PLC-G801	3	13	QA-G6071	Wet Well Ventilation Failure Signal	Okay	Alarm	
PLC-G801	3	14		SPARE			
PLC-G801	3	15		SPARE			

## Analog Inputs

Rack	Slot	Point	Tag	Description	Type	EU Range	Notes
PLC-G801	4	0	FT-G6013	SF-G601 Air Flow	4-20 mA	0 - 1500 l/s	
PLC-G801	4	1	TT-G6011	SF-G601 Outdoor Air Temperature	4-20 mA	-40-40 °C	
PLC-G801	4	2	TT-G6032	SF-G601 Intermediate Temperature	4-20 mA	-40-40 °C	
PLC-G801	4	3	TT-G6033	HE-G603 Flushing Water Inlet Temperature	4-20 mA	-10-30 °C	
PLC-G801	4	4	TT-G6034	HE-G603 Flushing Water Discharge Temperature	4-20 mA	-10-30 °C	
PLC-G801	4	5	TT-G6052	SF-G601 Discharge Air Temperature	4-20 mA	-40-40 °C	
PLC-G801	4	6		SPARE			
PLC-G801	4	7		SPARE			
PLC-G801	5	0	FT-G6023	SF-G602 Air Flow	4-20 mA	0-4000 l/s	
PLC-G801	5	1	PDT-G6081	Wet Well Differential Pressure	4-20 mA	-250 - 250 Pa	
PLC-G801	5	2	VFD-G687.IT	EF-G687 Motor Current	4-20 mA	0 - 10A	
PLC-G801	5	3		SPARE			
PLC-G801	5	4		SPARE			
PLC-G801	5	5		SPARE			
PLC-G801	5	6		SPARE			
PLC-G801	5	7		SPARE			

## Analog Outputs

PLC	Slot	Point	Tag	Description	Type	EU Range	Notes
PLC-G801	6	0	VFD-G601.CmdS	SF-G601 Speed Control	4-20 mA	0 - 100%	
PLC-G801	6	1	TV-G6032.CmdZ	HE-G603 Flushing Water Control Valve	4-20 mA	0 - 100%	
PLC-G801	6	2	TV-G6052.CmdZ	HE-G605 Hot Water Control Valve	4-20 mA	0 - 100%	
PLC-G801	6	3	VFD-G687.CmdS	EF-G687 Speed Control	4-20 mA	0 - 100%	
PLC-G801	7	0	VFD-G602.CmdS	SF-G602 Speed Control	4-20 mA	0 - 100%	
PLC-G801	7	1		SPARE			
PLC-G801	7	2		SPARE			
PLC-G801	7	3		SPARE			


	<div style="border: 1px solid black; padding: 5px; text-align: center;"> <b>Company Logo</b> </div>	<h2 style="margin: 0;">INTERFACE MAP</h2>	Document Code	SD-A103
			Revision	00
Client City of Winnipeg				
Project SAMPLE				
Package / Area				
Prepared By	Name	Signature	Date	
Checked By	Name	Signature	Date	
Approved By	Name	Signature	Date	
Notes / Comments			Seal	

Revisions					
Rev	Description	Date	By	Checked	Approved
00	Issued with Automation Design Guide	2015-08-19	B. Clevon	T. Church	T. Church

Discrete Variable	Var. Type	PLC	PLC Address	Modbus Address	Description	0 State	1 State
SF_G601.Alm	EBOOL	PLC-G801	%M100	000100	SF-G601 Wet Well Supply Fan Alarm	OK	Alarm
FT_G601.Alm	EBOOL	PLC-G801	%M101	000101	SF-G601 Flow Transmitter Alarm	OK	Alarm
GP_G603.Alm	EBOOL	PLC-G801	%M102	000102	P-G603 Glycol Pump Alarm	OK	Alarm
TV_G603.Alm	EBOOL	PLC-G801	%M103	000103	TV-G603 Flushing Water Control Valve Alarm	OK	Alarm
GP_G605.Alm	EBOOL	PLC-G801	%M104	000104	P-G605 Alarm	OK	Alarm
TV_G605.Alm	EBOOL	PLC-G801	%M105	000105	TV-G605 Hot Water Control Valve Alarm	OK	Alarm
EF_G687.Alm	EBOOL	PLC-G801	%M106	000106	G687-EF Wet Well Exhaust Fan Alarm	OK	Alarm
PC_G608.Alm	EBOOL	PLC-G801	%M107	000107	PC-G608 Wet Well Differential Pressure Alarm	OK	Alarm
SF_G602.Alm	EBOOL	PLC-G801	%M108	000108	SF-G602 Wet Well Supply Fan Alarm	OK	Alarm
FT_G602.Alm	EBOOL	PLC-G801	%M109	000109	SF-G602 Flow Transmitter Alarm	OK	Alarm
EF_G686.Alm	EBOOL	PLC-G801	%M110	000110	EF-G686 Wet Well Exhaust Fan Alarm	OK	Alarm
KQA_G606	EBOOL	PLC-G801	%M111	000111	Wet Well Occupied for > 8 hours	OK	Alarm
EA_G901_1	EBOOL	PLC-G801	%M112	000112	LCP-G1 PS01 Power Supply Fail	OK	Alarm
EA_G901_2	EBOOL	PLC-G801	%M113	000113	LCP-G1 PS02 Power Supply Fail	OK	Alarm
P_G603.Run	EBOOL	PLC-G801	%M401	000401	P-G603 Running	Not Running	Running
P_G605.Run	EBOOL	PLC-G801	%M403	000403	P-G605 Running	Not Running	Running
EF_G686.Run	EBOOL	PLC-G801	%M405	000405	EF-G686 Running	Not Running	Running
SF_G601.Run	EBOOL	PLC-G801	%M434	000434	SF-G601 Running	Not Running	Running
SF_G602.Run	EBOOL	PLC-G801	%M442	000442	SF-G602 Running	Not Running	Running
EF_G687.Run	EBOOL	PLC-G801	%M451	000451	G687-EF Running	Not Running	Running
AHU_G682.Alm	EBOOL	PLC-G802	%M100	000100	AHU-G682 Electrical Room AHU Alarm	OK	Alarm
TT_G682_3.Alm	EBOOL	PLC-G802	%M101	000101	AHU-G682 Return Air Temperature Alarm	OK	Alarm
TT_G682_2.Alm	EBOOL	PLC-G802	%M102	000102	AHU-G682 Supply Air Temperature Alarm	OK	Alarm
FV_G682_1.Alm	EBOOL	PLC-G802	%M103	000103	AHU-G682 Intake Damper Alarm	OK	Alarm
FV_G682_2.Alm	EBOOL	PLC-G802	%M104	000104	AHU-G682 Return Air Damper Alarm	OK	Alarm
PC_G682.Alm	EBOOL	PLC-G802	%M105	000105	Grit Electrical Room Pressure Alarm	OK	Alarm
PV_G682_3.Alm	EBOOL	PLC-G802	%M106	000106	AHU-G682 Relief Air Damper Alarm	OK	Alarm
G692_TT.Alm	EBOOL	PLC-G802	%M107	000107	Grit Electrical Room Temperature Alarm	OK	Alarm
G692_EF.Alm	EBOOL	PLC-G802	%M108	000108	EF-G692 Grit Electrical Room Exhaust Fan Alarm	OK	Alarm
EA_G902_1	EBOOL	PLC-G802	%M109	000109	G902 LCP-G2 PS01 Power Supply Fail	OK	Alarm
EA_G902_2	EBOOL	PLC-G802	%M110	000110	G902 LCP-G2 PS02 Power Supply Fail	OK	Alarm
AHU_G682.Run	EBOOL	PLC-G802	%M401	000401	AHU-G682 Running	Not Running	Running
EF_G692.Run	EBOOL	PLC-G802	%M404	000404	EF-G692 Fan Running	Not Running	Running



Analog Variable	Var. Type	PLC	PLC Address	Modbus Address	Description	Min	Max	Units
G6001_FC.State	INT	PLC-G801	%MW100	400100	G6001 Ventilation State	0	3	
SI_G601	REAL	PLC-G801	%MW102	400102	SF-G601 Speed	0.0	100.0	%
FI_G601	REAL	PLC-G801	%MW104	400104	SF-G601 Airflow (ACH)	0.0	14.98	ACH
TC_G603	REAL	PLC-G801	%MW106	400106	TV-G603 Flushing Water Control Valve Position Output	0.0	100.0	%
TC_G605	REAL	PLC-G801	%MW108	400108	TV-G605 Hot Water Control Valve Position Output	0.0	100.0	%
SI_G687	REAL	PLC-G801	%MW110	400110	EF-G687 Speed	0.0	100.0	%
PDT_G608	REAL	PLC-G801	%MW112	400112	Wet Well Differential Pressure	-250.0	250.0	Pa
SI_G602	REAL	PLC-G801	%MW114	400114	SF-G602 Speed	0.0	100.0	%
FI_G602	REAL	PLC-G801	%MW116	400116	SF-G602 Airflow (ACH)	0.0	15.93	ACH
PLC_G801.Heartbeat	INT	PLC-G801	%MW118	400118	PLC-G801 Heartbeat	0	32767	
TT_G682_3	REAL	PLC-G802	%MW100	400100	AHU-G682 Return Air Temperature	0.0	50.0	°C
TT_G682_2	REAL	PLC-G802	%MW102	400102	AHU-G682 Supply Air Temperature	-40.0	60.0	°C
ZT_G682_1	REAL	PLC-G802	%MW104	400104	ZT-G6821 Intake Air Damper Position Feedback, % Open	0.0	100.0	%
ZT_G682_2	REAL	PLC-G802	%MW106	400106	ZT-G6822 Return Air Damper Position Feedback, % Open	0.0	100.0	%
PDT_G682	REAL	PLC-G802	%MW108	400108	PDT-G682 Grit Electrical Room Differential Pressure	-100.0	100.0	Pa
ZT_G682_3	REAL	PLC-G802	%MW110	400110	AHU-G682 Relief Air Damper Position Feedback, % Open	0.0	100.0	%
TT_G692	REAL	PLC-G802	%MW112	400112	TT-G692 Grit Electrical Room Temperature – VFD Area	0.0	50.0	°C
PLC_G802.Heartbeat	INT	PLC-G802	%MW114	400114	PLC-G802 Heartbeat	0	32767	

	<div style="border: 1px solid black; padding: 5px; text-align: center;"> <b>Company Logo</b> </div>	<b>AUTOMATION CABLE SCHEDULE</b>		Document Code	SD-A104
				Revision	00
Client City of Winnipeg					
Project SAMPLE					
Package / Area					
Prepared By	Name	Signature	Date		
Checked By	Name	Signature	Date		
Approved By	Name	Signature	Date		
Notes / Comments				Seal	


Revisions						
Rev	Description	Date	By	Checked	Approved	
00	Issued with Automation Design Guide	2015-08-19	B. Cleven	T. Church	T. Church	

Cable ID	Cable Type	From	To	Spacing See Note 1	Length (m)	Notes	Rev
CA-G601-1	20C, 16 AWG, ACIC, 600V	LCP-G1	VFD-G601	0%	4.5		00
CA-G601-2	1 PR, 18 AWG, ACIC, 300V, OS	LCP-G1	VFD-G601	0%	4.5		00
CA-G6011	5C, 14 AWG, TECK90, 600V	VFD-G601	JBA-XV-G6011	0%	17		00
CA-G6014	5C, 14 AWG, TECK90, 600V	VFD-G601	JBA-XV-G6014	0%	19		00
CA-G6013	2 PR, 16 AWG, ACIC, 300V, ISOS	LCP-G1	FT-G6013	0%	14.5		00
CA-G6012	2C, 16 AWG, ACIC, 300V	LCP-G1	PDS-G6012	0%	13.5		00
CA-G6015	1PR, 18 AWG, ACIC, 300V, OS	LCP-G1	TT-G6015	0%	15.5		00
CA-G602-1	20C, 16 AWG, ACIC, 600V	LCP-G1	VFD-G602	0%	5.5		00
CA-G602-2	1 PR, 18 AWG, ACIC, 300V, OS	LCP-G1	VFD-G602	0%	5.5		00
CA-G6021	5C, 14 AWG, TECK90, 600V	VFD-G602	JBA-XV-G6021	0%	6		00
CA-G6022	5C, 14 AWG, TECK90, 600V	VFD-G602	JBA-XV-G6022	0%	8		00
CA-G6023	2 PR, 16 AWG, ACIC, 300V, ISOS	LCP-G1	FT-G6023	0%	8		00
CA-G603-1	4C, 14 AWG, TECK90, 600V	LCP-G1	MCC-G710	0%	47.5		00
CA-G6032-1	2 PR, 16 AWG, ACIC, 300V, ISOS	LCP-G1	TV-G6032	0%	20		00
CA-G6031	3C, 16 AWG, ACIC, 300V	LCP-G1	FSL-G6031	0%	24		00
CA-G6032-2	1 PR, 18 AWG, ACIC, 300V, OS	LCP-G1	TT-G6032	0%	13		00
CA-G6033	1 PR, 18 AWG, ACIC, 300V, OS	LCP-G1	TT-G6033	0%	22		00
CA-G6034	1 PR, 18 AWG, ACIC, 300V, OS	LCP-G1	TT-G6034	0%	22		00
CA-G605-1	4C, 14 AWG, TECK90, 600V	LCP-G1	MCC-G710	0%	45		00
CA-G6052-1	1 PR, 18 AWG, ACIC, 300V, OS	LCP-G1	TT-G6052	0%	14		00
CA-G6052-2	2 PR, 16 AWG, ACIC, 300V, ISOS	LCP-G1	TV-G6052	0%	20		00
CA-G6051	3C, 16 AWG, ACIC, 300V	LCP-G1	FSL-G6051	0%	24		00
CA-G6061	2C, 14 AWG, TECK90, 600V	JBA-G606	HS-G6061	0%	1.5		00
CA-JBA-G606	5C, 14 AWG, TECK90, 600V	LCP-G1	JBA-G606	0%	31.5		00
CA-G607-1	2C, 16 AWG, ACIC, 300V	LCP-G1	JBA-GDC-G1	0%	28		00
CA-G6081	1 PR, 18 AWG, ACIC, 300V, OS	LCP-G1	PDT-G6081	0%	25		00
CA-G6823	1 PR, 18 AWG, ACIC, 300V, OS	LCP-G2	TT-G6823	0%	11.5		00
CA-G6824-1	1 PR, 18 AWG, ACIC, 300V, OS	LCP-G2	TT-G6824-1	0%	8.5		00
CA-G6824-2	1 PR, 18 AWG, ACIC, 300V, OS	LCP-G2	TT-G6824-2	0%	6		00
CA-G6821-1	3PR, 16 AWG, ACIC, 300V, ISOS	LCP-G2	JBA-TV-G6821-1	0%	5		00
CA-G6821-2	3PR, 16 AWG, ACIC, 300V, ISOS	LCP-G2	JBA-TV-G6821-2	0%	7		00
CA-G6825-1	3PR, 16 AWG, ACIC, 300V, ISOS	LCP-G1	JBA-PV-G6825	0%	5.5		00
CA-G6824-1	3PR, 16 AWG, ACIC, 300V, ISOS	LCP-G2	TV-G6824-1	0%	6.5		00
CA-G6824-2	3PR, 16 AWG, ACIC, 300V, ISOS	LCP-G2	TV-G6824-2	0%	6.5		00
CA-G6825-2	1 PR, 18 AWG, ACIC, 300V, OS	JBA-G7	PDT-G6825	0%	4		00

Cable ID	Cable Type	From	To	Spacing See Note 1	Length (m)	Notes	Rev
CA-G682-1	5C, 14 AWG, TECK90, 600V	LCP-G2	MCC-G720	0%	50		00
CA-G6827	3C, 16 AWG, ACIC, 300V	LCP-G2	FSL-G6827	0%	8.5		00
CA-G6826-1	2C, 14 AWG, TECK90, 600V	LCP-G2	TSL-G6826	0%	11.5		00
CA-G6826-2	2C, 16 AWG, ACIC, 300V	LCP-G2	TSL-G6826	0%	11.5		00
CA-G6861	5C, 14 AWG, TECK90, 600V	LCP-G1	XV-G6861	0%	16		00
CA-G686-1	6C, 14 AWG, TECK90, 600V	MCC-G720	LCP-G1	0%	45		00
CA-G687-1	20C, 16 AWG, ACIC, 600V	LCP-G1	VFD-G687	0%	6		00
CA-G687-2	2 PR, 18 AWG, ACIC, 300V, ISOS	LCP-G1	VFD-G687	0%	6		00
CA-G6871	5C, 14 AWG, TECK90, 600V	VFD-G687	XV-G6871	0%	18		00
CA-G6922	1 PR, 18 AWG, ACIC, 300V, OS	JBA-G7	TT-G6922	0%	4		00
CA-JBA-G7	2 PR, 18 AWG, ACIC, 300V, ISOS	LCP-G2	JBA-G7	0%	60		00
CA-G692-1	10C, 14 AWG, TECK90, 600V	LCP-G2	MCC-G720	0%	50		00
CA-G6921	5C, 14 AWG, TECK90, 600V	MCC-G720	JBA-XV-G6921	0%	30		00
CN-LCP-G1	ARMOURED CAT-5E	NP-G901	LCP-G1	0%	56.5		00
CN-LCP-G2	ARMOURED CAT-5E	NP-G901	LCP-G2	0%	26		00
CA-G501-10	6C, 16 AWG, ACIC, 300V	LCP-G1	CP-G821	0%	56.5		00
CA-B5801	1 PR, 18 AWG, CIC, 300V, OS	CP-B821	JBA-B580	0%	49		00
CA-B580-1	8C, 14 AWG, 600V, RW90	PCU-SA	MCC-B720	0%	45		00

**Notes:**

1. The Spacing column refers to the minimum percentage of a cable diameter, that must be between the nearest adjacent cable. Where two cables are adjacent, the spacing between the cables shall be the larger of the two spacings specified. Note that cables with a minimum spacing of 0% may not be adjacent to existing or new cables with unspecified spacing except as directed by the Contract Administrator.
2. The length is an estimate only, and is not to be utilized for construction. The Contractor is responsible for determining the required cable lengths.
3. This schedule is provided for reference only. The potential omission of any cables on this schedule, which may be required, does not reduce the Contractor's responsibility in providing a complete installation.
4. All conductors are copper, unless indicated otherwise.


	<div style="border: 1px solid black; padding: 5px; text-align: center;"> Company Logo </div>	<b>LAMACOID SCHEDULE</b>	Document Code	SD-A105
			Revision	00
Client City of Winnipeg				
Project SAMPLE				
Package / Area				
Prepared By	Name	Signature	Date	
Checked By	Name	Signature	Date	
Approved By	Name	Signature	Date	
Notes / Comments				

Revisions					
Rev	Description	Date	By	Checked	Approved
00	Issued with Automation Design Guide	2015/08/19	B. Clevon	T. Church	T. Church

ID No.	Line 1	Line 2	Size (mm)	Note
1	LIT-P5521		5	
2	LE-P5521		5	
3	LIT-P5531		5	
4	LE-P5531		5	
5	P-P552	E-STOP	5	6
6	P-P553	E-STOP	5	6
7	HS-P5521		5	7
8	HS-P5531		5	7
9	PSL-P5523		5	
10	PSL-P5533		5	
11	LSL-P5522		5	
12	LSH-P5522		5	
13	LSHH-P5522		5	
14	LSL-P5532		5	
15	LSH-P5532		5	
16	LSHH-P5532		5	
17	FE-P5524		5	
18	FIT-P5524		5	
19	FE-P5534		5	
20	FIT-P5534		5	
21	HS-P6011		5	7
22	FV-P6011		5	
23	FV-P6012		5	
24	FV-P6013		5	
25	TT-P6011		5	
26	TT-P6021		5	
27	PDS-P6011		5	
28	PDS-P6022		5	
29	TT-P6512		5	
30	XV-P6511		5	
31	TT-P6131		5	

**Notes:**


1. This schedule includes lamacoids for electrical and automation equipment only. Identification requirements for other divisions are not shown.
2. This schedule is provided for reference only and the potential omission of any lamacoids on this schedule does not reduce the Contractor's responsibility in providing lamacoids as specified.
3. Cable tags are not shown. Lighting and receptacle labels are not shown.
4. Lamacoids required for control panels and junction boxes specified to be manufactured by a panel shop are not shown.
5. Lamacoids sizes in accordance with specification section 26 05 01 - Common Work Results.
6. Install the lamacoid above the pushbutton.
7. Install the lamacoid below the pushbutton.

	<div style="border: 1px solid black; padding: 2px;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
			Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes	

Prepared By:		
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			Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes	

### Table of Contents

1.0	Overview .....	3
1.1	Definitions .....	3
2.0	General Requirements .....	4
2.1	PLC Control from HMI .....	4
2.2	Control Interface Requirements .....	4
3.0	Implementation .....	7
3.1	HMI Application .....	7
3.2	PLC Application .....	7
4.0	Standard Function Block Classes .....	8
4.1	Alm Alarm .....	8
4.2	Alm_TD Alarm Time Delay .....	8
4.3	Duty_DS .....	9
4.4	Duty_D2S1 .....	10
4.5	FFC_MOV Flow Ratio Controller Utilizing Most-Open-Valve .....	11
4.6	FIC .....	13
4.7	FIC_MOV .....	15
4.8	Ind Indicator .....	17
4.9	MTR_FBus .....	18
4.10	MTR_VFD_FBus .....	20
4.11	Pump_CleanSpd .....	23
4.12	RAS_UC RAS Withdrawal Controller .....	25
4.13	Samp_Init Sample Initiator .....	26
4.14	Sampler .....	27
4.15	Tank .....	28
4.16	TimeRly Timed Relay .....	29
4.17	ValveD .....	30
4.18	ValveM .....	32




 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

## 1.0 OVERVIEW

This document is intended to provide a description of the common control functions implemented in the process control system (PCS) throughout the entire facility. Common control functions are described using pseudo code and encapsulated in classes. These classes may be instantiated as necessary to control similar types of equipment throughout the facility. Each class also defines a control interface, whose inputs and outputs are interconnected to implement the overall control strategy.

### 1.1 Definitions

Class	A template definition of the logic and variables associated with a particular object. Within the Schneider Unity Pro software, this is typically implemented as a derived function block.
Instance	This is a specific realization of any object. Within the Schneider Unity Pro software, each time a derived function block is used within a PLC program it is an instance of that particular class.
Elementary Function Block	Predefined function blocks in the function block library.
Derived Function Block	A user defined function block containing specific logic that has been added to the function block library. Typically, this is used to be able to re-use PLC program code and make PLC programs more readable.
Control System Function	Functions within a PLC program related to the control and monitoring of equipment/instruments. Control System Functions shown on the P&IDs are typically in the form of a square enclosed circle.
Variable	Data used by a PLC that is stored at a unique memory address within the PLC program.
Tagname	A name for a variable utilized within a PLC program.
Parameter	An attribute of an object. This portion of the tagname provides a description of the signal. These are referred to as functional signal designations in the Identification Standard.

 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

## 2.0 GENERAL REQUIREMENTS

### 2.1 PLC Control from HMI

Configure HMI commands to utilize a SET operation rather than the Momentary On operation. The PLC shall reset the bit. This prevents discrete PLC tags from being stuck on in the event of communication failures, timing issue, or control from multiple HMI nodes.

Pushbuttons on the HMI shall be disabled and enabled appropriately to indicate to the operator which commands/actions are possible at any given time.

Setpoint values from the HMI will be maintained in memory by the PLC until they are modified by the HMI. The HMI will continually read setpoint values from the PLC to ensure that the current value is correctly displayed on the HMI.

### 2.2 Control Interface Requirements

The class definitions contained in this document specify the control interface for each class in tables containing Parameter, Type, Description, Range and HMI columns.

#### 2.2.1 Parameter

The Parameter is the name given to each input or output associated with the class.

#### 2.2.2 Control Interface Type

Type	Description
I	Input – General
IH	Input from the HMI
O	Output
SP	Setpoint (value retained, typically set from HMI)


#### 2.2.3 Range

The Range field is utilized to indicate the extent of acceptable values for the parameter. Examples are indicated in the table below.

Type	Description
0/1	Discrete Value – True / False
0 - 1000	A number between 0 and 1000
10 - 500 ML	Analog value ranging from 10 to 500 megaliters
W1	A discrete command signal from the HMI (reset by the PLC)

#### 2.2.4 HMI Interface

The HMI column in the Control Interface indicates the typical type and location for the corresponding HMI interface. The HMI Interface Type Codes are indicated below.


 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

HMI Type Code	Description
-	Do not show on the HMI
EF-G	Show as graphic on the equipment faceplate, which will popup when the operator clicks on the specific piece of equipment.
EF-L	Show as an indicator light on the equipment faceplate.
EF-PB	Show as a pushbutton on the equipment faceplate.
EF-T	Show as a text display on the equipment faceplate.
EF-TE	Show as a text entry on the equipment faceplate.
EF2-*	Show as a 2 <sup>nd</sup> tab on the equipment faceplate.
EF3-*	Show as a 3 <sup>rd</sup> tab on the equipment faceplate.
GD*-A	Show as an animation on the graphic display, where * is the level of the display.
GD*-BG	Show as a bar graph on the graphic display, where * is the level of the display.
GD*-BGT	Show as a threshold / setpoint on a bar graph.
GD*-CA	Show as a common animation on the graphic display, where * is the level of the display. More than one variable may affect the same animation.
GD*-F	Show as a flag on the graphic display, where * is the level of the display.
GD*-G	Show as a graphic on the graphic display, where * is the level of the display.
GD*-L	Show as an indicator light on the graphic display, where * is the level of the display.
GD*-PB	Show as a pushbutton on the graphic display, where * is the level of the display.
GD*-T	Show as text on the graphic display, where * is the level of the display.
SW-T	Show as text on a settings window.

### 2.2.5 Security

Each input parameter with an HMI Type Code specified in the HMI field will be assigned a security level to restrict the ability of users to perform manual HMI control and modify control system parameters.

Security Type	Description
N	None
L	Low (Accessible to operator security level)
M	Medium (Accessible to senior operators only)
H	High (Accessible to maintenance only)

 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

The following is an example of how an HMI type code and a security level is assigned in the Parameters table within a class definition:

Parameter	Type	Description	Range	HMI
CtrlAutoCmd	IH	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	IH	Set to Manual Control Mode	W1	EF-PB (L)
F	I	Flow	As Req'd	GDx-BG

### 2.2.6 Alarms


The PLC Generated Alarms table in each class definition specifies the alarm points that will be displayed on the alarm list in the HMI. Alarms are inherently designated outputs of the Control Interface, even though they are not explicitly identified in the Control Interface table. The alarm descriptions defined in each class are generic, and are intended to be preceded by the equipment identifier and description corresponding to each instance.

Each alarm is assigned a default priority which indicates the action/response required if that alarm becomes active. See the following table for a list of alarm priorities and corresponding actions. Note that the default priority shown in the class definitions may be superseded by the class instance for a particular piece of equipment, as specified in the supporting FRS documents. When this occurs, the revised alarm priority will be shown in brackets following the alarm tag name (E.g. AlmFit(1)) in the corresponding class instance table

Pri	Description
1	Emergency / High Priority. The alarm requires immediate attention. Also, indicates a requirement for a callout when unmanned.
2	Medium (Warning) Priority. The alarm requires attention within approximately a day, but does not require a callout when unmanned.
3	Low (Advisory) Priority. The alarm does not require immediate attention.

Example

Alarm	Description	Logic	DPri	Reset
S_Fault	Speed Fault	ABS(S - CmdS) > 5% for 30 sec	2	Auto

 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

### 3.0 IMPLEMENTATION

#### 3.1 HMI Application

##### 3.1.1 Layout and Animation

Implement the HMI system in accordance with the City of Winnipeg HMI Layout and Animation Plan, document 612620-0015-40ER-0001.

##### 3.1.2 Variable Naming Convention

Variables are to be named as per the City of Winnipeg Tagname Identification Standard, document 612620-0014-40ER-0001.

#### 3.2 PLC Application

##### 3.2.1 Software Automatic/Manual Modes

In addition to the physical Hand-Off-Auto or Local-Remote switch, each piece of equipment that is controlled by the PLC shall also have a software Automatic and Manual mode. The software Manual mode allows operators to manually control equipment from the HMI rather than the MCC room.


##### 3.2.2 PIDs

The PLC logic shall be written such that bump-less transfer occurs when switching from Automatic to Manual, and vice versa. When a change from software Automatic mode to software Manual mode occurs, move the output of the PID into the Manual speed setpoint. This prevents the speed from changing when entering software Manual mode.

PIDs that are controlling variable frequency drives are to have their Lower Limit configured to be the same as the drive's minimum speed setting to prevent integral windup.

##### 3.2.3 Variable Naming Convention

Variables are to be named as per the City of Winnipeg Tagname Identification Standard, document 612620-0014-40ER-0001.

	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

## 4.0 STANDARD FUNCTION BLOCK CLASSES

### 4.1 Alm Alarm

The Alm class implements a discrete alarm without time delay.

#### 4.1.1 Control Interface

Parameter	Type	Description	Range	HMI
Enbl	I	Enable Alarm (Default = 1)	0/1	
Inp	I	Alarm Signal Input	0/1	
Rst	I	Alarm Reset (Default = 1)	0/1	

#### 4.1.2 PLC Generated Alarms

Alarm	Description	Logic	DPri	Reset
Alarm	As Req'd	If Inp and Enbl	2	As per Rst

*Note: The alarm set logic takes a higher precedence than the reset logic. That is, the alarm will not reset unless the alarm condition is no longer true.*

### 4.2 Alm\_TD Alarm Time Delay

The Alm\_TD class implements a time delay alarm.


#### 4.2.1 Control Interface

Parameter	Type	Description	Range	HMI
Dly	I	Time Delay	0 – X ms	
Enbl	I	Enable Alarm	0/1	
Inp	I	Alarm Signal Input	0/1	
Rst	I	Alarm Reset	0/1	

#### 4.2.2 PLC Generated Alarms

Alarm	Description	Logic	DPri	Reset
Alarm	As Req'd	If Inp and Enbl for Dly msec	2	As per Rst

*Note: The alarm set logic takes a higher precedence than the reset logic. That is, the alarm will not reset unless the alarm condition is no longer true.*

 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

### 4.3 Duty\_DS

The Duty\_DS class selects a lead pump/fan and a standby pump/fan. The class is not configured to run both pumps in parallel.

#### 4.3.1 Control Interface

Parameter	Type	Description	Range	HMI
Eq1_Rdy	I	Equipment 1 is ready	0/1	EF-L
Eq2_Rdy	I	Equipment 2 is ready	0/1	EF-L
EqLead	SP	Desired Lead Equipment	1 - 2	EF-RB
RunInp	I	Equipment is required to run	0/1	
Eq1_CmdRun	O	Equipment 1 Run Command	0/1	EF-L
Eq2_CmdRun	O	Equipment 2 Run Command	0/1	EF-L

#### 4.3.2 PLC Generated Alarms


Alarm	Description	Logic	DPri	Reset
NoEquipment	No Equipment Available to Run	RunInp AND NOT Eq1_Rdy AND NOT Eq2_Rdy	2	Auto

#### 4.3.3 Control Narrative

Perform range checking on EqLead setpoint.

Eq1\_CmdRun = RunInp AND Eq1\_Rdy AND ((EqLead == 1) OR NOT Eq2\_Rdy)

Eq2\_CmdRun = RunInp AND Eq2\_Rdy AND ((EqLead == 2) OR NOT Eq1\_Rdy)

 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

## 4.4 Duty\_D2S1

The Duty\_D2S1 implements a duty / standby arrangement whereby there are two independent duty units of equipment, and one standby unit of equipment, which may be manually set to act as standby for either of the two duty units of equipment. The class is not configured to run the standby in parallel with either of the duty units.

### 4.4.1 Control Interface

Parameter	Type	Description	Range	HMI
EqD1_Rdy	I	Equipment Duty 1 is ready	0/1	EF-L
EqD2_Rdy	I	Equipment Duty 2 is ready	0/1	EF-L
EqS1_Rdy	I	Equipment Standby 1 is ready	0/1	EF-L
EqS1_Assign	SP	Standby Equipment Assignment	1 - 2	EF-RB
RunP1_Inp	I	Equipment Process 1 is required to run	0/1	
RunP2_Inp	I	Equipment Process 2 is required to run	0/1	
EqD1_CmdRun	O	Equipment Duty 1 Run Command	0/1	EF-L
EqD2_CmdRun	O	Equipment Duty 2 Run Command	0/1	EF-L
EqS1_CmdRun	O	Equipment Standby 1 Run Command	0/1	EF-L

### 4.4.2 PLC Generated Alarms

Alarm	Description	Logic	DPri	Reset
NoP1Equipment	No Process 1 Equipment Available to Run	RunP1_Inp AND NOT EqD1_Rdy AND NOT EqS1_Rdy	2	Auto
NoP2Equipment	No Process 2 Equipment Available to Run	RunP2_Inp AND NOT EqD2_Rdy AND NOT EqS1_Rdy	2	Auto

### 4.4.3 Control Narrative


Perform range checking on EqS1\_Assign setpoint.

EqD1\_CmdRun = RunP1\_Inp AND EqD1\_Rdy

EqD2\_CmdRun = RunP2\_Inp AND EqD2\_Rdy

EqS1\_CmdRun = EqS1\_Rdy AND ((RunP1\_Inp AND (EqS1\_Assign == 1) AND NOT EqD1\_Rdy) OR (RunP2\_Inp AND (EqS1\_Assign == 2) AND NOT EqD2\_Rdy))



	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

## 4.5 FFC\_MOV Flow Ratio Controller Utilizing Most-Open-Valve


The FFC\_MOV class allows for flow splitting to ensure a balanced flow to each destination. The flow to each destination is determined by a ratio of the flow capacities of each destination that is in service.

### 4.5.1 Control Interface

Parameter	Type	Description	Range	HMI
D1_F	I	Destination 1 Flow	As Req'd	
D2_F	I	Destination 2 Flow	As Req'd	
D3_F	I	Destination 3 Flow	As Req'd	
D4_F	I	Destination 4 Flow	As Req'd	
D1_F_Cap	SP	Destination 1 Flow Capacity	As Req'd	EF2-TE (H)
D2_F_Cap	SP	Destination 2 Flow Capacity	As Req'd	EF2-TE (H)
D3_F_Cap	SP	Destination 3 Flow Capacity	As Req'd	EF2-TE (H)
D4_F_Cap	SP	Destination 4 Flow Capacity	As Req'd	EF2-TE (H)
D1_InService	I	Destination 1 In Service	0/1	
D2_InService	I	Destination 2 In Service	0/1	
D3_InService	I	Destination 3 In Service	0/1	
D4_InService	I	Destination 4 In Service	0/1	
MOV	SP	Most-Open-Valve	1, 2, 3, 4	EF-RB (L)
D1_F_Perc	O	Destination 1 Percentage of Flow	0 – 100%	GD3-T
D2_F_Perc	O	Destination 2 Percentage of Flow	0 – 100%	GD3-T
D3_F_Perc	O	Destination 3 Percentage of Flow	0 – 100%	GD3-T
D4_F_Perc	O	Destination 4 Percentage of Flow	0 – 100%	GD3-T
D1_F_Tgt	O	Destination 1 Flow Target	As Req'd	EF-T
D2_F_Tgt	O	Destination 2 Flow Target	As Req'd	EF-T
D3_F_Tgt	O	Destination 3 Flow Target	As Req'd	EF-T
D4_F_Tgt	O	Destination 4 Flow Target	As Req'd	EF-T

### 4.5.2 Alarms

Tagname	Description	Logic	Pri	Reset
MOV_Alarm	Most-Open-Valve Selection Error	MOV out of service	1	Auto

 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

### 4.5.3 Control Narrative

Perform range checking on all interface inputs.

For below, i is a reference to all numbers from 1 to 4.

$$F\_Total = \Sigma (Di\_F)$$

$$Di\_F\_Perc = 100 * Di\_F / F\_Total \text{ (Handle case } F\_Total = 0 \text{)}$$

$$F\_CapacityTotal = \Sigma (Di\_InService * Di\_F\_Cap)$$

$$F\_MOV = Select4(D1\_F, D2\_F, D3\_F, D4\_F, MOV)$$

$$F\_MOV\_Cap = Select4(D1\_F\_Cap, D2\_F\_Cap, D3\_F\_Cap, D4\_F\_Cap, MOV)$$


FOR i = 1 to 4

IF i == MOV THEN

$$Di\_F\_Tgt = D1\_F$$

ELSE

$$Di\_F\_Tgt = F\_MOV * Di\_F\_Cap / F\_MOV\_Cap$$

	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

## 4.6 FIC

The FIC class is utilized to implement a Flow-Indicating-Controller control strategy.

### 4.6.1 Control Interface

Parameter	Type	Description	Range	HMI
CtrlAutoCmd	IH	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	IH	Set to Manual Control Mode	W1	EF-PB (L)
F	I	Flow	As Req'd	GDx-BG GDx-T
F_Min	SP	Minimum Flow Capability	As Req'd	EF-TE (M)
F_Max	SP	Maximum Flow Capability	As Req'd	EF-TE (M)
IntIA	I	Interlock When In Auto (Default = 1)	0/1	EF-L
ManPos	IH	Manual Mode Position Output	0 – 100%	EF-TE (L)
SP	I	Setpoint	As Req'd	EF-T
CtrlMan	O	Control Mode Manual	0/1	GDx-F EF-T
CV	O	Controlled Variable Output	0-100%	

### 4.6.2 Alarms


Alarm	Description	Logic	DPri	Reset
InputFail	Transmitter Failure	F is bad quality (Out of range or bad quality from instrument via fieldbus).	2	Auto
SP_FAL	Flow Setpoint Too Low	$F > 0$ AND $F < F\_Min$	3	Auto
SP_FAH	Flow Setpoint Too High	$F > F\_Max$	3	Auto

### 4.6.3 Interlocks

Initiating Event	Action	Control Mode		Set Intlocked Output	Description
		Auto	Manual		
IntIA	Set CV = 0	Y	N	-	Set controller output to 0 upon interlock in auto mode.

### 4.6.4 Control Narrative


When in Auto Mode

	<div style="border: 1px solid black; padding: 5px; text-align: center;"> Company Logo </div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
			Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes	

Utilize PID control to control the CV based upon the SP (Setpoint). Set the direction of control (direct / reverse acting) as required. Provide bumpless control when in Manual Mode.

Where appropriate, link the Auto/Manual Control mode to the corresponding valve/device control station block. Limit the Flow to within [F\_Min, F\_Max]

SAMPLE

 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

## 4.7 FIC\_MOV

The FIC\_MOV class is utilized to implement a Flow-Indicating-Controller that utilizes a MOV (most-open-valve) control strategy to determine the desired flow setpoint.

### 4.7.1 Control Interface


Parameter	Type	Description	Range	HMI
CtrlAutoCmd	I	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	I	Set to Manual Control Mode	W1	EF-PB (L)
F	I	Flow	As Req'd	GDx-BG GDx-T
IntIA	I	Interlock When In Auto (Default = 1)	0/1	EF-L
ManPos	I	Manual Mode Position Output	0 - 100%	EF-TE (L)
MOV	I	Most Open Valve	0/1	EF-L
MOV_Open	SP	Most Open Valve – Open Perc	0 - 100%	EF-TE (M)
SP	I	Setpoint	As Req'd	EF-T
CtrlMan	O	Control Mode Manual	0/1	GDx-F EF-T
CV	O	Controlled Variable Output	0-100%	

### 4.7.2 Alarms

Alarm	Description	Logic	DPri	Reset
InputFail	Transmitter Failure	F is bad quality (Out of range or bad quality from instrument via fieldbus).	2	Auto

### 4.7.3 Interlocks

Initiating Event	Action	Control Mode		Set Intlocked Output	Description
		Auto	Manual		
IntIA	Set CV = 0	Y	N	-	Set controller output to 0 upon interlock in auto mode.

 <div style="border: 1px solid black; padding: 5px; display: inline-block;"> Company Logo </div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

#### 4.7.4 Control Narrative

When in Auto Mode

If the MOV input is active:


Set the CV value to the MOV\_Open setpoint.

If the MOV input is not active:

Utilize PID control to control the CV based upon the SP (Setpoint). Set the direction of control (direct / reverse acting) as required. Provide bumpless control when in Manual Mode.

Where appropriate, link the Auto/Manual Control mode to the corresponding valve/device control station block.

SAMPLE

 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

## 4.8 Ind Indicator

The Ind class is utilized to implement an indicator for an analog value such as flow, temperature, pressure.

### 4.8.1 Control Interface

Parameter	Type	Description	Range	HMI
PV	I	Process Variable	As Req'd	GDx-BG GDx-T

### 4.8.2 Alarms


Alarm	Description	Logic	DPri	Reset
InputFail	Transmitter Failure	PV is bad quality (Out of range or bad quality from instrument via fieldbus).	2	Auto

### 4.8.3 Interlocks

N/A

### 4.8.4 Control Narrative

N/A

	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes


## 4.9 MTR\_FBus

The MTR\_FBus class controls a single speed motor via an intelligent motor starter connected via a fieldbus.

### 4.9.1 Control Interface

Parameter	Type	Description	Range	HMI
CtrlAutoCmd	IH	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	IH	Set to Manual Control Mode	W1	EF-PB (L)
CtrlRem	I	Remote Control (Pump is Controlled by PLC)	0/1	GDx-F EF-L
Flt	I	Starter Fault	0/1	EF-L
FltCode	I	Starter Fault Code	0 - 1000	EF-T
I	I	Motor Average Current	0 - 150% FLC	GD4-T
Intl	I	Interlock (Man/Auto)	0/1	EF-L
IntlA	I	Interlock When In Auto	0/1	EF-L
KQ_Rst	IH	Runtime Totalizer Reset	W1	EF-PB (M)
ManStart	IH	Manual Start Command	W1	EF-PB (L)
ManStart	IH	Manual Stop Command	W1	EF-PB (L)
PowerOn	I	Motor Starter Input Power On	0/1	
PowerStartDly	SP	Start Time Delay After Power On	0 - 1000 sec	EF-TE (M)
Run	I	Motor Running	0/1	GDx-A EF-L
RunInp	I	Auto Run Input	0/1	
Rst	IH	Reset	W1	EF-PB (L)
StarterRdy	I	Motor Starter Ready	0/1	GDx-F EF-T
Warn	I	Starter Warning	0/1	EF-L
WarnCode	I	Starter Warning Code	0 - 1000	EF-T
CtrlMan	O	Control Mode Manual	0/1	GDx-F EF-T
CmdRun	O	Run Command	0/1	
KQ	O	Runtime	0 - 2 <sup>32</sup> -1 min	EF-T
Intlocked	O	Interlocked	0/1	GDx-F



 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

Parameter	Type	Description	Range	HMI
Rdy	O	Motor Ready in Auto	0/1	

#### 4.9.2 PLC Generated Alarms

Alarm	Description	Logic	DPri	Reset
RunFault	Run Fault	PowerOn AND CtrlRem AND ((Run AND NOT CmdRun for 0.5 sec OR (CmdRun AND NOT Run for 0.5 sec) Auto Reset on PowerOn	2	Manual
Starter_Fault	Starter Fault	PowerOn AND Flt	2	Auto

#### 4.9.3 Interlocks

Initiating Event	Action	Control Mode		Set Intlocked Output	Description
		Auto	Manual		
Not PowerOn	Stop	Y	Y	Y	Stop the motor on a power failure.
PowerOn for < PowerStartDly	Stop	Y	N	Y	Prevent motor starting in Auto until the power has been on for the designated time.
NOT StarterRdy OR NOT CtrlRem	Stop	Y	Y	N	Turn off the Run Cmd output if the Starter is not ready or in Remote Mode.
Flt	Stop	Y	Y	N	Stop on a Starter Fault
Intl	Stop	Y	Y	Y	Stop motor regardless if in Auto or Manual Mode.
IntlA	Stop	Y	N	Y	Stop motor if in Auto Mode.


#### 4.9.4 Control Narrative

In Auto mode, set the speed based upon S\_Tgt. Limit the speed to the range [S\_Min, 100% ].

Increment the runtime totalizer (KQ) whenever the pump is running, regardless of Auto/Manual/Local mode.

Ensure that transitions between Auto and Manual are bumpless.

Set the Rdy output to true when the pump is ready for automatic control.


	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

## 4.10 MTR\_VFD\_FBus

The MTR\_VFD\_FBus class controls a VFD driven motor.

### 4.10.1 Control Interface

Parameter	Type	Description	Range	HMI
CtrlAutoCmd	IH	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	IH	Set to Manual Control Mode	W1	EF-PB (L)
CtrlRem	I	Remote Control (Motor is Controlled by PLC)	0/1	GDx-F EF-L
Flt	I	VFD Fault	0/1	
FltCode	I	VFD Fault Code	0 - 1000	EF-T
I	I	Motor Current	0 – 150% FLA	EF-T
Intl	I	Interlock (Man/Auto)	0/1	EF-L
IntlA	I	Interlock When In Auto	0/1	EF-L
KQ_Rst	IH	Runtime Totalizer Reset	W1	EF-PB (M)
ManStart	IH	Manual Start Command	W1	EF-PB (L)
ManStart	IH	Manual Stop Command	W1	EF-PB (L)
PowerOn	I	VFD Input Power On	0/1	
PowerStartDly	SP	Start Time Delay After Power On	0 - 1000 sec	EF-TE (M)
Run	I	Motor Running	0/1	GDx-A EF-L
RunInp	I	Auto Run Input	0/1	
Rst	IH	Reset	W1	EF-PB (L)
S	I	Speed Feedback	0 – 100%	GD4-T EF-T
S_Tgt	I	Speed Target	0 – 100%	
S_Man	I	Manual Mode Speed Input	0 – 100%	EF-TE (L)
S_Min	SP	Minimum Motor Speed	0 – 100%	EF-TE (M)
VFD_Rdy	I	VFD Ready	0/1	GDx-F EF-T
Warn	I	VFD Warning	0/1	EF-L
WarnCode	I	VFD Warning Code	0 - 1000	EF-T

 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes


Parameter	Type	Description	Range	HMI
CtrlMan	O	Control Mode Manual	0/1	GDx-F EF-T
CmdRun	O	Run Command	0/1	
CmdS	O	Speed Output Signal	0-100%	
KQ	O	Runtime	0 - 2 <sup>32</sup> -1 min	EF-T
Intlocked	O	Interlocked	0/1	GDx-F
Rdy	O	Motor Ready in Auto	0/1	

#### 4.10.2 PLC Generated Alarms

Alarm	Description	Logic	DPri	Reset
RunFault	Run Fault	PowerOn AND CtrlRem AND ((Run AND NOT CmdRun for 10 sec OR (CmdRun AND NOT Run for 0.5 sec) Auto Reset on PowerOn	2	Manual
S_Fault	Speed Fault	ABS(S – CmdS) > 5% for 30 sec	2	Auto
VFD_Fault	VFD Fault	PowerOn AND Fit	2	Auto

#### 4.10.3 Interlocks

Initiating Event	Action	Control Mode		Set Intlocked Output	Description
		Auto	Manual		
Not PowerOn	Stop	Y	Y	Y	Stop the motor on a power failure.
PowerOn for < PowerStartDly	Stop	Y	N	Y	Prevent motor starting in Auto until the power has been on for the designated time.
Fit	Stop	Y	Y	N	Stop on a VFD Fault
NOT VFDRdy OR NOT CtrlRem	Stop	Y	Y	N	Turn off the Run Cmd output if the VFD is not ready or in Remote Mode.
Intl	Stop	Y	Y	Y	Stop motor regardless if in Auto or Manual Mode.
IntlA	Stop	Y	N	Y	Stop motor if in Auto Mode.

 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

#### 4.10.4 Control Narrative


In Auto mode, set the speed based upon S\_Tgt. Limit the speed to the range [S\_Min, 100%].

Increment the runtime totalizer (KQ) whenever the motor is running, regardless of Auto/Manual/Local mode.

Ensure that transitions between Auto and Manual are bumpless.

Set the Rdy output to true when the motor is ready for automatic control.

SAMPLE

 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

## 4.11 Pump\_CleanSpd

The Pump\_CleanSpd class controls a variable speed pump to be periodically run at a high speed to clean the pump and associated line.

### 4.11.1 Control Interface


Parameter	Type	Description	Range	HMI
CtrlEnbCmd	IH	Enable Cleanout Mode	W1	EF-PB (L)
CtrlDisCmd	IH	Disable Cleanout Mode	W1	EF-PB (L)
ManStart	IH	Manual Initiate Cleanout	W1	EF-PB (L)
RunInp	I	Countdown Timer	0/1	
K1_SP	SP	Time Before cleanout	0 - 2 <sup>32</sup> -1 min	EF-TE (M)
K2_SP	SP	Cleanout duration	0 - 2 <sup>32</sup> -1 min	EF-TE (M)
S_Inp	I	Speed Input	0 – 100%	
S_Cleanout	SP	Cleanout Speed	0 – 100%	EF-TE (M)
CtrlEnb	O	Cleanout Mode Enabled	0/1	GDx-F EF-T
CmdS	O	Speed Output Signal	0-100%	
KQ	O	Time Until Next Cleanout	0 - 2 <sup>32</sup> -1 min	EF-T
Active	O	Cleanout Active	0/1	GDx-T

### 4.11.2 PLC Generated Alarms

None

### 4.11.3 Interlocks

None

 <div style="border: 1px solid black; padding: 5px; display: inline-block;"> Company Logo </div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

#### 4.11.4 Control Narrative

If CtrlEnb THEN

If K1\_Timer (K1\_SP) expires OR ManStart THEN

Set Active = 1

Initiate K2\_Timer

Reset K1\_Timer

If K2\_Timer expires THEN

Set Active = 0;

Reset K2\_Timer

IF Active THEN // cleanout active


CmdS = S\_Cleanout

ELSE

CmdS = S\_Inp

ELSE // Cleanout not enabled → just pass speed through

CmdS = S\_Inp

	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

## 4.12 RAS\_UC RAS Withdrawal Controller

The RAS Withdrawal Controller determines the appropriate flow setpoint for the RAS pumping.

### 4.12.1.1. Control Interface

Parameter	Type	Description	Range	HMI
CalcModel	SP	Calculation Model (1 = Flow, 2 = Mass)	1 - 2	EF-RB (M)
CtrlAutoCmd	IH	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	IH	Set to Manual Control Mode	W1	EF-PB (L)
F_Man	IH	Manual Mode Flow	0 – 1000 l/s	EF-TE (L)
F_ML	I	Clarifier Mixed Liquor Flow	0 – 1000 ML/d	
F_Perc_SP	SP	Flow Percentage Setpoint	0 – 100%	EF-TE (M)
CtrlMan	O	Control Mode Manual	0/1	Gdx-F EF-T
F_Tgt	O	Target RAS Flow	0 – 1000 l/s	EF-T

### 4.12.2 Control Narrative

When in manual mode (CtrlMan == 1) set F\_Tgt = F\_Man

When CalcModel == 1 (1 = Flow)

$$F\_Tgt \text{ (l/s)} = K (F\_ML \times F\_Perc\_SP)$$

Where


K = 11.574 (unit conversion constant)

F\_ML is the mixed liquor flow

F\_Perc\_SP is the percentage of mixed liquor to be withdrawn as RAS

When CalcModel == 2 (2 = Mass)

Implementation not required as part of demonstration system

 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

## 4.13 Samp\_Init Sample Initiator


### 4.13.1 Control Interface

Parameter	Type	Description	Range	HMI
F	I	Flow	0 – 1000 ML/d	
FQ_SP	FQ	Volume Setpoint	0 – 1000 ML	EF-TE (M)
Compl	I	Sample Complete	0/1	
Out	O	Initiate Sample	0/1	

### 4.13.2 Control Narrative

Integrate the Flow (F) until the total volume reaches the Volume Setpoint (FW\_SP), at which time set the Initiate Sample output (Out) to true. Reset the integrator when the Sample Complete (Compl) input is activated.



	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

## 4.14 Sampler

### 4.14.1 Control Interface

Parameter	Type	Description	Range	HMI
CtrlAutoCmd	IH	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	IH	Set to Manual Control Mode	W1	EF-PB (L)
CtrlRem	I	Remote Control (Sampler is Controlled by PLC)	0/1	GDx-F EF-L
FailInp	I	Fail	0/1	GD3-F
On	I	On	0/1	GD3-A
ManStart	IH	Manual Start Command	W1	EF-PB (L)
ManStop	IH	Manual Stop Command	W1	EF-PB (L)
Rst	IH	Reset	W1	EF-PB (L)
RunInp	I	Initiate Run	0/1	
CtrlMan	O	Control Mode Manual	0/1	GDx-F EF-T
CmdRun	O	Run Command	0/1	

### 4.14.2 PLC Generated Alarms

Alarm	Description	Logic	DPri	Reset
Fail	Sampler Failed	FailInp	2	Auto
RunFault	Run Fault	CtrlRem and CmdRun and NOT On for 3 sec	2	Auto


### 4.14.3 Interlocks

Initiating Event	Action	Control Mode		Set Intlocked Output	Description
		Auto	Manual		
Fail OR RunFault	Stop	Y	Y	N	Turn off the sampler if in alarm.

### 4.14.4 Control Narrative

In Auto mode, set the run output (CmdRun) whenever the RunInp signal is on.

Ensure that transitions between Auto and Manual are bumpless.

 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

## 4.15 Tank

The Tank class is utilized to implement a basic tank, with an in-service flag.

### 4.15.1 Control Interface

Parameter	Type	Description	Range	HMI
InService	SP	In Service	0/1	EF-RB

### 4.15.2 Alarms


N/A

### 4.15.3 Interlocks

N/A

### 4.15.4 Control Narrative

N/A

 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

## 4.16 TimeRly Timed Relay


The TimeRly class is utilized to control a discrete device for a timed duration based upon an input signal.

### 4.16.1 Control Interface

Parameter	Type	Description	Range	HMI
Duration	SP	Duration	0 – 10,000 sec	EF-TE
Inp	I	Input Signal	0/1	
Out	O	Output Signal	0/1	

### 4.16.2 Control Narrative

Upon the Inp signal being activated, set the Output signal to true for the designated Duration.

	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

## 4.17 ValveD


The ValveD class is utilized to control a discrete valve.

### 4.17.1 Control Interface

Parameter	Type	Description	Range	HMI
CtrlAutoCmd	I	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	I	Set to Manual Control Mode	W1	EF-PB (L)
CtrlRem	I	Remote Control (Controlled by PLC)	0/1	GDx-F EF-L
FbkDly	I	Feedback Delay (Default = 2 sec)	0 – 1000 sec	-
Intl	I	Interlock (Man/Auto)	0/1	EF-L
IntlA	I	Interlock When In Auto	0/1	EF-L
OpnReq	I	Open Request - AutoMode	0/1	
ManCls	IH	Manual Close Command	W1	EF-PB (L)
ManOpn	IH	Manual Open Command	W1	EF-PB (L)
ZSC	I	Position Closed	0/1	GD3-A EF-T
ZSO	I	Position Open	0/1	GD3-A EF-T
CtrlMan	O	Control Mode Manual	0/1	GD3-F EF-T
CmdOpn	O	Position Cmd	0 – 100%	EF-T

### 4.17.2 Alarms

Alarm	Description	Logic	DPri	Reset
ClsFail	Close Fail	NOT CmdOpen AND (ZSO OR NOT ZSC) for FbkDly sec	2	Auto
FbkFail	Limit Switch Feedback Fail	(ZSC AND ZSO) OR NOT (ZSC OR ZSO) for FbkDly sec	2	Auto
OpnFail	Open Fail	CmdOpen AND (ZSC OR NOT ZSO) for FbkDly sec	2	Auto


 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

#### 4.17.3 Interlocks

Initiating Event	Action	Control Mode		Set Intlocked Output	Description
		Auto	Manual		
Intl	Close	Y	Y	Y	Close valve regardless if in Auto or Manual Mode.
IntlA	Close	Y	N	Y	Close valve if in Auto Mode.

#### 4.17.4 Control Narrative

If in Auto mode, open the valve (CmdOpn) when the OpnReq signal is on.

	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A106
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: A - Standard Function Block Classes

## 4.18 ValveM

The ValveM class is utilized to control a modulating valve.

### 4.18.1 Control Interface

Parameter	Type	Description	Range	HMI
CtrlAutoCmd	I	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	I	Set to Manual Control Mode	W1	EF-PB (L)
Intl	I	Interlock (Man/Auto)	0/1	EF-L
IntlA	I	Interlock When In Auto	0/1	EF-L
PV	I	Position Input Signal	0 – 100%	
ZFbk	I	Position Feedback Signal	0 – 100%	GD3-A EF-T
CtrlMan	O	Control Mode Manual	0/1	GD3-F EF-T
ZCmd	O	Position Cmd	0 – 100%	EF-T

### 4.18.2 Alarms


Alarm	Description	Logic	DPri	Reset
ZFail	Position Feedback Error	ZFbk Fail (Bad quality or out of range)	2	Auto
ZFbkFail	Position Feedback Fail	ABS(Z – ZCmd) > 5% for 30 seconds	2	Auto

### 4.18.3 Interlocks

Initiating Event	Action	Control Mode		Set Intlocked Output	Description
		Auto	Manual		
Intl	Close	Y	Y	Y	Close valve regardless if in Auto or Manual Mode.
IntlA	Close	Y	N	Y	Close valve if in Auto Mode.

### 4.18.4 Control Narrative


Set the output signal (ZCmd) to the PV if in Auto mode. Ensure the manual mode is linked to any upstream controller.

	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> Company Logo </div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A107
			Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: S – Secondary Clarifiers	

Prepared By:		
Name	Signature	Date
Checked By:		
Name	Signature	Date
Approved By:		

Certificate of Authorization	Professional Seal
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REVISION REGISTER					
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			Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: S – Secondary Clarifiers	

### Table of Contents

1.0	Overview .....	3
1.1	Associated Documents .....	3
2.0	Implementation.....	4
2.1	HMI Application .....	4
2.2	PLC Application.....	6
3.0	Secondary Clarifiers.....	8
3.1	Secondary Clarifier 1.....	8
3.2	Secondary Clarifier 2.....	9
3.3	Secondary Clarifier 3.....	10
3.4	Samplers .....	11
3.5	Clarifier 1 & 2 RAS Pumping.....	12
3.6	Clarifier 1 & 2 RAS Flow Control.....	13
3.7	Clarifier 3 RAS Pumping .....	14
3.8	Clarifier 3 RAS Flow Control .....	15
3.9	WAS Pumping.....	17

SAMPLE



 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A107
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: S – Secondary Clarifiers


## 1.0 OVERVIEW

The logic specified in this document is intended to provide functional requirements for Area S – Secondary Clarifiers. It is written from a technical perspective, and is intended to be read along with the associated Process & Instrument Diagram (P&ID) drawings.

### 1.1 Associated Documents

The documents and drawings associated with this functional requirements specification are listed below. Additional P&ID drawings may be referenced in this document.

Document / Drawing Number	Description
SD-A106	Functional Requirements Specification – Standard Function Block Classes
-	Legend and Details
-	Clarifier 1
-	Clarifier 2
-	Clarifier 3
-	Secondary Clarifier Effluent and Sample System
-	Return Activated Sludge Pump P-S101
-	Return Activated Sludge Pumps P-S102 & P-S103
-	Return Activated Sludge Pumps P-S108 & P-S109
-	RAS Header
-	Waste Activated Sludge Pumps P-S202 & P-S203

 <div style="border: 1px solid black; padding: 5px; display: inline-block;"> Company Logo </div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A107
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: S – Secondary Clarifiers

## 2.0 IMPLEMENTATION

### 2.1 HMI Application

#### 2.1.1 Graphic Displays

Create a process graphic (process mimic) display containing a representation of the process shown on the process and instrumentation diagrams.

Below are the anticipated groupings of process displays.

##### 2.1.1.1. Facility Overview

Level - 1

This is the default display for the system. The Secondary Clarifier process should only utilize a small portion of the available graphic area.

Specific requirements include, but are not limited to:


- Display bar graphs for the following:
  - Total Secondary Clarifier Inflow
  - Total RAS Flow
  - Total WAS Flow
  - RAS Header Flow Splits
    - FIT-S1210 Oxygen Reactor 1 RAS Flow
    - FIT-S1220 Oxygen Reactor 2 RAS Flow
    - FIT-S1230 Oxygen Reactor 3 RAS Flow
    - FIT-S1240 Oxygen Reactor 4 RAS Flow

##### 2.1.1.2. Secondary Clarifier Overview

Level - 2

Specific requirements include, but are not limited to:

- Display bar graphs for the following:
  - Secondary Clarifier Inflow
    - FIT-S0121 Secondary Clarifier 1 Inflow
    - FIT-S0221 Secondary Clarifier 2 Inflow
    - FIT-S0321 Secondary Clarifier 3 Inflow
  - Sludge Blanket Levels
    - LIT-S0101 Secondary Clarifier 1 Sludge Blanket Level
    - LIT-S0201 Secondary Clarifier 2 Sludge Blanket Level
    - LIT-S0301 Secondary Clarifier 3 Sludge Blanket Level
  - Clarifier 1 RAS Flow
  - Clarifier 2 RAS Flow
  - Clarifier 3 RAS Flow
  - Total RAS Flow
  - Total WAS Flow
  - RAS Header Flow Splits

	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> Company Logo </div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A107
			Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: S – Secondary Clarifiers	

- FIT-S1210 Oxygen Reactor 1 RAS Flow
- FIT-S1220 Oxygen Reactor 2 RAS Flow
- FIT-S1230 Oxygen Reactor 3 RAS Flow
- FIT-S1240 Oxygen Reactor 4 RAS Flow

- Equipment graphics (without process flow linking)
  - RAS Pump P-S101 Status
  - RAS Pump P-S102 Status
  - RAS Pump P-S103 Status
  - RAS Pump P-S108 Status
  - RAS Pump P-S109 Status

### 2.1.1.3. Process Graphic Displays

Level - 3

Provide a comprehensive set of displays to show the process indicated on the reference P&IDs as a guide.

Provide equipment faceplate links, as well as links to controllers.

### 2.1.1.4. Control System Status

Level - 3

Create a graphic display showing a hierarchical layout of the control system components including but not limited to the following:

- Main controller rack(s).
- Remote I/O rack(s), as applicable.
- Networking components,
- Power supplies.

Display comprehensive health/alarm information adjacent to each control system component.

### 2.1.1.5. Process Detail Displays

Level - 4

Provide detail displays as required to detail any portion of the Level 3 displays which cannot be adequately addressed by the Level 3 displays.


Provide equipment faceplate links, as well as links to controllers.

## 2.1.2 Trend Displays

Create, at minimum, the following trend displays, with the indicated pens.

Create appropriate links from the various graphic screens to the trend displays.

- Secondary Clarifier Inflow
  - FIT-S0121 Secondary Clarifier 1 Inflow
  - FIT-S0221 Secondary Clarifier 2 Inflow
  - FIT-S0321 Secondary Clarifier 3 Inflow

 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A107
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: S – Secondary Clarifiers

- Sludge Blanket Levels
  - LIT-S0101 Secondary Clarifier 1 Sludge Blanket Level
  - LIT-S0201 Secondary Clarifier 2 Sludge Blanket Level
  - LIT-S0301 Secondary Clarifier 3 Sludge Blanket Level
- RAS Pump P-S101
  - P-S101.S RAS Pump P-S101 Speed
  - FIT-S1015 RAS Pump P-S101 Flow
- RAS Pump P-S102
  - P-S102.S RAS Pump P-S102 Speed
  - FIT-S1025 RAS Pump P-S102 Flow
- RAS Pump P-S103
  - P-S103.S RAS Pump P-S103 Speed
  - FIT-S1035 RAS Pump P-S103 Flow
- RAS Pump P-S108
  - P-S108.S RAS Pump P-S108 Speed
  - FIT-S1085 RAS Pump P-S108 Flow
- RAS Pump P-S109
  - P-S109.S RAS Pump P-S109 Speed
  - FIT-S1095 RAS Pump P-S109 Flow
- RAS Header Flow Splits
  - FIT-S1210 Oxygen Reactor 1 RAS Flow
  - FIT-S1220 Oxygen Reactor 2 RAS Flow
  - FIT-S1230 Oxygen Reactor 3 RAS Flow
  - FIT-S1240 Oxygen Reactor 4 RAS Flow

## 2.2 PLC Application


### 2.2.1 Software Automatic/Manual Modes

In addition to the physical Hand-Off-Auto or Local-Remote switch, each piece of equipment that is controlled by the PLC shall also have a software Automatic and Manual mode. The software Manual mode allows operators to manually control equipment from the HMI rather than the MCC room.

### 2.2.2 PIDs

The PLC logic shall be written such that bump-less transfer occurs when switching from Automatic to Manual, and vice versa. When a change from software Automatic mode to software Manual mode occurs, move the output of the PID into the Manual speed setpoint. This prevents the speed from changing when entering software Manual mode.


PIDs that are controlling variable frequency drives are to have their Lower Limit configured to be the same as the drive's minimum speed setting to prevent integral windup.

 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A107
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: S – Secondary Clarifiers

### 2.2.3 Variable Naming Convention

Variables are to be named as per the City of Winnipeg Tagname Identification Standard, document 612620-0014-40ER-0001.

SAMPLE

	<div style="border: 1px solid black; padding: 2px; display: inline-block;"> Company Logo </div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A107
			Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: S – Secondary Clarifiers	


### 3.0 SECONDARY CLARIFIERS

#### 3.1 Secondary Clarifier 1

P&ID Drawing: -  
PLC: PLC-S810

##### 3.1.1 Class Instances

Equipment	Instance	Class	Control Input Links	I/O Links & Fieldbus Links
TK-S010	YK-S0100	Tank	-	-
LIT-S0101	LI-S0101	Ind	-	I/O: PV = LIT-S0101
CM-S011	YK-S0110	MTR_FBus	Intl = OAHH-S0110.Alarm PowerOn = MCC-S711.PowerOn RunInp = Set true when YK-S0100.InService for 1 minute OR (NOT YK-S0100.InService for the first 2 minutes)	FBus: MS-S011
	OAH-S0110	Alm_TD	Dly = 2 sec Enb = YK-S0110.Run	I/O: Inp = OSH-S0110
	OAAH-S0110	Alm	Enb = YK-S0110.Run Rst = YK-S0110.Rst	I/O: Inp = OSHH-S0110
-	FFC-S0021	FFC_MOV	D1_F = FIC-S0121.F D2_F = FIC-S0221.F D3_F = FIC-S0331.F D1_InService = YK-S0100.InService D2_InService = YK-S0200.InService D3_InService = YK-S0300.InService	
FIT-S0121	FIC-S0121	FIC_MOV	MOV = (FFC-S0021.MOV == 1) SP = FFC-S0021.D1_F_Tgt	I/O: F = FIT-S0121 FV-S0121.ZCmd = CV
FV-S0121	FK-S0121	ValveM	PV = FIC-S0121.CV IntlA = NOT YK-S0100.InService	HART: FV-S0121.(Z, ZCmd)
XV-S3031	ZY-S3031	TimeRly	Inp = ZS-S3031	ZS-S3031
	XK-S3031	ValveD	OpnReq = ZY-S3031.Out	I/O: XV-S3031.(ZSC, ZSO, Rem, CmdCls, CmdOpn)


	<div style="border: 1px solid black; padding: 2px; display: inline-block;"> Company Logo </div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A107
			Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: S – Secondary Clarifiers	

## 3.2 Secondary Clarifier 2

P&ID Drawing: -  
PLC: PLC-S810

### 3.2.1 Class Instances

Equipment	Instance	Class	Control Input Links	I/O Links & Fieldbus Links
TK-S020	YK-S0200	Tank	-	-
LIT-S0101	LI-S0201	Ind	-	I/O: PV = LIT-S0201
CM-S011	YK-S0210	MTR_FBus	Intl = OAHH-S0210.Alarm PowerOn = MCC-S711.PowerOn RunInp = Set true when YK-S0200.InService for 1 minute OR (NOT YK-S0200.InService for the first 2 minutes)	FBus: MS-S021
	OAH-S0210	Alm_TD	Dly = 2 sec Enb = YK-S0210.Run	I/O: Inp = OSH-S0210
	OAAH-S0210	Alm	Enb = YK-S0210.Run Rst = YK-S0210.Rst	I/O: Inp = OSHH-S0210
FIT-S0221	FIC-S0221	FIC_MOV	MOV = (FFC-S0021.MOV == 1) SP = FFC-S0021.D1_F_Tgt	I/O: F = FIT-S0221 FV-S0221.ZCmd = CV
FV-S0221	FK-S0221	ValveM	PV = FIC-S0221.CV IntlA = NOT YK-S0200.InService	HART: FV-S0221.(Z, ZCmd)
XV-S3041	ZY-S3041	TimeRly	Inp = ZS-S3041	ZS-S3041
	XK-S3041	ValveD	OpnReq = ZY-S3041.Out	I/O: XV-S3041.(ZSC, ZSO, Rem, CmdCls, CmdOpn)

 <div style="border: 1px solid black; padding: 2px; display: inline-block;"> Company Logo </div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A107
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: S – Secondary Clarifiers


### 3.3 Secondary Clarifier 3

P&ID Drawing: -  
PLC: PLC-S810

#### 3.3.1 Class Instances

Equipment	Instance	Class	Control Input Links	I/O Links & Fieldbus Links
TK-S030	YK-S0300	Tank	-	-
LIT-S0101	LI-S0301	Ind	-	I/O: PV = LIT-S0301
CM-S011	YK-S0310	MTR_FBus	Intl = OAHH-S0310.Alarm PowerOn = MCC-S711.PowerOn RunInp = Set true when YK-S0300.InService for 1 minute OR (NOT YK-S0300.InService for the first 2 minutes)	FBus: MS-S031
	OAH-S0310	Alm_TD	Dly = 2 sec Enb = YK-S0310.Run	I/O: Inp = OSH-S0310
	OAHH-S0310	Alm	Enb = YK-S0310.Run Rst = YK-S0310.Rst	I/O: Inp = OSHH-S0310
FIT-S0321	FIC-S0321	FIC_MOV	MOV = (FFC-S0021.MOV == 1) SP = FFC-S0021.D1_F_Tgt	I/O: F = FIT-S0321 FV-S0321.ZCmd = CV
FV-S0321	FK-S0321	ValveM	PV = FIC-S0321.CV IntlA = NOT YK-S0300.InService	HART: FV-S0321.(Z, ZCmd)




 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A107
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: S – Secondary Clarifiers

### 3.4 Samplers

P&ID Drawing: -  
PLC: PLC-S810

#### 3.4.1 Class Instances

Equipment	Instance	Class	Control Input Links	I/O Links & Fieldbus Links
-	FY-S5291	Samp_Init	F = FI-S0121 – (FIC-S1015.F + FIC-S1025.F + FIC-S1035.F) / 2 Compl = YK-S5290.On	-
SA-S529	YK-S5290	Sampler	Run_Inp = FY-S5291.Out	I/O: SA-S529 (Rem, Fail, On, CmdRun)
-	FY-S5301	Samp_Init	F = FI-S0121 – (FIC-S1015.F + FIC-S1025.F + FIC-S1035.F) / 2 Compl = YK-S5300.On	-
SA-S530	YK-S5300	Sampler	Run_Inp = FY-S5301.Out	I/O: SA-S530 (Rem, Fail, On, CmdRun)
-	FY-S5311	Samp_Init	F = FY-S5291.F + FY-S5301.F + FY-S5321.F Compl = YK-S5310.On	-
SA-S531	YK-S5310	Sampler	Run_Inp = FY-S5311.Out	I/O: SA-S531 (Rem, Fail, On, CmdRun)
-	FY-S5321	Samp_Init	F = FI-S0121 – (FIC-S1085.F + FIC-S1095.F) Compl = YK-S5320.On	-
SA-S532	YK-S5320	Sampler	Run_Inp = FY-S5321.Out	I/O: SA-S532 (Rem, Fail, On, CmdRun)


	<div style="border: 1px solid black; padding: 2px;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A107
			Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: S – Secondary Clarifiers	

### 3.5 Clarifier 1 & 2 RAS Pumping

P&ID Drawing: 1  
 PLC: PLC-S810

#### 3.5.1 Class Instances

Equipment	Instance	Class	Control Input Links	I/O Links & Fieldbus Links
P-S101	SY-S1018	Pump_CleanSpd	S_Inp = FIC.S1015	
	SK-S1010	MTR_VFD_FBus	Intl = PAL-S1011.Alarm IntlA = YK-S0100.InService PowerOn = MCC-S711.PowerOn RunInp = YY-S1001.Eq1CmdRun S_Tgt = SY-S1018.CmdS	FBus: VFD-S101 (CtrlRem, Flt, I, Run, Rdy, S, CmdRun, CmdS)
	PAL-S1011	Alm_TD	Dly = 2 sec Enb = SK-S101.Run Rst = SK-S101.Rst	I/O: PSL-1011
P-S102	SY-S1028	Pump_CleanSpd	S_Inp = FIC.S1025	
	SK-S1020	MTR_VFD_FBus	Intl = PAL-S1021.Aalarm IntlA = 1 PowerOn = MCC-S712.PowerOn RunInp = YY-S1001.Eq2CmdRun S_Tgt = SY-S1018.CmdS	FBus: VFD-S102 (CtrlRem, Flt, I, Run, Rdy, S, CmdRun, CmdS)
	PAL-S1021	Alm_TD	Dly = 2 sec Enb = SK-S102.Run Rst = SK-S102.Rst	I/O: PSL-S1021
P-S103	SY-S1038	Pump_CleanSpd	S_Inp = FIC.S1035	
	SK-S1030	MTR_VFD_FBus	Intl = PAL-S1031.Aalarm IntlA = YK-S0200.InService PowerOn = MCC-S711.PowerOn RunInp = YY-S1001.Eq3CmdRun S_Tgt = SY-S1018.CmdS	FBus: VFD-S103 (CtrlRem, Flt, I, Run, Rdy, S, CmdRun, CmdS)
	PAL-S1031	Alm_TD	Dly = 2 sec Enb = SK-S103.Run Rst = SK-S103.Rst	I/O: PSL-S1031

	<div style="border: 1px solid black; padding: 2px;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A107
			Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: S – Secondary Clarifiers	


Equipment	Instance	Class	Control Input Links	I/O Links & Fieldbus Links
-	YY-S1029	Duty_D2S1	EqD1_Rdy = SK-S1010.Rdy EqD2_Rdy = SK-S1030.Rdy EqS1_Rdy = SK-S1020.Rdy RunP1_Inp = YK-S0100.InService RunP2_Inp = YK-S0200.InService	

### 3.6 Clarifier 1 & 2 RAS Flow Control

P&ID Drawing: -  
PLC: PLC-S810

#### 3.6.1 Class Instances

Equipment	Instance	Class	Control Input Links	I/O Links & Fieldbus Links
-	UY-S0129	RAS_UC	F_ML = FIC_S0121.F	-
-	UY-S0229	RAS_UC	F_ML = FIC_S0221.F	-
FIT-S1015	FIC-S1015	FIC	SP = UY-S0129.F_Tgt Intl = YY-S1029.EqD1_CmdRun	FIT-S1015
FIT-S1025	FIC-S1025	FIC	SP = IF UY-S1029.EqS1_Assign == 1 SP = UY-S0129.F_Tgt ELSE SP = UY-S0229.F_Tgt Intl = YY-S1019.EqS1_CmdRun	FIT-S1025
FIT-S1035	FIC-S1035	FIC	SP = UY-S0229.F_Tgt Intl = YY-S1029.EqD2_CmdRun	FIT-S1035


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		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: S – Secondary Clarifiers

### 3.7 Clarifier 3 RAS Pumping

P&ID Drawing: -  
PLC: PLC-S810

#### 3.7.1 Class Instances

Equipment	Instance	Class	Control Input Links	I/O Links & Fieldbus Links
P-S108	SY-S1088	Pump_CleanSP	S_Inp = FIC.S1085	
	SK-S1080	MTR_VFD_FBUS	Intl = PAL-S1081.Alarm IntlA = YK-S0300.InService PowerOn = MCC-S712.PowerOn S_Tgt = SY-S1088.CmdS	FBus: VFD-S108 (CtrlRem, Flt, I, Run, Rdy, S, CmdRun, CmdS)
	PAL-S1081	Alm_TD	Dly = 2 sec Enb = SK-S108.Run Rst = SK-S108.Rst	I/O: PSL-1081
P-S109	SY-S1098	Pump_CleanSP	S_Inp = FIC.S1095	
	SK-S1090	MTR_VFD_FBUS	Intl = PAL-S1091.Aalarm IntlA = YK-S0300.InService PowerOn = MCC-S711.PowerOn S_Tgt = SY-S1098.CmdS	FBus: VFD-S109 (CtrlRem, Flt, I, Run, Rdy, S, CmdRun, CmdS)
	PAL-S1091	Alm_TD	Dly = 2 sec Enb = SK-S109.Run Rst = SK-S109.Rst	I/O: PSL-S1091
-	YY-S1089	Duty_DS	Eq1_Rdy = SK-S1080.Rdy Eq2_Rdy = SK-S1090.Rdy RunInp = YK-S0300.InService	


 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A107
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: S – Secondary Clarifiers

### 3.8 Clarifier 3 RAS Flow Control

P&ID Drawing: -  
PLC: PLC-S810

#### 3.8.1 Class Instances

Equipment	Instance	Class	Control Input Links	I/O Links & Fieldbus Links
-	UY-S0329	RAS_UC	F_ML = FIC_S0321.F	-
FIT-S1085	FIC-S1085	FIC	SP = UY-S0329.F_Tgt Intl = YY-S1089.Eq1_CmdRun	FIT-S1085
FIT-S1095	FIC-S1095	FIC	SP = UY-S0329.F_Tgt Intl = YY-S1089.Eq2_CmdRun	FIT-S1095


	<div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A107
			Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: S – Secondary Clarifiers	

### 3.8.2 RAS Flow Splitting

P&ID Drawing: -  
 PLC: PLC-S810

### 3.8.3 Class Instances

Equipment	Instance	Class	Control Input Links	I/O Links & Fieldbus Links
-	AI-S1041	Ind	-	I/O: AIT-S1041
-	FFC-S1200	FFC_MOV	D1_F = FIC-S1210.F D2_F = FIC-S1220.F D3_F = FIC-S1230.F D4_F = FIC-S1240.F D1_InService = Reactor1_InService D2_InService = Reactor2_InService D3_InService = Reactor3_InService D4_InService = Reactor4_InService	-
-	FIC-S1210	FIC_MOV	MOV = (FFC-S1200.MOV == 1) SP = FFC-S1200.D1_F_Tgt	FBus: FIT-S1210
-	FIC-S1220	FIC_MOV	MOV = (FFC-S1200.MOV == 2) SP = FFC-S1200.D2_F_Tgt	FBus: FIT-S1220
-	FIC-S1230	FIC_MOV	MOV = (FFC-S1200.MOV == 3) SP = FFC-S1200.D3_F_Tgt	FBus: FIT-S1230
-	FIC-S1240	FIC_MOV	MOV = (FFC-S1200.MOV == 4) SP = FFC-S1200.D4_F_Tgt	FBus: FIT-S1240
-	FK-S1210	ValveM	PV = FIC-S1210.CV IntIA = NOT Reactor1_InService	FBus: FV-S1210
-	FK-S1220	ValveM	PV = FIC-S1220.CV IntIA = NOT Reactor2_InService	FBus: FV-S1220
-	FK-S1210	ValveM	PV = FIC-S1230.CV IntIA = NOT Reactor3_InService	FBus: FV-S1220
-	FK-S1210	ValveM	PV = FIC-S1240.CV IntIA = NOT Reactor4_InService	FBus: FV-S1230


 <div style="border: 1px solid black; padding: 2px; display: inline-block;">Company Logo</div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A107
		Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: S – Secondary Clarifiers

### 3.9 WAS Pumping

P&ID Drawing: -  
PLC: PLC-S810

#### 3.9.1 Class Instances

Equipment	Instance	Class	Control Links	I/O Links & Fieldbus Links
-	UY-2011	Custom See 3.9.2	RAS_SS = AI-S1041	
-	FIC-S2012	FIC	SP = UY-2011.F_Tgt	F = FIT-S2011
-	YC-S2013	Duty_DS	Eq1_Rdy = SK-S2020.Rdy Eq2_Rdy = SK-S2030.Rdy RunInp = FIC-S2012.CV > 0 L/s	
P-S202	SK-S2020	MTR_VFD_FBus	Intl = 0 IntlA = TK-S030.InService PowerOn = MCC-S712.PowerOn S_Tgt = IF(YC-S2014.P1_CmdRun, FIC-S2011.CV, 0)	VFD-S202 (CtrlRem, Flt, I, Run, Rdy, S, CmdRun, CmdS)
P-S203	SK-S2030	MTR_VFD_FBus	Intl = 0 IntlA = TK-S030.InService PowerOn = MCC-S711.PowerOn S_Tgt = IF(YC-S2014.P2_CmdRun, FIC-S2011.CV, 0)	VFD-S203 (CtrlRem, Flt, I, Run, Rdy, S, CmdRun, CmdS)

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			Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: S – Secondary Clarifiers	


### 3.9.2 UY-S2011 WAS Withdrawal Rate

The WAS Withdrawal Controller determines the appropriate flow setpoint for the WAS pumping, and also determines when the WAS pumps should run

#### 3.9.2.1. Control Interface

Parameter	Type	Description	Range	HMI
CalcModel	SP	Calculation Model (1 = Solids Retention Time, 2 = Total Mass Removal)	1 - 2	EF-RB (M)
CtrlAutoCmd	IH	Set to Auto Control Mode	W1	EF-PB (L)
CtrlManCmd	IH	Set to Manual Control Mode	W1	EF-PB (L)
F_Man	IH	Manual Mode Flow Input	0 – 1000 l/s	EF-TE (L)
K1_SP	SP	Interval Time When in Interval Mode	6 – 24 hrs	EF-TE (M)
K1_Start	SP	Interval Start Time	0 – 24 hrs	EF-TE (M)
K2_SP	SP	Intermittent Time When in Intermittent Mode	10 – 60 min	EF-TE (M)
ML_SS	SP	Mixed Liquor Suspended Solids	0 – X mg/l	EF-TE (L)
RAS_SS	I	RAS Suspended Solids	0 – X mg/l	
ReactVol	SP	Volume of each Reactor	0 – X ML	EF-TE (L)
ReactNo	SP	Number of Reactors in Service	0 - 4	EF-TE (L)
SRT	SP	Solids Retention Time	1 – 12 days	EF-TE (L)
TMass	SP	WAS Mass Removal Per Day (TMR Mode)	0 – 10,000 kg	EF-TE (M)
WMode	SP	Withdrawal Mode (0 = Continuous 1 = Interval 2 = Intermittent)	0 - 2	EF-RB (M)
CtrlMan	O	Control Mode Manual	0/1	GDx-F EF-T
F_Tgt	O	Target WAS Flow	0 – 1000 l/s	EF-T



	<div style="border: 1px solid black; padding: 5px; display: inline-block;"> Company Logo </div>	<b>FUNCTIONAL REQUIREMENTS SPECIFICATION</b>	Document Code: SD-A107
			Revision: 00
Client: City of Winnipeg	Project: Sample	Package / Area: S – Secondary Clarifiers	

### 3.9.3 Control Narrative

When in manual mode (CtrlMan == 1) set  $F\_Tgt = F\_Man$

When CalcModel == 1 (1 = Solids Retention Time)

$$F1 \text{ (l/s)} = K [(ML\_SS \times ReactVol \times ReactNo) / SRT / RAS\_SS]$$

Where

$K = 11.574$  (unit conversion constant)

ML\_SS is an operator entered value for the mixed liquor suspended solids (mg/l)

ReactVol is the volume of one reactor (Default 1.8 ML)

ReactNo is the number of reactors in service

SRT is the operator entered solids retention time (days)

RAS\_SS is the RAS suspended solids value (mg/l)

When CalcModel == 2 (2 = Total Mass Removal)

$$F1 \text{ (l/s)} = K \times TMass / RAS\_SS$$

Where

$K = 11.574$  (unit conversion constant)

TMass is the operator entered total WAS mass to be removed per day.

RAS\_SS is the RAS suspended solids value (mg/l)

Set the Target WAS Flow Rate based upon the Withdrawal Mode (WMode)

CASE WMode == 0 (Continuous)

$$F\_Tgt = F1$$

WMode == 1 (Interval)

$$F2 = F1 * 24 \text{ hours} / K1\_SP$$

IF current hour is within the interval  $[K1\_Start, K1\_Start + K1\_SP]$  THEN

$$F\_Tgt = F2$$

ELSE

$$F\_Tgt = 0$$

WMode == 2 (Intermittent)

$$F2 = F1 * 60 \text{ minutes} / K2\_SP$$

IF current minute is within the interval  $[0, K2\_SP]$  THEN

$$F\_Tgt = F2$$

ELSE

$$F\_Tgt = 0$$