

APPENDIX J – CITY OF WINNIPEG DESIGN STANDARDS

Winnipeg Sewage Treatment Program Integrated Management System



Project Document Numbering Standard

DOCUMENT NUMBER: PG-RC-PC-05

This document supersedes PG-RC-PC-03 Technical Document Numbering System.

Rev	Prepared by	Reviewed by	Date	Approved by	Date
2015-08-04	Curtis Reimer			Jackie Veilleux	2015-08-14

Introduction

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Introduction

1 INTRODUCTION

1.1 Scope of the Document

This document is a procedure that implements a common document numbering standard for all project documents, including design documents and drawings within the scope of the Winnipeg Sewage Treatment Program (WSTP). The procedure will allow for consistent file naming in an organized fashion to allow for systematic storage of all project and contract related files.

Note that this document is not applicable to facilities outside of the scope of the WSTP.

The phasing of implementation is governed by procedure PG-RC-PC-04 Technical Document Numbering Systems Management Procedure.

1.2 Definitions

For the purpose of this standard, the following definitions are utilized in the document types:

Class A Document	A Class A document is required to be maintained as a facility lifecycle document for records and maintenance purposes. All Class A Documents should be “as-built” upon project completion and stored in an accessible location for Operations’ use.
DMS	Document Management System
List	A document containing a sequence of connected items, not related to a historical occurrence.
Log	A document containing a register (list) of an event, occurrence, issue, or status.
Plan	A document that outlines the processes and tasks required to implement a project or goal.
Procedure	A document that defines the specific instructions necessary to perform a task or process.
Record	An official document which permanently contains the particulars regarding a specific event, issue, or occurrence. For example, a worker orientation record that documents the orientation of a specific or group of workers. However, a document which tracks the orientation of all workers would be a log.
Report	A document which contains an account given of a particular subject, after thorough investigation or consideration by the author.
VDR	Vendor Document Requirement (See Section 5.2.4)
WBS	Work Breakdown Structure

Document Numbering Formats

2 DOCUMENT NUMBERING FORMATS

Documents are numbered as per the format designated in Table 2-1.

Table 2-1 : Document Numbering Formats

Document	Description	Reference
Class A Documents	Technical design documents and drawings produced to describe the work and utilized as a facility lifecycle document for records and maintenance purposes. Most Class A documents are drawings, but they also include equipment lists, process control narratives, and other documents maintained throughout the facility life. Class A documents should be "as-built" upon project completion and stored in an accessible location for Operations use.	Section 3
Project Documents	Project documents are created for and utilized during the execution of projects. For example, contract administration documents would be under this format. They include many design documents, but exclude Class A documents (including drawings), contractor submittals and quality test results.	Section 4
Contractor Submittals	Contractor Submittal documents are typically shop drawings and product datasheets produced by the contractor or other vendors. The submittals indicate specific manufacturing and construction details, but not overall design concepts.	Section 5
Quality Test Results	Quality Test Result documents provide a record of completed test results during the construction, pre-commissioning, and commissioning phases of the project. Examples include construction tests such as concrete strength testing, pre-commissioning tests such as cable continuity tests, and commissioning tests.	Section 6

Class A Documents

3 CLASS A DOCUMENTS

3.1 Description

Class A Documents are technical design documents and drawings produced to describe the work and utilized as a facility lifecycle document for records and maintenance purposes. Most Class A documents are drawings, but they also include equipment lists, process control narratives, and other documents. Class A documents should be “as-built” upon project completion and stored in an accessible location for Operations use.

3.2 Format

The organization, structure and coding of the design documents and drawings is derived from the City Drawing Standard numbering system, with some additions and/or changes introduced to fulfill the system objectives. These are explained in the following sections.

See Table 3-1 for the Class A Document number format.

Table 3-1 : Document Number Format – Class A Documents

Field	Source Code		Facility Code		Discipline Code	Document Type		Area Code	Process Code	Sequence Number		Sheet Number (Optional)		Suffix (Optional)
Format	C	-	NNNN	-	L	LLL	-	L	C	NN	-	CC	_	*
Example	1	-	0102	-	C	GAD	-	A	1	01	-	01	_	C01

Legend: N= numeral, L= Letter, C= character (i.e. =N or L), * = Multiple Characters

Notes:

1. The file extension, such as “.docx” or “.pdf” would be appended to the end of the filename, but is not technically considered to be part of the document number.
2. The suffix is separated by an underscore (_), not a hyphen (-).
3. The suffix is technically not part of the document number, but rather an extension to be utilized in special case scenarios.

Class A Documents

3.2.1 Source Code

See Table 3-2 for a list of Source Codes and their definition.

Table 3-2 : Source Codes

Code	Description
-	Drawings
1	Design drawings
2	Manufacturer's drawings (See Note 2)
3	Construction drawings (See Note 3)
4	Demolition drawings (See Note 4)
-	Non-Drawings
A	Design documents (Class A)
C	Construction documents (See Note 3)

Notes:

1. Sections of the table are shown in strikethrough format to show change from the previous Technical Document Numbering Standard. Where a project has been started with source codes 2, 3, 4, or C coordinate with the City Project Manager for specific direction.
2. Number manufacturer's drawings as per Section 5.
3. Temporary construction and demolition drawings/documents shall be indicated via the Process Code, as described in Section 3.2.6.1.

Implementation Note:

1. The use of the Source Code has been reworked to provide more logical document sorting.

3.2.2 Facility Code

The Class A Document Numbering System uses the same facility codes as the City Water and Waste Drawing Standard, and in addition introduces the code "0100" as a virtual facility for Program standard documents that are not specific to a particular site.

Table 3-3 : WSTP Facility List

Code	Description
0100 to 0109	Wastewater Treatment Facilities
0100	WSTP standard documents (not specific to a site)
0101	NEWPCC (North Plant)
0102	SEWPCC (South Plant)
0103	WEWPCC (West Plant)

Class A Documents

(Other codes for facilities not included in the Program do not pertain to this document).

3.2.3 Discipline Code

The disciplines are coded as per Table 3-4. The discipline should generally be chosen based upon the group responsible for creating and/or implementing the work. For example: A motor starter schematic is an electrical document, even though it might be associated with a unit of process equipment.

In the event that a discipline is not applicable, or the document is truly multi-disciplinary, the *D - General* discipline code should be selected.

Table 3-4 : Discipline Codes

Code	Discipline	Examples
A	Automation	Instrumentation and Control including Control system block diagrams, instrument loop diagrams, networking drawings (if associated with automation system), control system functional requirements specification.
B	Building-Architectural	General architectural including building layouts and architectural finishes.
C	Civil-Geotechnical	Civil surveys, erosion control, grading, roads, fencing, landscaping, underground utilities.
D	General	Legends, code summary, General site plan, orientation maps, staging areas.
E	Electrical	Electrical site plans, grounding drawings, lighting, motor starter schematics, telecommunications, hazardous location plans.
M	Mechanical (<i>Includes HVAC/Plumbing</i>)	Domestic water plumbing, sanitary and storm drainage, ductwork, air handling equipment, HVAC piping, fire protection systems.
O	Operations	Area Manual, Operating and Maintenance Manual, Standard Operating Procedures.
P	Process (<i>Process and Process Mechanical</i>)	Process Flow Diagrams, Process and Instrumentation Diagrams, Process Equipment General Arrangement, Process Piping, Process hydraulics, Odour Control General Arrangement.
S	Structural	Structural Site Plan, Foundations, Reinforcement, Piers, Piling, Slabs and Retaining Walls, Structural Framing, Floor and Roofs.
Y	Commissioning	Commissioning Design Plan, Commissioning Calculations.

Class A Documents

3.2.4 Document Type

3.2.4.1 Drawings

The Document Type coding for drawings is as per Table 3-5.

Table 3-5 : Document Type - Drawings

Code	Description	Discipline Codes									
		A	B	C	D	E	M	O	P	S	Y
		Automation	Building / Architectural	Civil	General	Electrical	Mechanical	Operations	Process	Structural	Commissioning
AAA	Legend & General Notes (<i>sort first</i>)	1	1	1	1	1	1	1	1	1	1
BDG	Block diagram	1				1					1
CBD	MCC / Cabinets drawing	1				1					1
CDW	Cable drawing	1				1					1
CTR	Cable Trays / Conduit / Cable Routing	1				1					
DRN	Drains			1							
DTL	Discipline Specific Standard details	1	1	1	1	1	1	1	1	1	1
ENV	Environmental			1							
FAF	Fixture and Furniture		1								
FAS	Fire Alarm System					1					
FDW	Foundation drawings									1	
FNC	Fencing			1							
GAD	General Arrangement drawing (<i>including section views</i>)	1	1	1	1	1	1	1	1	1	1
GRD	Earthing/grounding					1					1
HLC	Hazardous Location Classification (<i>Plans / Sections</i>)					1		1			1
HYD	Hydraulic line								1		1
IDW	Installation drawing	1				1	1				1
IFS	Instrumentation Fieldbus Segment Drawings	1									1
ILD	Instrumentation Loop Diagrams	1									1
ISO	Piping isometrics						1		1		1
LSC	Landscaping			1							

Class A Documents

Code	Description	Discipline Codes									
		A	B	C	D	E	M	O	P	S	Y
		Automation	Building / Architectural	Civil	General	Electrical	Mechanical	Operations	Process	Structural	Commissioning
LTG	Lighting Drawings (<i>Plan and schematics</i>)					1					
LYT	Layout			1							1
MCL	Motor Control (<i>Includes, motor starter schematics and connection diagrams</i>)	1				1					
MOD	3D Models		1	1	1	1	1		1	1	
MST	Master/Extraction Files		1	1	1	1	1		1	1	
NET	Networking	1				1					
PCC	Precast concrete									1	
PFD	Process Flow Diagram							1	1		1
PID	Process and Instrumentation Diagram								1		1
RDW	Reinforcement drawing									1	
RSW	Roads and sidewalks			1							
SCH	Discipline Specific Schedules (<i>Door, Hardware, Luminaire, HVAC, etc.</i>)	1	1	1	1	1	1	1	1	1	1
SCY	Security	1				1					
SDW	Form drawings.									1	
SLD	Single line diagram					1					1
SST	Structural steel									1	
SVY	Survey			1							
TDW	Terminal drawing					1					1
TLD	Three-line diagram					1					1
UTY	Utilities (<i>site utilities such as buried piping and electrical services</i>)			1							
WDG	Wiring / connection diagram	1				1					1

Class A Documents

3.2.4.2 Class A Documents Other Than Drawings

The Document Type coding for Class A Documents, other than drawings, is as per Table 3-6.

Table 3-6 : Document Types – Class A Documents Other Than Drawings

Code	Description	Discipline Codes									
		A	B	C	D	E	M	O	P	S	Y
		Automation	Building / Architectural	Civil	General	Electrical	Mechanical	Operations	Process	Structural	Commissioning
DTS	Datasheet (Equipment/Instrument)	1	1	1	1	1	1		1	1	1
ELI	Engineering List (Equipment, Instruments, I/O, cables etc)	1	1	1	1	1	1		1	1	1
FRS	Functional Requirement Specification	1									
MAN	Manual (i.e. Area Manual)							1			
PCN	Process Control Narrative								1		
PRO	Procedure / Protocol							1			1
SUR	Survey Report			1	1	1					

3.2.5 Area Code

The area code is composed of a single letter, which represents a specific location in the Facility. Where a document is not specific to an area, then the following general area code shall be used:

- A General or area not applicable

For area codes specific to each facility, refer to the following documents:

- NEWPCC CD-RC-RF-01 NEWPCC Facility Process Areas
- SEWPCC CD-RC-RF-02 SEWPCC Facility Process Areas
- WEWPCC CD-RC-RF-03 WEWPCC Facility Process Areas

Class A Documents

3.2.6 Process Code

For most Class A documents, the *Process Code* is a single digit that refers to a specific process within each area (Area Code). The set of *Process Codes* are unique for each Area Code within each facility and the same digit will typically represent different processes within different areas. However, standard process codes are also available for certain scenarios, as described below.

3.2.6.1 Standard Process Codes

Standard process codes are shown in Table 3-7

Table 3-7 : Standard Process Codes

Code	Title	Description
0	General	The document / drawing is not associated with a specific process, or is associated with multiple processes.
1 - 9	Specific	See Section 3.2.6.2.
D	Demolition	The document / drawing is a demolition document.
T	Temporary Construction	The document / drawing is a temporary construction document that will have no purpose after the construction is complete.

3.2.6.2 Specific Process Codes

The Process Code digits 1 – 9 are reserved for specific codes, unique for each Area Code within each facility. The same digit will typically represent different processes within different Area Codes. For example:

- 1-0102-PPID-G101 Process Code 1 represents Raw Sewage Pumping in the SEWPCC G area.
- 1-0102-PPID-R101 Process Code 1 represents Tanks, Mixing and Chemicals in the SEWPCC R area

For process codes specific to each facility and area, refer to the following documents:

- NEWPCC CD-RC-RF-01 NEWPCC Facility Process Areas
- SEWPCC CD-RC-RF-02 SEWPCC Facility Process Areas
- WEWPCC CD-RC-RF-03 WEWPCC Facility Process Areas

3.2.7 Sequence Number

The sequence number is two digits long and identifies the individual documents within the document numbering scheme. The user may chose non-sequential numbering if deemed appropriate for the situation.


Class A Documents

3.2.8 Sheet Number - Optional

The sheet number is a two digit field used for multiple sheet drawings. Multiple sheet drawings are utilized when the content cannot fit within one drawing sheet. Multiple sheet drawings shall have the same title. If it is desired to have a different title, then a new document number shall be utilized. Some examples of situations where multi-sheet drawing are appropriate are as follows:

- A complicated motor starter schematic that cannot fit on one drawing.
- Document lists that cannot fit on one drawing.
- A room layout plan that cannot fit on one drawing.

Documents without multiple sheets shall have a sheet number indicated as a (Blank) on the document itself. However, the DMS may require that the number 00 be entered in the Sheet number field, if multiple sheets do not exist. For example:

 THE CITY OF WINNIPEG WATER AND WASTE DEPARTMENT			
SOUTH END WATER POLLUTION CONTROL CENTRE SEWPCC UPGRADING/EXPANSION PROJECT PROCESS AND INSTRUMENTATION DIAGRAM HRC LAMELA AIR SCOUR BLOWER			
CITY DRAWING NUMBER	SHEET	REV.	SIZE
1-0102-PPID-K003		B0	A1

Sheet number blank if drawing does not have multiple sheets

For non-drawing Class A documents, the number of sheets will typically not be utilized; however it may be utilized to manage large documents that are split into multiple parts. For example, a large engineering list could be split as follows to allow for smaller file sizes (for e-mailing):

- A-0102-DELI-A005-01 Part 1 of an engineering list.
- A-0102-DELI-A005-02 Part 2 of an engineering list.

Sheet numbers shall not be utilized to attach documents together, which are otherwise intended to be identified as separate documents.

3.2.9 Suffix

Implement the suffix as per Section 7.3.

Class A Documents

3.3 Additional Information Elements

The following additional information elements are not part of the actual document number; however, they provide useful metadata which will be utilized for tracking documents. This information should be attached as metadata when supported by the document management system (DMS).

3.3.1 Revision Number

Implement as per Section 7.2.

Implementation Note:

1. *The superseded Technical Document Numbering System utilized a specific coding system to indicate the level of design stage. To provide consistency with the other document numbering formats in this standard, which do not have revisions that correspond to the level of design stage, the design stage specific revision codes have been eliminated. For existing documents, at the next revision stage implement the next appropriate revision code as per this standard. For example, a drawing might have last been released as a D1 revision, and is being subsequently revised during the design stage. Select the appropriate revision level as per Section 7.2, which would be a preliminary P series revision, such as PE.*

3.3.2 Document Size

The document size shall be shown on all drawings, and recorded in the metadata of the DMS. Typically the size is shown on the border of the drawing.

Table 3-8 : Document Size Code

Code	Size
A	8.5 x 11 Inches (215.9 x 279.4 mm)
B	11 x 17 Inches (279.4 x 431.8 mm)
A2	420 x 594 mm (16.5 x 23.4 Inches)
A1	594 x 841 mm (23.4 x 33.1 Inches)
B1	707 x 1000 mm (27.8 x 39.4 Inches)
A0	841 x 1189 mm (33.1 x 46.8 Inches)

Notes:

1. *Sizes refer to true ANSI Engineering or true ISO formats*
2. *Dimensions in brackets indicate approximate measurement*

Class A Documents

3.4 Organization and Referencing

3.4.1 Referencing Design Documents

Design documents may be referenced within the body of any base document within an overall design package.

When referenced in a base document within the same design package, the first 2 fields (source code and facility code) of the document that are common to the base document are optional. Additional information fields are not indicated.

Example 1:

Full document number of reference: 1-0102-AGAD-P601
Document reference shown: AGAD-P601

Example 2:

Full document number of reference: 1-0102-AILD-R101-02
Document reference shown: AILD-R101-02

3.4.2 Document Sorting

The sorting of documents outside the DMS should be alphabetical from left to right, within a given document package or set. This provides the most intuitive system for people to find documents and will match computer sorting of the documents. However, document filtering may be utilized to package documents by other criteria, such as area code.

Examples are indicated below:

Document Package – No Filtering

- 1-0102-AGAD-P001
1-0102-AGAD-S001
1-0102-EGAD-P001
1-0102-EGAD-S001
1-0102-PGAD-P001
1-0102-PGAD-S001
4-0102-BGAD-P001

Document Package – Area Code P

- 1-0102-AGAD-P001
1-0102-EGAD-P001
1-0102-PGAD-P001
4-0102-BGAD-P001

Document Package – Area Code S

- 1-0102-AGAD-S001
1-0102-EGAD-S001
1-0102-PGAD-S001

Minimum Requirement: Unless otherwise indicated, document snapshot sets should be filtered and packaged by area code.

Class A Documents

3.5 Electronic File Name

3.5.1 Single Documents

3.5.1.1 General Case within a Document Management System

Table 3-9 : File Name Format – Within DMS

Field	Document Number	Extension
Format	As per Table 3-1	.LLL(L)
Examples	1-0102-CGAD-B601	.pdf
	1-0102-CGAD-B602-01	.pdf

Note:

1. The Revision Code is not included as document revision management is handled within the DMS system.

3.5.1.2 General Case for Documents Managed Manually in a Windows Environment

This case is applicable when documents are managed in a standard file-based network drive.

Table 3-10 : File Name Format – Managed Manually

Field	Document Number	Revision	Extension
Format	As per Table 3-1	_RNN	.LLL(L)
Examples	1-0102-CGAD-B601	_R00	.pdf
	1-0102-CGAD-B602-01	_R02	.pdf

Implementation Note:

1. The inclusion of the *_R* code in front of the Revision Code to allow for consistency with Tender Drawing filenames.

3.5.1.3 Tender Drawings

When drawings are included within a tender package posted on the City Material Management web site, the file name convention must be modified to meet the Materials Management naming convention (refer to Material Management document “Bid Opportunity document file naming convention) adapted as in the following example;

Table 3-11 : File Name Format – Tender Drawings

Field	Prefix	Document Number	Revision	Extension
Format	####-YYYY_Drawing_	As per Table 3-1	_RNN	.LLL(L)
Examples	682-2014_Drawing_	1-0102-CGAD-B601	_R00	.pdf
	682-2014_Drawing_	1-0102-CGAD-B602-01	_R02	.pdf

Class A Documents

3.5.2 Document Snapshot Sets

Document snapshot sets (also known as document sets) allow for multiple documents to be contained within a single file. The snapshot set is not to be considered an official document, and in no way eliminates the requirements in the other parts of this document. The use of document snapshot sets in no way eliminates the requirement to load individual documents into the DMS.

The most common use of a document set is to package multiple drawings in a single PDF file to allow for simplified distribution. All of the documents within a document set shall still have unique document numbers and be tracked by revision.

The following rules shall apply to document snapshot sets:

- The documents within a set shall be applicable to a single Source Code.
- The documents within a set shall be applicable to a single Facility.
- The documents within a set may be applicable to either a single or multiple disciplines. If multiple disciplines are within the set, a lowercase “x” character shall be utilized for the Discipline Code in the set filename.
- The documents within a set may have either a single or multiple Document Types. If multiple disciplines are within the set, a lowercase “xxx” document type shall be utilized in the set filename.
- The documents within a set may have a single or multiple Area Codes. Where multiple Area Codes are in the set, the Area Codes shall be coded as “x” in the set filename.
- The documents within a set may have a single or multiple Process Codes. Where multiple Process Codes are in the set, the Process Code shall be coded as “x” in the set filename.
- The Sequence Number for the set shall be indicated as “xx” to reflect that multiple documents are in the set.
- The document snapshot set does not have a revision, but rather a date. The documents within the set shall be the most recent published versions on the date that the snapshot set is created. The date shall be included in the set filename in “YYYY-MM-DD” format, after the “SET_” prefix.
- Document snapshot sets shall not be loaded into the Technical Document Library of the DMS. An alternate storage location will be provided.

Example: File with a set of mechanical drawings for the SEWPCC facility.

SET_2014-08-01_1-0102-Mxxx-xxxx.pdf

Example: File with a set of Bioreactor P&ID drawings for the SEWPCC facility.

SET_2014-08-01_1-0102-PPID-Rxxx.pdf

Class A Documents

3.6 Examples

Examples of Class A document numbers are indicated below:

Name	Title
A-0102-EELI-S001	SEWPCC – Secondary Clarifier Area – Electrical Load List
A-0103-CSUR-Y001	WEWPCC – Yard – Survey of West Field
1-0102-PPID-G105	SEWPCC Raw Sewage Pumping P&ID
1-0102-BGAD-K011	SEWPCC – HRC – Architectural Section D

General Project Documents

4 GENERAL PROJECT DOCUMENTS

4.1 Description

Project documents are created for and utilized during the execution of projects, and are not design documents, submittals, or quality test results. For example, contract administration documents would be under this format.

4.2 Format

The document number format for general project documents is shown in Table 4-1, with a description of each field in the subsequent sections.

Table 4-1 : Document Number Format – General Project Documents

Field	Project Code		WBS Code	Category Code		Document Type Code		Sequence Number		Suffix (Optional)
Format	LNNNN	-	NN	LL	-	LLL	-	NNNN	_	*
Examples	S0926	-	01	CA	-	CCN	-	0001	_	R01
	S0926	-	00	FI	-	BUD	-	0001		

Legend: N = numeral, L= Letter, * = Multiple Characters.

Notes:

1. The file extension, such as “.docx” or “.pdf” would be appended to the end of the filename, but is not technically considered to be part of the document number.
2. The suffix is separated by an underscore (_), not a hyphen (-).
3. The suffix is technically not part of the document number, but rather an extension to be utilized in special case scenarios.

4.2.1 Project Code

The *Project Code* is the City of Winnipeg project number assigned by Records Management, without a hyphen and with four numeric digits. Examples of Records

General Project Documents

Management assigned project numbers and the corresponding *Project Code* are shown below.

Records Project Number	Project Code for Use in Document Numbering Standard
S-926	S0926
S-1521	S1521
S-2111	S2111

4.2.2 WBS Code

A Work Breakdown System (WBS) Code is provided for medium and large sized projects, to provide an organizational structure to the documents. It is a two digit code that is set up by the Project Manager on a case-by-case basis. For small projects, the WBS Code may be fixed at 00, if so decided by the project manager.

The WBS may follow the contract structure of the project, but may follow another logical organization, as applicable for the work. It would be desirable, but not mandatory, that the WBS Code follow the high level work-breakdown structure utilized for project management. Three example WBS coding structures are shown in Table 4-2 below.

Table 4-2 : Sample WBS Code Structures

WBS Code	Description
Small Projects WBS	
00	All aspects of the project are grouped under a single WBS item.
Contract-Based WBS	
00	General Project Development
01	Consultant Contract
02	Civil Works Contract
03	Building Construction Contract
04	Electrical / Mechanical Installation Contract
11	Equipment Supply Contract 1
12	Equipment Supply Contract 2
21	Chemical Delivery Contract 1
Work-Based WBS	
00	General Project Development
01	NEWPCC RAS Gallery Pipe Replacement
02	WEWPCC Secondary Flushing Water Pipe Replacement
03	WEWPCC Perimeter Road Water Pipe Replacement

General Project Documents

4.2.3 Category Code

The *Category Code* provides an organizational structure to the document numbering system. See Table 4-3 for a list of *Category Codes*.

Table 4-3 : Category Codes

Code	Description	Notes
BC	Bid and Contract	Bid Opportunity or RFP bids as well as associated evaluation documents.
CA	Contract Administration	Documents typically controlled, managed, and utilized by the Contract Administrator.
CS	Contractor Submittals	Shop drawings and product datasheets produced by the contractor or other vendors. The submittals indicate specific manufacturing and construction details, but not overall design concepts. Submittal documents are numbered as per Section 5.
D*	DA Design - Automation	Project Design documents. Note that Class A Design documents are coded as per Section 3. For small projects, the project manager may consider only utilizing the DD (Design – General) Category Code if appropriate.
	DB Design – Building / Architectural	
	DC Design – Civil	
	DD Design – General	
	DE Design – Electrical	
	DM Design - Mechanical	
	DP Design – Process	
	DS Design – Structural	
	DY Design - Commissioning	
FI	Financial	All documents primarily of a financial nature.
GE	General	May be utilized for miscellaneous documents, not applicable to any above class.
N*	NA Construction - Automation	Documents associated with the management of construction. The audience of these documents would typically include the Design Team and possibly the contractor. Typical documents would include: Daily construction reports, Engineer construction inspections, etc. <i>Note: Automation includes instrumentation and control.</i>
	NB Construction – Building / Architectural	
	NC Construction – Civil	
	ND Construction – General	
	NE Construction – Electrical	
	NM Construction - Mechanical	
	NP Construction – Process	
	NS Construction – Structural	
	NY Construction - Commissioning	
PM	Project Development and Management	Management of the project as a whole, at a higher level than the Contract Administration. Typically, these documents would largely be internal to the City.

General Project Documents

Code	Description	Notes
PU	Public	Information delivered to or received from the public.
QT	Quality Test Results	Quality Test Result documents are numbered as per Section 6.
SA	Safety	Safety documents or records.
TC	Target Cost	Target Cost documents.
YM	Commissioning Management	Commissioning Procedures, planning documents, and records.

General Project Documents

4.2.4 Document Type Code

The *Document Type Code* describes the general subject or nature of the document. Note that the *Document Type Code* does not describe the detailed document content, which should be identified in the Document Title as per Section 7.1. For example, the following documents are both coded with the same type code (Project Management Plan), but have different titles.

Name	Title
S5812-00PM-PLA-0001	WEWPCC Bioreactor Project Charter
S5812-00PM-PLA-0002	WEWPCC Bioreactor Project Plan

The document types are coded as per Table 4-4.

Table 4-4 : Document Type Codes

Code	Description	Typical Category	Description / Examples
ACC	Approved Contract Change	CA	Includes both contractor and consultant change orders.
BCA	Business Case	PM	
BDC	Bid Documents	BC	Bid Opportunity or RFP documents. See Section 4.4.2.
BID	Bid Submission	BC	The bid documents submitted by the bidders.
BOD	Basis of Design	D*	
BUD	Financial Budget	FI	
BUL	Safety Bulletin	SA	Notice to employees / contractor regarding a safety issue.
CCN	Contemplated Change Notice	CA	
CER	Certificate	CA	Examples: Certificate of Substantial Performance Certificate of Total Performance Certificate of Acceptance
		N*	Examples: Certificate of Equipment Delivery Certificate of Readiness to Install Certificate of Satisfactory Installation
		YM	Examples: Certificate of Commissioning Completion Certificate of Equipment Satisfactory Performance Certificate of Satisfactory Process Performance

General Project Documents

Code	Description	Typical Category	Description / Examples
CIR	Construction Inspection Report	N*	
CLA	Contractor Claims	CA	
COF	Correspondence - Formal	Any	Examples: Letters (i.e. bid clarification, formal consultant notice), memos
COI	Correspondence - Informal	Any	Example: e-mails
CON	Contract	BC	Letter of Intent, Contract Award, POs
COP	Public Correspondence	PU	Includes Complaints, Notifications
CRD	Construction Report - Daily	N*	Daily Construction Report
CRG	Construction Report - General	N*	
DNC	Design Notes and Calculations	D*	
EST	Financial Estimate	FI	
EVA	Bid Evaluation	BC	Bid evaluation documents, bid clarification analysis.
EVC	Earned Value Calculations	CA	
FIN	Field Instruction (Design)	CA	Instruction from the design team to the contractor.
FWA	Field Work Authorization	CA	Authorizes the contractor to proceed with a limited contract change to expedite the contract change process.
GEN	General	Any	Document that does not fall under any other document type.
INS	Insurance	CA	Insurance documents.
INV	Financial Invoice	FI	
IRC	Safety Incident Record	SA	Example: Near Miss Record
JHA	Job Hazard Assessment	SA	
LIS	List	Any	Any type of list document that is not a record (log of event that has occurred)
LOG	Log	Any	A document which a register (list) of an event, occurrence, issue, or status.
MAG	Meeting Agenda	Any	
MOM	Minutes of Meeting	Any	
OER	Over Expenditure Report	CA	City internal document to approve a contract change.
PER	Permit	N*	Construction permit, building permits and other government permits.
		SA	Safety permit. Examples: Confined Space Permit, Critical Lift Permit, Hot Work Permit

General Project Documents

Code	Description	Typical Category	Description / Examples
PES	Progress Estimate	CA	Contractor Progress Estimate (Basis of Payment)
PHO	Photographs	Any	
PLA	Plan	N*	Example: Traffic Management Plan
		PM	Any plan document written from a project management perspective. Examples: Consultant Services Management Plan, Project Charter, Project Plan, Quality Plan
		SA	Examples: Contractor Safety Manual, Safe Work Plan, Emergency Response Plan
POR	Purchase Order	CA	A purchase order associated with a contract. For example, a chemical purchase.
PPR	Public Press Release	PU	
PRE	Presentation	Any	Presentation (i.e. PowerPoint)
PRO	Procedure / Protocol	PM	Project Management Procedure
		N*	Construction Procedure or Protocol: Example: Construction shutdown procedure
		YM	Commissioning procedure
		SA	Safety Procedure: Examples: Lockout/Tagout Procedure
PRP	Progress Report	CA, PM	Progress reports and status reports.
PSC	Project Schedule	CA,PM	Any project time schedule document. Example: Commissioning Schedule. See Note 2
QDR	Non-Conformance Report / Quality Deficiency Report	N*	
QIR	Quality Inspection Record	N*, D*	A document which records a specific quality inspection event .
QTR	Quality Test Result	QT	Quality Test Results are numbered as per Section 6.
REF	Reference Information	Any	Set of reference documents, website info, 3 rd party publications, etc.
REG	Regulatory Document	PM	Example: Regulatory Inspection
RFI	Request for Information	CA	Contractor request and response
RIS	Risk Document	PM	
RPM	Report - Memorandum	Any	Small reports including technical memorandums.

General Project Documents

Code	Description	Typical Category	Description / Examples
RPT	Report	Any	Reports including design reports, award reports and general reports other than those identified with a specific document type code.
SPC	Specifications	D*	Construction Specifications
SKT	Sketch	CA, D*	
TRA	Transmittal	DC	
TRC	Training Record	CA, SA	Example: Worker Orientation Record
WAR	Warranty	CA	Contract warranty documents

Note:

1. *It is required that the Document Types for General Project Documents do not conflict with the Document Types for Class A Documents.*
2. *The Code PCH was utilized rather than SCH for the Project Schedule document type as the SCH document type is utilized in Table 3-5.*

General Project Documents

4.2.5 Sequence Number

The *Sequence Number* is a four digit number to uniquely identify the specific document, with a given *Project Code*, *Category Code* and a specific *Document Type Code*. It is usually assigned in a sequential manner with the first document assigned a *Sequence Number* of 0001 and the next document 0002.

Notes:

1. *Where documents are not auto-numbered (outside of the DMS), assignment of the Sequence Number will typically be performed by searching for the last document with the given Project Code and Document Type Code, and incrementing the sequence number. For example, if the last meeting minutes document for S0924 was S0924-00CA-MOM-0014 the next meeting minute document would be identified as S0924-00CA-MOM-0015.*
2. *The project manager may assign a specific coding system to the sequence number for a specific project, if so required. For example 1000 series document may be associated with phase one of the project and 2000 series documents may be associated with phase two of the project.*

4.2.6 Suffix

Implement as per Section 7.3.

4.3 Example Project Documents

The following examples demonstrate correct application of this standard to project documents.

Name	Title	Description
S0926-01CA-ACC-0003	New SF-G652	Approved Contract Change 0003, which is regarding a new supply fan SF-G652 for project contract 1 (123-2014).
S0926-01CA-ACC-0003_APP01	SF-G652 Datasheet	Appendix to CA-ACC-0003
S0926-01CA-CCN-0001_RES01	Additional Concrete	Contractor response (quote) to S0926-01CA-CCN-0001 document regarding Additional Concrete.
S0926-01CA-PES-0015_S	2014-10-31	Signed copy of Progress Estimate 15 for the period ending 2014-10-31.
S0926-02CA-MOM-0001	2014-09-10 Progress Meeting	Minutes of Meeting for the Contractor Progress Meeting dated 2014-09-10.
S0926-11YM-PRO-0001	Commissioning Procedure	
S0926-02DS-SPC-0003	Division 03 Specifications	Division 03 specifications for the contract represented by the project WBS code 02.

General Project Documents

4.4 Clarifications

4.4.1 Class A Documents

Class A Documents will be identified as per Section 3. Class A Documents are technical design documents and drawings produced to describe the work and utilized as a facility lifecycle document for records and maintenance purposes.

4.4.2 Tender Documents

Tender (Bid Opportunity and Request for Proposal) documents will be identified as per Materials Management file naming convention, as described in [Naming_conventions.pdf](#).

Contractor Submittal Documents

5 CONTRACTOR SUBMITTAL DOCUMENTS

5.1 Description

Contractor Submittal documents are typically shop drawings and product datasheets produced by the contractor or other vendors. The submittals indicate specific manufacturing and construction details, but not overall design concepts. Design documents (including drawings), produced either by a consultant, or as part of a design build project, shall be numbered as per the Class A Document format shown in Section 3 or the Project Document format shown in Section 4, as appropriate.

5.2 Format

The document number format for Contractor Submittal documents is shown in Table 5-1, with a description of each field in the subsequent sections.

Table 5-1 : Contractor Submittal Document Number Format

Field	Project Code		WBS Code	Category Code		VDR Code (See Note 2)		Sequence Number		Suffix (Optional)
Format	LNNNN	-	NN	LL	-	[L]CCC[CCC]	-	NNN	_	*
Example	S0926	-	11	CS	-	001	-	001	_	R01

Legend: N = numeral, L= Letter, C= character (i.e. =N or L), * = Multiple Characters

Notes:

1. The Category Code is always CS for project Contractor Submittal documents.
2. Two alternatives for VDR Codes are presented in Section 5.2.4.
3. The file extension, such as “.docx” or “.pdf” would be appended to the end of the filename, but is not technically considered to be part of the document number.
4. The suffix is separated by an underscore (_), not a hyphen (-).
5. The suffix is technically not part of the document number, but rather an extension to be utilized in special case scenarios.

Contractor Submittal Documents

5.2.1 Project Code

The *Project Code* is implemented as per Section 4.2.1.

5.2.2 WBS Code

The *WBS Code* is implemented as per Section 4.2.2.

5.2.3 Category Code

The *Category Code* is implemented as per Section 4.2.3. The *Category Code* is always CS for Contractor Submittal documents.

5.2.4 VDR Code

The Vendor Document Requirement (VDR) Code is a number that uniquely identifies each submittal package required from the Contractor. The *VDR Code* is to be between three and six numbers, depending upon the coding system utilized on the project. The two available VDR coding systems are described in the following sections.

5.2.4.1 VDR Code Scenario 1 – Custom VDR List

In this scenario, the project manager has decided that a custom Vendor Document Requirement (VDR) list is created and that the submittal requirements are to be organized and referenced based upon a custom list for the project. This list shall include discipline coding, as per Table 3-4. The discipline should generally be chosen based upon the primary group responsible for creating and/or implementing the work. For example: A process pump datasheet is a process document, even though it might have electrical motor data included.

Scenario 1 is the recommended format for large projects, to ensure that submittals are not missed. Example document numbers for this scenario are shown below, based on the sample VDR schedule shown in Table 5-2.

Document Number	Title
S0926-12CS-S104-01	Structural - HRC Building Foundation Concrete mix design
S0926-12CS-S104-02	Structural - HRC Building Wall Concrete mix design
S0926-12CS-E103-01	Electrical - Distribution Panel DP-G701 submittal
S0926-12CS-E104-01	Electrical - Distribution Panel PNL-S702 submittal

Contractor Submittal Documents

Table 5-2 : Sample VDR Schedule

VDR	Discipline	Description	
S1**	Structural	Headworks and Grit	
S101		Excavation Plan	
S102		Shoring Plan / Shop Drawings	
S103		Piles	
S104		Concrete Mix Design	
S2**		High-Rate Clarifier Building	
S201		Excavation Plan	
S202		Shoring Plan / Shop Drawings	
S203		Piles	
S204		Concrete Mix Design	
E1**		Electrical	Headworks and Grit
E101			Transformers - MV
E102	Transformers - LV		
E103	Panelboards – 600V		
E104	Panelboards – 120/208V		
E2**	High-Rate Clarifier Building		
E202	Transformers - LV		
E203	Panelboards – 600V		
E204	Panelboards – 120/208V		

5.2.4.2 VDR Code Scenario 2 – VDR Based upon Construction Specification Reference

In this scenario, the project manager has decided that no custom Vendor Document Requirement (VDR) list is created and that the submittal requirements are to be organized and referenced purely upon the specification reference number. The specification reference number is typically based on the Construction Specifications Institute (CSI) format, which is sometimes referred to as National Master Specifications (NMS) format. Examples for this scenario are shown below.

Document Number	Title
S0926-12CS-033000-001	Structural - HRC Building Foundation Concrete mix design
S0926-12CS-033000-002	Structural - HRC Building Wall Concrete mix design
S0926-12CS-262417-001	Electrical - Distribution Panel DP-R701 submittal
S0926-12CS-262417-002	Electrical - Distribution Panel DP-S702 submittal

Contractor Submittal Documents

5.2.5 Sequence Number

The *Sequence Number* is a three digit number to uniquely identify the specific document, with a given *Project Code*, *WBS Code*, *Category Code* and *VDR Code*. It is usually assigned in a sequential manner with the first document assigned a Sequence Number of 001 and the next document 002.

5.2.6 Suffix

Implement the suffix as per Section 7.3.

Quality Test Results

6 QUALITY TEST RESULTS

6.1 Description

Quality Test Result documents provide a record of completed test results during the construction, pre-commissioning, and commissioning phases of the project. Examples include construction tests such as concrete strength testing, pre-commissioning tests such as cable continuity tests, and commissioning tests. These test results are stored as records under the project.

6.2 Format

Table 6-1 : Quality Test Result Document Number Format

Field	Project Code		WBS Code	Category Code		Equipment Identifier		Sequence Number		Suffix (Optional)
Format	LNNNN	-	NN	LL	-	C[CCC]-NNN	-	NNN	-	*
Example	S0926	-	11	CQ	-	P-K311	-	001	-	S1

Legend: N = numeral, L= Letter, C= character (i.e. =N or L), * = multiple characters

Note:

1. The Category Type Code is always QT for Quality Test Results.
2. The file extension, such as “.docx” or “.pdf” would be appended to the end of the filename, but is not technically considered to be part of the document number.
3. The suffix is separated by an underscore (_), not a hyphen (-).
4. The suffix is technically not part of the document number, but rather an extension to be utilized in special case scenarios.

6.2.1 Project Code

The *Project Code* is implemented as per Section 4.2.1

6.2.2 WBS Code

The *WBS Code* is implemented as per Section 4.2.2.

Quality Test Results

6.2.3 Category Code

The *Category Code* is implemented as per Section 4.2.3. The *Category Code* is always QT for project Quality Test Result documents.

6.2.4 Equipment Identifier

The *Equipment Identifier* is the unique set of numbers and characters applied to each piece of equipment, as per the Identification Standard. However, for some disciplines, an equipment Identifier does not apply. In this case, utilize the letter “X” for the functional designator, and create a scheme for the equipment number that is appropriate for the project. An example of a scheme is as follows

Equipment Identifier	Description
X-Y001	North Road
X-Y002	South Road

It is noted that this scheme may be developed as the construction progresses.

In some cases it may be acceptable to group test results. For example, for small electrical cables, multiple cables could be shown on one test result. In this case, the equipment descriptor would utilize one or more small letter “x” in the equipment number to show that multiple pieces of equipment are included within the test result.

6.2.5 Sequence Number

The *Sequence Number* is a three digit number to uniquely identify the specific document, with a given *Project Code*, *WBS Code*, *Category Code*, and *Equipment Identifier*. It is usually assigned in a sequential manner with the first document assigned a *Sequence Number* of 001 and the next document 002, although utilizing a non-sequential system is permitted.

6.2.6 Suffix

See Section 7.3.

6.3 Examples

Document Number	Title
S0926-12QT-X-Y001-001	Compaction Test 1 Result for North Road
S0926-12QT-X-Y001-002	Compaction Test 2 Result for North Road
S0926-12QT-X-Y002-001	Compaction Test 1 Result for South Road
S0926-12QT-X-K001-001	HRC Building Foundation Pour 1 Concrete Strength Test
S0926-12QT-X-K001-002	HRC Building Foundation Pour 2 Concrete Strength Test
S0926-12QT-P-K301-001	Pump P-K301 pre-commissioning form
S0926-12QT-P-K301-002	Pump P-K301 Vibration test result
S0926-12QT-C-Kxx1-001	HRC Building (K) small cable test results (Part 1 of 2)
S0926-12QT-C-Kxx1-002	HRC Building (K) small cable test results (Part 2 of 2)
S0926-12QT -C-K711-01	Cable test form for cable C-K711.

General Requirements

7 GENERAL REQUIREMENTS

The general requirements apply to all documents.

7.1 Document Titles

Every document shall have a document title clearly indicated on the cover of the document. The document number and document title are independent fields. Where a DMS is utilized, the title shall also be entered into the DMS document metadata.

Document titles should contain concise descriptive information regarding the content of the document, without duplicating information that is found in the document type. The information, together with the document number should provide users with sufficient information to identify the document. Where dates are applicable, they shall be in YYYY-MM-DD format.

7.2 Revision Codes

Every document shall clearly have a revision code indicated on the cover page of the document. The revision shall be in the format as per Table 7-1.

Table 7-1 : Revision Codes

Code	Description
PA - PZ	Preliminary / Draft Release
00	First Official Revision (Tender / Construction)
01 - 99	Subsequent Official Released Revisions
##[A-Z]	A draft release of changes to the ## revision release, which when approved would be incremented to the next release. For example: revision 01B is the second draft of the changes to the 01 release document, and when approved, would later become the 02 release document.

The revision code is not part of the document number, but shall be shown on the cover page / title block of all documents.

7.2.1 Revision Description

All documents should indicate a Revision Description, to indicate the purpose of the issue, or the changes made. Examples are indicated below:

Revision	Revision Description
PA	Initial Concept
PC	Issued for 60% Review
00	Issued for Tender
01	Modified pump horsepower

General Requirements

7.3 Suffix Codes

The *Suffix Code* is technically not part of the document number, but rather an optional extension to be utilized in special case scenarios. The *Suffix Code* consists of one to three letters and an optional subsequent sequence number. While the information in the suffix is limited, it should be noted that the document title should be utilized to fully describe the document. See Table 7-2 for a list of *Suffix Codes* and their definition.

Table 7-2 : Suffix Code Designations

Code	Description
APP	Appendix
C	Commented version of the document
RES	Response to document. (Example – CCN Quote)
R	Revision of a document
S	Signed / approved version of the document

Note:

1. *As a DMS has not yet been implemented, compatibility of this field with the DMS has not been confirmed. Use of this field within a network drive filesystem or SharePoint site is appropriate.*
2. *Stacking of multiple suffix codes is acceptable where required to indicate the document content. The suffixes are to be separated utilizing an underscore character.*

7.3.1 Appendix Files

Appendix files are additional documents appended to a main document. In some cases they may have a completely independent document number, but in other cases it is appropriate to number the document as an appendix to the main document by utilizing the APP suffix code.

7.3.2 Commented Files

During project implementation, documents are reviewed and commented on. The comments can either be integrated into the native document, such as Microsoft Word comments, or into a PDF file. The commented files are not official versions of the document, and thus require a separate filename. The filename is to be appended with “_C#”, where # is a sequential number to be applied. Multiple comment files can be produced with respect to a single document. Where a comment file is applicable to a single revision, the revision number should also be included in the filename.

Note:

1. *If the DMS incorporates a commenting system, it shall be utilized rather than the use of commented files.*

General Requirements

7.3.3 Examples

The following examples demonstrate correct application of suffixes.

Name	Title	Description
S0924-01DS-RPT-0001_C0		Excel review log on a design report that is applicable to all revisions of the document
S0924-11CA-PES-0015_S	2014-10-31	Signed copy of Progress Estimate 15 for the period ending 2014-10-31.
S0924-12CA-ACC-0003_APP01	SF-G652 Datasheet	Appendix to CA-ACC-0003
S0924-12CA-CCN-0001_RES01	Additional Concrete	Contractor response (quote) to CA-CCN-0001 document regarding Additional Concrete.
S0924-12CA-PES-0015_S	2014-10-31	Signed copy of Progress Estimate 15 for the period ending 2014-10-31.
S0924-12CA-MOM-0001_R01	2014-09-10 Progress Meeting	Revision 01 of the Minutes of Meeting for the Contractor Progress Meeting dated 2014-09-10.
1-0102-CGAD-B601_RPA_C0		1 st Commented file on PA rev.
1-0102-CGAD-B601_RPB_C0		1 st Commented file on PB rev
1-0102-CGAD-B601_RPB_C1		2 nd Commented file on PB rev
S0924-11DD-RPT-0001_C0	Document Comments	Excel comment file applicable to all revisions of the document (alternative to examples above)

FAQ – Frequently Asked Questions

8 FAQ – FREQUENTLY ASKED QUESTIONS

Why do Class A Documents have a different coding system than General Project Documents?

Class A Documents have a different lifecycle than General Project Documents. Project documents, such as a progress estimate or meeting minutes, do not typically need to be referenced past the life of the project. However, Class A Documents, including drawings, have a life for as long as the facility is in service. Thus, Class A Documents have a document number coded by facility and area rather than by project.

How should a HAZOP workshop report be numbered?

Workshop reports are not considered to be design documents, and thus should be numbered as General Project Documents per Section 4. For example, a valid project document number would be:

S0926-05DS-RPT-0005 HRC Building HAZOP Report

What should the Revision Code be for a preliminary drawing, sealed by a professional engineer for costing purposes?

Preliminary drawings should be coded with a Revision Code in the PA to PZ series, regardless of whether the drawing is an authenticated sealed drawing. An example is shown below:

Document Number:	1-0102-PPID-S201
Revision	PC
Revision Description:	Issued for Costing

What should the Revision Code be for a drawing issued for tender, but not sealed by a professional engineer?

A drawing issued for tender is an official release. If this is the first official release of the drawing, it should have a Revision Code of 00. A subsequent revision to issue the drawing for construction and seal the document would have a Revision Code of 01.

FAQ – Frequently Asked Questions

A drawing is currently at the as-built stage and changes are proposed as part of a new construction package. Should a new document be created? How should the Revision Code be applied?

If the changes to the document are minor and do not change the overall design intent, then modify the existing drawing. The following is an example sequence of drawings revisions, which would be appropriate for the indicated situation:

Document Number	Revision	Revision Description
1-0101-PPID-D521	02	As-Built – Bid Opp. 123-2015
1-0101-PPID-D521	02A	Proposed Modifications
1-0101-PPID-D521	02B	Issued for City Review
1-0101-PPID-D521	03	Issued for Tender – Bid Opp. 456-2018

How should National Master Specification (NMS) format specifications be numbered?

Response to be developed.

How should Construction Inspections by the Engineer be numbered?

Construction inspections reports by the engineers are considered to be Construction documents, not Quality Test Results. Construction documents are organized by discipline, as per Table 4-3. The Document Type Code for construction inspection reports is found in Table 4-4 to be CIR. Thus, for a structural inspection report for project S-924 and WBS Code 11, the document code would be:

S0924-11NS-CIR-0001

Where 0001 is the next available incremental number.

If a project is in the construction stage, and the contract administrator holds a meeting with the City, how should the meeting minutes be numbered?

Meeting minutes of meeting held with the contractor during the contract administration phase are typically numbered as follows:

S0924-21CA-MOM-0001, S0924-21CA-MOM-0002, etc

The concern is that a meeting held without the contractor should not interrupt the meeting number sequence. Thus, if meetings are held without the contractor, it is recommended to utilize the sequence number to differentiate the meetings as follows:

S0924-21CA-MOM-1001, S0924-21CA-MOM-1002, etc

How can I tell which organization created the document for the document number?

The document number does not indicate who created the document. The document's originator should be shown on the document's title page. In addition, if a DMS is utilized on the project, the DMS should have a metadata field for the document's originator.

FAQ – Frequently Asked Questions

What is the document number for a single comment file that applies to a large group of drawings?

The document number should utilize the LIS (List) document type. For example:

S0976-11DD-LIS-0001 WSTP Level 2 Design Report Comment List

	Automation Design Guide	Revision: 00	Page 1 of 107
		Document Code: 612620-0013-40ER-0001	



The City of Winnipeg
Water & Waste Department

Wastewater Treatment Facilities
Automation Design Guide

Document Code: 612620-0013-40ER-0001
Revision: 00

Approved By:	 <hr/> Duane Griffin, Branch Head – WW Planning & Projects	 <hr/> Date
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2015/08/19

Rev. 00

REVISION REGISTER					
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00	Issued for City Use	2015-08-19	B. Cleven	T. Church	T. Church

This document is owned and maintained by the Asset Management Branch of the Engineering Services Division. For questions, comments or revisions please contact the Asset Management Branch Head.

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		Document Code: 612620-0013-40ER-0001	

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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

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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

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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.

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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.

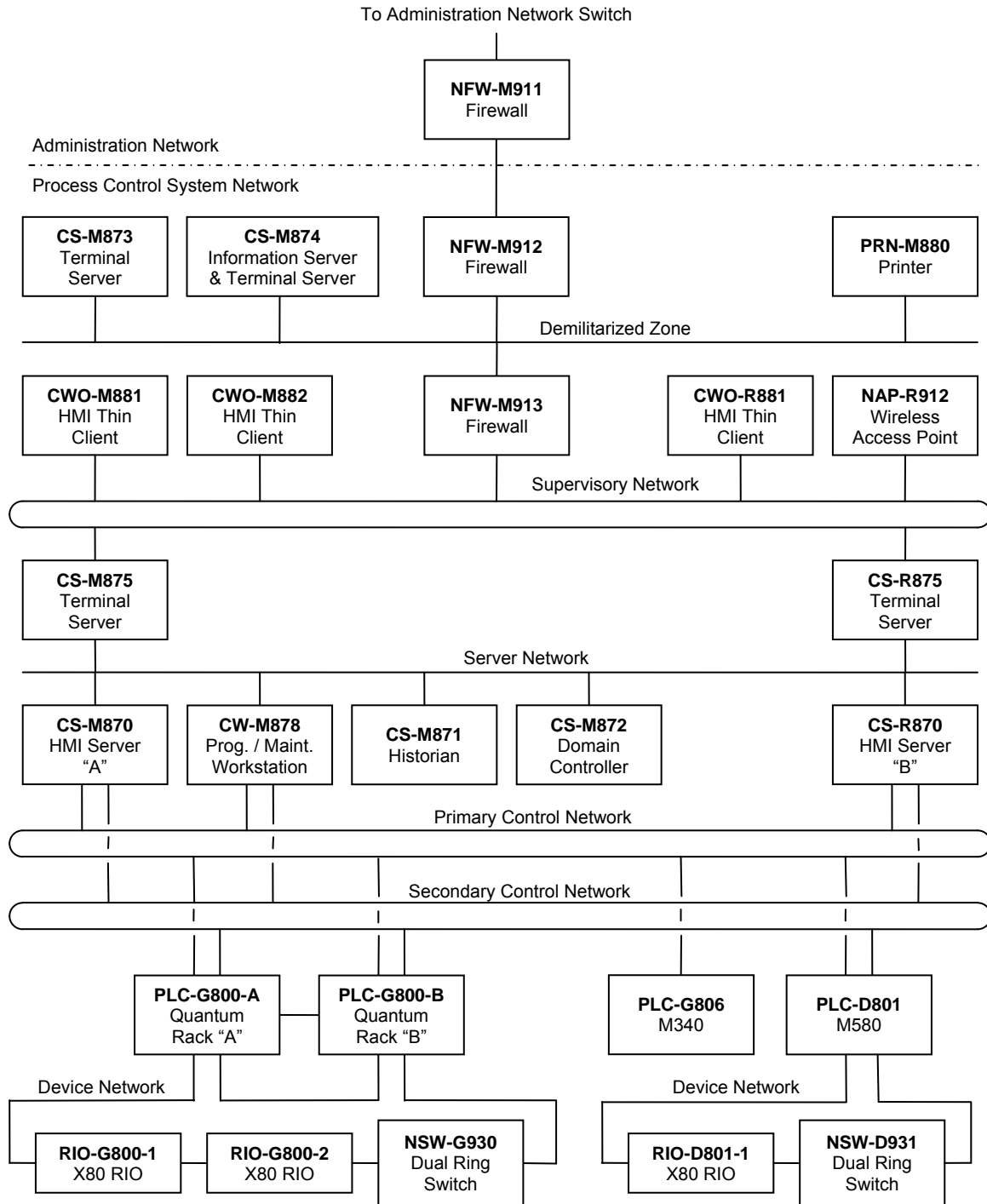


Figure 3-1: Facility PLC-based Process Control System Architecture

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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).

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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

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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.

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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.

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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.

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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.

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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.

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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

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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.

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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,

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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.

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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.

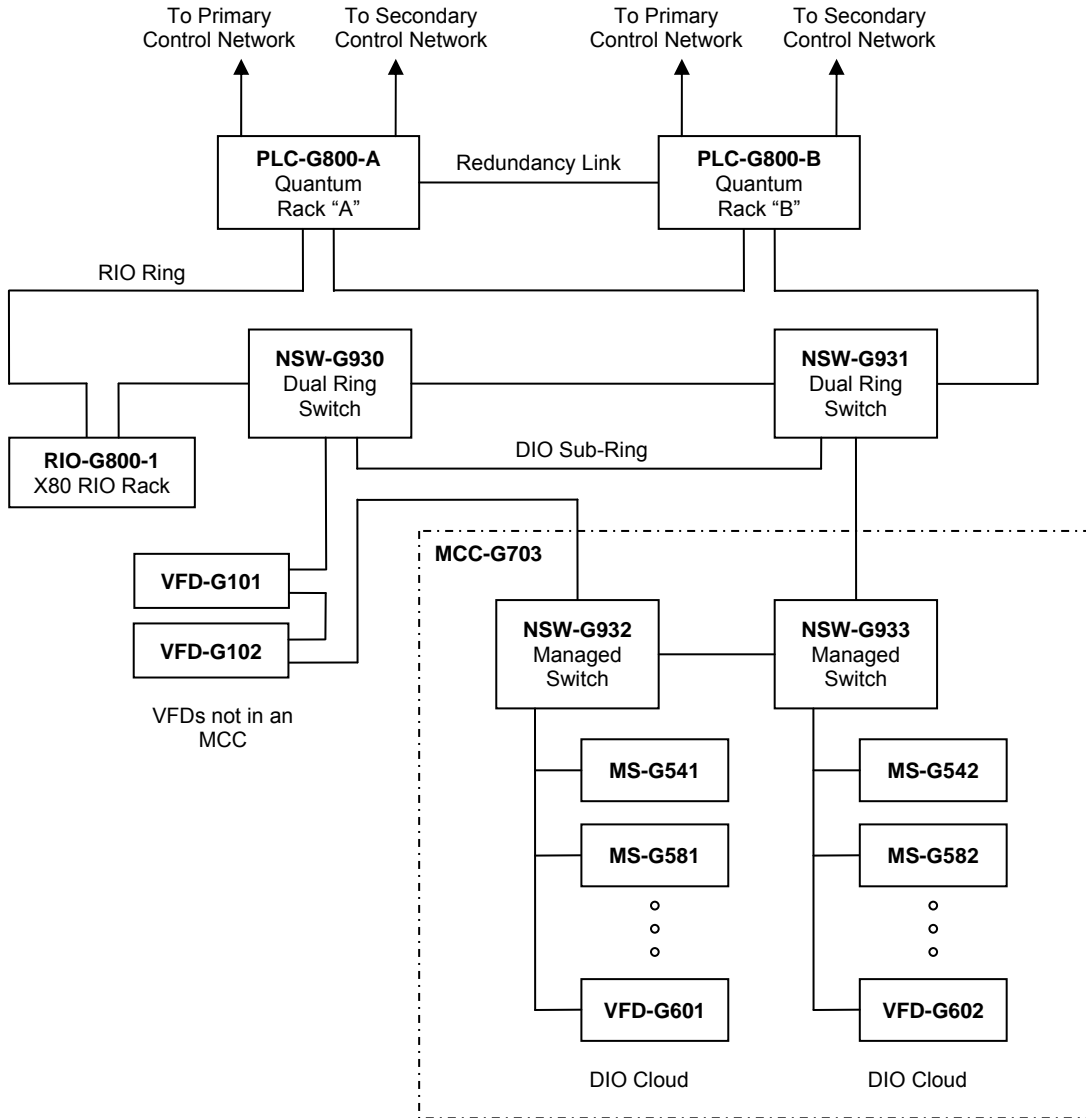


Figure 3-2: Quantum Hot-Standby Architecture

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.

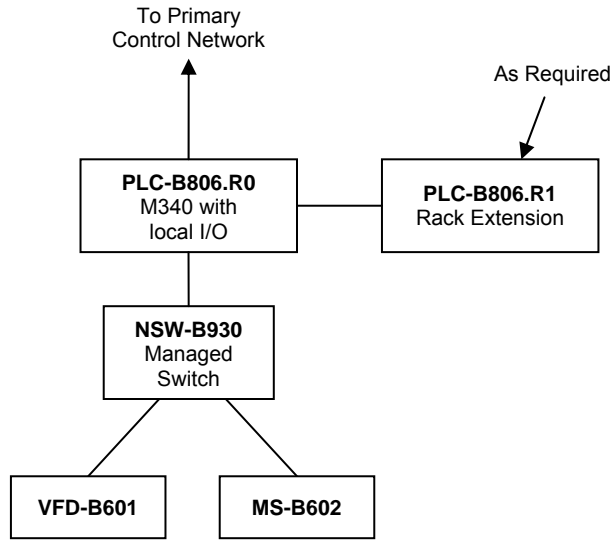


Figure 3-3: Mid-grade PLC System Architecture with M340 Processor

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.*

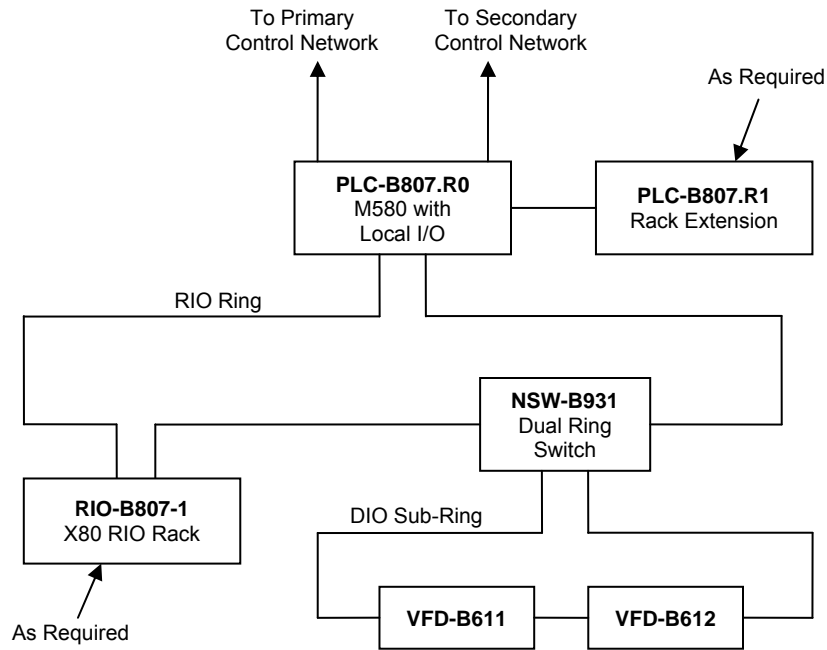


Figure 3-4: Mid-grade PLC System Architecture with M580 Processor

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.

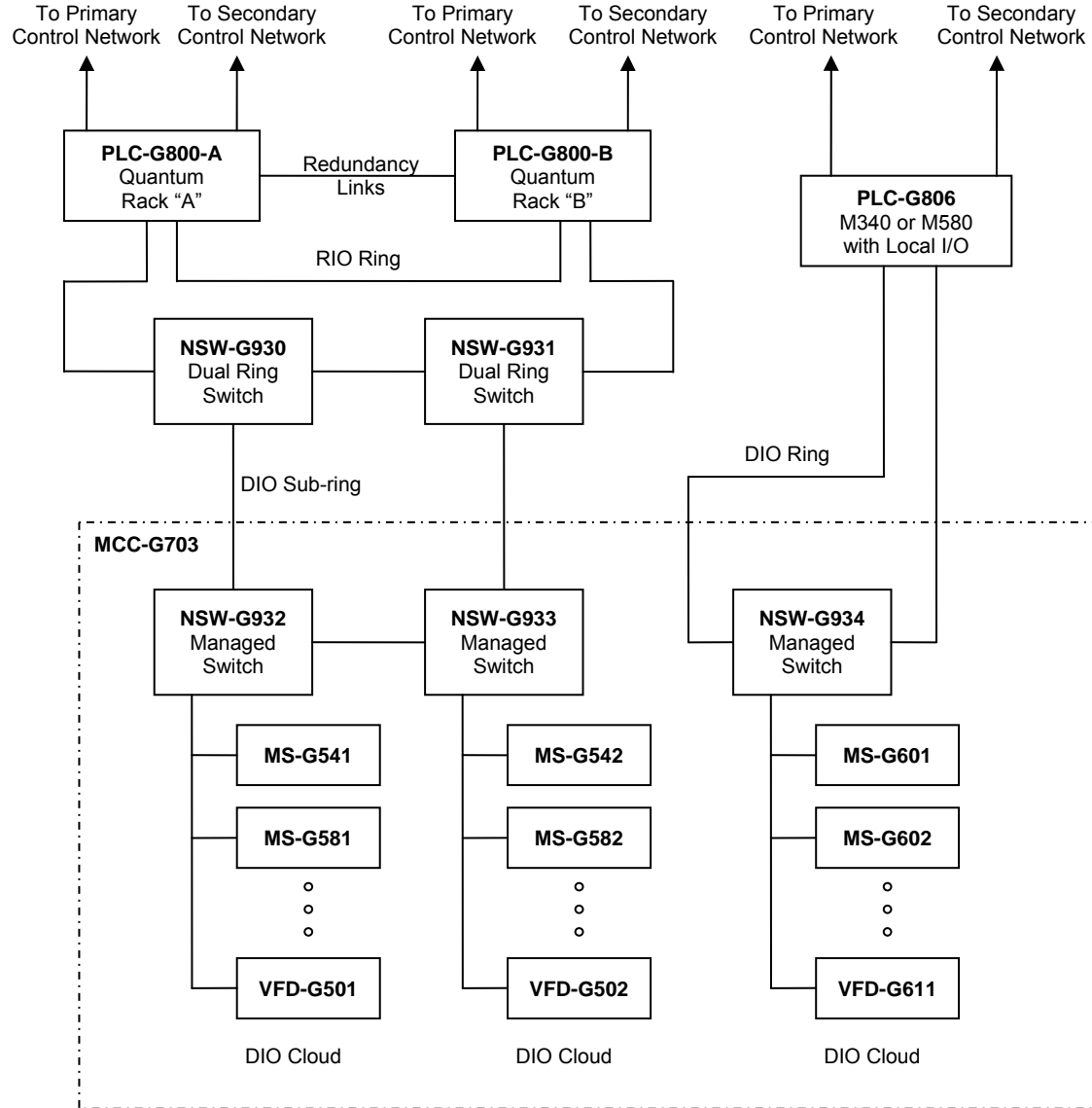


Figure 3-5: Multiple PLCs controlling a single MCC

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.

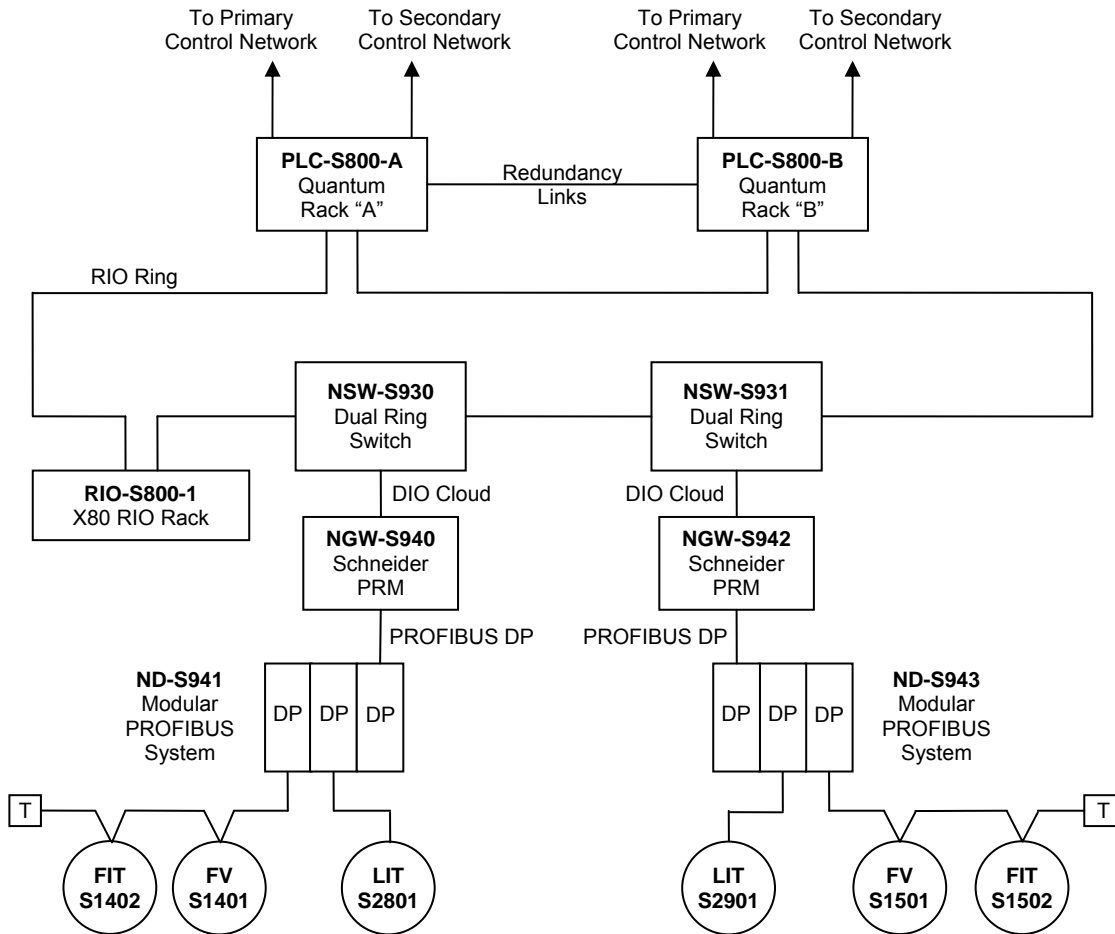


Figure 3-6: Connection of PROFIBUS DP Devices

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.

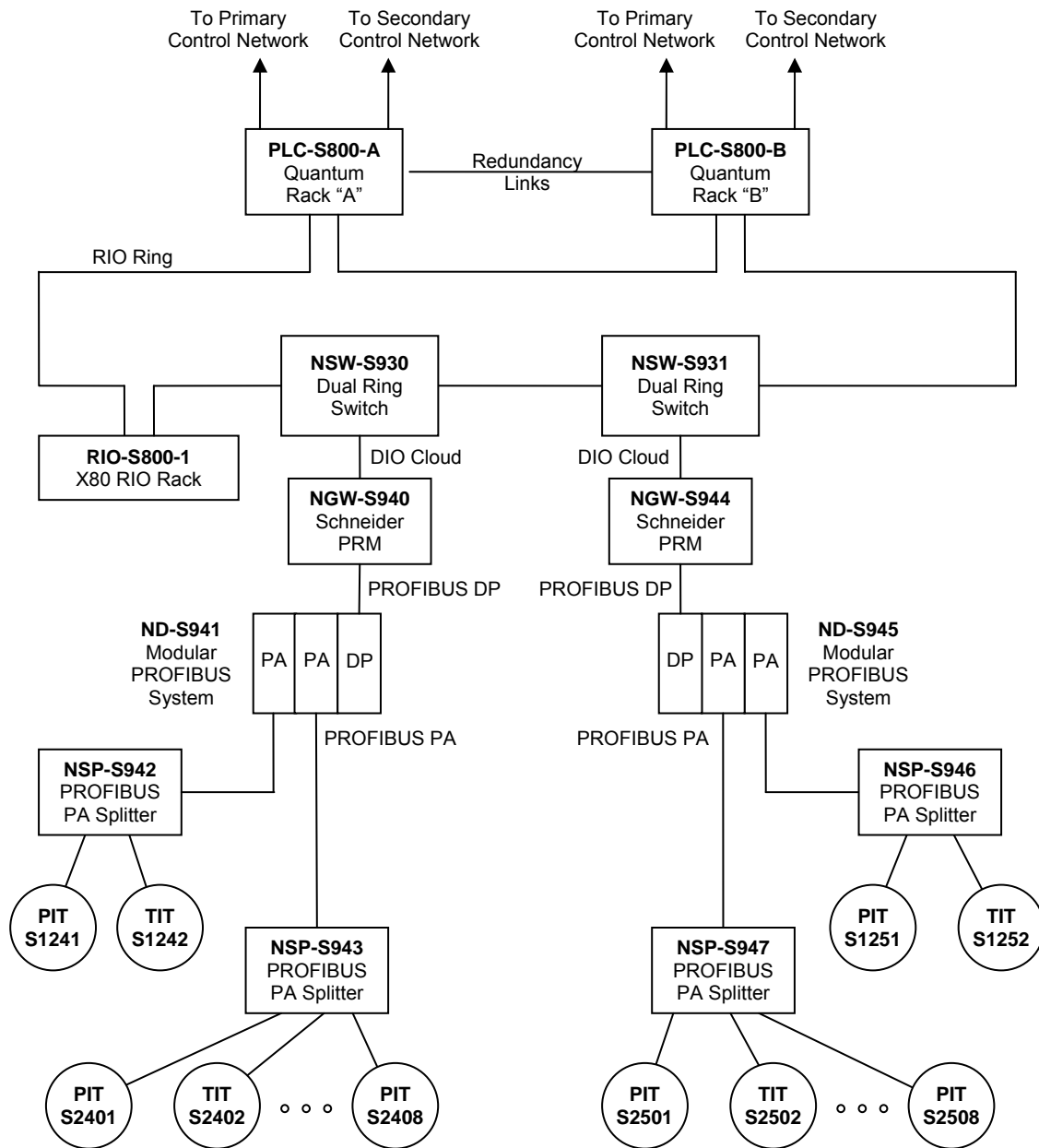


Figure 3-7: Connection of PROFIBUS PA Devices

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

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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.

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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.

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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,

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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.

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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

Application	Type
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.

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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.

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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.

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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),

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- 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 ^(Note 3)
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.*

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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.

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

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

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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.

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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.

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

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

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

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

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

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.

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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 – 28th 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

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

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"> Position command 	<ul style="list-style-type: none"> Valve Position Actuator Torque Actuator Moving Closed Limit Open Limit Running Closed Running Open Remote Selected Local Stop Selected Local Selected Thermostat Tripped Monitor Relay Valve Obstructed Valve Jammed Valve Moving by Hand Moving Inhibited Position Control Enabled Watchdog Recovery Battery Low Control Contention
On/Off Valve, Pneumatic Control	<ul style="list-style-type: none"> Open Command Close Command 	<ul style="list-style-type: none"> Closed Limit Open Limit
Modulating Valve, Pneumatic Control	<ul style="list-style-type: none"> Position Command 	<ul style="list-style-type: none"> Valve Position

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.

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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.

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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.

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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.

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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.

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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.

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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 μ 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,

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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.

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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.

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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.

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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.

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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.

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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.

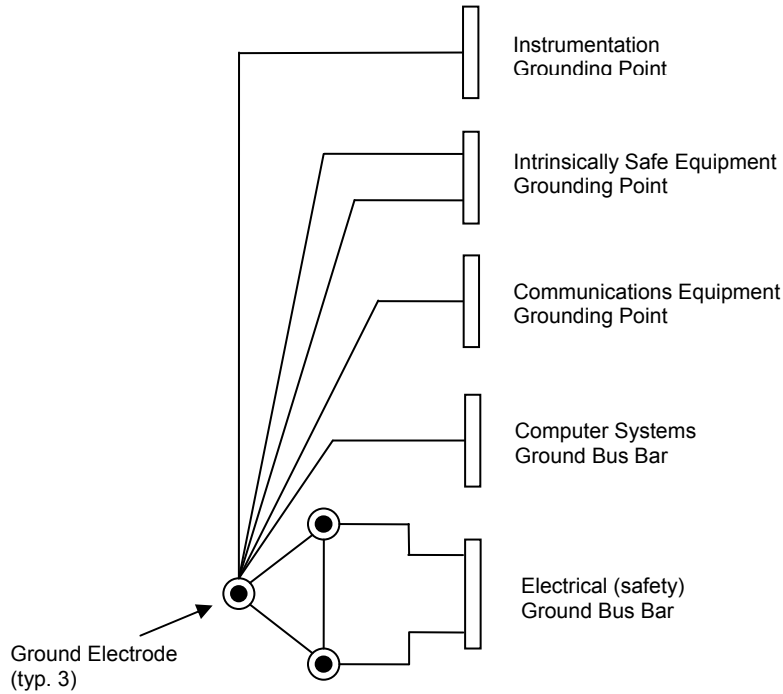


Figure 16-1: Typical Grounding System Implementation with Three Grounding Electrodes

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.*

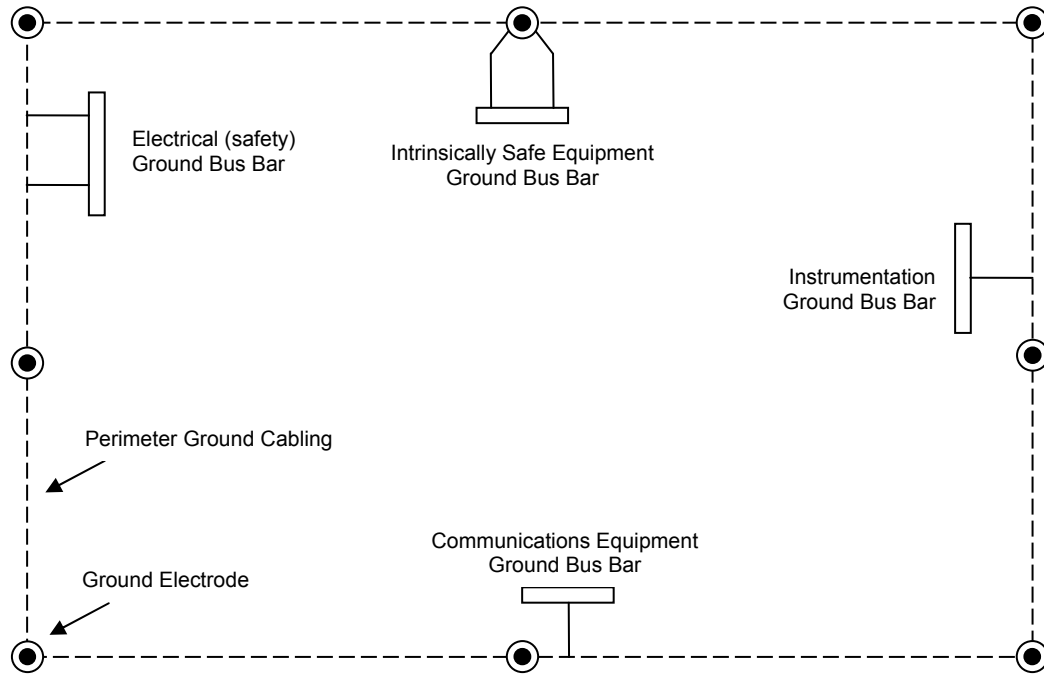


Figure 16-2: Typical Grounding System Implementation with a Perimeter Ground

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.

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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.

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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.

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- 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.

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- 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.

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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

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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.

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- 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".

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- 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.

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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.

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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

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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.

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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.

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- 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.

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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:

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- 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.

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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.

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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.

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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.

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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.

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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.

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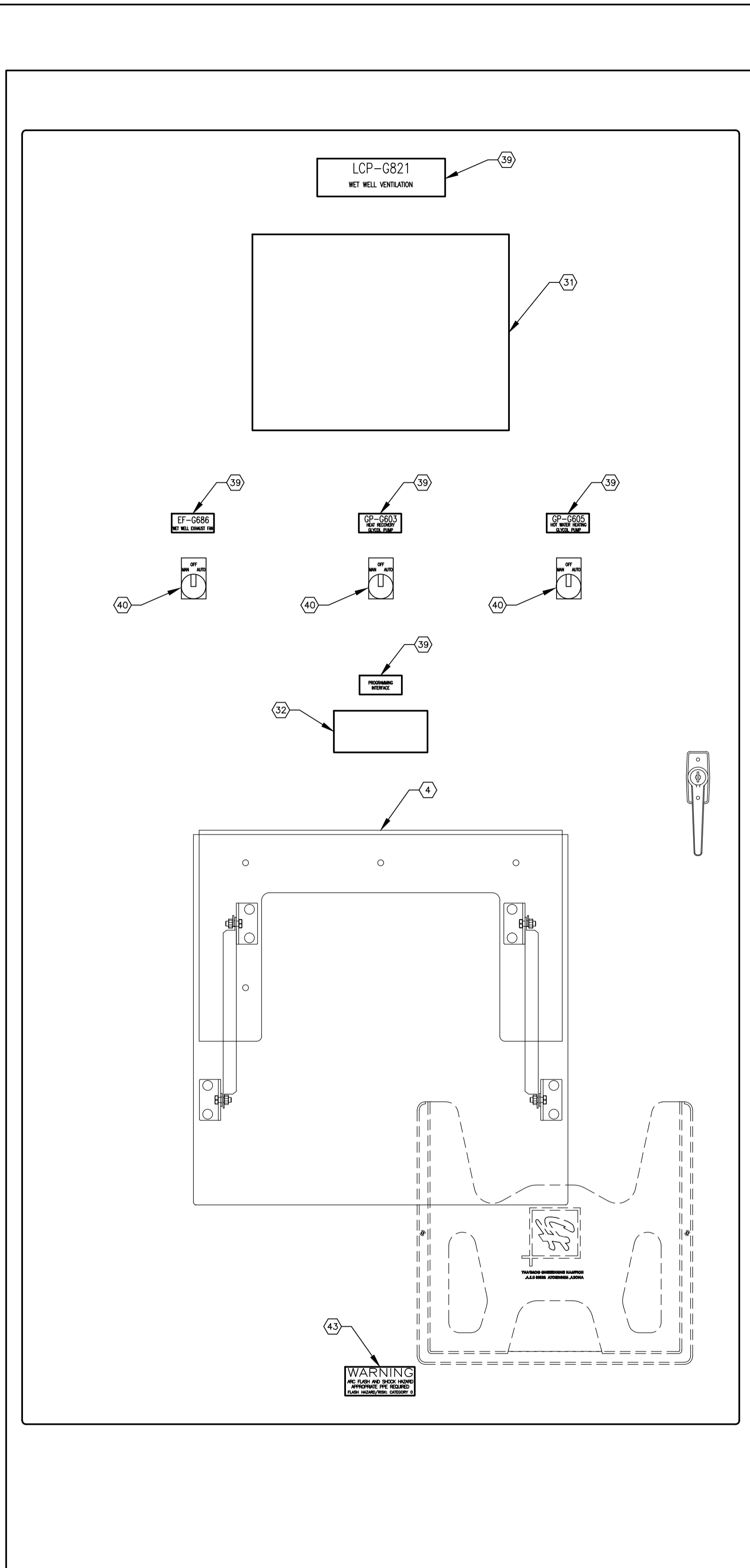
18 SAMPLE DRAWINGS

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

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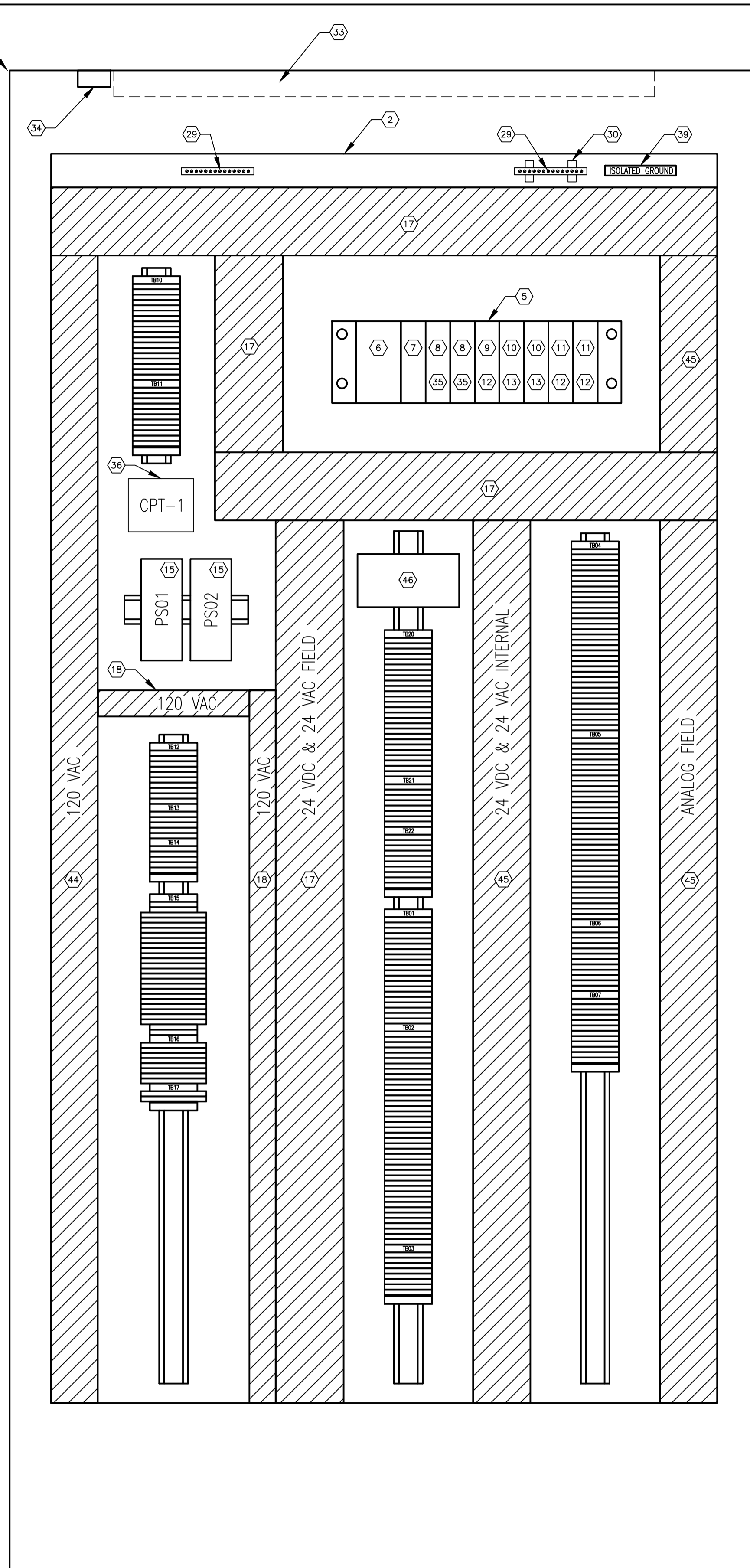
19 SAMPLE DOCUMENTS

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

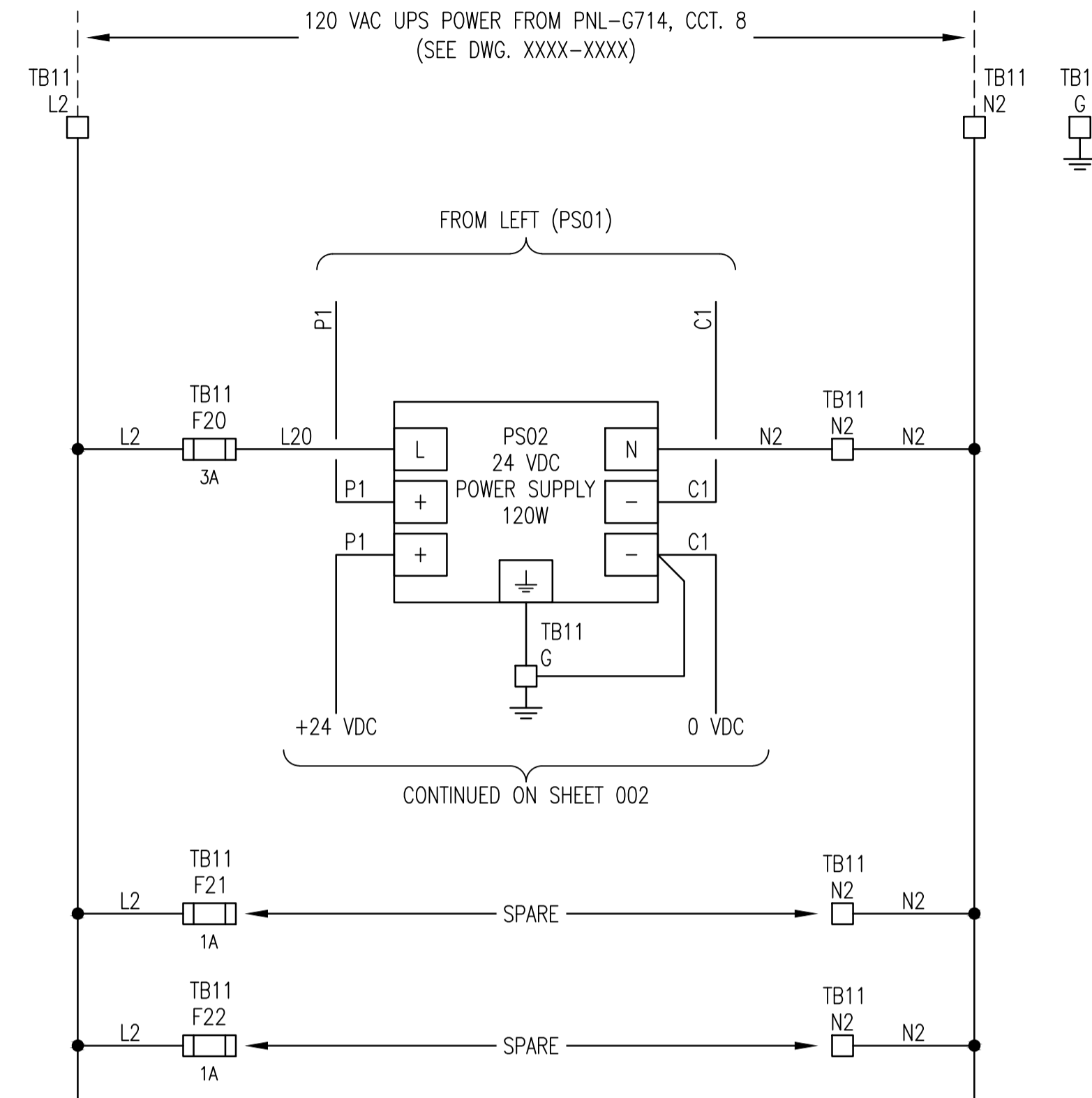
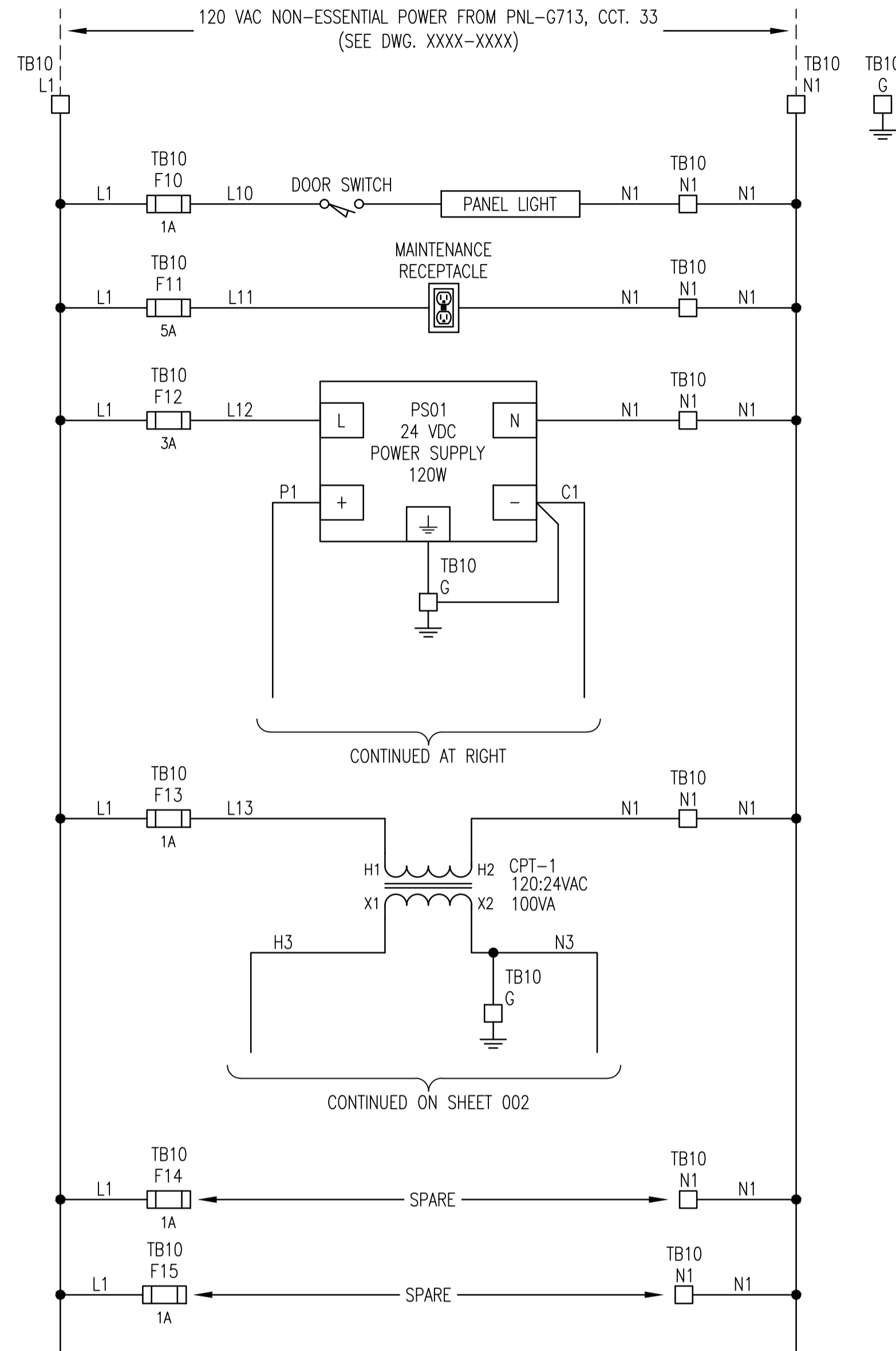
GENERAL NOTES:

- 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.

		SNC-LAVALIN INC. 148 Nature Park Way Winnipeg, MB, Canada R3P 0X7 204-786-8080		ENGINEER'S SEAL	
DESIGNED BY:	CHECKED BY:	SAMPLE	 DESIGN STANDARD DRAWINGS WINNIPEG SEWAGE TREATMENT PROGRAM PANEL LAYOUT LCP-G821		
DRAWN BY:	APPROVED BY:				
SCALE:	ISSUED FOR CONSTRUCTION BY:				
DATE:	DATE:				
00 ISSUED WITH AUTOMATION DESIGN GUIDE	2015/08/19	-	-	CONSULTANT NO.:	
NO. REVISIONS	DATE	DESIGN	CHECK	CITY DRAWING NUMBER	SHEET REV. SIZE
				SK-A101	001 00 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

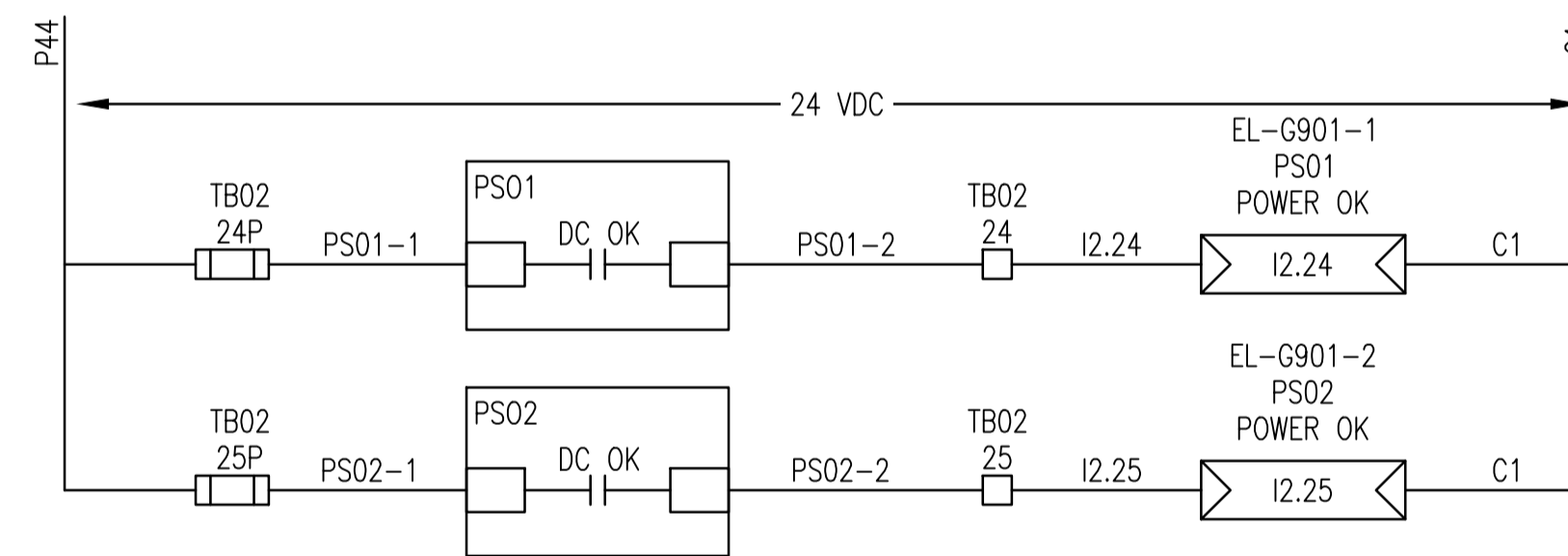
TERMINAL LAYOUT TB10	
L1	
N1	
G	
F10	
F11	
F12	
F13	
F14	
F15	
N1	
N1	
N1	
N1	
N1	



GENERAL NOTES:

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

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

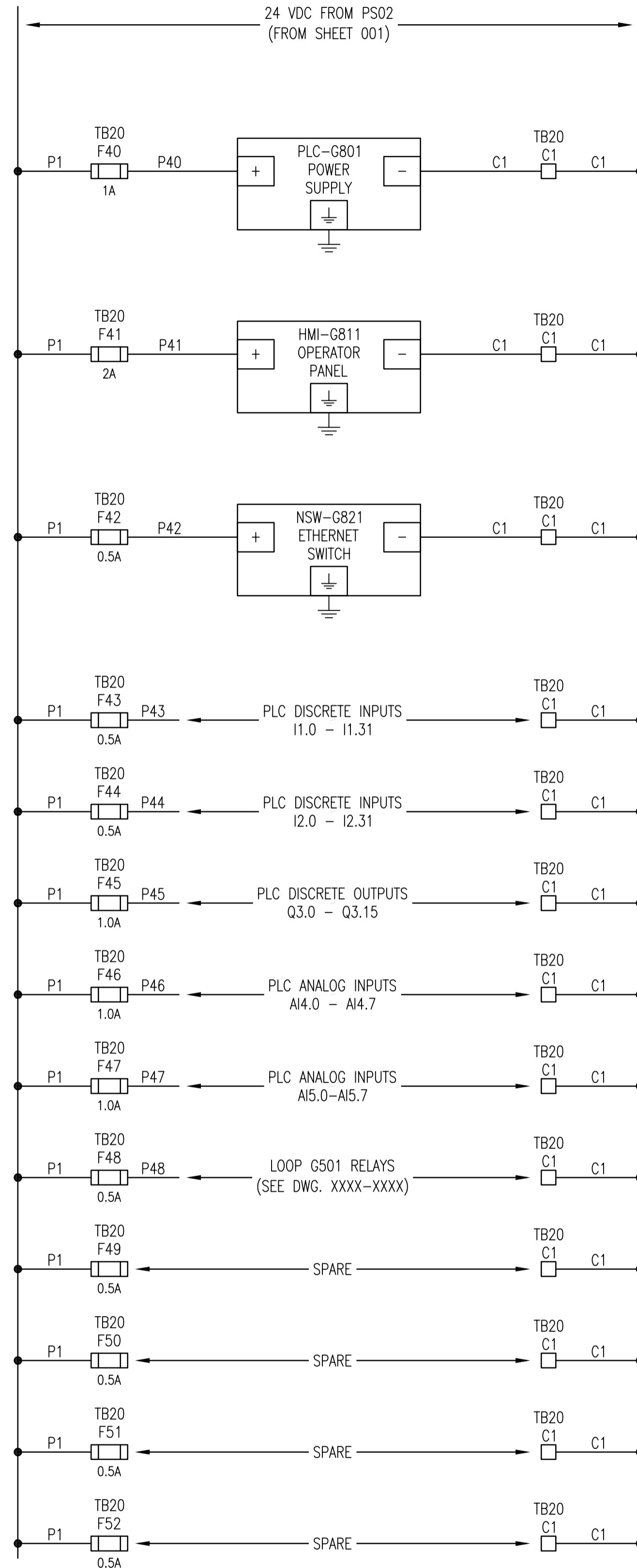


NOTE: THIS DRAWING IS A SAMPLE DRAWING THAT INDICATES THE TYPICAL REQUIREMENTS FOR POWER DISTRIBUTION SCHEMATICS. REFER TO AUTOMATION DESIGN GUIDE (612620-0013-40ER-0001) FOR FURTHER DETAILS.

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

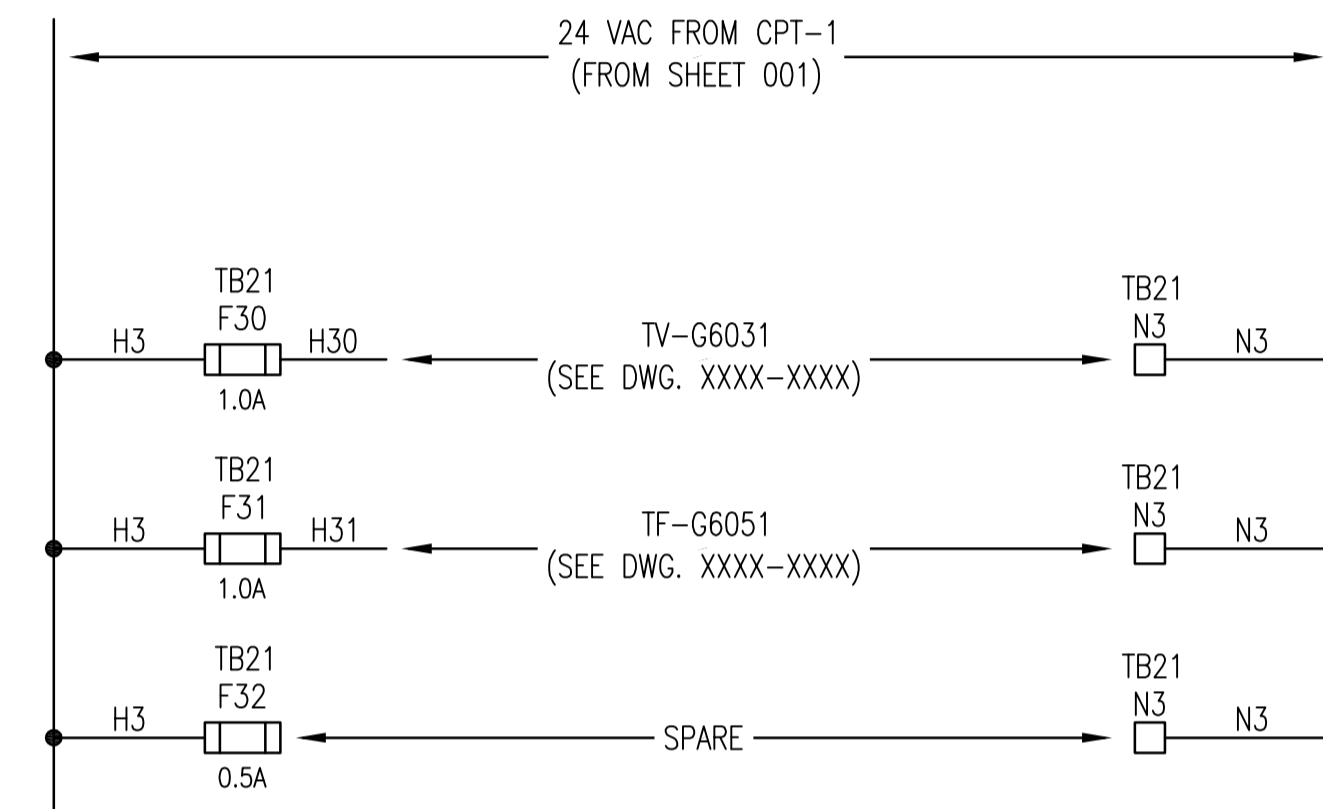
FUSE SCHEDULE			
M	IDENTIFIER	SIZE	RATED CURRENT
TB20	F40	5x20mm	1A
	F41	5x20mm	2A
	F42	5x20mm	0.5A
	F43	5x20mm	0.5A
	F44	5x20mm	0.5A
	F45	5x20mm	1.0A
	F46	5x20mm	1.0A
	F47	5x20mm	1.0A
	F48	5x20mm	0.5A
	F49	5x20mm	0.5A
	F50	5x20mm	0.5A
	F51	5x20mm	0.5A
TB21	F30	5x20mm	1.0A
	F31	5x20mm	1.0A
F32	5x20mm	0.5A	

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
TOTAL			3642



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
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C1



TERMINAL LAYOUT TB21

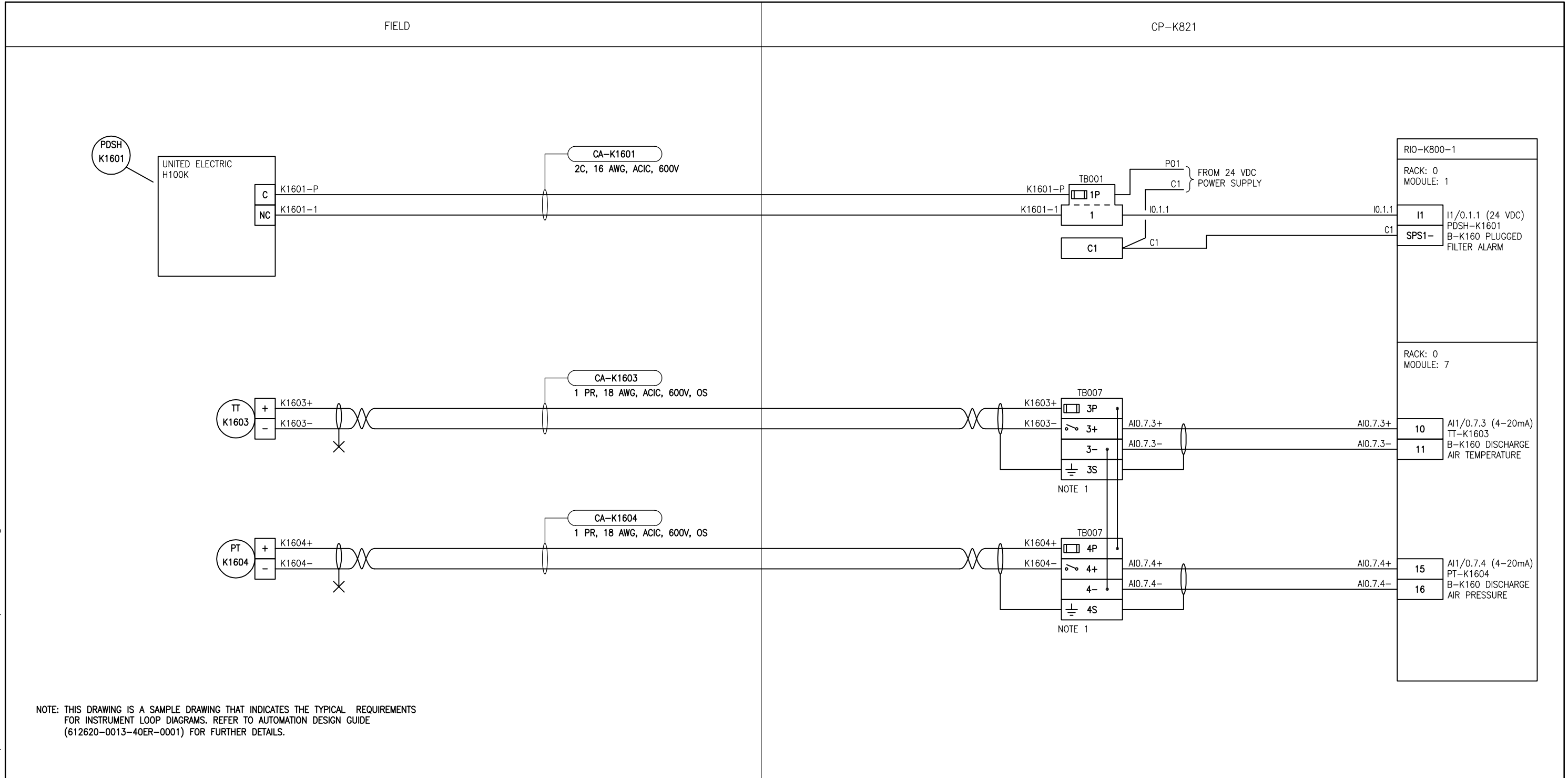
F30
N3
N3
F31
N3
F32
N3
N3
S

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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DESIGNED BY:	CHECKED BY:	SAMPLE			
DRAWN BY:	APPROVED BY:		DESIGN STANDARD DRAWINGS WINNIPEG SEWAGE TREATMENT PROGRAM POWER DISTRIBUTION SCHEMATIC LCP-G821		
SCALE:	ISSUED FOR CONSTRUCTION	CITY DRAWING NUMBER	SHEET		
DATE:	DATE:			REV.	SIZE
ISSUED WITH AUTOMATION DESIGN GUIDE	2015/08/19	SK-A102	002	00	A1
NO. REVISIONS	DATE DESIGN CHECK	SK-A102-002.dwg			

B SIZE - 279mm x 432mm

LAST SAVE: 2015/08/19 - 11:30am
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GENERAL NOTES:

1. GROUNDED TERMINALS CONNECTED TO ISOLATED GROUND THROUGH DIN RAIL.

NO.	REVISIONS	DATE	DESIGN	CHECK
00	ISSUED WITH AUTOMATION DESIGN GUIDE	2015/08/19	-	-

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ENGINEER'S SEAL

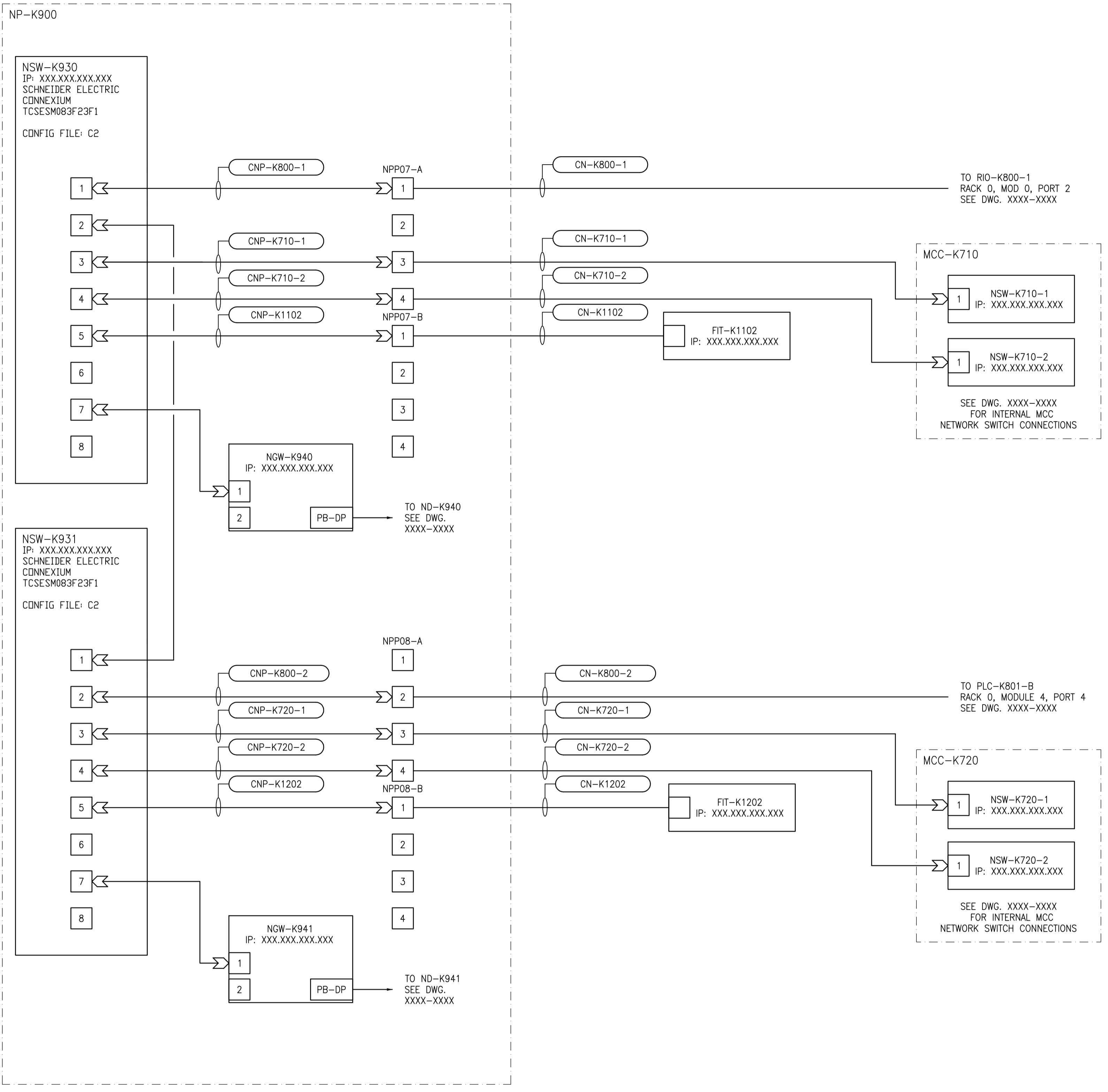
DESIGNED BY: _____ CHECKED BY: _____
 DRAWN BY: _____ APPROVED BY: _____
 SCALE: _____ DATE: _____
 ISSUED FOR CONSTRUCTION
 BY: _____ DATE: _____
 CONSULTANT NO.: _____

SAMPLE

THE CITY OF WINNIPEG
 WATER AND WASTE DEPARTMENT

DESIGN STANDARD DRAWINGS
 WINNIPEG SEWAGE TREATMENT PROGRAM
 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.

						SNC-LAVALIN INC. 148 Nature Park Way Winnipeg, MB, Canada R3P 0X7 204-796-8080		ENGINEER'S SEAL	
				SAMPLE				THE CITY OF WINNIPEG WATER AND WASTE DEPARTMENT	
DESIGNED BY:		CHECKED BY:		DRAWN BY:		APPROVED BY:		DESIGN STANDARD DRAWINGS WINNIPEG SEWAGE TREATMENT PROGRAM NETWORK DIAGRAM DEVICE NETWORK	
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

LAST SAVE: 2015/08/19 - 11:24am
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FIELD

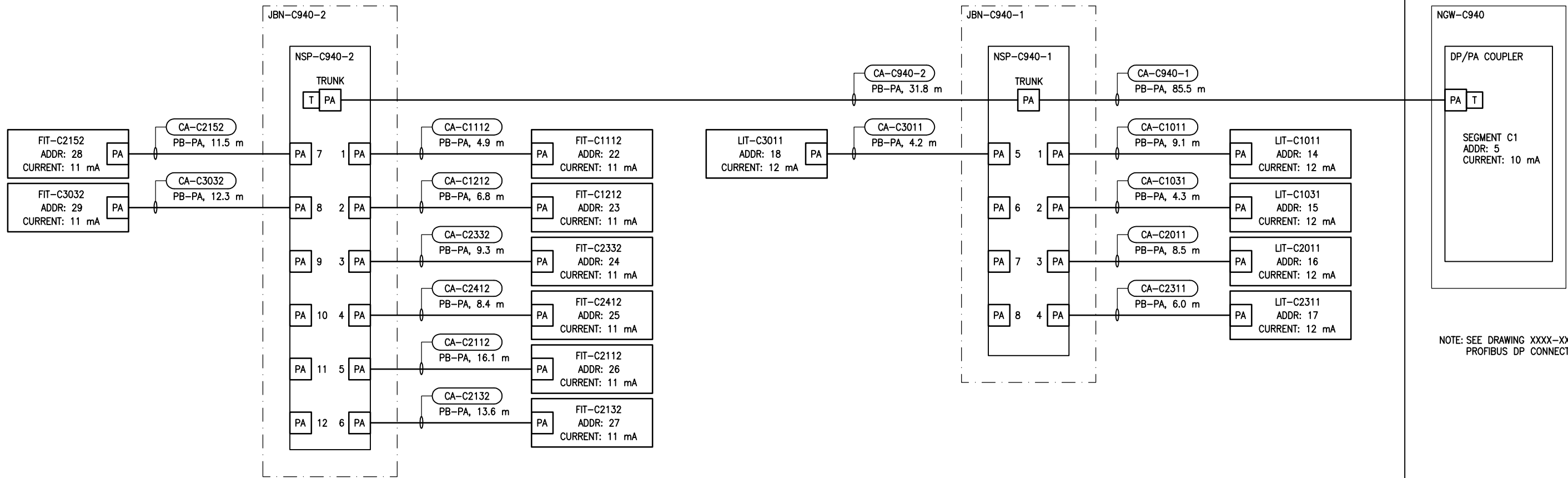
NP-C900

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.



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.



SNC-LAVALIN INC.
 148 Nature Park Way
 Winnipeg, MB, Canada R3P 0X7
 204-786-8080

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
00	ISSUED WITH AUTOMATION DESIGN GUIDE	2015/08/19	-	-

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>	INSTRUMENT LIST	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; text-align: center;"> Company Logo </div>	I/O LIST - PLC-G801	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; width: fit-content;"> Company Logo </div>	INTERFACE MAP	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;"> Company Logo </div>	AUTOMATION CABLE SCHEDULE	Document Code SD-A104
			Revision 00
Client City of Winnipeg			
Project SAMPLE			
Package / Area			
Prepared By	Name	Signature	Date
Checked By	Name	Signature	Date
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Notes / Comments		Seal	


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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; width: fit-content;"> Company Logo </div>	LAMACOID SCHEDULE	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
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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.

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Name	Signature	Date
Checked By:		
Name	Signature	Date
Approved By:		

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Rev.	Description	Date	By	Checked	Approved
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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.

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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.


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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 nd tab on the equipment faceplate.
EF3-*	Show as a 3 rd 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)

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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

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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.

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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>	FUNCTIONAL REQUIREMENTS SPECIFICATION	Document Code: SD-A106
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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)

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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))

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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

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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.

$$F_Total = \Sigma (Di_F)$$

$$Di_F_Perc = 100 * Di_F / F_Total \text{ (Handle case } F_Total = 0)$$

$$F_CapacityTotal = \Sigma (Di_InService * Di_F_Cap)$$

$$F_MOV = Select4(D1_F, D2_F, D3_F, D4_F, MOV)$$

$$F_MOV_Cap = Select4(D1_F_Cap, D2_F_Cap, D3_F_Cap, D4_F_Cap, MOV)$$


FOR i = 1 to 4

IF i == MOV THEN

$$Di_F_Tgt = D1_F$$

ELSE

$$Di_F_Tgt = F_MOV * Di_F_Cap / F_MOV_Cap$$

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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

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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

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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.

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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

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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


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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 ³² -1 min	EF-T
Intlocked	O	Interlocked	0/1	GDx-F

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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.


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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

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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 ³² -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.

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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.

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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 ³² -1 min	EF-TE (M)
K2_SP	SP	Cleanout duration	0 - 2 ³² -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 ³² -1 min	EF-T
Active	O	Cleanout Active	0/1	GDx-T

4.11.2 PLC Generated Alarms

None

4.11.3 Interlocks

None

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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

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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

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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.

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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.

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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

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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.

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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


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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.

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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.

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Prepared By:		
Name	Signature	Date
Checked By:		
Name	Signature	Date
Approved By:		

Certificate of Authorization	Professional Seal
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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

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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

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- 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

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- 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.

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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.

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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)


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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)


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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)


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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)


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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

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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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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	


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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


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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>	FUNCTIONAL REQUIREMENTS SPECIFICATION	Document Code: SD-A107
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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	IntI = 0 IntIA = 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	IntI = 0 IntIA = 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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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

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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)

$$F2 = F1 \times 24 \text{ hours} / K1_SP$$

IF current hour is within the interval [K1_Start, K1_Start + K1_SP] THEN

$$F_Tgt = F2$$

ELSE

$$F_Tgt = 0$$

WMode == 2 (Intermittent)

$$F2 = F1 \times 60 \text{ minutes} / K2_SP$$

IF current minute is within the interval [0, K2_SP] THEN

$$F_Tgt = F2$$

ELSE

$$F_Tgt = 0$$



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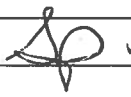
The City of Winnipeg
Water & Waste Department

Electrical Design Guide


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Prepared By:	C. Reimer N. Bradoo B. Clevon
Checked By:	C. Weiss-Bundy E. Ryczkowski

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1 INTRODUCTION

This Water and Waste Department Electrical Design Guide is intended to serve as a reference for consistent design of new electrical systems for City of Winnipeg owned facilities. This document provides guidance to department personnel, as well as external consultants, regarding electrical design standards and requirements.

1.1 Scope of the Standard

These design requirements will apply to the following facilities:

- Water treatment plants
- Water pumping stations
- Wastewater treatment plants
- Flood pumping stations
- Wastewater lift pumping stations
- Land drainage and underpass pumping stations.
- Other collections facilities including pumping.

1.2 Application

The scope and intent of this document is intended to convey general design guidance regarding electrical systems at water and waste facilities. This document does address specifics related to equipment type, selection, and configuration; however the designs are 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 electrical design details with general conformance to the concepts presented herein. This standard 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.

Where significant deviations from this standard are deemed to be appropriate by the design engineer, these shall be approved by the City. As technology evolves and new application requirements are identified, it is recommended that this document is updated to ensure that it remains relevant and applicable.

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


- All new designs, not related to an existing facility, are expected to comply with this standard.
- All major upgrades to a facility, or a larger facility's process area, are expected to comply with this standard, however in some cases compromise with the configuration of the existing facility design may be required.
- All minor upgrades should utilize this standard as far as practical for new equipment, however in some cases compromise with the configuration of the existing facility design may be required.

1.3 Definitions

A	Amperes
ATL	Across-the-Line
ATS	Automatic Transfer Switch
AWG	American Wire Gauge
BIL	Basic Impulse Level
CCTV	Closed Circuit Television
CPT	Control Power Transformer
CT	Current Transformer
CSA	Canadian Standards Association
CSO	Combined Sewer Overflow
DC	Direct Current
DCS	Distributed Control System
DOL	Direct-On-Line
EMT	Electrical Metallic Tubing
E-Stop	Emergency Stop
E&I	Electrical and Instrumentation
FAT	Factory Acceptance Test
FVNR	Full Voltage Non-Reversing (Starter)
GFCI	Ground Fault Circuit Interrupter
H ₂ S	Hydrogen Sulfide
HMI	Human Machine Interface
H/O/A	Hand – Off – Auto (switch)
hp	Horsepower
HPS	High Pressure Sodium
HVAC	Heating Ventilation and Cooling
I/O	Input / Output
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
kcmil	Thousand Circular mil (cable size)
kVA	Kilovolt-Amperes
kVAR	Kilovolt-Amperes Reactive
kW	Kilowatt
LC	Lucent Connector (fibre)
LED	Light Emitting Diode
MCB	Moulded Case Circuit Breaker

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MCC	Motor Control Centre
MCM	Thousand Circular Mil (old version – utilize kcmil for new projects)
MH	Metal Halide
MTBF	Mean Time Between Failure
MV	Megavolt
MVA	Megavolt-Amperes
MW	Megawatt
NEMA	National Electrical Manufacturers Association
NFPA	National Fire Protection Association
NGR	Neutral Grounding Resistor
PA	Public Address
PDF	Portable Document Format
PID	Proportional Integral Derivative
PLC	Programmable Logic Controller
PFC	Power Factor Correction
PT	Potential Transformer
PVC	Polyvinyl Chloride
RMS	Root Mean Square
RTD	Resistance Temperature Device
RW90	Rubber-insulated building wire, 90°C rated
SCADA	Supervisory Control and Data Acquisition
SCCR	Short Circuit Current Rating
TDD	Total Demand Distortion
Teck90	PVC jacketed armoured cable, 90°C rated
TEFC	Totally Enclosed Fan Cooled
THD	Total Harmonic Distortion
TVSS	Transient Voltage Surge Suppressor
UPS	Uninterruptible Power Supply
UV	Ultraviolet
V	Volts
VA	Volt-Amperes
VAC	Volts Alternating Current
VFD	Variable Frequency Drive
VRLA	Valve Regulated Lead Acid
WSTP	Winnipeg Sewage Treatment Program
XLPE	Cross-linked polyethylene insulation

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2 GENERAL

2.1 General Design Requirements

General design requirements are as follows:

- All designs are to comply with municipal, provincial, and national codes and bylaws.

2.2 References

2.2.1 General

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

2.2.2 City of Winnipeg Standards

Water and Waste Department Identification Standard

WSTP Automation Design Guide

2.2.3 Codes and Standards

API	American Petroleum Institute
CSA	Canadian Standards Association
NBC	National Building Code (as applicable to Manitoba)
CEC	Canadian Electrical Code (modified by Winnipeg regulations)
cUL	Underwriters Laboratories (approved for compliance with Canadian Electrical Code)
ANSI	American National Standards Institute
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronic Engineers
NFPA	National Fire Protection Association
ULC	Underwriters Laboratories of Canada
NEMA	National Electrical Manufacturers Association
NETA	InterNational Electrical Testing Association
IES	Illuminating Engineering Society
ICEA	Insulated Cable Engineers Association
IEC	International Electro-technical Commission
ISA	International Society of Automation
ISO	International Organization for Standardization
TIA	Telecommunications Industry Association

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WSHA The Workplace Safety and Health Act (Manitoba)

2.2.4 Design Codes and Standards


Ensure all designs shall comply with municipal, provincial, and national codes and bylaws. This includes but is not limited to:

- Canadian Electrical Code
- Manitoba Electrical Code
- Winnipeg Electrical Bylaw
- Manitoba Building Code (National Building Code of Canada with Manitoba Amendments)
- Manitoba Energy Code / National Energy Code

2.2.5 Units

All drawings and documentation shall use the International System of Units (SI units). Imperial units will be provided in parenthesis after the metric unit, where requested or appropriate. Exceptions are as follows:

- Electrical conductor sizes are to be shown using units of AWG or kcmil and the wire size is not to be preceded with the number sign (#). For example, 14 AWG or 250 kcmil.
- Arc flash energies are to be expressed in cal/cm^2
- Motor power is to be expressed on all drawings and formal documents with both metric and imperial units. For example: 37 kW (50 hp).

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2.3 Identification

All equipment identification must follow the City of Winnipeg Water and Waste Identification Standard.

2.3.1 Identification Lamacoids

1. All lamacoids to be 3 mm thick plastic lamacoid nameplates, white face, black lettering.
2. Mechanically attach with self-tapping stainless steel screws.
3. Apply lamacoids as per Table 2-1. Additional information shall be provided where required.

Table 2-1 : Lamacoid Requirements

Application	Text Size	Text
Electrical Equipment - General	5 mm	Line 1: Identifier
Circuit Breaker - Separate	5 mm	Line 1: Identifier Line 2: Load: Load Identifier If Load Identifier not clear: Line 3: Load Description
Disconnect Switch - Separate	5 mm	Line 1: Identifier Line 2: Load: Load Identifier If Load Identifier not clear: Line 3: Load Description
Fire Alarm Devices	8 mm	Line 1: Identifier
Light Switches	3 mm	Source Panel and Circuit Number
Motor Control Centre	8 mm	Line 1: Identifier Line 2: Description (Optional) Line 3: System Voltage Line 4: Fed By
Motor Starter or MCC Bucket	5 mm	Line 1: Load Identifier Line 2: Load Description
Panelboards	8 mm 5mm may be used for space limitations	Line 1: Identifier Line 2: Description (Optional) Line 3: System Voltage Line 4: Fed By
Receptacles	3 mm	Source Panel and Circuit Number
Switchgear	8 mm	Line 1: Identifier Line 2: Description (Optional) Line 3: System Voltage Line 4: Fed By
Switchgear Breaker	8 mm	Line 1: Load Identifier Line 2: Load Description
Transformer – Indoor	8 mm	Line 1: Identifier Line 2: Rating, System Voltage Line 3: Fed By
Transformer - Outdoor	10 mm	Line 1: Identifier Line 2: Rating, System Voltage Line 3: Fed By

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3 DESIGN REQUIREMENTS

3.1 Voltage Levels

3.1.1 System Voltage Levels

The acceptable system voltage levels to be utilized are shown in Table 3-1. See Section 7.2 regarding the relationship of motor voltage levels to system voltage levels. Note that the supply voltage level will be dependent upon the utility.

3.2 System Configuration Concepts

The electrical system configuration for a facility is typically selected in the early planning stages for design. This section presents various system configuration concepts to guide the designer in typical configurations that may be applicable to the project at hand. Note that a facility could potentially use multiple concepts from the proposed configurations. For larger facilities, it is expected that the overall system configuration will be complex, and will not necessarily be categorized in the indicated configurations.

Notes:

1. *The system distribution must always be designed by a professional engineer. The indicated system configurations are typical and are not necessarily appropriate for all installations. Detailed review of the specific constraints and risks associated with the particular application must be performed to identify potential modifications or additions required to the proposed system configurations.*
2. *The term “standby generator” is utilized in this section to represent a generator that is not rated for continuous duty. If the generator is utilized to power life-safety systems, it must be designated as an emergency generator, as discussed in Section 11.*

Table 3-1 : Acceptable System Voltage Levels

Line-to-Line Voltage Level	Application	Notes
66 kV	Supply	Receive bulk power from the utility at large facilities
	Distribution	Not recommended to be typical.
	Utilization	Not applicable.
12.47 kV	Supply	Receive bulk power from the utility at medium to large sized facilities.
	Distribution	Preferred voltage for distribution at new large facilities, with distribution capacity > 7.5 MVA.
	Utilization	Motor loads > 1500 kW (2000 hp). Not expected to be typical.
4.16 kV	Supply	Receive bulk power from the utility at medium sized facilities.
	Distribution	For in-plant distribution at a medium to large sized facility, with distribution capacity in the approximate range of 1.5 to 7.5 MVA
	Utilization	For powering motor loads 260 kW – 1500 kW (350 hp to 2000 hp)
600 V	Supply	Preferred supply voltage for small to medium sized facilities up to 2000 MVA.
	Distribution	For in-plant distribution over short distances, up to 2 MVA.
	Utilization	Preferred voltage for motors 0.37 kW (0.5 hp) to 260 kW (350 hp).
480 V	Supply	Not recommended.
	Distribution	Not recommended.
	Utilization	Where required to feed specific equipment only available with a 480V utilization voltage.
208/120 V	Supply	Acceptable supply voltage for small facilities (< 50 kVA load)
	Distribution	Not recommended.
	Utilization	Fractional horsepower motors, lighting, and other small misc. plant loads. Preferred over 120/240 V 1Ø systems in facilities with 3Ø distribution systems.
120/240 V 1Ø	Supply	Acceptable supply voltage for small facilities (< 30 kVA load)
	Distribution	Not recommended.
	Utilization	Fractional hp motors, lighting, and other small misc. plant loads.

Note:

1. *There will be exceptions to the above table. Exceptions are to be reviewed and approved on a case-by-case basis.*

3.2.1 Configuration A - 208/120V

Configuration A, which is a simple system with 208/120V supply from the utility, is only applicable to the smallest of facilities. It would typically only be utilized for small buildings without any significant loads. A single phase 120/240V service could also be considered where no significant motor loads are present. A single line diagram is shown in Figure 3-1.

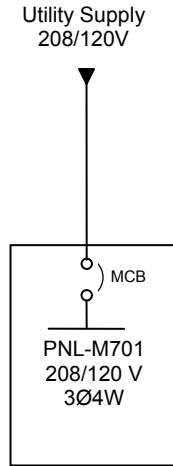


Figure 3-1: Configuration A - 208/120V

3.2.2 Configuration B – 600V Distribution

Configuration B, which is a simple radial system with a 600V supply from the utility, is applicable to the facilities with lower reliability requirements. A sample single line diagram is shown in Figure 3-2.

Internal distribution within the facility, if any, is at 600V. While not shown on the sample drawing, additional 600V panels or MCCs fed from the main distribution would still be considered under this configuration.

No redundancy, or standby generation, is provided by this configuration. While any utility power failure or equipment failure will result in an outage, operation is simple and the capital cost is relatively low.

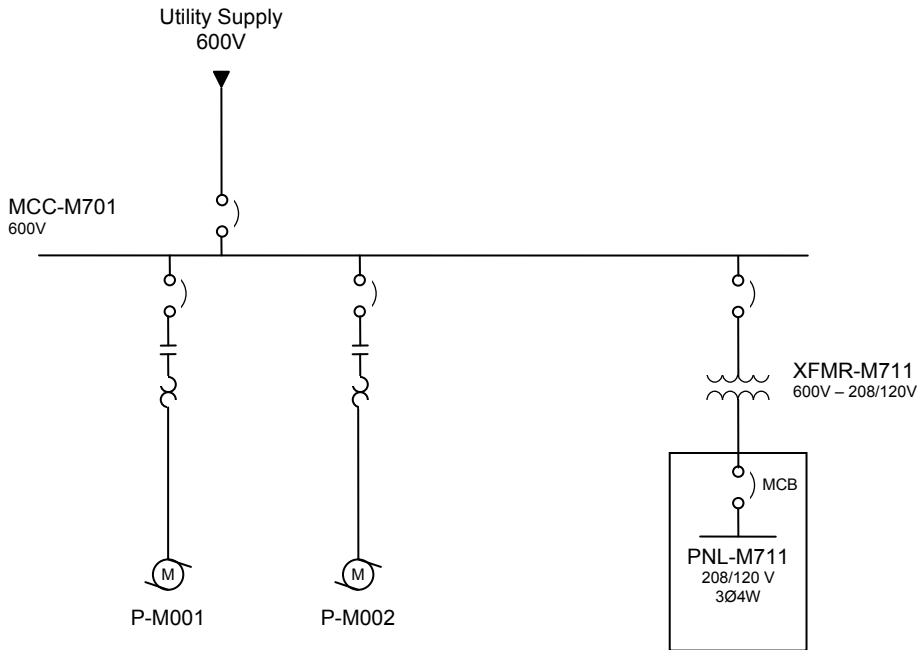


Figure 3-2: Configuration B - 600V Distribution

3.2.3 Configuration C - 600V Distribution with Portable Generator Provision

Configuration C is similar to Configuration B, except that a provision for a temporary standby generator is provided for the whole facility. This would typically only be applicable for facilities with less than 400A of essential 600V load, and delay in provision of the standby power is acceptable. It should also be noted that confirmation of the City's current available portable generator ratings should be undertaken. A sample single line diagram is shown in Figure 3-3.

This configuration should be considered when short term utility power failures are deemed to be acceptable, but longer power failures are not. It is recommended to assume, at minimum, a three hour response time for City crews to connect portable standby generation.

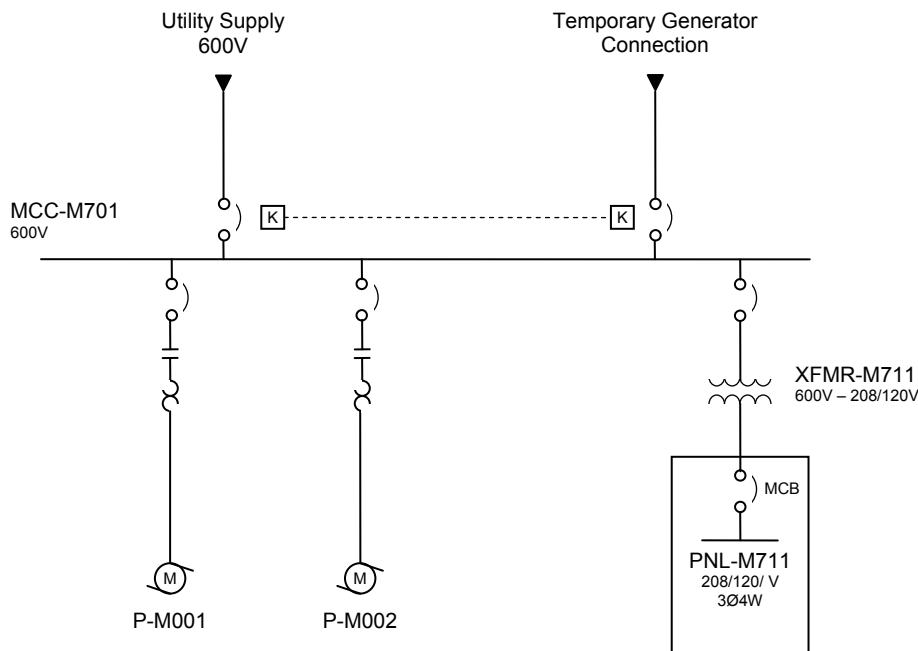


Figure 3-3: Configuration C - 600V Distribution with Portable Generator Provision

Notes:

1. If the maximum demand load is larger than the capacity of the temporary generator, it may be discussed with the City whether manual load shedding may be utilized to allow for partial operation under temporary generator power.

3.2.4 Configuration D - 600V Distribution with Standby Generator

Configuration D is similar to Configuration C, except that a standby generator is provided to increase availability in the event of a utility power failure. In this configuration, the standby generator is sized to provide power for the entire facility load. A sample single line diagram is shown in Figure 3-4.

This configuration should be considered when:

- Power failures are not acceptable;
- The plant can be taken offline for maintenance, with proper planning; and
- Rare events of equipment failure that cause a total plant outage are an acceptable risk.

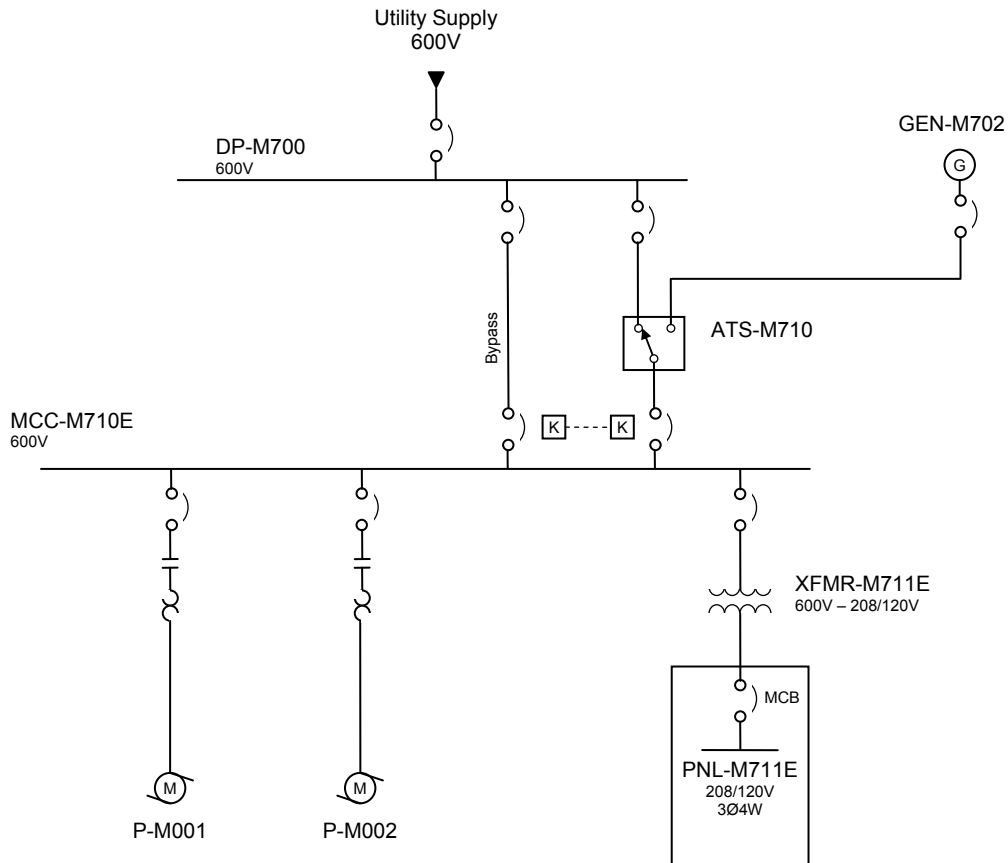


Figure 3-4: Configuration D - 600V Distribution with Standby Generator

Notes:

1. The above system configuration includes a bypass around the transfer switch to allow for servicing. The bypass may be optional in less critical installations.

3.2.5 Configuration E - 600V Distribution with Essential Bus

Configuration E, 600V Distribution with Essential Bus, is the same as Configuration D, 600V Distribution with Standby Generator, except that the loads are split between essential and non-essential loads. The standby generator only services critical loads, allowing the standby generator rating to be reduced. This configuration would be appropriate when a significant portion of the total load is non-essential. See Figure 3-5 for an example simplified single line diagram.

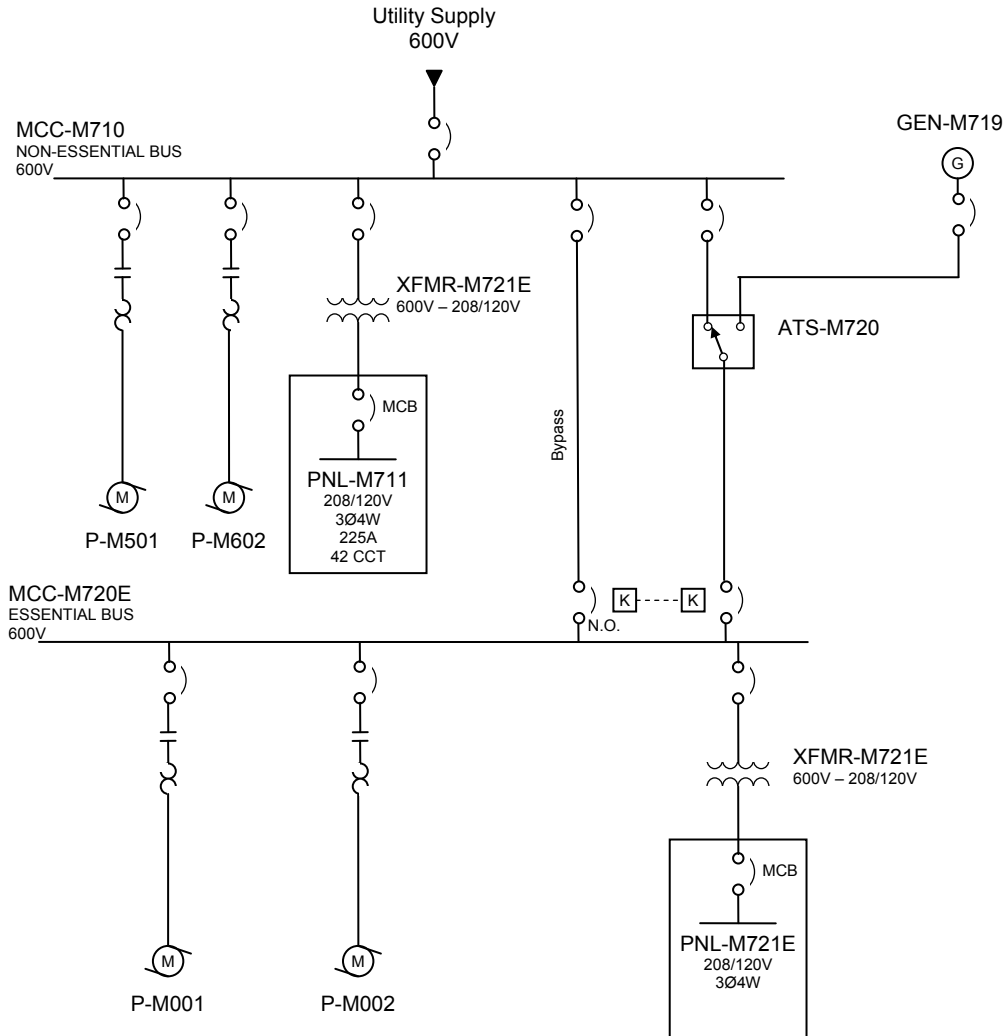


Figure 3-5: Configuration E - 600V Distribution with Essential Bus

Notes:

1. The above system configuration includes a bypass around the transfer switch to allow for servicing. The bypass may be optional in less critical installations.

3.2.6 Configuration F - 600V Redundant with Standby Generation

Configuration F provides redundancy for the electrical distribution system. In addition, a standby generator is provided to address power failure of one or both of the electrical services. A sample single line diagram is shown in Figure 3-6. This configuration should be considered when the size and criticality of the facility warrants redundancy, and power failures are not acceptable. Some variations of the shown single line diagram are possible where full standby generation for the entire facility is not deemed to be required.

It is typically required that each service is sized to accommodate the total facility load from a single service. If load shedding is required to operate with a single service active, this should be clearly indicated on the drawings and approved by the City.

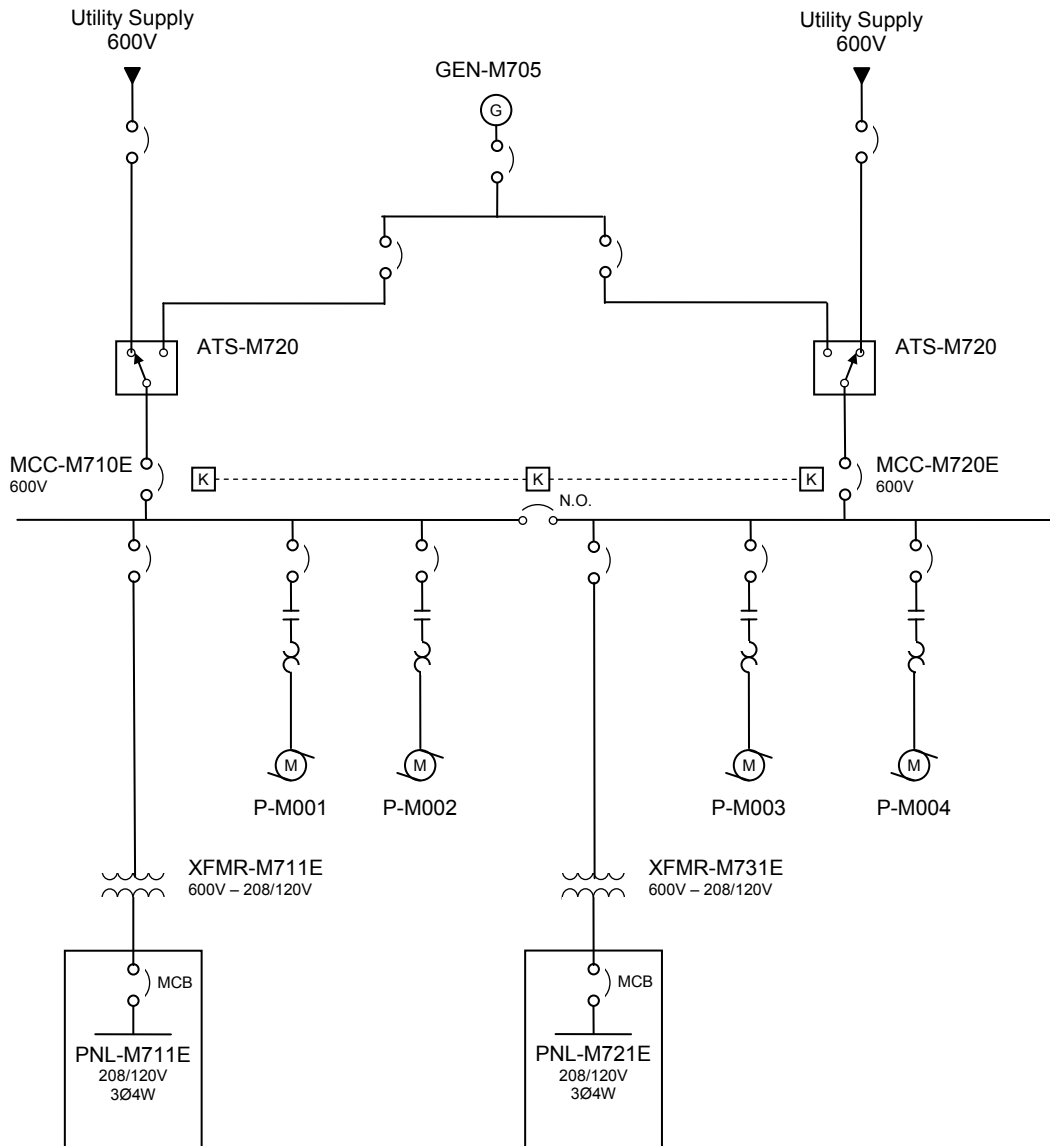


Figure 3-6: Configuration F - 600V Redundant with Standby Generator

3.2.7 Configuration G - MV Distribution

Configuration G is a radial system with a medium voltage supply from the utility. Typically, transformation and utilization at 600V and 208/120V would also be provided. A sample single line diagram is shown in Figure 3-7.

Internal distribution within the facility is typically at medium voltage, and the system may or may not have motors or other loads fed directly via medium voltage. No redundancy, or standby generation, is provided by this configuration. While any utility power failure or equipment failure will result in an outage, operation is simple and the capital cost is relatively low. Figure 3-7 shows a utility owned transformer configuration, however a City owned supply transformer is also a potential configuration. With a City owned transformer configuration, a customer owned disconnect is required on the primary side of the transformer.

Medium voltage distribution should be considered over 600V distribution when:

- The required current levels at 600V are high;
- The utility is unable to supply the required power at 600V; or
- The potential arc flash energies are at dangerous levels ($> 40 \text{ cal/cm}^2$).

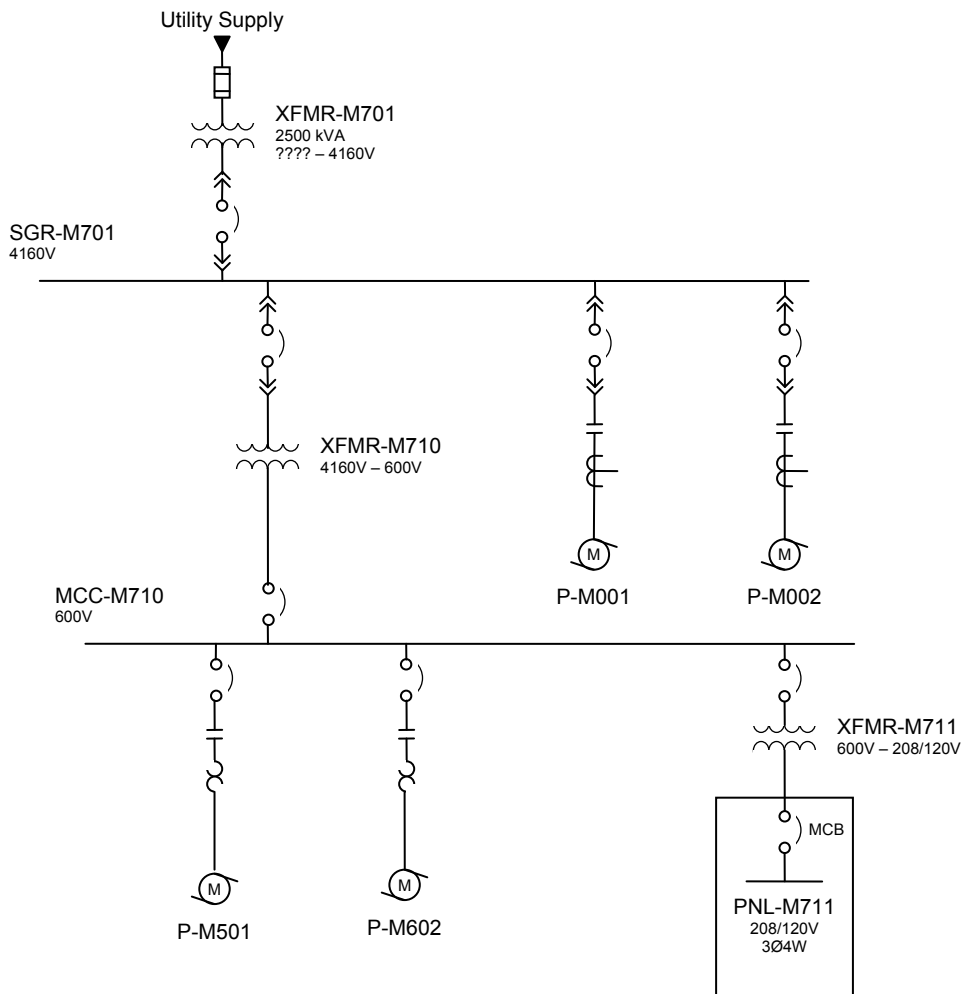


Figure 3-7: Configuration G - MV Distribution

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3.2.8 Configuration H - MV Distribution with Essential Bus

Configuration H, MV Distribution with Essential Bus, is similar to Configuration E, 600V Distribution with Essential Bus, except that medium voltage distribution is utilized in addition to 600V distribution. The standby generator only services critical loads, allowing the standby generator rating to be less than the total facility load. This configuration would typically be considered when the service size exceeds 2 MVA or medium voltage motors are utilized. See Figure 3-8 for an example simplified single line diagram. Note that a utility owned transformer configuration is shown, however a City owned supply transformer is also a potential configuration. With a City owned transformer configuration, a customer owned disconnect is required on the primary side of the transformer.

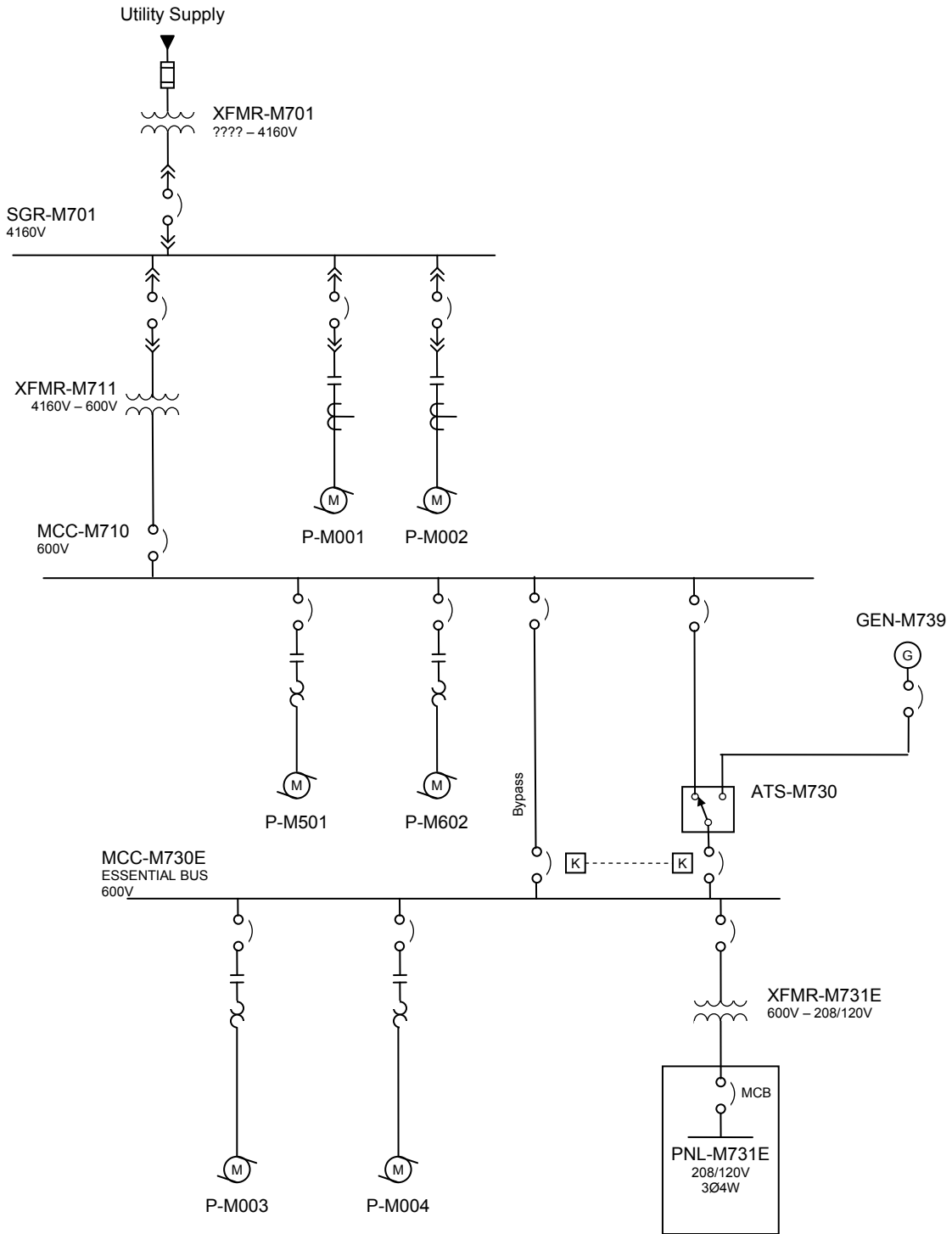



Figure 3-8: Configuration H - MV Distribution with Essential Bus

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3.2.9 Configuration I - MV Redundant with Essential Bus

Configuration I, MV Redundant with Essential Bus, utilizes medium voltage for distribution and large motor loads. Most of the load is not protected by standby generation, but tie breakers are provided to allow for operation with a single feeder out of service. The services are typically rated such that the entire facility can be fed from a single service. This configuration would typically be considered when the service size exceeds 2 MVA or medium voltage motors are utilized. See Figure 3-9 for an example simplified single line diagram. Note that utility owned transformer configurations are shown; however City-owned supply transformers are also a potential configuration. With a City-owned transformer configuration, a customer owned disconnect is required on the primary side of each transformer.

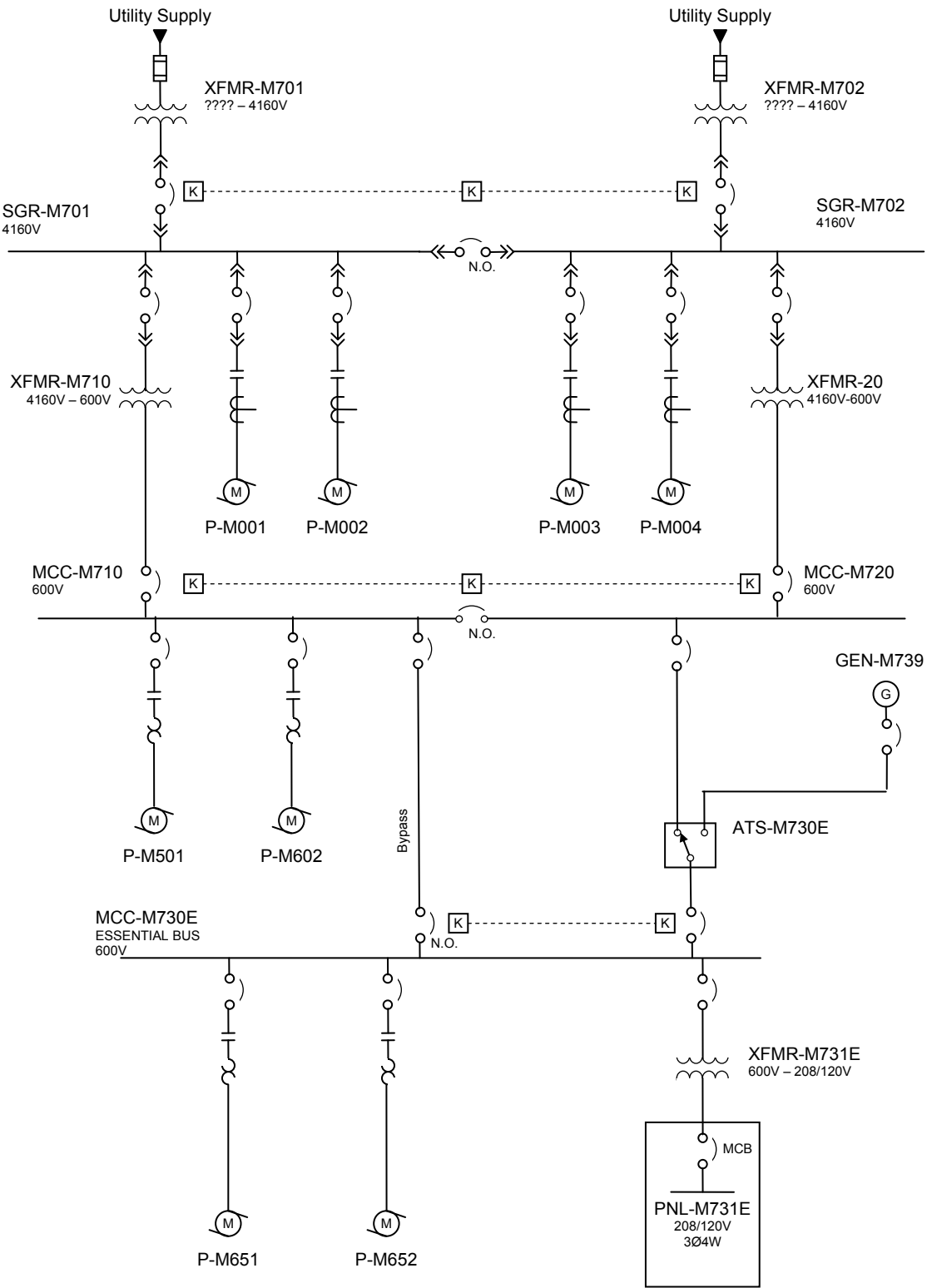



Figure 3-9: Configuration I - MV Redundant with Essential Bus

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3.2.10 Configuration J - MV Redundant with Integrated Generation

Configuration J, MV Distribution with Integrated Generation, utilized medium voltage for distribution and potentially motor loads. Generation is provided at the top level of the distribution, with synchronizing switchgear, to allow for seamless transitions between utility and generator power for testing purposes. Load shedding would be an option under this configuration as well. This configuration would typically be considered when the service size exceeds 2 MVA or medium voltage motors are utilized, and a high level of availability is required. See Figure 3-10 for an example simplified single line diagram.

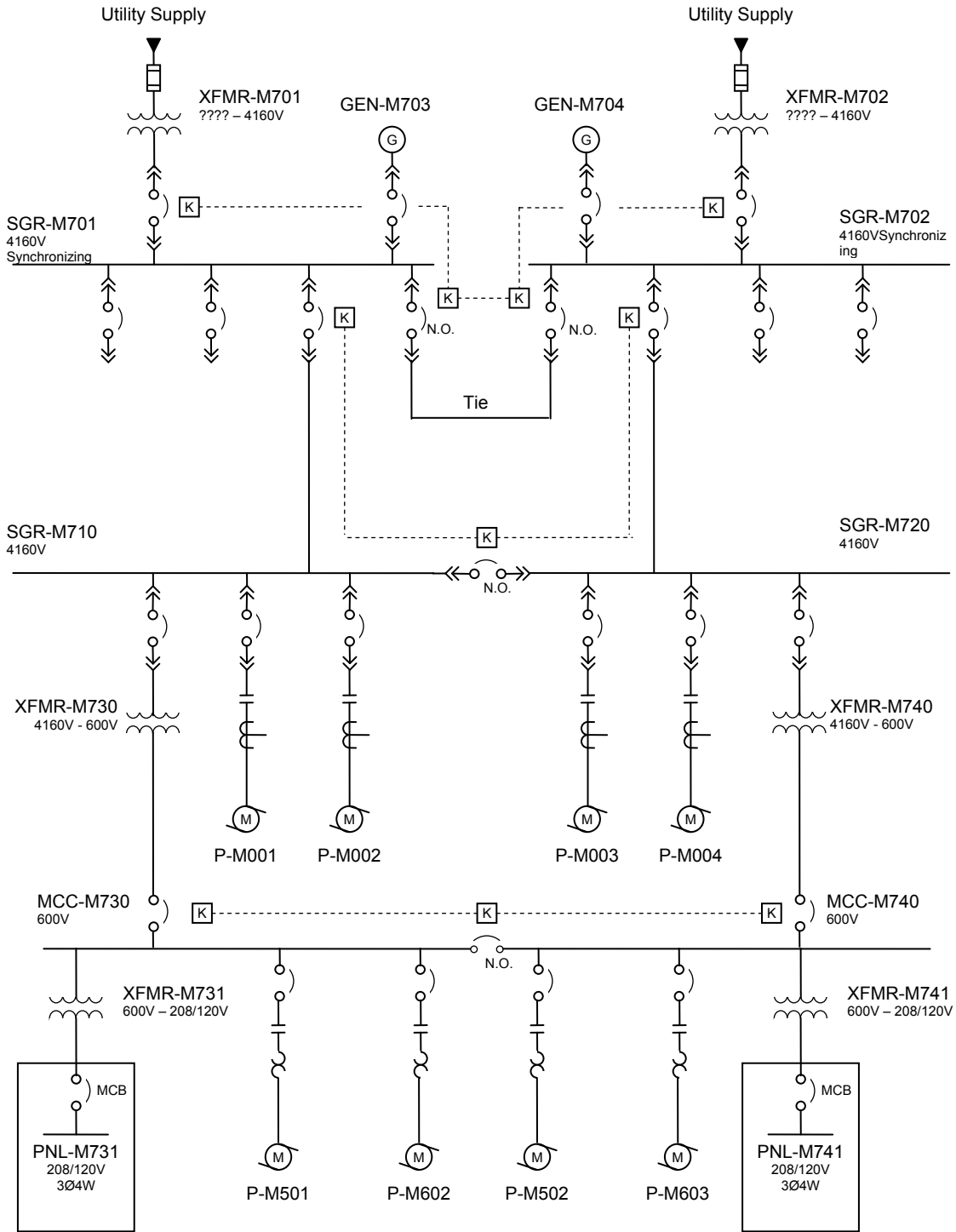


Figure 3-10: Configuration J - MV Redundant with Integrated Generation

3.2.11 Preferred System Configurations

The selection of the appropriate system configuration for each application is an engineering decision that must be made, with consideration to the specific requirements of the application. The preferred system configurations, shown in Table 3-2 are deemed to be general guidance regarding system configurations that are generally acceptable to the City. However, in some cases, the application requirements or reliability requirements are not necessarily clear and detailed discussion with the City may be required. Where selection of an appropriate system configuration is not clear, it is recommended to consider reliability analysis to aid in system selection.

Table 3-2 : Preferred System Configurations

Application	Risk	Preferred Configurations
Land Drainage Pumping Station	Low	(B) 600V Distribution
	Medium	(C) 600V Distribution with Portable Generator Provision
	High (4)	(D) 600V Distribution with Standby Generator
Wastewater Flood Pumping Station	Low	(B) 600V Distribution
	Medium (5)	(B) 600V Distribution (C) 600V Distribution with Portable Generator Provision
	High	(D) 600V Distribution with Standby Generator
Wastewater Lift Station - Small	Low	(A) 208/120V (*) (C) 600V Distribution with Portable Generator Provision
	Medium	(D) 600V Distribution with Standby Generator (E) 600V Distribution with Essential Bus
	High	(D) 600V Distribution with Standby Generator (E) 600V Distribution with Essential Bus (F) 600V Redundant with Standby Generation
Wastewater Lift Station – Large (6)	Low	(D) 600V Distribution with Standby Generator (E) 600V Distribution with Essential Bus (H) MV Distribution with Essential Bus
	Medium	(E) 600V Distribution with Essential Bus (*) (F) 600V Redundant with Standby Generation (I) MV Redundant with Essential Bus
	High	(F) 600V Redundant with Standby Generation (I) MV Redundant with Essential Bus
Wastewater Treatment Facility	-	(F) 600V Redundant with Standby Generation (*) (I) MV Redundant with Essential Bus (J) MV Redundant with Integrated Generation
Regional Water Pumping Station	-	(I) MV Redundant with Essential Bus (J) MV Redundant with Integrated Generation

See Notes next page.

Note:

1. *The existing City facilities do not necessarily conform to the preferred system configurations.*
2. *It is recommended that the City provide further definition of the risk classification.*
3. *Configurations marked with a (*) require specific City approval.*
4. *An underpass pumping station on a major route is considered a high risk installation.*
5. *Currently, most/all flood pumping stations in the City are not provided with standby power. It is recommended to prioritize provision of standby power to lift stations over flood stations in combined sewer areas.*
6. *A large lift station is deemed to be one with more than 200 kVA of demand load. This size is based upon the capacity of the portable generator that the City intends to purchase.*

3.3 Electrical Service

Electrical service sizing for new applications should be as shown in Table 3-3. Review potential future loads with the City and ensure that they are accommodated in the design. Significant deviations in the sizing of the electrical service are to be approved by the City.

Table 3-3 : Minimum Electrical Service Sizing


Application	Redundant Service	Minimum Size
Land Drainage Pumping Station	No	Design load + 25% spare
Wastewater Flood Pumping Station	No	Design load + 25% spare
Wastewater Lift Station	No	Design load + 25% spare
	Yes	Total design load + 10% spare on each service (See Note 1)
Wastewater Treatment Facility	Yes	Total design load + 25% spare on each service
Regional Water Pumping Station	No	Design load + 25% spare
	Yes	Total design load + 10% spare on each service (See Note 1)

Notes:

1. *Each of the redundant services would be sized to carry the full design load of the facility + 10%. Thus, under normal operation with two services, the total loading of the total capacity should not exceed 45%.*


Coordinate the service details including voltage, size and point of delivery with the supply utility (Manitoba Hydro). Provide the utility with data indicating connected load, demand load, the associated load factors and a list of large motors (greater than 150 hp) that are included in the total load requirements for the plant.

Where technically and economically feasible (the total lifecycle costs are not significantly higher), it is the City's preference to locate the point of delivery downstream of high and medium voltage transformation.

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The design of the configuration and location for the service should consider the following factors:

- Location of the principal loads on the site.
- Redundancy requirements.
- Management of electrical system parameters including short circuit levels and associated coordination, arc flash levels, harmonics and power factor.
- Essential power requirements.
- Future growth.

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3.4 System Grounding

Historically, most systems within the City of Winnipeg have been solidly grounded. However, the use of neutral grounding resistors has significant benefits in certain applications. Some typical benefits of a neutral grounding resistor are:


- Minimizes the risk of arc flash and arc blast on the first ground fault
- Reduces electric-shock hazards to personnel caused by stray ground-fault currents in the ground return path.
- Reduces the arc blast or flash hazard of a line-to ground arc fault.
- Reduces burning and melting effects in faulted electrical equipment, such as switchgear, transformers, cables, and motors.
- Limits energy available to a ground fault
- To reduce the momentary line-voltage dip occasioned by the occurrence and clearing of a ground fault.
- Can improve availability by allowing equipment to continue to operate during a single line-to-ground fault, provided a continuously rated neutral grounding resistor is provided.

Some disadvantages of neutral grounding resistors are:

- Transformer neutral bushings must be rated for the full secondary voltage.
- Transformer secondary windings must be fully insulated for the full secondary voltage at the neutral end.
- Additional costs and complexities.
- Additional protection and coordination requirements.

System Applications:

1. 208/120V Systems
 - 1.1 Solid grounding is mandatory.
2. 600V (and 480V if applicable) Systems:
 - 2.1 These systems are typically solidly grounded, however high-resistance grounding (HRG) should be considered for cases where continuity of service is required in the event of a ground fault or reduction of the potential arc flash risk in the event of a L-G fault is desired.
 - 2.2 For most 600V (and 480V if applicable) systems within the water and waste facilities:
 - 2.2.1 Systems \leq 1000 kVA would typically be solidly grounded.
 - 2.2.2 Systems $>$ 1000 kVA and \leq 2000 kVA should be reviewed for potential benefits of high-resistance grounding.
 - 2.2.3 Systems $>$ 2000 kVA: Serious consideration should be given to high resistance grounding.
3. 4160V Systems
 - 3.1 High-resistance or low-resistance grounding is highly recommended.
 - 3.2 Solid grounding should only be provided with special permission from the City, unless the power supply from the utility is a 4160V solidly grounded system.

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4. Medium Voltage Systems > 4160V
 - 4.1 Low resistance grounding is mandatory for all medium voltage systems > 4160V on the secondary of a City-owned transformer.
 - 4.2 Solid grounding is acceptable where no motor loads are utilized at the voltage and the power directly comes from the utility without City-owned transformation. That is, it is acceptable to distribute medium voltage power around a site, provided the power supply is from the utility at that voltage. However, specific engineering review is required to justify the proposed installation.

3.5 Short Circuit Current Rating

Short Circuit Current Rating (SCCR) is the maximum prospective symmetrical fault current that a device, panel or a system can safely withstand for a short specified time. The SCCR is usually expressed in kA at a specified voltage, and in some cases may be linked to specific upstream overcurrent protection devices, which will clear a fault within a specified time. The SCCR is also sometimes known as fault current *withstand rating*.

The SCCR is also closely related to the *interrupting rating* for protective circuit devices. The interrupting rating is the highest current at a specific voltage that the device can interrupt.

The SCCR rating should exceed the available fault current of the system, at the point of application of the device, panel or system.


A short circuit current study shall be completed to determine the fault currents for the equipment being designed with the results being used to determine the appropriate SCCR for the equipment.

Refer to the minimum transformer impedance values outlined in the City of Winnipeg Electrical Bylaw when determining the fault current available from utility supply transformers. All systems with a service voltage of 600V or less shall assume an infinite bus on the primary of the utility transformers in SCCR calculations. Note that the actual utility fault currents must always be obtained for performance of the coordination and arc flash studies.

Maximum SCCR values for unmarked components (i.e. with no SCCR rating) that can be safely assumed for calculations are as follows:

Table 3-4 : Assumed Short Circuit Current Rating (SCCR) for Unmarked Components

System/ Component	SCCR [kA]
Bus-bars	10
Circuit Breaker (including GFCI)	5
Current shunt	10
Fuse Holder	10
Industrial Control Equipment:	
Auxiliary devices (overloads)	5
Switches	5
Motor Controllers	
0 - 37.3 kW (0 - 50 hp)	5
38 - 149.2 kW (51 - 200 hp)	10
149.9 kW - 298.4 kW (201 - 400 hp)	18
299.1 kW - 447.6 kW (401 - 600 hp)	30
448.3 - 671.4 kW (601 - 900 hp)	42
672.1 - 1118 kW (901 - 1500 hp)	85
Meter Socket Base	10
Miniature fuse (maximum use at 125V)	10
Receptacle (GFCI type)	2
Receptacle other	10
Supplementary protector	0.2
Switch Unit	5
Terminal Block	10

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3.6 Harmonics

1. The electrical design should ensure that harmonics are within IEEE 519 requirements at all major points in the electrical distribution, and not just at the utility service.
2. Voltage harmonics shall be limited as follows at all panelboards, MCCs, switchboards, switchgear, and other electrical busses:
 - 2.1 Individual frequency harmonics < 3%
 - 2.2 Total Harmonic Distortion (THD) < 5%
3. Ensure current harmonics at major points in the electrical distribution are within IEEE 519 Table 10-3.
4. Harmonic studies are required for facilities with significant harmonic sources, as discussed in Section 18.4.

3.7 Environmental

Design / specify all electrical equipment, enclosures, etc. located outdoors for ambient temperatures of +/- 40°C. Consider additional prevailing conditions, including humidity and any environmental contaminants or conditions that could affect equipment performance and longevity.

Electrical equipment below 1,000 volts shall conform to the NEMA classifications detailed below. For electrical equipment above 1,000 volts, the enclosure ratings shall be utilized as a guideline to achieve the ratings described. Enclosure utilization will generally conform to the following guidelines:

- Indoor, clean areas (electrical rooms, etc.) – NEMA 1.
- Plant process areas that are neither hazardous nor corrosive – NEMA 12 or NEMA 4 (based on sound engineering judgement).
- Outdoors – NEMA 4.
- Plant process areas that are corrosive (typical wastewater environment containing hydrogen sulfide) – NEMA 4X minimum. Other corrosion resistant materials may be required depending upon the nature of the chemicals present.

Hazardous rated plant process areas require appropriate enclosures. This may require NEMA 7 enclosures, however alternate enclosure types are also appropriate for certain installations. Refer to Section 12 for further details.

4 WIRING AND CABLING

4.1 Type Identification

To provide consistency between drawings, all wire and cables types shall be designated utilizing the following format.

4.1.1 Power Conductors

A	-	N	C	+ BND	, Size	, Type	, Volt	, Other
Number of cables (Optional)	-	Number of Cond.		Bonding Conductor (Optional)	Conductor Size	Conductor Type	Voltage Rating	Other

Where,

- A is the number of cables in parallel. For many applications, this is one (1) and therefore is omitted.
- N is the number of individual conductors in the cable or conduit. Include neutral conductors as applicable, unless the neutral conductor is a different size.
- C is the letter C, to indicate “Conductors”
- + BND is an optional indication to include a bonding conductor of the same size and type as the power conductors. This would not be utilized for cable assemblies where the bonding conductor is an inherent part of the cable, but could be utilized for conduit applications. If the bonding conductor is a different size of type, refer to Section 4.1.2.
- Size is the conductor size in AWG or kcmil.
- Type is the cable / wire type. Utilize CSA standard type references where applicable. The conductor shall always be copper, unless otherwise indicated.
- Volt is the voltage rating of the cable / wires (Not the applied system voltage).
- Other is an optional field for other special characteristics of the cable, such as “Shielded” or insulation class for medium voltage cabling

Notes:

1. *Where individual wires are in conduit, they are expressed as parallel conductors, not parallel cables.*
2. *Do not utilize the “#” symbol to represent AWG.*
3. *Do not indicate the bonding conductor if it is part of a standard cable assembly, such as Teck90 cable.*
4. *Large AWG sizes shall be expressed as follows: 1/0, 2/0, 3/0, and 4/0 AWG and not 0, 00, 000, and 0000 AWG.*

4.1.2 Bonding Conductors

Where bonding conductors are a different size or construction from the phase conductors, they shall be designated in the following format. Note that bonding conductors in a conduit, of the same size and type as the phase conductors may be designated as shown in Section 4.1.1.

N	-	BND	, Size	, Type	, Volt	, Other
Number of Cond. (Optional)	-		Conductor Size	Conductor Type	Voltage Rating	Other

Where,

- N is the number of individual conductors in the cable or conduit. Include neutral conductors as applicable, unless the neutral conductor is a different size.
- BND is the shortened designation for bonding conductors.
- Size is the conductor size in AWG or kcmil.
- Type is the cable / wire type. Utilize CSA standard type references where applicable. The conductor shall always be copper, unless otherwise indicated.
- Volt is the voltage rating of the cable / wires (Not the applied system voltage).
- Other is an optional field for other special characteristics of the cable

4.1.3 Neutral Conductors

Where neutral conductors are a different size or construction from the phase conductors, they shall be designated in the following format. Note that neutral conductors of the same size and construction as phase conductors may be identified as per Section 4.1.1.

N	-	NEU	, Size	, Type	, Volt	, Other
Number of Cond. (Optional)	-		Conductor Size	Conductor Type	Voltage Rating	Other

Where,

- N is the number of individual conductors in the cable or conduit. Include neutral conductors as applicable, unless the neutral conductor is a different size.
- NEU is the shortened designation for neutral conductors.
- Size is the conductor size in AWG or kcmil.
- Type is the cable / wire type. Utilize CSA standard type references where applicable.
- Volt is the voltage rating of the cable / wires (Not the applied system voltage).

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Other is an optional field for other special characteristics of the cable, such as “Shielded”

4.1.4 Examples

3C, 250 kcmil, TECK90, 1000V	Three conductor TECK cable in cable tray.
4C, 1 AWG, RW90, 600V	Four, 1 AWG RW90 wires in conduit.
6-1C, 500 kcmil, RA90, 1000V	Six parallel 1-conductor cables.
2-3C, 750 kcmil, TECK90, 1000V	Two 3-conductor cables in parallel.
4C, 10 AWG, RW90, 600V	Four 10 AWG plus one 12 AWG ground wire.
BND, 12 AWG, RW90, 300V	
6C, 250 kcmil, RW90, 600V	Six 250 kcmil plus two 3/0 AWG neutrals plus two
2C, NEU, 3/0 AWG, RW90, 600V	4 AWG bonding wires.
2C, BND, 4 AWG, RW90, 300V	
2-3C, 250 kcmil, HVTECK AL, 15kV, Shielded, 133%	Two three-conductor shielded 15 kV cables, aluminum conductors.

4.2 Conductor Material

1. All conductors shall be copper, except as follows:
 - 1.1 Aluminum conductors may be utilized if and only if:
 - 1.1.1 The load is an MCC, transformer, switchgear, or distribution panel or other similar equipment. Aluminum conductors are not permitted for end loads such as motor loads;
 - 1.1.2 The aluminum conductor is sized a minimum of 250 kcmil; and
 - 1.1.3 All terminations are appropriately rated for aluminum conductors.
2. Ensure the project specifications are clear regarding the conductor material requirements. All aluminum conductors shall be clearly shown on the single line drawings.
3. Ensure all project construction specifications are clear and complete regarding the installation requirements of aluminum conductors.

4.3 Insulation Ratings

- Provide wire and cable insulation ratings that are consistent with the minimum insulation ratings indicated in Table 4-1.

Table 4-1 : Minimum Wire Insulation Ratings

Nominal 3Ø Voltage	System Grounding	Application	Minimum Insulation Rating
12.47 kV	Low Resistance ¹	Any	15 kV 133%
	Solid	Any	15 kV 100%
4.16 kV	Low Resistance ¹	Any	5 kV 133% or 8kV 100%
	High Resistance ¹	Any	
	Solid	Any	
600 V	High Resistance	Any	1000 V
	Solid	VFD and other high harmonic loads	1000 V
		Buried Wire / Cables	1000 V
		All Teck90 cables	1000 V
		Indoor RW90 applications– no VFD	600 V
480 V	High Resistance	Buried Wire / Cables	1000 V
		Other	600 V
	Solid	Any	600 V
120/208V	Solid	Any	600 V

Notes:


- Low Resistance grounding is assumed to be set-up to clear faults within one hour. Higher insulation ratings may be required for systems that allow longer duration faults.*

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4.4 Indoor Power Distribution

4.4.1 Conduits vs. Cables

1. The decision to use conduits or cables for interior power distribution 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.
2. It is acceptable for a facility to have a mixture of conduits and cables.
3. Conduits should be considered in the following applications:
 - 3.1 Where the existing installation is conduit based.
 - 3.2 Fire alarm systems.
 - 3.3 Where aesthetics are a concern.
 - 3.4 Where there is potential for physical abuse or damage.
 - 3.4.1 For example, rigid aluminum conduits are preferred in lift stations that have limited space such that the removal of a pump could result in physical damage to the electrical system.
 - 3.5 Where the specific cables required do not have a FT4 rating.

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4.5 Cable Types and Ratings

In general, cable with galvanized steel armour covered with PVC outer sheath is acceptable. In very corrosive areas, aluminum armour with PVC outer sheath should be used subject to verifying the suitability of aluminum for the corrosive compounds present.

4.5.1 Cable Requirements

- 12.47kV (15 kV Class) Distribution system:
 - CSA TECK cable, Tree-Resistant XLPE RW90, 15kV, semi-conductive shielded with insulation as per Table 4-1.
 - Phase marking/colour codes - Phase A - Red, Phase B – Black, Phase C - Blue.
 - Outer jacket – Orange/Red PVC jacket rated FT-4.
- 4.16kV Distribution system:
 - CSA TECK cable, Tree-Resistant XLPE RW90, 5kV, semi-conductive shielded with insulation as per Table 4-1.
 - Phase marking/colour codes - Phase A - Red, Phase B – Black, Phase C - Blue.
 - Outer Jacket – Orange/Red PVC jacket rated FT-4.
- 600V, 208/120V, 120/240V Low Voltage Distribution system:
 - CSA TECK cable, XLPE RW90, 600V/1000V, with insulation as per Table 4-1.
 - Phase marking/colour codes - Phase A - Red, Phase B – Black, Phase C - Blue.
 - Jacket – Black PVC jacket rated FT-4 and low acid gas emitting. The jacket will be UV, moisture and oil resistant.
- Control and Instrumentation cables:
 - CIC or ACIC, XLPE RW90, 600/300V, with 100% insulation.
 - 600V cable is to be utilized for any cable termination in an enclosure containing voltages above 300V.
 - Phase numbering marking/colour codes – Standard numbering and colour coding.
 - Jacket – Black PVC jacket rated FT-4 and low acid gas emitting. The jacket will be UV, moisture and oil resistant.

4.6 Conductor Sizes

1. Select wire size based upon conductor ampacity and voltage drop requirements.
2. Ensure conductors are appropriately derated as per the Canadian Electrical Code. Derating to include factors for maximum termination temperature, ambient conductor temperature, and the number of conductors in the conduit or cable tray.
3. Do not necessarily size cables as per the minimum ampacity. Utilize good engineering judgement to ensure each cable ampacity will be sufficient for the life of the cable.
 - 3.1 For example, if a motor feeder cable ampacity is calculated, based on a specific actual motor FLA, to be 258A, do not select a cable with an ampacity of 260A. In the event the motor is replaced with one that has a slightly higher FLA, the cable with an ampacity of 260A would no longer be technically acceptable.
4. Minimum wire size to be as per Table 4-2.

Table 4-2 : Minimum Conductor Sizes

Application	Minimum Size
Medium Voltage Power (> 1000V)	2 AWG
Low Voltage Power (120 – 750V)	12 AWG
Control	16 AWG
Instrumentation	18 AWG
Voltage Signal (PT)	14 AWG
CT Signal	12 AWG

Note: The minimum conductor sizes only apply to electrical power cables. See the Automation Design Guide for automation cable sizes.

4.7 Conduit Materials and Sizes

1. Conduit to be CSA, cUL listed.
2. 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 utilized within office areas if there are no environmental issues.
3. Rigid galvanized steel conduit is not acceptable for use within wastewater facilities. See Table 4-3.
4. The minimum conduit size is 21 mm (3/4 ").
5. Conduit boxes to be aluminum with cast covers. Use spring door covers for areas with circulating dust and contamination.
6. Liquid tight flexible conduit c/w correct watertight fittings may be used in short lengths for application areas where vibration will be an issue.
 - 6.1 Flexible conduit to be CSA, cUL listed.

6.2 Maintain fill factors as stipulated in Code.

7. For areas where conduit is installed and there is a risk of migration of gases and vapour, the conduits are to be sealed with suitable conduit seals to prevent entry of moisture, vapour and gases into another area, panel enclosure, etc.
8. Where EMT and PVC conduit is used, provide a separate green insulated ground wire in each conduit.
9. Ensure fittings allow cable/conductor bending radius to be maintained.
10. Wire pulling calculations shall be performed for all cables in conduits or ducts sized 2 AWG or larger. Modify the design as required to limit forces and sidewall pressure. Document all cable pulling calculations as per Section 18.4.

Table 4-3 : Facility Conduit Application

Facility Type	Application	Type
All	In poured concrete walls and floors	PVC
	Underground	PVC
Wastewater Collections Facilities (Lift, Flood, CSO)	General Use – Where prone to potential mechanical damage or acceptable support spans exceed PVC capabilities.	Rigid Aluminum
	General Use – Where not prone to potential mechanical damage	PVC
	Hazardous Locations	Rigid Aluminum
Wastewater	General Use	Rigid Aluminum
	Corrosive locations not suitable for aluminum	PVC
	Exterior	Rigid Aluminum
	Hazardous Locations	Rigid Aluminum
	Office and similar locations, without environmental contamination.	EMT
Water	Corrosive Locations (Category 2)	PVC
	Exterior	Rigid Galvanized Steel
	General Use	Rigid Galvanized Steel
	Hazardous Locations	Rigid Galvanized Steel
	Office and similar locations	EMT

4.8 Conduit Colour Coding

Code with plastic tape or paint at points where conduit or cable enters wall, ceiling, or floor, and at 5 m intervals based on the system, per Table 4-4. The width of the prime and auxiliary bands are to be 38 mm and 19 mm, respectively.

Table 4-4 : Conduit Colour Bands

System	Prime Band	Aux. Band
Medium Voltage (>750 V)	Orange	
347/600 V	Yellow	
208/120/240 V Power	Black	
UPS 208/120/240 V Power	Black	Green
Control Wiring (120 V)	Black	Orange
Fire Alarm	Red	
Low Voltage Communication/General	Blue	
Low Voltage Control Wiring (<50 V)	Blue	Orange
Intrinsically Safe	Blue	White
Grounding	Green	

4.9 Device and Pull Boxes

1. Joints and splices are not acceptable in conduits. All joints shall be in conduit bodies or junction boxes.
2. Only connections for lighting and receptacles shall be made in device boxes. All other connections shall be made in boxes with terminals.
3. Pull boxes should be sized as per the Canadian Electrical Code (Rule 12-3036).

4.10 Cable Trays

4.10.1 General

1. Size:
 - 1.1 A side rail height of 152 mm (6") is preferred. Utilize 102 mm (4") side rail height where vertical space is limited.
 - 1.2 Size cable tray to meet current and future cable requirements. Minimum tray width is 152 mm (6").
2. Tray to be CSA, cUL listed.
3. The rungs of the ladder shall typically be at 305 mm (12") spacing. However for single conductor 1/0 to 4/0 AWG the rung spacing shall not exceed 229 mm (9").
4. Tray load ratings:
 - 4.1 Cable tray load ratings are to be sufficient for the cables installed and any additional loads such as snow, ice and wind, where applicable.
 - 4.2 Allow for spare cables in cable tray loading calculations. For trays where cables may be installed with no spacing, assume the tray will be filled in the future.
 - 4.3 Minimum load rating for indoor tray: CSA Class C1
 - 4.4 Minimum load rating for outdoor tray: CSA Class D
5. The tray shall be installed in accordance with manufacturer's instructions.
6. Use tray covers in dusty areas, outdoors, for aesthetic reasons and for trays passing under walkways or where there is a risk of falling debris.
7. Use stainless steel SS316 bolting and fixing hardware.
8. Select cable tray material as per Table 4-5.
 - 8.1 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.

Table 4-5 : Standard Cable Tray Material

Application	Standard Material	Alternates
Wastewater Collection / Treatment	Aluminum	Fibreglass Stainless Steel
Water Treatment Plant	Aluminum	Fibreglass Stainless Steel
Regional Water Pumping Stations	Rigid Galvanized Steel	Aluminum Fibreglass Stainless Steel

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4.11 Buried Installation Requirements

1. All buried cables and conduits shall be protected by treated planks or concrete blocks. Concrete blocks or cast-in place red-dyed concrete shall be utilized in applications with a high reliability requirement.
2. Bright orange vinyl warning tape shall be installed above all buried cable installations, including above duct banks.
3. Buried cable installations shall be based upon the requirements of CSA standard C22.3 No. 7 for underground systems.
4. Where buried cable installations terminate into indoor equipment, bottom equipment entry is required to avoid potential water migration issues. Where top entry of equipment is required ensure that potential water migration through cables is addressed.
5. Direct Buried Cables
 - 5.1 Provide a minimum of 100mm of sand cover on all sides of the cable. Consider additional depth below conduits for critical applications.
 - 5.2 Provide cable slack loops as required to address ground movement.
 - 5.3 Provide water-tight seals at the building entry.
6. PVC Conduit
 - 6.1 The use of PVC DB2 conduit for buried applications is only permitted for certain applications, as indicated in Table 4-6.
 - 6.2 Arrange PVC conduit such that drainage is provided to a suitable location.
 - 6.3 Transition from underground to above ground shall use PVC rigid conduit. Expansion fittings shall be provided where required.
 - 6.4 Provide water-tight seals at the building entry.
 - 6.5 Provide a minimum of 100mm of sand cover on all sides of the conduit. Consider additional depth below conduits for critical applications.
7. Concrete duct banks
 - 7.1 Underground duct banks will be PVC DB2 ducts, sized 50mm or larger, encased in concrete.
 - 7.2 A minimum spacing of 50mm between ducts, and outer covering of 75 mm of concrete must be maintained.
 - 7.3 Duct runs will be sloped to drain any water entering the system, towards manholes provided with a sump pit.

Table 4-6 : Buried Installation Requirements

Application	Acceptable Installations	Notes
Control / Communications – Std. Reliability Requirement	Buried armoured cable	
	PVC Conduit	
Control / Communications – High. Reliability Requirement	Concrete Duct Bank	
	Buried armoured cable	Cables to be protected by concrete blocks / concrete.
Low Voltage Power < 750V – Std. Reliability Requirement	Buried TECK Cable	
Low Voltage Power < 750V – High Reliability Requirement	Concrete Duct Bank	
	Buried TECK Cable	Cables to be protected by concrete blocks / concrete.
Medium Voltage – Std. Reliability Requirement	Concrete Duct Bank	
	Buried TECK Cable	Cables to be protected by concrete blocks / concrete.
Medium Voltage – High Reliability Requirement	Concrete Duct Bank	

4.12 Terminations

4.12.1 Power Wiring – Medium Voltage

1. Lugs
 - 1.1 Two hole long barrel (double crimp) lugs shall be utilized wherever possible.
 - 1.2 Belleville washers shall be used on all bolts.
2. Medium voltage terminations shall be heat shrink type, CSA, cUL listed and tested to IEEE standards.
3. For 1/C cable – single (1/C) terminations are required with grounding kits.
4. For 3/C cable – one three conductor (3/C) termination kit is required with grounding kit.
 - 4.1 A breakout boot is required for outdoor installations or those where any possibility of moisture or debris is present.
5. Shielded cables are to be grounded at both ends for three conductor cables, or three single conductors in one duct or conduit. Shielded cables ≤ 250 kcmil installed in separate ducts must also be grounded at both ends. Ensure that the cable ampacity accounts for shield heating due to circulating currents. Cable ampacity adjustments are a requirement > 250 kcmil where the phase conductors are in separate ducts.
6. All shielded cables proposed to be bonded at one end only require approval of the City, along with supporting calculations of the safety of the installation.

7. Use in-line terminations for motor terminations.
8. Generally for medium and high voltage, *creepage extending sheds* are not required to be used for Indoor areas. However if the termination is installed in an indoor area where there is a presence of high humidity, saturated water vapour or presence of free droplets then these sheds shall be used. Sheds shall always be installed with the open end of the cone down irrespective of whether the termination is installed “up” or “down”. Creepage extending sheds are required on outdoor terminations.

4.12.2 Power Wiring – Low Voltage (<750V)

1. Lugs
 - 1.1 Two hole long barrel (double crimp) lugs are preferred over mechanical connectors for high ampacity and critical applications.
 - 1.2 Belleville washers shall be used on all bolts.

4.12.3 Control Wiring – Low Voltage

1. Wire barrel ferrules shall be used for all stranded wiring connections to terminals.
2. Wire labels shall be used wherever a wire is terminated.

4.13 Framing and Support Systems

1. Utilize strut framing and support systems from a single manufacturer for each project. Materials shall be as per Table 4-7.

Table 4-7 : Framing and Support Materials

Application	Application	Preferred Material	Alternate Material	Hardware
Wastewater Collections and Treatment	All	Aluminum	Stainless Steel	Stainless Steel
Water Treatment	All	Aluminum	Stainless Steel	Stainless Steel
Regional Water Pumping Stations	All	Galvanized Steel	Stainless Steel	Stainless Steel


4.14 Segregation of Systems

1. Segregation of cable systems shall be as per Table 4-8. Note that typical good design practice would be to allocate a separate cable tray for power cables vs. instrumentation cables.

Table 4-8 : Segregation of Cable Systems

Cable	Other Cable	Minimum Segregation	Notes
Communication - Fibre	Communication	None	
	Instrumentation / Control < 50V	None	
	Other	Separate Raceway	To reduce risk of physical damage to fibre cable.
Communication - Copper	Instrumentation / Control < 50V	50 mm	
	120 VAC, 8 AWG or smaller	100 mm	
	120 VAC, > 8 AWG	300 mm	
	600 VAC Power	300 mm	
	VFD or other high harmonic cable	300 mm	Metallic Conduit
		600 mm	Other raceway
	Medium Voltage – 3C armoured and shielded	300 mm	May be in metallic conduit instead of armoured.
Medium Voltage – 1C or 3C unshielded	450 mm		
Instrumentation (Analog)	Control < 50V	None	
	120 VAC, 8 AWG or smaller	100 mm	
	120 VAC, > 8 AWG	300 mm	
	600 VAC Power	300 mm	
	VFD or other high harmonic cable	300 mm	Metallic Conduit
		600 mm	Other raceway
	Medium Voltage – 3C armoured and shielded	300 mm	May be in metallic conduit instead of armoured.
Medium Voltage – 1C or 3C unshielded	450 mm		

Cable	Other Cable	Minimum Segregation	Notes
Control < 50V	120 VAC, 8 AWG or smaller	50 mm	
	120 VAC, > 8 AWG	300 mm	
	600 VAC Power	300 mm	
	VFD or other high harmonic cable	300 mm	Metallic Conduit
		450 mm	Other raceway
	Medium Voltage – 3C armoured and shielded	300 mm	May be in metallic conduit instead of armoured.
Medium Voltage – 1C or 3C unshielded	450 mm		
120 VAC Control	120 VAC, 8 AWG or smaller	none	
	120 VAC, > 8 AWG	Metal barrier or 150 mm	
	600 VAC Power	Metal barrier or 150 mm	
	VFD or other high harmonic cable	150 mm	Metallic Conduit
		300 mm	Other raceway
	Medium Voltage – 3C armoured and shielded	300 mm	May be in metallic conduit instead of armoured.
Medium Voltage – 1C or 3C unshielded	450 mm		
120 VAC Power	600 VAC Power	Metal barrier	Cable Armour is acceptable
	VFD or other high harmonic cable	100 mm	Metallic Conduit
		150 mm	Other raceway
	Medium Voltage – 3C armoured and shielded	300 mm	May be in metallic conduit instead of armoured.
Medium Voltage – 1C or 3C unshielded	450 mm		
600 VAC Power	VFD or other high harmonic cable	100 mm	Metallic Conduit or both armoured cables
		150 mm	Other raceway
	Medium Voltage – 3C armoured and shielded	150 mm	May be in metallic conduit instead of armoured.
	Medium Voltage – 1C or 3C unshielded	300 mm	

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4.15 Redundant Cables

1. Redundant cables are two or more cables serving the same system, or parallel systems serving the same objective, where the failure of one cable does not compromise the operation of the load.
2. Redundant cables should be physically and electrically separated to the greatest extent possible. The goal shall be that no single event would prevent the ultimate operation of the load.
3. Routing of redundant cables within the same conduit or cable tray is not acceptable.
4. In some cases, a formal or informal economic evaluation may be required to justify the additional expense of an alternate cable route.

5 LIGHTING

5.1 Fixture Type Selection

1. The types of lighting fixtures and their mounting methods shall be selected to satisfy the various project requirements and conditions. Particular attention to colour renditions, light distribution and stroboscopic effects is needed when choosing the type of lamps, starting system, controls and reflection accessories. Due consideration shall also be given to the provision of proper re-lamping facilities. Specifically, care shall be taken to avoid the need for scaffolding or the need to drain tanks or to shut down processes in order to re-lamp or repair light fixtures safely.
2. Refer to Table 5-1 for a general comparison of various fixture types.
3. Fluorescent or LED fixtures are preferred for most indoor applications as they provide instant on capability.
4. Light fixtures must be selected for the correct environment and installed (mounted) to facilitate lamp replacement and maintenance. Selection of accessories and other related materials must also bear the same degree of protection and be properly installed.
5. Refer to Table 5-2 for fixture selection for various applications. Note that the specific requirements of each application must be considered prior to final selection. Where an alternate type of lighting is proposed, review the proposed selection with the City.
 - 5.1 Lifecycle costs of original price, lamp replacement, and energy use will guide the choice of lighting fixtures employed.
6. The final number and array of fixtures used in the final required design must be supported by calculation using recognised methods; the use of vendor software is acceptable. The final design must ensure that the illumination levels will be met and maintained for the specified maintenance requirements and re-lamping intervals.

Table 5-1 : Fixture Type Comparison

Type	Efficacy	L70 Lamp Life (hrs)	Colour Rendering Index (CRI)	Instant On	Cost	Notes
Fluorescent	80 – 100	24K – 40K	80 – 90	Yes	\$	Not suitable for outdoor
High Pressure Sodium (HPS)	100 – 130	24K – 30K	22	No	\$	Not recommended for indoor.
Induction	60 – 75	100K	80	Yes	\$\$	
LED	70 – 140	50K – 70K	65 – 85	Yes	\$\$\$	
Metal Halide (MH)	70 - 120	12K – 20K	65 - 90	No	\$	

Notes:

1. Cost is the construction cost, not the operating cost.

Table 5-2 : Typical Preferred Lighting Fixtures

Facility Type	Area	Fixture Type	Notes
All	Mechanical Rooms	F32T8	
	Electrical Rooms	F32T8	
	Control Rooms	F32T8	
	Offices	F32T8	
	Washrooms	F32T8	
	Stairways - switched	F32T8	
	Stairways – always on	LED	
	Corridors	F32T8	
	Bright Locations such as Instrument Shop	F54T5HO	
	High-Bay Applications	MH or F32T8	
	Emergency Lighting	LED	
	Exterior - Building Entrances	HPS or LED	
	Exterior - Driveways	HPS or LED	
Wastewater Lift Station	All interior spaces	F32T8	
Flood Pumping Station	All interior spaces	F32T8	
Water Pumping Stations	All interior spaces	F32T8	

5.2 Means of Lighting Control

1. The method of lighting control to be utilized is dependent upon the application.
2. Refer to Table 5-3 for potential methods of lighting control. Note that the list is not exhaustive.
3. Refer to Table 5-4 for typical lighting control application requirements. Note that this table is not deemed to be mandatory, and each application should be reviewed with the City.

Table 5-3 : Lighting Control Methods

Legend	Method	Description
AO	Always On	Lighting is always on.
MS	Master Switch	Contactors are utilized to switch multiple circuits from one switch.
MSPDO	Master Switch Partial Delay Off	A master switch is utilized, but upon turning the lighting off, a portion of the lighting remains on for a time delay. In the event that someone is still in the building, this provides the occupants opportunity to exit.
OS	Occupancy Sensor	An occupancy sensor is utilized to control lighting in the room. Timers are typically involved.
PC	Photocell Control	The lighting is controlled by ambient light.
S	Switch	Standard switches are utilized for each lighting circuit. The switches may be a 3-way/4-way circuit as required.
S/AO	Switched / Always On	Combination switched lighting and partial always on. Also known as a night-lighting arrangement.
T	Timer	The lighting turns on and off via a timer.
TO	Timer with Override	The lighting turns on and off via a timer, but an override system is present to allow personnel to turn the lighting on during typical off hours.
TO/A	Timer with Override and partial lighting always on	Same as TO, except that a night-lighting circuit is present to provide a low level of base lighting.

5.3 Illumination Levels

1. Illumination levels must meet or exceed requirements of building codes and fire safety norms for exit lighting.
2. Refer to Table 5-4 for recommend illumination levels for various applications.

Table 5-4 : Illumination Requirements

Facility Type	Area	Recommended Illumination (lux)	Control (See Table 5-3)	Notes
All	Offices	500	S	
	Electrical Rooms	500	S S/AO	
	Control Rooms	500	S/AO TO/AO	Dimming may be required.
	Laboratory	550 - 1000	S	May require means of dimming.
	Stairways – High Use	200	AO TO/AO	
	Stairways – Low Use	150	AO TO/AO	
	Corridors – High Use	200	AO TO/AO	
	Corridors – Low Use	100-150	S TO/AO	
	Building Entrances	75	Photocell	
	Roads	5 - 10	Photocell	
	Parking Lots	25	Photocell	
	Workshop	500	S TO/AO	
	Instrument Shop	750 - 850	S	
	Outdoor Electrical Substations	300	S Photocell	Base lighting with photocell, additional lighting switched.
	Mechanical (HVAC) Rooms	250	S S/AO	
	Process Areas	300	S/AO TO/AO	
General – Not Specified	300	TBD	May discuss with City	

Facility Type	Area	Recommended Illumination (lux)	Control (See Table 5-3)	Notes
Wastewater Lift Station	Main Level – Electrical Area	300 - 350	S MS	
	Main Level – Non Electrical	250 - 300	MSPDO	
	Lower Levels including Pump Room	150 – 250	MSPDO	
	Areas not accessed for regular maintenance	100	S	
	Exterior equipment such as valve actuator.	50	S	
Flood Pumping Station	Main Level – Electrical Area	300-350	S	
	Main Level – Non Electrical	250 - 300	S	
	Lower Levels including Pump Room	150 – 250	S MSPDO	Select control as appropriate.
	Areas not accessed for regular maintenance	100	S	
	Exterior equipment such as valve actuator.	50	S	
Other Facilities	Areas with Small / Delicate Equipment.	500+	TBD	Select control as appropriate.
	Areas Requiring Frequent Inspection / Maintenance	300	TBD	
	Areas Requiring Routine Inspection / Maintenance	250	TBD	
	Areas Requiring Minimal Inspection / Maintenance	100 - 200	TBD	
	Areas Requiring Infrequent Inspection / Maintenance, but performance of visual tasks of small size is required.	300	TBD	

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5.4 Fixture Location Requirements

1. Locate fixtures to avoid interference with ductwork, piping, cable trays, and other items which may block the light or impede fixture access.
2. Where practical, lighting should not require scaffolding, fall arrest equipment, the drainage of tanks or the disruption of operations for it to be serviced safely and in accordance with safety legislation. Fixtures that are accessible via the use of a small motorized scissor lift are satisfactory, provided that the facility has ready access to a scissor lift, and the scissor lift can easily be brought to the applicable space.
 - 2.1 LED fixtures shall be accessible. Despite longer intervals between service, access is still required for lamp/lens cleaning and other maintenance.

5.5 Emergency Lighting and Associated Power Source

1. Emergency lighting must be installed in all facilities.
2. The emergency lighting power supply shall be one or more of the following:
 - 2.1 Unit based battery back-up units.
 - 2.2 Centralized UPS power, dedicated for lighting and separate from the control system UPS.
 - 2.3 An emergency generator.
3. Utilize an emergency generator set to power emergency lighting for mid to large sized facilities, where the facility may require occupancy during a power failure.
4. Where an emergency generator is utilized for emergency lighting:
 - 4.1 The generator installation shall comply with CSA C282.
 - 4.2 The emergency power system shall be separated from any non-life-safety loads via a separate transfer switch.
5. Where battery-based emergency lighting is utilized:
 - 5.1 Minimize the number of batteries utilized for unit-based emergency lighting.
 - 5.2 All batteries used in the unit shall be sealed maintenance free type, 10-year rated. Ensure the recommended date for first battery replacement is provided to the City project manager, to allow the required work to be added to City maintenance schedules.
 - 5.3 The units shall have auto-test capability.
 - 5.4 The size of circuit conductors to remote lamp heads shall be such that the voltage drop does not exceed 5% of the marked output voltage of the unit equipment, or such other voltage drop for which the performance of the unit is certified when connected to remote lamp.
 - 5.5 Unit emergency lighting equipment and lighting control units, other than remote lamp heads shall not be installed in a wet or corrosive locations.
6. Emergency power supply shall have adequate capacity and rating to ensure that all connected equipment can be operated safely when the normal power source fails.
7. Emergency lights shall be arranged so that the failure of any one lamp will not leave the area in total darkness. Use double lamp heads.
8. No other appliance or equipment other than for emergency purpose shall be supplied by the emergency power circuit.

9. In the event an emergency generator is utilized to provide emergency lighting, provide additional battery based unit emergency lighting in the following locations:
- 9.1 Generator room
 - 9.2 Major electrical rooms
 - 9.3 Major control rooms.
10. Typical emergency lighting application requirements are indicated in Table 5-5.

Table 5-5 : Typical Emergency Lighting Requirements

Facility Type	Area	Recommended Emergency Illumination (lux)	Min. Duration (hrs)	Notes
All	Below-Grade Walkways	> 10	0.5	
	Control Rooms	> 50	2	
	Corridors – High Use	> 20	0.5	
	Corridors – Low Use	> 10	0.5	
	Electrical Room	>10	1	Illumination should be above 50 lux on the front of all critical equipment.
	Electrical Substation – Outdoor	See Note 2	See Note 2	
	Exits	> 10	0.5	
	Generator Rooms	> 50	3	
	Laboratory	> 10	0.5	
	Mechanical Rooms	> 10	0.5	Along egress path.
	Offices	Not Req.	-	Required for corridors
	Process Areas	> 10	0.5	On major walkway / exit path
	Stairways – High Use	> 20	0.5	
	Stairways – Low Use	> 10	0.5	
	Washrooms – One Person	Not Req.	-	
	Washrooms – Multiple People	> 10	0.5	
Workshop	> 10	0.5	On major walkway through area.	
Wastewater Lift Station	Main Level	>10	1	
	Lower Levels including Pump Room	> 10	0.5	
	Areas not required for regular maintenance	Not Req.	-	

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Note:

1. *There will be exceptions to the above table. Exceptions are to be reviewed and approved on a case-by-case basis.*
2. *The requirement for emergency lighting in an outdoor electrical substation shall be determined on a case-by-case basis.*
3. *Minimum code requirements shall be adhered to.*

5.6 Requirements for Exit Signs

1. Exit signs shall be provided for all facilities, where required by code or egress would not be clear under all circumstances.
2. LED exit signs are the standard of acceptance. All alternatives must be approved by the City.
3. Exit signs shall comply with requirements of the City of Winnipeg Electrical Bylaw, the National Building Code of Canada with Manitoba Amendments and the National Fire Code.
4. Exit signs shall be installed such that they are visible and point towards the direction of building exit.
5. Preferably exit signs shall indicate a running person pictogram figure with arrow sign indicating direction of exit. In existing facilities, exit signs shall match the type of sign used elsewhere in the facility.
6. Where an emergency generator is available, avoid the use of battery based systems if possible, except as noted herein.
7. Where batteries are utilized, all batteries used in the unit shall be sealed 10-year rated maintenance-free type.

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6 EQUIPMENT DESIGN REQUIREMENTS

6.1 DC Power Supply

6.1.1 125 VDC Power Supplies

1. DC power supplies may be utilized for switchgear control power, as per Sections 6.8 and 6.9.
2. The voltage for switchgear DC power supplies shall be 125VDC, ungrounded.
3. Provide ground fault detection with alarming on all ungrounded conductors.
4. As a minimum this system or any individual unit, shall consist of a battery bank, a battery charger and a DC distribution board.
5. Batteries shall be Valve Regulated Lead Acid (VRLA). Battery sizing to be based upon the application requirements per IEEE Standard 485 "Recommended Practice to Size Lead Acid Batteries for Stationary Applications", but at minimum shall be sized to allow:
 - 5.1 Ten hours of continuous standby current, plus
 - 5.2 One operation for all momentary loads. (e.g. One breaker trip and close for all breakers).
6. Preferred input voltage is 600V, 3-phase. Alternately, 208V, 3-phase may be utilized with approval of the City.
7. The battery charger shall have the following features:
 - 7.1 Provide input AC voltmeter for each phase (or utilize voltage selector switch).
 - 7.2 Provide a rectifier output DC voltmeter.
 - 7.3 Provide minimum of two 2-pole DC rated output load circuit breakers (2pole, 250V DC) for 125V DC load circuits. One breaker to be utilized for the DC distribution panelboard. The second breaker is for connection to a second panelboard, if required, or utilized as a future spare.
 - 7.4 Provide one DC Battery circuit breaker (2pole, 250V DC) for connecting the 125V DC battery bank.
 - 7.5 Provide a load DC ammeter.
 - 7.6 Provide an auxiliary contact relay output and alarm for AC power failure.
 - 7.7 Provide a low DC battery voltage alarm to indicate battery over discharge.
 - 7.8 Provide high DC output voltage alarm and high DC output voltage automatic shutdown.
 - 7.9 Provide "no-charge" alarm to indicate charger has no DC output.
 - 7.10 Provide DC ground detector relay and alarm (+ve and -ve).
 - 7.11 Provide local indication and annunciation, as well as relay contacts for PLC/DCS/SCADA monitoring of all alarms including: failure of AC power, low DC voltage, high DC voltage, no rectifier output.
 - 7.12 Provide an equalize timer, automatic reset type with charge time compatible with battery type. Equalize interval shall be settable from 0-28 days.

6.1.2 24 VDC Power Supplies

1. The common conductor from 24VDC power supplies shall be grounded at the DC power supply.

6.2 Electric Heating

6.2.1 General


1. Tubular heating coils are preferred over open coils for most applications due to the ability of the heater to handle a wider variety of atmospheric conditions.
2. Ensure a high temperature cut-out and an airflow proving switch are provided for all electric heaters.
3. SCR systems should be utilized for applications requiring proportional control. Zero-crossing SCR systems are preferred to reduce harmonics.
4. For heaters > 50 kW where proportional control is required, consider utilizing staging in addition to SCR control.

6.2.2 Heater Voltage Levels

1. Heater voltages should be selected based upon the nominal system voltage. For example, the heater voltage rating should be 600V on a 600V rated system, and not 575V.
2. The preferred voltage levels for various electric heater sizes are shown in Table 6-1.

Table 6-1 : Acceptable Heater Voltage Levels

Heater Rating	Preferred Voltage Levels	Alternate Voltage (with approval)
< 1.5 kW	120V, 1Ø 240V, 1Ø 208V, 3Ø	
1.5 kW – 4.9 kW	240V, 1Ø 208V, 3Ø 600V, 3Ø	
5.0 kW – 9.9 kW	600V, 3Ø	240V, 1Ø 208V, 3Ø
> 10 kW	600V, 3Ø	

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6.3 Motor Control Centres

6.3.1 Low Voltage MCC (600V)

1. Typically, MCCs will be 3-phase, 3-wire. The use of 4-wire MCCs should not be typical, and should only be utilized where approved by the City.
2. Enclosure Type: NEMA 1A (gasketed) or better if the application requires.
3. Wiring Type: Class 1, Type B-D or B-T (as shown on the drawings).
4. Busbars: Tin-plated copper.
5. Short circuit withstand rating is based on fault level calculations at the point of connections.
6. Use surge arrestors at line terminals if MCC BIL rating is inadequate to meet system BIL requirements.
7. Provide a Transient Voltage Surge Suppressor (TVSS) at each MCC where there is possibility of transient voltages. Connect the TVSS to the control system for monitoring.
8. The MCC dimensions shall be such that it can be placed in its intended location maintaining required Code clearances.
9. As per Section Table 9-2, equip MCCs with a power meter complete with a Modbus/TCP communication interface to provide real-time measurements of voltage, current, power, power factor, and energy consumption.
 - 9.1 Power meters may be omitted for small applications, where approved by the City.
 - 9.2 Provide meter with harmonic voltage and current measurement capabilities where significant harmonics are present.
10. As required by Table 6-2, and Section 9.3, provide a voltage monitoring relay with dry alarm contacts for connection to the control system.
 - 10.1 Voltage relay to alarm on any phase loss or voltage imbalance > 10%.
 - 10.2 Voltage relay to automatically reset upon restoration of power.
 - 10.3 Standard of acceptance to be ABB SSAC WVM011AL.
 - 10.4 The voltage monitoring relay functionality may be combined with the power meter, provided all power failure modes are accounted for in the design.
11. All components shall be CSA approved or cUL listed.
12. Motor control circuits shall be 120 VAC and powered by a dedicated control power transformer within each motor starter.
 - 12.1 Size control power transformers with a minimum of 50 VA capacity above that required for starter components.
 - 12.2 Protect CPTs with two fuses on the primary winding and one fuse on the secondary. The secondary neutral shall be connected to ground.
13. Where space permits, provide a total of four individual and reversible auxiliary contacts from the contactor (3 NO & 1 NC). The contacts shall be wired to an isolated section of the starter's terminal block
14. Ensure motor protection and control is consistent with Section 7

15. All motor overloads are to be of electronic type, to allow for improved protection, easier adjustment of settings, and better phase-loss protection.
 - 15.1 It is preferred to connect overload contacts on the line-side of the contactor coil, to ensure that overload protection is not lost in the event of a contactor coil ground fault.
16. Smart / Intelligent MCCs have integrated communications capability to allow the control system to directly monitor and control the motor starters via a network. Smart / Intelligent MCCs are required for many new MCC installations.
 - 16.1 Apply smart/intelligent MCCs as per Table 6-2.
 - 16.2 Coordinate with the City to determine if the City has a current standard regarding manufacturer and/or communication protocol.
17. Drawing Requirements
 - 17.1 Provide a MCC Layout Drawing as per Section 18.2.9.
 - 17.2 Provide a MCC Schedule as per Section 18.2.10.

Table 6-2 : MCC Application Requirements

Facility Type	Voltage Monitoring Relay	Smart MCC	Notes
Wastewater Flood Station	Yes	No	
Wastewater Lift Station	Yes	No	
Wastewater Treatment Facility	See Note 1	Typically Yes	
Water Pumping Station	Yes	Yes	
Other	See Note 1	TBD	Review on a case-by-case basis.

Notes:

1. Refer to Section 9.3.

6.3.2 Medium Voltage MCC

1. Short circuit withstand rating is based on fault level calculations at the point of connections.
2. Use surge arrestors at line terminals if MCC BIL rating is inadequate to meet system BIL requirements.
3. The motor controllers shall be rated and designed for starting method to be compatible with motor starting characteristics.
4. The motor controllers shall be equipped with a motor protection relay having a Modbus/TCP communication interface to convey status monitoring and control commands from external Control system.
5. The MCC busbar and connections shall be designed to withstand electromechanical stresses of across the line motor starting.
6. The Main MCC busbar shall be designed to withstand and carry rated fault current.

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7. MCC shall be equipped with a power meter complete with a Modbus/TCP communication interface to provide real-time measurements of Voltage, Current, Power, Power Factor, and Energy consumption.
8. All MCC components shall be motor horsepower rated. All components shall be CSA approved or cUL listed. IEC components are not acceptable.
9. Motor control circuits shall be 120 VAC or 125 VDC.
10. Apply other design requirements from Section 6.3.1, as applicable.

6.4 Neutral Grounding Resistors

1. General Requirements
 - 1.1 All NGRs shall be monitored.
2. High Resistance Grounding
 - 2.1 The NGR shall be designed to be placed outdoors and use wire wound resistance elements.
 - 2.2 The NGR shall be rated for continuous duty.
3. Low Resistance Grounding
 - 3.1 The NGR shall be designed to be placed outdoors and use edge wound stainless steel resistance elements. It shall be designed to trip in 1 second on sensing a Ground fault.
 - 3.2 All downstream ground fault protection relays shall be coordinated to trip faster than NGR protection relay.
 - 3.3 NGR time ratings shall be appropriate for the application.
- 4.

6.5 Panelboards

1. All breakers are to be bolt-on type.
2. Surface mounted panelboards are preferred over flush mounted panelboards in industrial style occupancies.
3. Provide a minimum of 20% spare 15A breakers (or 5 breakers, whichever is less)
4. DC panelboard shall be suitable for 125V DC power and shall be rated either 125V/250V DC, 12/24 way distribution with individual DC rated circuit breakers. AC circuit breakers with equivalent DC rating are also acceptable.

6.6 Receptacles

1. 120V receptacles are to be provided in areas to suit maintenance requirements.
 - 1.1 Provide a receptacle within 7.5m of equipment requiring maintenance for portable tools and lighting.
2. 600V, three-phase welding receptacles are to be provided within 30m of locations where welding may be required. Welding receptacles to be 600V, 3Ø, 60A with integral disconnect switch. Coordinate to ensure only a single receptacle type is provided for each facility.

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- 2.1 Mount welding receptacles at 1.2 m.
- 3. GFCI receptacles shall be provided for:
 - 3.1 All locations where required by the Canadian Electrical Code.
 - 3.2 All outdoor locations.
 - 3.3 All wet locations.
 - 3.4 All receptacles located below grade in a wastewater lift or flood station.

6.7 Soft Starters

6.7.1 Design Requirements

1. Short circuit withstand rating based on fault level calculations at the point of connections. In some cases, upstream fuses may be required to address the expected short circuits.
2. The 600V soft starter shall be rated and designed for starting method to be compatible with motor starting characteristics. It shall be verified that the maximum torque developed by the soft starter exceeds the starting torque required by the load at standstill.
3. The soft starter shall be equipped with all the required motor protection functions.
4. Where installed in an intelligent MCC, the starter shall be equipped with a communication interface compatible with the intelligent MCC communications.
5. The soft starter shall be equipped with a programming and display keypad unit, which shall be front door mounted.
6. Adequate cooling shall be provided by integral fans or enclosure mounted fans to transfer the heat from soft starter to outside. A heat loading calculation shall be performed for all custom enclosures.
7. Under no condition may the SCRs be utilized for continuous operation of a motor, regardless of manufacturer's claims. Internal bypass contactors however are acceptable under certain applications, as per Table 6-3.
8. Where external contactors are utilized, IEC contactors shall only be acceptable in applications where internal bypass contactors are acceptable, as per Table 6-3. All other applications shall utilize appropriately rated NEMA contactors. An exemption may be granted in certain applications, with approval by the City, where the available space does not allow for installation of a NEMA contactor.
9. Where an External Bypass Starter is required, as per Table 6-3, the overload shall be on the bypass line, and of an electronic type. The bypass starter shall be utilized when the motor is up to speed. Provide a "Soft Start / Bypass selector" switch on the front of the starter, and monitor the switch from the control system. The external bypass starter must be capable of performing a full voltage, across the line start if the soft starter fails.
10. Several models of soft starters are available with an internal bypass contactor that closes once the motor is up to speed. Use of the internal bypass contactor is only permitted for applications as indicated in Table 6-3.

Table 6-3 : Soft Starter Application Requirements

Facility Type	Application	Internal Bypass Acceptable	External Bypass Starter Required	Line Isolation Contactors Required	Load Isolation Contactors Required	Notes
Wastewater Flood Station	Flood Pump	Yes	No	Yes (1)	No	
Wastewater Lift Station	Lift Pump	No	Yes	Yes (1)	No (2)	
Wastewater Treatment Facility	Raw Sewage Pump	No	TBD	TBD	TBD	Review on a case-by-case basis.
	Process Pump	TBD	TBD	No	No	Review on a case-by-case basis.
	Ventilation / HVAC	Yes	No	No	No	
	Misc. Other	Yes	No	No	No	
Water Pumping Station	HVAC	Yes	No	No	No	
Other	Other	TBD	TBD	TBD	TBD	Review on a case-by-case basis.

Notes:

1. In certain applications where space does not permit, the City may grant an exemption to the requirement for isolation contactors.
2. For wastewater lift stations, a load contactor shall be provided where it is required to implement the automatic bypass starter.

6.7.2 Bypass Starters

1. Bypass across-the-line (ATL) motor starting method to be used for very critical pumping loads required to be kept in operation upon a failure of the soft starter.
2. Ensure that the mechanical equipment and power system can handle the hard across the line start method via the bypass starter. If this is not technically feasible then a redundant soft starter may be required.
3. The bypass starter shall be designed for continuous operation with motor loads when its associated soft starter is unavailable.
4. The bypass starter components shall be NEMA rated. IEC components are not acceptable.
5. Bypass mode is to be selected via a door-mounted two-position selector switch.

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6. The bypass starter must be operable with the soft-starter removed. Ideally this would require no re-wiring, however for Schneider ATS48 installation it is acceptable to require minor power re-wiring to effect the removal of the soft starter.
 - 6.1 Where re-wiring is required to allow the bypass starter to operate without the soft starter in place, provide permanent diagrams and clear warnings on the starter door interior guiding maintenance personnel on the wiring for each configuration. Ensure that the motor starter schematics also provide a clear wiring diagram for each mode.
 - 6.2 With the soft starter in place, the bypass starter shall be operable by simply switching the *Soft Start/Bypass* switch on the door exterior into the *Bypass* position, without any rewiring.

6.7.3 Supervisory Monitoring and Control

1. Soft starter operating modes and status signals are to be monitored by the automation system and displayed on the SCADA HMI. Typical monitored points include:
 - 1.1 Ready Status
 - 1.2 Running Status
 - 1.3 Soft Starter Fault Status
 - 1.4 Bypass Starter O/L Trip Status
 - 1.5 Soft Starter/Bypass Mode, monitored directly from the selector switch
 - 1.6 Auto/Manual Mode, monitored directly from the selector switch
 - 1.7 Motor Current
2. Fault signals should be wired to a non-fail safe contact (normally open, closed upon a fault condition) to avoid fault alarms from appearing on the HMI when the soft starter is disconnected from the power source for maintenance purposes.

6.8 Switchgear – Low Voltage

1. Switchgear connected directly to utility services must be service entrance rated.
2. Instrument Transformers
 - 2.1 Instrument transformers include all the current transformers (CT's) and potential transformers (PT's) required for both metering and protection purposes.
 - 2.2 Current transformers shall be mounted in the breaker compartment around the stationary main contacts and shall have their thermal and mechanical rating capable of withstanding the short circuit rating of the associated circuit breakers. They shall be accessible from the front of the switchgear assembly. There shall be one CT per phase.
 - 2.3 The metering accuracy of the CT's shall be 0.3 B-0.2 as a minimum. Burden factor of 0.2 Ω shall be increased to higher values as needed for the application. For protection duty, sensors' accuracy class shall not be less than C100, and shall be increased as required by the application to comply with Class C. CT's used for metering and protection shall fulfill the accuracy requirements for both duties.
 - 2.4 Potential transformers with their primary and secondary fuses shall be mounted inside the switchgear's instrument compartment. Accuracy shall be 0.3WX0.6Y1.2Z, as a minimum. The fuses shall be of the pull out type.
 - 2.5 Potential transformers shall be connected in open delta with their secondaries at 120 V.

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- 2.6 Current and potential transformers shall be wired to test blocks. Whenever an instrument transformer is connected to more than one device, there shall be one test block for every device. Potential transformers shall be grounded at the input side of the test block.
3. Controls
 - 3.1 Control potential transformer with pull-out type primary (two fuses) and secondary fuse shall be mounted inside the switchgear instrument compartment.
 - 3.2 Control and timing relays shall be of the plug-in type. Timing relays shall be solid state.
4. Communication
 - 4.1 Review the requirement for Ethernet communication of relays and metering devices on a case-by-case basis.
5. Power Connections
 - 5.1 Two hole, long barrel, tin-plated, copper, NEMA standard spacing compression type lugs and cable support brackets for the incoming and outgoing cables.
 - 5.2 Where an incoming bus duct is specified, suitable flanges shall be provided.
 - 5.3 Provide removable conductive gland plate (non-magnetic and non-conductive for single conductors).
6. Control Wiring
 - 6.1 Control wiring shall be 14 AWG minimum, single conductor, stranded copper having 600 volt, flame retardant insulation, SIS switchboard type.
 - 6.2 Current transformer wiring shall be 10 AWG minimum, single conductor, stranded copper having 600 volt, flame retardant insulation, SIS switchboard type wiring.
 - 6.3 All external connections shall be via terminal blocks. Provide a minimum of 15% spare terminals.
7. Consider closed-door racking for all low-voltage switchgear.
8. Consider remote racking for switchgear with arc flash ratings exceeding Category 3.

6.9 Switchgear – Medium Voltage

1. Switchgear connected directly to utility services must be service entrance rated.
2. The main incoming service for critical facilities requiring medium voltage switchgear shall be metal-clad circuit breaker switchgear.
3. Medium voltage vacuum circuit breakers are preferred over air or SF6 circuit breakers.
4. 125 VDC switchgear control power is preferred over AC control power. AC control power should only be considered for small installations, and require provision of a dedicated UPS or capacitor trip supply.
5. The requirement for arc-resistant switchgear shall be discussed and decided on a per application basis with the City.
 - 5.1 Consider arc-resistant switchgear where the arc flash safety issues cannot be mitigated via alternate means. Typically arc-resistant switchgear would only be considered where the arc flash category level for the switchgear is above Category 2.
 - 5.2 Where arc-resistant switchgear is provided, the standard of acceptance shall be ANSI/IEEE C37.20.7 Type 2B.

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- 5.3 Where arc-resistant switchgear is provided, ensure that the maximum fault clearing time is within the switchgear design limits (typically 0.5 second).
6. Protection and metering shall be microprocessor based with integrated digital metering and display, as well as communications capability for remote display via the control system.
7. See Section 10.3 for protection requirements.
8. Provide at minimum the following signals to the control system for monitoring and alarming:
 - 8.1 Closed / open status of main and tie breakers.
 - 8.2 Breaker / Relay fail status.
 - 8.3 Metering signals as per Section 9.2.
9. Consider closed-door racking for all medium-voltage switchgear.
10. Consider the use of light-based arc detection protection relays.
11. Consider remote racking for switchgear with arc flash ratings exceeding Category 3.
12. Ensure viewing windows are provided to visually monitor the position of disconnect switch style switchgear.
13. Consider the provision of thermographic inspection windows in switchgear with arc flash ratings exceeding Category 2.

6.10 Transformers

1. General
 - 1.1 It is recommended to provide 25% spare capacity for future use, although in cases where future loads are not expected, the City may approve reduction of the spare capacity.
 - 1.2 Percent Impedance (%Z) in accordance with CSA.
 - 1.3 Copper windings only.
 - 1.4 All three phase transformers to be delta-wye unless otherwise approved by the City.
 - 1.5 Specify the relevant CSA standards for each transformer installation.
2. Outdoor liquid filled transformers
 - 2.1 Provide protection on both primary and secondary side to allow for better coordination.
 - 2.2 Secondary neutral terminal bushing is required. The neutral must be fully rated for all neutral grounding resistor applications.
 - 2.3 Provide surge arrestors on the primary side of the transformer.
 - 2.4 The NGR enclosure shall be stainless steel and NEMA 3-R rated.
 - 2.5 Primary terminal bushings shall be suitable for cable connections.
 - 2.6 Secondary terminals for connecting secondary cables or cable bus duct / bus way shall be tinned copper bus bars.
 - 2.7 Utilize PCB free transformer oil suitable for Arctic conditions (extreme cold climate).
 - 2.8 The transformer core shall be cold rolled grain oriented steel laminations.
 - 2.9 Windings shall be disc type and not layer type.
 - 2.10 Transformer shall withstand thermally and mechanically a two second short circuit at its secondary terminals.

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- 2.11 Transformer shall be equipped with all standard metering, pressure relief, and CTs as required by CSA.
 - 2.12 Transformer shall be provided with stainless steel grounding pads at two diagonally opposite ends.
 - 2.13 Transformer shall be equipped with oil fill, drain and sample valves.
 - 2.14 Transformer shall be equipped with an oil level monitoring gauge with alarm contacts.
 - 2.15 Transformer shall be equipped with a de-energized tap changer on the primary winding. The tap changer should be functional to -40°C ambient temperature operation. At minimum two taps above and two taps below at 2.5% increments shall be provided. All taps shall be full capacity.
 - 2.16 Applications requiring a load-tap changer (LTC) are beyond the scope of this design guide.
 - 2.17 Protection Requirements – Provide at minimum:
 - 2.17.1 Primary and secondary overcurrent protection.
 - 2.17.2 Winding temperature indicator with alarm and trip contacts.
 - 2.17.3 Sudden pressure relay for sealed-tank design transformers.
 - 2.17.4 Vacuum/pressure gauge for sealed-tank design transformers.
 - 2.17.5 Provide differential protection for transformers as per Section 10.3.
 - 2.18 Additional transformer protection is appropriate for many applications, especially for larger transformers. Apply protection in accordance with good engineering design practice.
3. Dry-Type Transformers
- 3.1 It is preferred that indoor transformers are dry type.
 - 3.2 Enclosure: NEMA 1 is typical. Specify NEMA 2 drip-proof or sprinkler-proof enclosure or NEMA 3R where required.
 - 3.3 Ensure adequate space for ventilation is provided.
 - 3.4 Provide at minimum two taps above and two taps below at 2.5% increments, full capacity.
 - 3.5 Protection Requirements – Provide at minimum:
 - 3.5.1 Primary and secondary overcurrent protection.
 - 3.5.2 Winding temperature indicator with one probe in the center winding, with alarm and trip contacts for transformers ≥ 150 kVA.
 - 3.5.3 For transformers ≥ 1000 kVA, provide a digital temperature monitoring unit with one probe in each winding, giving instantaneous temperature readings for each winding, average readings and maximum reading recorded. Unit shall provide three 120 Vac, 10A, SPDT dry contacts for alarm and trip outputs. All contacts shall have an adjustable temperature setpoint.
 - 3.6 Review the requirement for surge arrestors on the transformer primary terminals. Where applied, they shall comply with the requirements of Appendix B of CSA C9.
 - 3.7 Review the requirement for K-rated transformers in harmonic environments.
 - 3.8 Electrostatic shield between high voltage and low voltage windings, connected to the enclosure ground bar, except that the use of electrostatic shields shall be reviewed in high harmonic environments.
 - 3.9 Ensure lifting hooks for lifting complete transformer assembly are provided.
 - 3.10 Where required, neutral grounding resistors shall be made of stainless steel, completely protected by a hot dip galvanized enclosure, and mounted on top of the transformers.

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- 3.11 The grounding resistors shall be insulated for the full line to line voltage and hot spot temperature rise, above 30°C ambient, shall be limited to 385°C for continuous rating, and 760°C for 1 minute rating, as per IEEE Standard No. 32.
- 3.12 Neutral connection shall be made with 2/0 AWG copper conductors (minimum), insulated for the transformer secondary line to line voltage. Colour of insulation shall be green.
- 3.13 Provision shall be made for field installation of NGR current transformer on live side of NGR.
- 3.14 Protection for three-phase delta-wye transformers:
 - 3.14.1 Provide secondary overcurrent protection for all delta-wye transformer installations with a secondary breaker sized at 125% or less of the transformer full-load current. Note that secondary overload protection provides better delta-wye transformer protection than primary overload protection.
 - 3.14.2 For primary voltages > 750V, protection may be either by fuse or circuit breaker, as appropriate for the application.
 - 3.14.2.1 Ensure appropriate protection is provided to address transformer inrush and potential short circuit currents.
 - 3.14.2.2 Ensure selective coordination is provided.
 - 3.14.2.3 Refer to Section 10.3 for other protection requirements.
 - 3.14.3 For primary voltages < 750V, provide primary overcurrent protection for all delta-wye transformer installations with a primary breaker sized between 150% and 300% of the transformer full-load current, taking into account:
 - 3.14.3.1 Transformer inrush current
 - 3.14.3.2 Selective coordination between upstream and downstream breakers.
 - 3.14.3.3 Transformer short circuit protection.

6.11 Transient Voltage Surge Suppressors

1. Provide TVSS at each major point in the distribution connecting to load equipment. For example, all major MCCs should be equipped with a TVSS.
2. If TVSS units are utilized on resistance grounded systems, ensure that they are appropriately rated for potential overvoltages during a ground fault.

6.12 Unit Substations

1. The term “Unit substation” shall be used to refer to a fully co-ordinated and pre-assembled power supply unit consisting of:
 - 1.1 Primary switchgear; or feed through device with interrupting and isolating devices
 - 1.2 Step-down transformer
 - 1.3 Low voltage switchgear or cable termination compartment
 - 1.4 All necessary instrument transformers, ground fault detection and protection devices, locally mounted.
2. All components of a unit substation shall be directly coupled and suitable for indoor use.

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3. A feed through type switchgear or proper cable connection arrangement will be required if more than one unit substation will be connected from the same primary supply circuit (in daisy chain or loop configuration)
4. The low voltage section may be equipped for use as a single load feed or as a distribution board for multiple loads. Alternatively the low voltage switchgear required may be mounted within a short distance, in which case, a fully rated cable or bus-duct termination box shall be mounted directly on the secondary side of the transformer section.
5. The transformer section shall be fully enclosed and shall include all required instrument transformers, and monitoring devices pre-wired to the corresponding switchgear section or terminated in a separate junction box if external wiring is required.

6.13 Uninterruptible Power Supplies

There are many critical loads within water and wastewater facilities that require their power supply to remain available in the event of a utility power failure. Typically, an Uninterruptible Power Supply (UPS) is used to accomplish this.

6.13.1 Application Requirements

1. Uninterruptible power supplies are to be provided for process controls for all facilities. This shall be a dedicated UPS that does not serve other applications within the facility.
2. Uninterruptible power supplies may be utilized for provision of emergency lighting power where an emergency generator is not available or where no interruption of lighting is deemed to be acceptable, during the start of the generator.

6.13.2 Design Requirements

1. UPS Selection
 - 1.1 All AC UPS units shall be of the double-conversion (on-line) type.
 - 1.2 DC UPS units are acceptable for small loads, such as a single control panel. Preferred voltage is 24 VDC.
 - 1.3 In larger facilities, it is generally more efficient for the UPS to be a standalone unit. In these cases, UPS loads are distributed around the facility or process area and the UPS shall feed a standard panelboard for distribution of the UPS power.
2. Load Distribution
 - 2.1 Do not route UPS load cabling over long distances. Do not route parallel to other electrical cabling that could radiate harmonics or noise.
 - 2.2 Limit voltage drop from the UPS to the load to 3%.
 - 2.3 Provide selective coordination of the load breakers to the greatest extent possible. In some cases, this may require over-sizing the UPS.
 - 2.4 All load distribution wiring to be hard cabled. Where a UPS with hardwired connections is not available, a UPS with locking receptacles may be utilized. UPS units with non-locking receptacles are not permitted.
3. Bypass Requirements
 - 3.1 All 208/120V UPS units shall be provided with an external maintenance bypass switch to allow for removal of the UPS unit.

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6.13.3 Redundancy

1. UPS redundancy is typically only required for only the most critical loads. Note that paralleling UPS units to achieve a larger capacity does provide a level of redundancy.
2. Use of paralleled UPS units with a synchronized common distribution system is not a preferred redundancy solution, due to the following considerations:
 - 2.1 There are still single points of failure in the UPS load distribution system.
 - 2.2 Maintenance or modifications to the UPS load distribution system requires all UPS powered loads to be de-energized.
 - 2.3 If a common power source is provided to both UPS units, any maintenance or extended downtime on the upstream power supply for durations longer than the battery backup time would require that the UPS powered loads be de-energized.
3. If UPS redundancy is required, preferred solutions include:
 - 3.1 Distribution of critical loads across multiple UPS units such that a single UPS failure will not affect all critical loads. This is typically a good solution where parallel process trains are utilized.
 - 3.2 Utilizing load equipment that support multiple power supplies (dual corded equipment), such that each power supply can be connected to a different UPS.

6.13.4 Sizing Factors

1. The inverter must be capable of supplying power to the load under typical and peak conditions. Peak load inrush conditions are typical during equipment start-up, and can be significantly higher than the measured loads.
2. Other factors considered in sizing the UPS units are:
 - 2.1 Crest factor of the load. This accounts for the fact that switching mode power supplies may not draw current in a typical sinusoidal fashion, and that the peak cycle current may be significantly higher than the normal crest factor of 1.414 of a clean alternating current cycle. Utilize a crest factor of 2.4 in sizing of UPS units that primarily feed switching mode power supplies.
 - 2.2 Inrush of load transformers (on initial power-up). This inrush can be very high, and can potentially be addressed by starting the UPS up in bypass mode.
 - 2.3 Fault clearing capability of the UPS and its internal bypass line.
 - 2.4 Selective coordination of the upstream UPS protection and load circuit breakers.
 - 2.5 Whether the load is connected single or three-phase, and whether there is an isolation transformer present.
3. Include the following in battery runtime calculations:
 - 3.1 Age derating of the batteries. IEEE standards recommend replacing batteries when the measured capacity drops below 80%. Thus, it is recommended that the batteries are derated by 80% when determining the runtime of batteries, to account for end of life capacity.
 - 3.2 Include any losses in any isolation transformers that may be present.
 - 3.3 If there is potential for the UPS environment to become cold in the event of a power failure, it is recommended to de-rate the batteries by 80% to account for a reduced building temperature.
 - 3.4 Ensure that the rate of discharge is accounted for in the runtime calculations. Lead-acid battery capacity is dependent upon the discharge rate.

3.5 Provide a minimum of 20% spare capacity.

6.13.5 Battery Runtimes

Battery runtimes for each application shall be discussed with the City and documented. Minimum requirements are shown in Table 6-4.

Table 6-4 : Minimum UPS Runtime Requirements

Facility Type	Application	Standby Generator	Minimum Runtime (min)	Notes
Wastewater Lift Station	Control System	N	60	
		S	30	
		R	15	
Wastewater Flood Station	Control System	N	60	
Wastewater Treatment Facility	Control System	N	120	
		S	60	
		R	30	
Regional Water Pumping Stations	Control System	R	120	
Secondary Water Pumping Stations (Tache/Deacon)	Control System	N	600	
		S	60	
Water Treatment Plant	Control System	R	30	
Shoal Lake Aqueduct	Control System	S	720	Due to remote nature of facility.
Legend for Standby Generator Column: N No Standby Generation S Single Standby Generator or Generator System with No Redundancy R Standby Generation with Generator Redundancy				

6.13.6 Other Design Requirements

1. Power Supply
 - 1.1 Where a standby generator is available, the UPS power supply shall be powered from the standby generator.
 - 1.2 Address the potential harmonics associated with the UPS input current, and the associated affect on standby generators.
2. Environmental
 - 2.1 The optimum temperature for UPS batteries is 22°C + /- 5°C, and it should be noted that the temperature inside the UPS battery module/cabinet, may be higher than the typical room temperature. This is not expected to be a significant issue for the installations present. The optimum relative humidity is 35 to 55%.

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3. Ventilation

- 3.1 Lead-acid batteries produce hydrogen gas. Valve Regulated Lead Acid (VRLA) batteries are sealed, such that the hydrogen gas recombines into water inside the battery. However, under certain fault conditions, the hydrogen gas may build up faster than it can be recombined, and a safety valve opens to vent the excess hydrogen. For most UPS installations with VRLA batteries, normal building ventilation rates are typically above that required to disperse the hydrogen gas of VRLA batteries. However, if the UPS batteries are contained within a small room or enclosure, review of the required ventilation is required.


6.14 Variable Frequency Drives

6.14.1 Medium Voltage (4160V) VFD Requirements

1. The VFD rated output current should exceed the motor nameplate current, irrespective of the motor power and VFD power ratings not being matched.
2. Short circuit withstand rating based on fault level calculations at the point of connections.
3. Use surge arrestors at line terminals if VFD BIL rating is inadequate to meet system BIL requirements.
4. The VFD shall be minimum 24 pulse, or optionally utilize an active front end.
5. The VFD controller shall be rated and designed for starting method to be compatible with motor starting characteristics. Motor RPM encoder is not required.
6. VFD shall be programmable for V/F as well as Sensorless vector control in the field. User can choose either based on field conditions.
7. The VFD shall comply with IEEE-519 harmonic requirements at its Line terminals.
8. The VFD shall be equipped with a network communication interface to convey status monitoring and control commands from external Control system.
9. All VFD power control components shall be CSA approved or cUL listed. IEC components are not acceptable.
10. Use integral primary isolation transformer to reduce short circuit fault levels on the VFD side, and also to reduce the Common Mode Voltages developed in the Inverter Bridge.
11. The VFD inverter shall be minimum three levels, and shall use Pulse width modulation (PWM) technique for voltage synthesis.
12. The system designer in coordination with the manufacturer is to review potential resonance effects and address any issues at design time.

6.14.2 Low Voltage (600V) VFD Requirements

1. Select the VFD manufacturer based upon the City's standard, for motors rated less than 75 kW (<100 hp). Specialized applications may deviate from this standard.
2. Adequate cooling shall be provided by integral fans or enclosure mounted fans to transfer the heat from the VFD to outside. A heat loading calculation shall be performed for all custom panels.
3. Confirm that the building ventilation and cooling is adequate for the VFD heat loading.
4. Ensure that corrosive gases are not present in the VFD cooling air.

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5. The system designer must review the harmonic impact of the VFD on the power supply.
6. At a minimum, utilize a line reactor on the line side of all VFDs to reduce inrush currents and the level of harmonics. Line reactors can also protect the VFD against some power line disturbances. The selection of the appropriate reactor is to be based upon harmonics and voltage analysis.
 - 6.1 Line reactors shall be provided for all VFDs, regardless of size, unless it can be clearly demonstrated that they do not provide a benefit and approval of the City is provided.
7. Load reactors are utilized to protect the motor if the wiring distance between the VFD and motor is long.
 - 7.1 The appropriate selection of an appropriate load reactor is beyond the scope of this guide, and the application details should be reviewed in each case, however the following is provided as “rule-of-thumb” general guidance:
 - 7.1.1 Load reactors are recommended for motors greater than 37 kW (50 hp) to reduce motor temperatures and increase motor life.
 - 7.1.2 Load reactors are recommended when motor leads exceed 30m.
 - 7.1.3 Load reactors are mandatory when motor leads exceed 100m.
 - 7.1.4 Filters (dv/dt) are required when motor leads exceed 150m.
8. Utilize inverter rated cabling for all six-pulse VFD load cabling, with three copper grounding conductors, 1000V rated insulation, continuous copper tape shield with 50% overlap or continuous (non-interlocked) aluminum armour, and approved for six-pulse VFD use.

6.14.3 Bypass Starters

1. 60Hz AC operation with Across the Line (ATL) motor starting method to be used for very critical pumping loads required to be kept in operation upon a failure of the main motor controller.
2. Ensure that the mechanical equipment and power system can handle the hard across the line start method via the bypass starter. If this is not technically feasible then a Reduced Voltage bypass starter or a soft-start bypass starter may be utilized instead of the conventional ATL bypass starter.
3. The bypass starter shall be equipped with its own motor protection relay as the motor protections inside VFD would be unavailable.
4. The bypass starter components shall be NEMA rated. IEC components are not acceptable.
5. The bypass starter shall be interlocked with VFD such that at any time only one can operate.
6. Provide isolation disconnects / and contactors on VFD load side to prevent power back-feed into the VFD inverter module when the VFD is not running.
7. Bypass mode is to be selected via a door-mounted two-position selector switch.

6.14.4 Supervisory Monitoring and Control

1. VFD operating modes and status signals are to be monitored by the automation system and displayed on the HMI. Typical monitored points include:
 - 1.1 Ready Status
 - 1.2 Running Status
 - 1.3 VFD Fault Status

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- 1.4 Bypass Starter O/L Trip Status (if applicable)
 - 1.5 VFD/Bypass Mode, monitored directly from the selector switch (if applicable)
 - 1.6 Auto/Manual Mode, monitored directly from the selector switch
 - 1.7 Motor Current
2. The VFD/Bypass mode is typically controlled via a door-mounted selector switch on the VFD panel. However, for critical applications where maintenance personnel are not able to reach the facility in a reasonable amount of time, selection of the Bypass mode may be made from the HMI system.
 3. Fault signals should be wired to a non-fail safe contact (normally open, closed upon a fault condition) to avoid fault alarms from appearing on the HMI when the VFD is disconnected from the power source for maintenance purposes.

6.14.5 Functional Requirements

1. Wastewater Pumping (Lift) Stations
 - 1.1 VFDs used in wastewater pumping (lift) stations should operate such that upon a start command, the VFD ramps up from zero speed to a minimum operating speed, which corresponds with the minimum scouring velocity of the forcemain. After reaching minimum speed, the speed command to the VFD can be PID controlled to maintain the setpoint level in the wet well. The VFD shall not be allowed to operate below the minimum operating speed, otherwise solids will settle out of the wastewater, which may plug the forcemain over time. Upon receiving a stop signal, the VFD shall ramp down in speed, rather than coast, to reduce equipment and pipe stresses.
 - 1.2 Typical lift stations contain multiple pumps that discharge to a common header or forcemain. When multiple VFD driven pumps are in operation at one time, the commanded speed to all of the pumps is to be identical, provided the pumps are matched. If one of several pumps is operating in bypass mode (and therefore running at full speed) then the other VFDs shall be commanded to run at full speed when they are called to start.
 - 1.3 Provided local manual speed control by means of a door-mounted potentiometer on the VFD panel.

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7 MOTORS

7.1 General Requirements

1. General Requirements for all motors
 - 1.1 All motors are to have a service factor of 1.15 under normal full voltage operation.
 - 1.2 Operating Temp Class B (130°C)
 - 1.3 Insulation Class F
 - 1.4 Terminal boxes rated NEMA 4.
 - 1.5 Motors must meet or exceed the efficiencies outlined in either Table 2 (energy efficient) or Table 3 (premium efficiency) of CAN/CSA C390-10, depending on their design.
2. General Duty motors for non-process equipment are to have the following requirements:
 - 2.1 TEFC enclosures.
3. Process motor requirements include:
 - 3.1 TEFC enclosures.
 - 3.2 Suitable for moist and corrosive locations.
4. Motors for use with a variable frequency drive:
 - 4.1 TEFC enclosures.
 - 4.2 Suitable for moist and corrosive locations.
 - 4.3 Inverter duty rated, in conformance with NEMA MG1.
 - 4.4 Ensure that the driven load is not rated at more than 85% of the motor's effective service rating.
 - 4.5 Ensure motors have adequate cooling over the operating speed range.
 - 4.6 Motors larger than 150 kW (200 hp) shall have an insulated bearing on the non-driven end (NDE) when driven by VFD.
5. Explosion-proof motor requirements include:
 - 5.1 Rated for Class I, Zone 1 (or Div 1) as applicable.
 - 5.2 Provide an approved breather / drain device at the motor drain hole.

7.2 Motor Voltage Levels

- The preferred motor power for each voltage level is shown in Table 7-1.

Table 7-1 : Acceptable Motor Voltage Levels


System Voltage Level	Motor Voltage Level	Minimum	Preferred Low	Preferred High	Maximum
120 V 1Ø	115 V 1Ø	-	-	0.37 kW (½ hp)	3.7 kW (5 hp)
240 V 1Ø	230 V 1Ø	-	-	0.37 kW (½ hp)	7.5 kW (10 hp)
208 V 3Ø	200 V 3Ø	-	-	0.75 kW (1 hp)	37 kW (50 hp)
600 V 3Ø	575 V 3Ø	-	0.37 kW (½ hp)	261 kW (350 hp)	556 kW (750 hp)
4160 V 3Ø	4000 V 3Ø	75 kW (100 hp)	261 kW (350 hp)	1492 kW (2000 hp)	5595 kW (7500 hp)

Note:

- Motor sizes outside of the preferred ranges should be reviewed and approved by the City prior to finalizing the design.*
- Three-phase motors are preferred over single-phase motors.*
- Utilize higher voltage motors where the higher voltage is available.*

7.3 Special Requirements

- The use of oversized terminal boxes is desirable. Size of power cable will have an influence in the size of the terminal box and must be taken into account.
- Motor winding temperature protection should generally be provided for motors 75 kW (100 hp) and above. Provide RTD Winding Temperature Detectors embedded in the stator for motors above 150 kW (200 hp). Provide a dedicated terminal box separate from the motor box for termination of the RTD leads. Motors less than 150 kW (200 hp) may utilize thermistors.
- Specify motors equipped with anti-condensation heaters in the following cases:
 - 3.1 Medium voltage motors
 - 3.2 Low voltage motor above 37 kW (50 hp), where the motors could potentially not be operating for a significant period of time in an area with high humidity.

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7.4 Acceptable Methods of Control

1. The following methods of control are deemed to be acceptable, as per application requirements. Other methods of control require specific approval of the City.
 - 1.1 Full Voltage Direct On Line (DOL) - Fixed speed
 - 1.2 Soft Start – Fixed speed
 - 1.3 Variable Frequency Drive (VFD) – Variable speed
 - 1.4 DC Electrically Commutated.

2. The use of magnetic couplings or eddy current drives may be acceptable for certain applications where the variable speed requirements are limited (~85% - 100% speed). Review would be required on a case-by-case basis.

3. Contactors
 - 3.1 All full voltage motor starter contactors shall be NEMA rated contactors.
 - 3.2 NEMA labelled IEC style contactors are acceptable for most applications.
 - 3.3 IEC style contactors are permitted for the following applications:
 - 3.3.1 Soft Starter isolation contactors.
 - 3.3.2 Soft starter bypass contactors, provided the bypass contactor is not utilized for full voltage starting.
 - 3.4 For applications in wastewater collections, wastewater flood pumping, or land drainage, where IEC contactors are utilized for bypass or isolation purposes, they shall, at minimum, be sized as follows:
 - 3.4.1 One size larger than required, or
 - 3.4.2 125% of FLA.

4. Typical special motor control requirements are as per Table 7-2, however the control of each motor shall be reviewed in light of the specific application requirements.

5. Most wastewater flood pumping stations have a special requirement in that the motors cannot be tested at full speed during a non-flood event as this would pump wastewater to the river. Thus, all applications where full speed testing cannot be performed must have a slow speed jog capability. The Allen-Bradley SMC-Flex series of soft starter is known to have this capability.

Table 7-2 : Typical Special Motor Control Requirements

Facility Type	Equipment	Rating	Motor Control
Underpass Pumping Station	Lift Pump – Single Speed	≥ 18.7 kW (25 hp)	Soft Starter
Wastewater Lift Pumping Stations	Wastewater Lift Pumps – Single Speed	< 18.7 kW (25 hp)	Full Voltage Starter
		≥ 18.7 kW (25 hp)	Soft Starter with isolation contactors and bypass starter
	Wastewater Lift Pumps – Variable Speed	Any	VFD with isolation contactors and bypass starter
Wastewater Flood Pumping Stations	Flood Pumps – Single Speed	≥ 18.7 kW (25 hp)	Soft starter with bypass contactor (internal or external) and upstream isolation contactor.

7.5 Control Circuits

7.5.1 Motor Restart Control

Motor control circuits are to be designed to have anti-restart prevention, to prevent or delay automatic immediate restart after a stop or power failure situation. The purpose is to prevent restart of the motor while residual voltage could still be present in the motor. For motors 75 kW (100 hp) or greater, provide motor restart prevention. As per NEMA MG1 guidelines, motor restart shall be prevented until 1.5x the motor open circuit time constant. The delay could potentially be accomplished via a three-wire control (stop/start) control arrangement, timers to delay restart, or potentially an undervoltage relay with a restart time.

7.6 General Protection Requirements

1. The typical protection requirements for various applications are identified in Table 7-3. Note that the below is a general guide, and additional protection requirements may be required for specific applications. See Section 7.7 for some special protection requirements.

Table 7-3 : Typical Motor Protection Requirements

Application	Rating	Protection
600V motors, single speed, general service	< 75 kW (100 hp)	Electronic Overload
	>= 75 kW (100 hp) < 187 kW (250 hp)	Overload Overcurrent Locked Rotor Ground Fault (zero-sequence CT) Winding Temperature (Thermistor or RTD)
	> 187 kW (250 hp)	Overload Overcurrent Locked Rotor Ground Fault (zero-sequence CT) Winding Temperature (RTD)
600V motors, single speed, critical service	< 37 kW (50 hp)	Electronic Overload
	>= 37 kW (50 hp) < 75 kW (100 hp)	Electronic Overload Winding Temperature (Thermistor or RTD) Ground Fault (zero-sequence CT)
	>= 75 kW (100 hp) < 187 kW (250 hp)	Overload Overcurrent Locked Rotor Ground Fault (zero-sequence CT) Winding Temperature (RTD)
	>= 187 kW (250 hp)	Overload Overcurrent Locked Rotor Ground Fault (zero-sequence CT) Winding Temperature (RTD) Bearing Temperature
600V motors, VFD driven	< 37 kW (50 hp)	Standard VFD protection
	>= 37 kW (50 hp) < 75 kW (100 hp)	Standard VFD protection Winding Temperature (Thermistor - PTC)
	>= 75 kW (100 hp) < 187 kW (250 hp)	Standard VFD protection Winding Temperature (RTD)
	>= 187 kW (250 hp)	Standard VFD protection Winding Temperature (RTD) Bearing Temperature

Application	Rating	Protection
Medium Voltage Motor, non-critical service	< 746 kW (1000 hp)	Overload Overcurrent Locked Rotor Ground Fault (zero-sequence CT) Phase Balance Undervoltage Winding Temperature (RTD)
Medium Voltage Motor, critical service	< 746 kW (1000 hp)	Overload Overcurrent Locked Rotor Ground Fault (zero-sequence CT) Phase Balance Undervoltage Winding Temperature (RTD) Bearing Vibration Bearing Temperature

7.7 Special Protection Requirements

Special motor protection requirements for specific applications are identified in Table 7-4. Note that the table is not comprehensive and a review of the protection requirements for special applications is required on a case by case basis. Special protection requirements are in addition to standard protection requirements discussed in Section 7.6.

Table 7-4 : Special Motor Protection Requirements (Minimum)

Application	Rating	Protection
Submersible Pumps – Process Applications	> 2.2 kW (3 hp)	Humidity / leak
	> 7.5 kW (10 hp)	Humidity / leak Winding Temperature (switch)
	>= 75 kW (100 hp)	Humidity / leak (in applicable compartments such as connection housing / stator / oil) Winding Temperature (RTD) Bearing Temperature
	>= 186 kW (250 hp)	Humidity / leak (in applicable compartments such as connection housing / stator / oil) Winding Temperature (RTD) Bearing Temperature Bearing vibration

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7.8 Local Controls

The following are considered standard minimum requirements, and shall be augmented as required by the application.

7.8.1 Wastewater Collections & Land Drainage Facilities

1. Motor Driven Equipment – Single Speed
 - 1.1 Small motors (Not pumps)
 - 1.1.1 Install a *Hand-Off-Auto* (H/O/A) or *On/Off* switch at the MCC/Starter as appropriate.
 - 1.2 Pump motors (< 37 kW (50 hp))
 - 1.2.1 Install a *Hand-Off-Auto* (H/O/A) switch at the MCC/Starter
 - 1.2.2 Provide a blue *Ready* pilot light to indicate the motor is ready to run.
 - 1.2.3 Install an *E-Stop* mushroom pushbutton at the starter, pump and motor levels. Provide a *Reset* pushbutton to allow the pump to restart.
 - 1.3 Pump motors (>= 37 kW (50 hp))
 - 1.3.1 Install a *Manual/Auto* (M/A) and *Start/Stop* buttons at the MCC/Starter
 - 1.3.2 Provide a blue *Ready* pilot light to indicate the motor is ready to run.
 - 1.3.3 Install an *E-Stop* mushroom pushbutton at the starter, pump and motor levels. Provide a *Reset* pushbutton to allow the pump to restart.
 - 1.4 In addition, if a soft starter and bypass starter are provided
 - 1.4.1 Install a *Soft Start / Bypass* switch at the starter.
2. Motor Driven Equipment - VFD Drive
 - 2.1 Pump motors (< 37 kW (50 hp))
 - 2.1.1 Install a H/O/A switch at the VFD starter.
 - 2.1.2 Provide a blue *Ready* pilot light to indicate the motor is ready to run.
 - 2.1.3 Install a manual speed potentiometer to be utilized in Hand mode.
 - 2.1.4 Install an *E-Stop* mushroom pushbutton at the starter, pump and motor levels. Provide a *Reset* pushbutton to allow the pump to restart.
 - 2.2 Pump motors (>= 37 kW (50 hp))
 - 2.2.1 Install a *Manual/Auto* (M/A) and *Start/Stop* buttons at the MCC/Starter
 - 2.2.2 Provide a blue *Ready* pilot light to indicate the motor is ready to run.
 - 2.2.3 Install a manual speed potentiometer to be utilized in Hand mode.
 - 2.2.4 Install an *E-Stop* mushroom pushbutton at the starter, pump and motor levels. Provide a *Reset* pushbutton to allow the pump to restart.
 - 2.3 In addition, if a bypass starter is provided:
 - 2.3.1 Install a *VFD / Bypass* switch at the VFD starter.

Notes:

1. *For motors > 50 hp, momentary Start / Stop provided to ensure motor does not restart after brief power interruption, as is possible if a Hand position is provided.*
2. *Use of Lock-Off-Stop switches will not be permitted as they imply lock-off capability for the equipment, but are not suitable for use as a disconnecting means.*

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3. *Additional safety controls may be required for equipment with safety requirements. An emergency-stop switch is considered to be a minimum when there is a potential safety risk.*

7.8.2 Wastewater Treatment Plants

1. Small motors (≤ 19 kW (25 hp))
 - 1.1 Install a *Hand-Off-Remote* (H/O/R) switch at the MCC/Starter.
2. Motors (>19 kW (25 hp) and < 37 kW (50 hp)), standby operation
 - 2.1 Install a *Local-Off-Remote* (L/O/R) switch and start/stop pushbuttons at the MCC/Starter.
3. Medium size and larger motors (≥ 37 kW (50 hp))
 - 3.1 Install a *Local/Off/Remote* (L/O/R) and Start/Stop station at the MCC/Starter.
 - 3.2 Consider installation of a dedicated local e-stop near the equipment.

Notes:

1. *For motors ≥ 19 kW (25 hp), momentary Start / Stop provided to ensure motor does not restart after brief power interruption, as is possible if a Hand position is provided. This is both for motor protection in the event of a very brief interruption and for reduction of potential load on a centralized standby generator.*
2. *Use of Lock-Off-Stop switches will not be permitted as they imply lock-off capability for the equipment, but are not suitable for use as a disconnecting means. Existing Lock-Off-Stop switches can be maintained, provided that no significant modifications are made to the motor control circuit.*
3. *Additional safety controls may be required for equipment with safety requirements. An emergency-stop switch is considered to be a minimum for equipment with a safety risk.*
4. *Where an Emergency Stop pushbutton is provided together with local control, the equipment shall utilize a Local / Off / Remote set of control modes, with separate Start and Stop pushbuttons. Equipment shall not restart automatically upon the Emergency Stop pushbutton being released, but rather require a separate restart action from either a local Start/Reset pushbutton or a start or reset action from the HMI.*

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7.9 Local Disconnect Switches

The following are considered standard minimum requirements, and shall be augmented as required by the application.

7.9.1 Wastewater Collections & Land Drainage Facilities

Local disconnect switches are not typically required within these facilities, due to the limited number of loads and small size of the facilities. However, local disconnect switches should be provided where the upstream equipment lockout procedure would expose personnel to a significant arc flash hazard.

7.9.2 Wastewater Treatment Plants

1. Small motors (< 37 kW (50 hp))
 - 1.1 Non-hazardous / non-corrosive location:
 - 1.1.1 Install a local disconnect switch at the motor.
 - 1.2 Hazardous / corrosive location:
 - 1.2.1 Local disconnect switches will not typically be provided unless maintenance disconnect requirements are very frequent (more than weekly). See Note 2.
2. Medium size and larger motors (\geq 37 kW (50 hp))
 - 2.1 Local disconnect switches will not typically be provided unless maintenance disconnect requirements are very frequent (more than weekly)

Where a local disconnect switch is installed, provide an early-break auxiliary contact from the disconnect switch to provide indication when the motor disconnect is open for the following cases:

- VFD driven equipment; or
- Equipment that is utilized for standby operation and is critical to start when required.

Notes:


1. *For all disconnect switch applications, ensure that the disconnect SCCR is appropriate for the application. Where the SCCR is higher than the typical disconnect switch capability, a case may be made for omission of the disconnect switch provided that the maintenance requirements are not excessive. Fuse-based disconnects to obtain a higher SCCR may only be utilized where deemed absolutely necessary.*
2. *Local disconnect switches should also be provided where the upstream equipment lockout procedure would expose personnel to a significant arc flash hazard.*

7.10 Emergency Stop Systems

Where emergency stop systems are implemented, they shall comply with CSA Z432 Clause 6.2.5.2.2 which states:

6.2.5.2.2 Effects of emergency stop and reset commands

Once active operation of the emergency stop device has ceased following an emergency stop command, the effect of this command shall be sustained


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until the device is reset. This reset shall be possible only at that location where the emergency stop command has been initiated. The reset of the command shall not restart the machinery but shall only permit restarting.

This requires a *Reset* or *Power On* pushbutton to allow the restarting of equipment after an e-stop has been reset. Within the Water and Waste Department, most equipment runs unattended 24 hours a day, with automatic controls. Thus, typical implementation requirements of an e-stop system include the following:

- Provide a reset button on the motor starter (or control panel) to latch in a *ready* coil after an e-stop. Alternately, the function could be written in PLC logic, if appropriate for the application.
- Ensure that systems where continuous unattended operation is required will appropriately restart after a power failure. This may require an automatic reset of the e-stop system after a power failure.

Some e-stop applications require a higher level of safety reliability as per the ISA-84 series of standards. Applications where equipment is not fully guarded, such as open conveyors, are one example where additional requirements apply.

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8 EQUIPMENT APPLICATION REQUIREMENTS

8.1 HVAC Equipment

1. Air Handling Units

1.1 Natural Gas Fired Air Handlers:

1.1.1 On/Off (non-variable speed) applications may have the motor starter included as part of the natural gas-fired package system.

1.1.2 Variable speed applications:

1.1.2.1 AHU's located on the roof shall have the VFD located in the electrical room.

1.1.2.2 AHU's located in a location with potential corrosive or explosive gases shall have the VFD located in the electrical room.

1.1.2.3 Where the AHU is not on the roof and it is not in a location with potential explosive or corrosive gases, it may be located in the electrical room, adjacent to the AHU in a separate enclosure, or as part of the AHU cabinet. The VFD may be packaged with the AHU; however, all other requirements associated with VFDs still apply. Ensure that the VFD display is easily accessible.

1.2 Hydronic or Electric Heater Air Handlers:


1.2.1.1 AHU's located on the roof shall have the VFD / motor starter located in the electrical room.

1.2.1.2 AHU's located in a location with potential corrosive or explosive gases shall have the VFD / motor starter located in the electrical room.

1.2.1.3 Where the AHU is not on the roof and it is not in a location with potential explosive or corrosive gases, it may be located in either the electrical room or in an enclosure adjacent to the AHU. Packaging of the AHU motor control with the AHU is not acceptable.

2. Exhaust Fans

2.1 Motor starters and VFDs for Exhaust Fans shall always be located in electrical rooms.

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9 POWER SYSTEM MONITORING

9.1 Pilot Lights

- Where pilot lights are utilized, the colour convention shall be as per Table 9-1.

Table 9-1 : Pilot Light Colors


Function	Wastewater	Water	Notes
Alarm	Red	Amber	
Circuit De-energized	Red	Green	
Circuit Energized	Green	Red	
Miscellaneous Status	Blue	Blue	
Motor Not Running	Blue	Green	Not Normally Provided
Motor Running	Green	Red	
Switch / Breaker Closed	Green	Red	
Switch / Breaker Open	Red	Green	
Warning	Amber	Amber	

Notes:

- The colours for the wastewater system have been selected from an operations perspective. The colour red indicates an abnormal situation that requires attention, while the colour green indicates that equipment / power is in a normal condition.*
- Many existing systems within the wastewater facilities currently are based upon the colors indicated in the Water column.*

9.2 Power Meter Requirements


- Multifunction power meters shall be provided utilizing Table 9-2 as a guide.
- Enhanced power meter requirements include:
 - Local display for all measurements.
 - Functional Requirements:
 - Volts, Amps, kW, kVAR, PF, kVA (per phase)
 - Frequency, kWh, kVAh, kVARh
 - Minimum 17 μ s transient detection
 - Sampling rate of 1024 samples/cycle or better
 - Voltage and current harmonics measurement, individual, even, and odd, up to 63rd, %THD (Total Harmonic Distortion) Monitoring for voltage and current per phase.
 - Min / Max recording capability

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- 2.3 The meter shall have an accuracy of +/- 0.5% or better for volts and amps, and 0.2% for power and energy functions. The meter shall meet the accuracy requirements of IEC62053-22 (class 0.5%) and ANSI C12.20 (Class 0.2%).
- 2.4 The meter shall provide true RMS measurements of voltage, phase to neutral and phase to phase; current, per phase and neutral.
- 2.5 Modbus TCP Communication capability for communicating with the control system.
- 3. Basic power meter requirements include:
 - 3.1 Local display for all measurements.
 - 3.2 Functional Requirements:
 - 3.2.1 Volts, Amps, kW, kVAR, PF, kVA
 - 3.2.2 Frequency, kWh, kVAh, kVARh
 - 3.2.3 % THD (Total Harmonic Distortion) Monitoring for voltage
 - 3.2.4 Min / Max recording capability
 - 3.3 The meter shall have an accuracy of +/- 0.5% or better for volts and amps, and 0.2% for power and energy functions. The meter shall meet the accuracy requirements of IEC62053-22 (class 0.5%) and ANSI C12.20 (Class 0.2%).
 - 3.4 The meter shall provide true RMS measurements of voltage, phase to neutral and phase to phase; current, per phase and neutral.
- 4. Note that the City is undertaking an initiative to standardize on a specific power meter manufacturer/model for wastewater treatment applications.

Table 9-2 : Recommended Power Meter Requirements

Facility Type	Equipment	Basic	Enhanced
All	Medium voltage main breakers.		X
	Medium voltage feeder breakers.		X
	Medium voltage main switches of fused gear, unless the equivalent current reading can be provided by upstream feeders.		X
	600V switchgear main breakers.		X
	600V switchgear feeder breakers rated 500A or greater, where there is no downstream power meter. Note that power meters at the load are preferred in this case for accurate load voltage measurements.		X
	600V distribution panelboards rated 1000A or greater.		X
	600V distribution panelboards rated 400A – 800A.	X	
	MCCs with a demand load of 600A or greater.		X
	MCCs with a demand load of 250A – 599A.	X	
	Essential Power System – Main breaker / Distribution rated ≥ 500 kW		X
	Essential Power System – Main breaker / Distribution rated ≥ 100 kW and < 500 kW	X	
	Essential Power System - 600V distribution panelboards with a demand load of 200A or greater.	X	
	Essential Power System – MCC with demand load of 100A – 599A	X	

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9.3 HMI / SCADA Monitoring Requirements

1. All enhanced power meters, as per Section 9.2 shall be connected to the HMI / SCADA system via a network connection.
2. Other HMI / SCADA monitoring requirements of the electrical distribution system shall be as per Table 9-3
3. The PLC / DCS shall have one or more power fail status inputs from the power distribution system.
 - 3.1 The requirement for power fail status inputs shall be reviewed with the automation system designers.
 - 3.2 Network power meter connections shall not be relied upon for power fail status in control systems, where real-time control associated with the power status is required. Power meter response time of the network has in the past been demonstrated to cause issues in control logic applications.
 - 3.3 Sufficient power fail status input shall be provided to allow a reasonably accurate representation of power availability to controlled motor loads.
 - 3.4 In the event that a *Ready* input is provided from each motor starter, the requirement for power fail status inputs may be waived.

Table 9-3 : Monitoring of Electrical Power System

Facility Type	Item	Monitoring	Required
All	Automatic Transfer Switch	Normal Position Emergency Position	Mandatory
		Common Fault	Recommended
	Main Breaker – Medium Voltage	Breaker Closed Status Breaker Open Status Breaker / Relay Fail Status	Mandatory
	Feeder Breaker – Medium Voltage	Breaker Closed Status Breaker Open Status Breaker / Relay Fail Status	Recommended
	Breaker Position – 600V (Major Feeders)	Breaker Closed Status Breaker Open Status	Recommended
	Capacitor Bank	Alarm / Trouble	Recommended
	Neutral Grounding Resistor	Ground Fault Alarm	Mandatory if applicable.
	Motor Control Centre	Power Fail Status	See 9.3.3
	Protection Relay – Medium Voltage	Alarm Trip	Recommended
	Standby Generator	Run Trouble Failure	Mandatory
	Switchgear Battery System	AC Power Fail DC Power fail High VDC Low VDC Positive Ground Fault Negative Ground Fault	Mandatory
	Transformers >= 300 kVA	Temperature Alarm	Mandatory
	Transformers >= 1000 kVA	Other alarms as appropriate to the application.	Mandatory
	TVSS	Status/Fault	Recommended
UPS	Battery Low Fault	Mandatory	
Wastewater Lift Station	Incoming Power Distribution (600V)	Voltage and Phase Loss (One alarm)	Mandatory
	120 VAC Power	Power Failure	Recommended
Wastewater Flood Station	Incoming Power Distribution	Voltage and Phase Loss (One alarm)	Mandatory
	120 VAC Power	Power Failure	Recommended

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10 PROTECTION

10.1 Instrument Transformers

1. Current transformer circuits shall be grounded on the secondary side.
2. Provide test blocks for all CT circuits.
3. Test blocks are not required on all PT circuits. Utilize good engineering practice for application.
4. Potential transformer circuits shall be grounded on the secondary side.

10.2 Protection for Distribution \leq 600V

10.2.1 Circuit Breakers

1. Circuit breakers are preferred over fuses for 600V distribution and below.
2. Ensure that circuit breakers are rated for the design SCCR at the specific point in the distribution.
3. Series ratings are not permitted for the purpose of reducing the SCCR of downstream circuit breakers, unless no other options are available. All exceptions shall be approved by the City.
4. Ensure that the breakers selected provide selective coordination to the greatest extent possible. LS, LSI, and LSIG breakers shall be specified where required.
5. Indicate all breaker settings on the drawings.

10.2.2 Fuses

1. Fuses are acceptable in 600V distribution and below in the following situations:
 - 1.1 For protection of VFDs to meet manufacturer's requirements.
 - 1.2 For protection of capacitors.
 - 1.3 For protection of staged electric heaters.
 - 1.4 For meeting required short circuit current ratings where options involving circuit breakers are not acceptable.
2. Where fuses are provided to meet short circuit current ratings, investigate the feasibility of providing coordination with a circuit breaker such that the circuit breaker will trip prior to the fuse.
3. Class J fuses are preferred for general purpose power use in new installations.

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10.2.3 Ground Fault Protection

1. Provide ground fault protection for systems as follows:
 - 1.1 For systems rated 1000A or more, ground fault protection is mandatory to de-energize all circuits.
 - 1.2 For systems rated less than 1000A, ground fault protection at the main breaker is optional. However, the following should be noted:
 - 1.2.1 Ground fault protection should be provided where additional protection is required to reduce damage in the event of a ground fault.
 - 1.2.2 Ground fault protection may be provided for individual loads and feeders.
2. The delay associated with ground fault protection must not exceed 1 second.
3. Where ground fault protection is provided, selective coordination of the ground fault protection must be provided to an acceptable level.
 - 3.1 For essential power systems with ground fault protection, the selective coordination of the ground fault protection system must limit the affected outage to the area of the ground fault. All exceptions are to be approved by the City.
 - 3.2 For non-essential power systems, the affected zone of ground fault protection must be carefully reviewed to ensure an appropriate level of selectivity. As a general rule, each feeder rated 200A and more should be provided with dedicated ground fault protection on a system protected by ground fault protection.
 - 3.3 Where practical without excessive cost, install ground fault protection on each individual load.
4. Ground fault protection applied solely to the facility main breaker is not acceptable.
5. Good practice would be that the ground fault setting of main breakers and feeders would be limited to 30% of the circuit breaker rating, however the selective coordination of the application must be reviewed, and there are application where selective coordination is deemed to be a higher requirement than a low ground fault protection setting.
6. For systems that have their neutral grounded through a Neutral Grounding Resistor (NGR), main ground fault detection can be provided using either voltage detection method (59N) and/or zero sequence current detection method (50/51G). A Startco SE-330 relay can perform both these functions.
7. Ground fault detection may utilize a residual CT connection if the ground fault trip current is 10% or higher of the CT current rating.
 - 7.1 Residual CT ground fault measurement is not applicable to high resistance grounded systems.
8. Ground fault detection on high-resistance grounded systems must utilize a zero-sequence CT.


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10.3 Protection for Medium Voltage Distribution

1. The application of fuses vs. circuit breakers in medium voltage applications is not as straightforward as in low voltage distribution. Typically medium voltage circuit breakers have a much higher cost, complexity, and space requirement. However, fuses only offer overcurrent protection, and can result in single-phase conditions.
 - 1.1 For large facilities, use of circuit breakers for the main distribution is recommended.
 - 1.2 Protection of individual loads or transformers ≤ 2 MVA with fuses will generally be accepted, provided that acceptable downstream protection is provided to address potential single phase issues.
2. The protection relays shall be provided with the following protection elements, at minimum:
 - 2.1 Short circuit protection at all levels (IEEE 50)
 - 2.2 Overload protection at all levels (IEEE 51)
 - 2.3 Ground fault protection (IEEE 51G)
3. The following protection is recommended for all applications:
 - 3.1 Phase loss/unbalance protection (IEEE 46) shall be provided in any case where upstream fusing is provided.
 - 3.2 Frequency protection (IEEE 81)
 - 3.3 Overvoltage protection (IEEE 59)
 - 3.4 Negative Sequence (IEEE 47N)
4. The requirement for under voltage protection (IEEE 27) shall be evaluated on a case-by-case basis. It is noted that it is not acceptable to trip a facility main breaker on temporary power failure, whereby a manual reset of the breaker is required to restore power.
5. Provide reverse power protection (IEEE 32) when generators are synchronized with the utility service.
6. Provide transformer differential protection (IEEE 87T) for:
 - 6.1 Transformers rated 5 MVA and above, for critical installations with no redundancy.
 - 6.2 Transformers rated 10 MVA and above, with no redundancy, regardless of criticality.
 - 6.3 For all transformers rated 15 MVA and above.
 - 6.4 Differential protection for smaller transformers may be evaluated on a case-by case basis.
7. Requirements for zone/bus (IEEE 87Z or IEEE 87B) differential protection shall be evaluated on a case-by-case basis. Typically, differential bus protection would only be required for indoor switchgear in a clean environment with a capacity of 15 MVA or greater and on outdoor switchgear with a capacity of 7.5 MVA or greater.

10.3.2 Ground Fault Protection

1. As discussed in Section 3.4, resistance grounding is recommended for medium voltage systems.
2. All medium voltage loads, such as motors, must be provided with dedicated ground fault protection.
3. All feeders must be provided with ground fault protection, unless it can be demonstrated that ground fault protection of the feeder is adequately provided via alternate protection, without impacting selective coordination.

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11 STANDBY AND EMERGENCY GENERATION

11.1 General Requirements

1. Generator ratings shall be selected based upon the ISO 8528 standard. It is acknowledged that generator manufacturers may provide additional or modified ratings, however care should be utilized when utilizing specific manufacturer ratings in a competitive procurement situation. ISO 8528 ratings are summarized as follows:
 - 1.1 Continuous Power
 - 1.1.1 The rated output is available continuously, with average power output within 70% to 100% of the rating.
 - 1.2 Prime Power
 - 1.2.1 The generator may run continuously, with an average power output of up to 70% of the rating over 24 hours.
 - 1.3 Limited Time Running Power
 - 1.3.1 The rated output is available for up to 500 hours per year, with average power output up to 100% of the rating.
 - 1.4 Emergency Standby Power
 - 1.4.1 The generator may run up to 200 hours per year, with an average power output of 70% of the rating over 24 hours.
2. Engine exhaust system:
 - 2.1 Exhaust gas piping to be insulated
 - 2.2 Piping designed to prevent vibration isolation from generator set to piping and therefore to building.
 - 2.3 Piping to be equipped with drain valves to drain condensation at the lowest point.
 - 2.4 Piping to be designed in such a way that exhaust is away from building ventilation air intakes.
 - 2.5 Piping to be designed in such ways that it is above the building perimeter to allow for easy dispersal of exhaust gases.
 - 2.6 Allow for expansion due to high temperature without affecting building supports.
 - 2.7 Provide piping of suitable size and length to prevent exceeding the backpressure on engine.
3. Generator cooling system:
 - 3.1 Provide the required ambient air temperature range for the generator room.
 - 3.2 Provide radiator based cooling/ or remote radiator cooling depending on engineering analysis of generator room temperature rises.
 - 3.3 Provide fresh air intake (combustion air + cooling air) and generator room ambient air exhaust fans as required to maintain the required operating ambient temperature.
4. Fuel supply system:
 - 4.1 Considerations to include when evaluating natural gas vs diesel fuel:
 - 4.1.1 The energy density of natural gas is lower than diesel fuel, which may require larger engines for large generator sets (typically in excess of 1 MW capacity), This will have an impact on initial purchase costs for the unit as well as the associated support infrastructure including building space and must be

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weighed against the cost of providing diesel fuel storage and the associated diesel fuel ongoing supply and maintenance issues.

- 4.1.2 In instances where the generator application would require extended periods of operation, the frequency of overhaul for natural gas engines is typically higher than for diesel engines.
- 4.2 Natural gas is the preferred fuel for City installations where:
 - Natural gas is available;
 - The availability, cost, and size differential of the natural gas generator compared to the diesel generator are acceptable.
 - 4.2.1 If the generator is an emergency generator, ensure that natural gas is acceptable as per CSA C282 and the AHJ.
- 4.3 Where diesel fuel is selected:
 - 4.3.1 Provide a day tank for fuel within the generator room.
 - 4.3.2 Comply with CSA C282 for fuel and piping requirements.
5. Generator set control panel
 - 5.1 Provide automatic remote start ability.
 - 5.2 Provide a “Hand-Off- Auto” selector for manual operation or Auto operation.
 - 5.3 Provide local alarm indications.
 - 5.4 Provide connections for remote alarms.
 - 5.5 Provide remote connections using discrete relays and communication ports for monitoring of generator set status, alarms
 - 5.6 Provide automatic controls for auxiliary heating, block and space heating.
 - 5.7 Provide generator paralleling controls if required for the application.
6. Engine starting systems:
 - 6.1 Provide storage battery/battery charger to power starting system.
 - 6.2 Batteries shall be as recommended by the manufacturer and designed for the required cold cranking cycles.
 - 6.3 Cold cranking cycles to comply with CSA C282.
 - 6.4 Provide monitoring of battery voltage and automatic alarm to warn of low battery.
 - 6.5 Battery system shall be designed to operate in extreme temperature range that may occur inside the generator room.
7. Alternators:
 - 7.1 For smaller generators, provide alternator winding with 2/3rd pitch. For larger generators > 1 MW, consider the use of higher pitch windings.
 - 7.2 Comply with CSA C22.2 No. 100 for construction.
 - 7.3 Windings shall be copper.
 - 7.4 Provide suitable exciter in static or direct connected type.
 - 7.5 Automatic voltage regulator shall be permanent magnet, quick voltage build up type.
 - 7.6 Provide complete alternator datasheet, and parameters.
 - 7.7 Alternator shall be designed to be able to withstand, electrically and mechanically, 300% of its full load current for 1 second with its terminals shorted.
8. Automatic transfer switches:
 - 8.1 Provide ATS in compliance with CSA C22.2 No. 178.

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- 8.2 Transfer equipment should be designed, installed and maintained in such a way that it will never allow inadvertent interconnection of the standby power source with the normal power source.
- 8.3 Most applications will utilize open transition transfer (break before make) for simplicity.
 - 8.3.1 Ensure that the open delay is sufficient for residual voltage of motor loads to dissipate.
- 8.4 Closed transition transfer switches should be considered when the facility cannot accept temporary power interruptions when transferring from the standby to utility source.
- 8.5 Where closed transition transfer switches are required, selection is typically between three major types:
 - 8.5.1 Momentary Passive:
 - 8.5.1.1 The transfer switch waits for the generator to passively synchronize with the utility source and then closes the utility switch. The generator switch is opened within 100ms of the utility switch closing.
 - 8.5.1.2 The transfer switch must be CSA approved.
 - 8.5.1.3 Under-voltage protection and an automatic synchronization check are required.
 - 8.5.2 Momentary Active:
 - 8.5.2.1 This type of transfer is the same as momentary passive discussed above, except that the generator is actively controlled by an automatic synchronizer.
 - 8.5.3 Soft Transition:
 - 8.5.3.1 In a soft transition transfer scheme, the synchronization is controlled by an automatic synchronizer, but the generator is paralleled with the utility source for longer than 100 ms. This allows the loads to be gradually transferred from the generator to the utility source over a short period of time, typically 2 to 10 seconds.
 - 8.5.3.2 This type of transition requires additional protection and coordination with the utility.
- 8.6 Ensure that separate, interlocked bypass feeders are provided around automatic transfer switches to allow for maintenance on transfer switches without interrupting critical loads.
- 9. Load bank connection
 - 9.1 If the generator is classified as an emergency generator, the system must be operated under a minimum of 30% load monthly, and 100% load annually.
 - 9.1.1 Unless the City has a portable load bank of the appropriate size, provide a permanent load bank for testing purposes.
 - 9.2 If not classified as an emergency generator, at minimum provide provision for connection of a temporary load bank.
- 10. Provide at minimum the following signals to the control system for each standby generator:
 - 10.1 Generator running
 - 10.2 Generator fail

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11.2 Emergency Loads

1. In accordance with the National Building Code, a generator shall be classified as an emergency generator if it feeds life safety equipment, such as:
 - 1.1 Fire alarm and emergency voice communications systems;
 - 1.2 Firefighters' elevators and elevators serving storeys above the first storey in a high building;
 - 1.3 Fire protection water supply pumps that depend on electrical power supplied to the building;
 - 1.4 Smoke control systems;
 - 1.5 Fans required for smoke control;
 - 1.6 Emergency lighting; and
 - 1.7 Exit signs.
2. An emergency generator may power other essential (non-emergency) loads, provided that they are switched via an independent transfer switch and arranged in a manner to not compromise the emergency power system.
3. Certain other critical loads should be considered for connection to the emergency generator via the emergency power branch; however these loads are not acknowledged in current codes as emergency loads. Thus, it is recommended to perform a review of the criticality of the loads, provide a recommendation based upon good engineering practice, and discuss with the AHJ for approval.
 - 3.1 Other loads for potential connection to the emergency power distribution include:
 - 3.1.1 Aircraft warning lights,
 - 3.1.2 Critical ventilation where a combustible or toxic atmosphere could be created within a short amount of time.
 - 3.2 While not applicable in Canada, it is recommended to review NFPA 70 requirements associated with Critical Operating Power Systems (COPS) as a reference.
4. Auxiliary systems associated with emergency generation must also be powered from the emergency power distribution system. An example is generator room ventilation equipment.
5. Emergency generators must meet the requirements of CSA C282.
6. Emergency loads must be provided with a separate transfer switch and distribution from the non-emergency essential power loads.

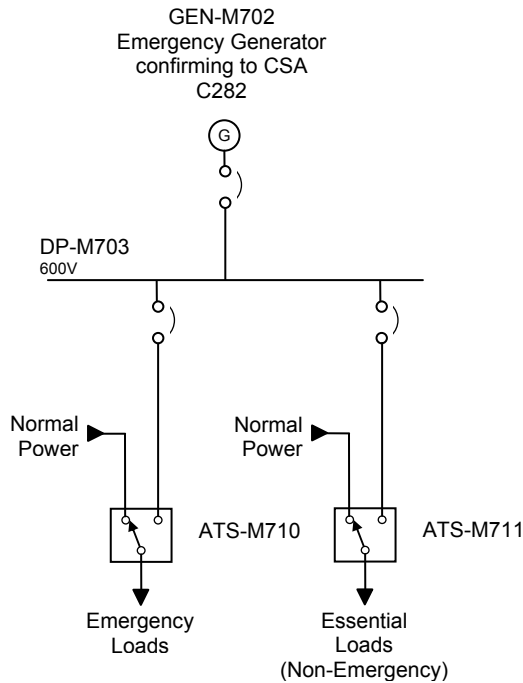


Figure 11-1: Emergency Generator utilized for both Emergency and Essential Loads

11.3 Essential Loads

1. Essential (non-emergency) loads should be powered via a standby generator, or the standby power branch of an emergency generator system (as shown in Figure 11-1).
2. The following loads should typically be considered for designation as Essential Loads:
 - 2.1 Essential process motor loads, including critical motor operated valves.
 - 2.2 UPS systems
 - 2.3 Switchgear DC control power supplies
 - 2.4 Plant security/CCTV systems
 - 2.5 Ventilation systems that must remain operable during a power failure.
3. The requirement for standby power for process systems shall be decided on a case-by-case basis. Consider risks to the process and operating licence conformance.

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11.4 Generator Set Sizing

1. It is recommended that the generator sizing be confirmed by the manufacturer based on load profile provided by the engineer.
2. A standby/emergency generator should be sized in such a manner that on average the running load will not be below 30% of its rated kVA capacity. Permanent load banks may be required to be operated in parallel with plant loads less than 30%, in order to protect the generator from engine related reliability issues. If loads less than 30% are expected, review the application with generator manufacturers.
3. Maximum allowable Step Loading: The maximum allowed single step loading will cause a voltage dip that should stay within the operating voltage range of all live loads, which indirectly will decide the generator kVA rating. Generators may be sized based on picking all load up in a single step or alternatively designing the single step to pick up a maximum load step in a sequential loading plan.
4. Maximum allowable single step frequency dip: The maximum allowed single step loading will also cause a single step frequency dip which in turn will have a bearing on the generator kVA rating.
5. Increased ambient temperatures will require higher kVA rating.
6. All generators are to be designed with a minimum of 10% reserve capacity.
 - 6.1 Where the generator is classified as an emergency generator, the 10% reserve capacity shall be retained throughout the life of the generator, as per CSA C282.
 - 6.2 Where the generator is not classified as an emergency generator, the 10% reserve capacity may be utilized for expansion, if accepted by the City.
7. Single Phase Loads versus Three Phase loads: Each load that is being analyzed must be converted into current loadings and power factor. Each phase must be summarized individually to arrive at the highest phase loading and power factor which will decide the generator kVA ratings, operability and stability.
8. Design Load Calculations:
 - 8.1 Conduct a thorough study to identify each and every type and size of emergency/essential loads that the emergency/standby generator will power after the normal power has failed. Note the individual load power factors as they will be required to establish the distribution of real power and reactive power in the alternator.
 - 8.1.1 Three phase generators are rated for 0.8 PF. Lower power factors at rated kVA will require larger alternators.
 - 8.1.2 Generators that will be supplying only leading power factor loads should be treated with extreme caution, as these can cause the generator set to lose control of its voltage. An example is UPS loads, or data servers which may exhibit leading PF load characteristics.
 - 8.2 Determine the maximum time delay that can be suffered by each load before each load is transferred to generator power. The time delay with the least value will be the deciding factor for adjusting the start-up delay of the generator.
 - 8.3 Determine all motor loads and calculate the starting kVA of each motor load. Based on diversity of all motor loads, calculate the total motor starting kVA which must be supported by the generator.

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- 8.4 Identify VFDs and non-linear loads with harmonic contribution to the generator voltage and current. Ensure that appropriate generation capacity is provided to address the harmonics present.
- 8.5 Review UPS loads to ensure sufficient generation capability is provided for charging current and harmonics.
- 8.6 After totalling all loads, add 10-25% to allow for future kVA capacity increase.
- 9. Regenerative loads:
 - 9.1 Regenerative loads are typically elevators, cranes, hoists and sometimes pumps. These loads when braking or decelerating will feed energy back to the generator leading to over-speeding and consequent tripping of the generator. This situation may require keeping some non-critical loads powered on the generator set so that they can absorb extra energy and prevent a mechanical overspeed of the engine.

11.5 Temporary Generator Connection

1. Temporary generator connections shall be utilized at critical facilities that do not have permanent emergency/standby generators.
2. Consult with the City to determine if a standard for a plug / receptacle system exists, which would allow for fast, straightforward hook-ups without errors.
3. Current design practice for the City is to supply a junction box with terminals. The breaker connected to the junction box shall be interlocked with the utility breaker.
4. Connect temporary (grounded wye) generators for 3Ø3W installations as shown in Figure 11-2. Note that 3Ø3W installations are preferred for systems interconnecting with generators.
5. Connect temporary (grounded wye) generators for 3Ø4W installations as shown in Figure 11-3.
6. The generator frame must be bonded.

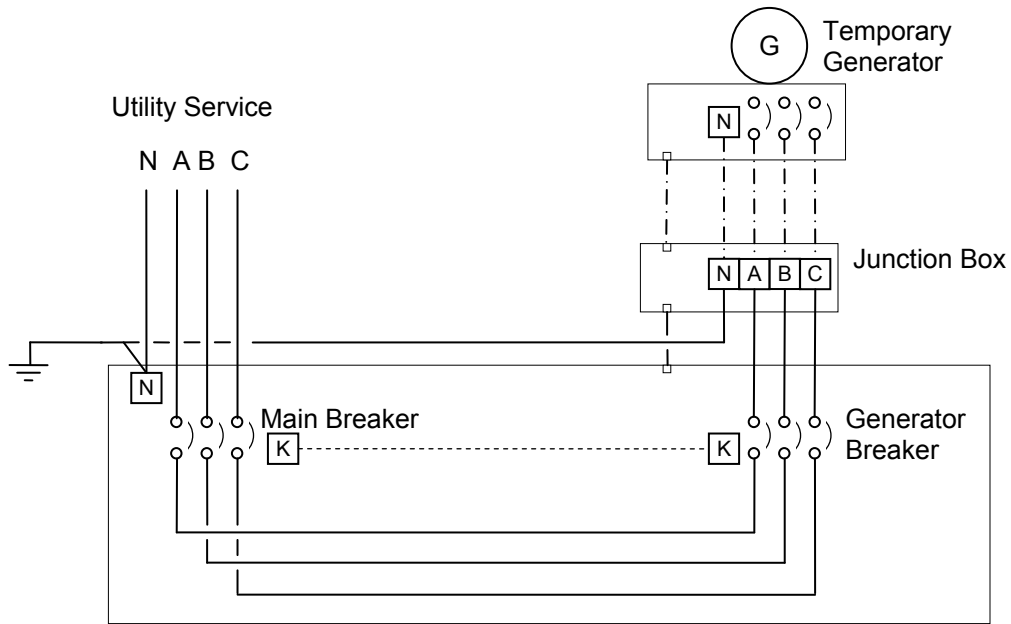


Figure 11-2: Temporary Generator Connection - 3Ø3W

Note: The above assumes a grounded wye connected generator.

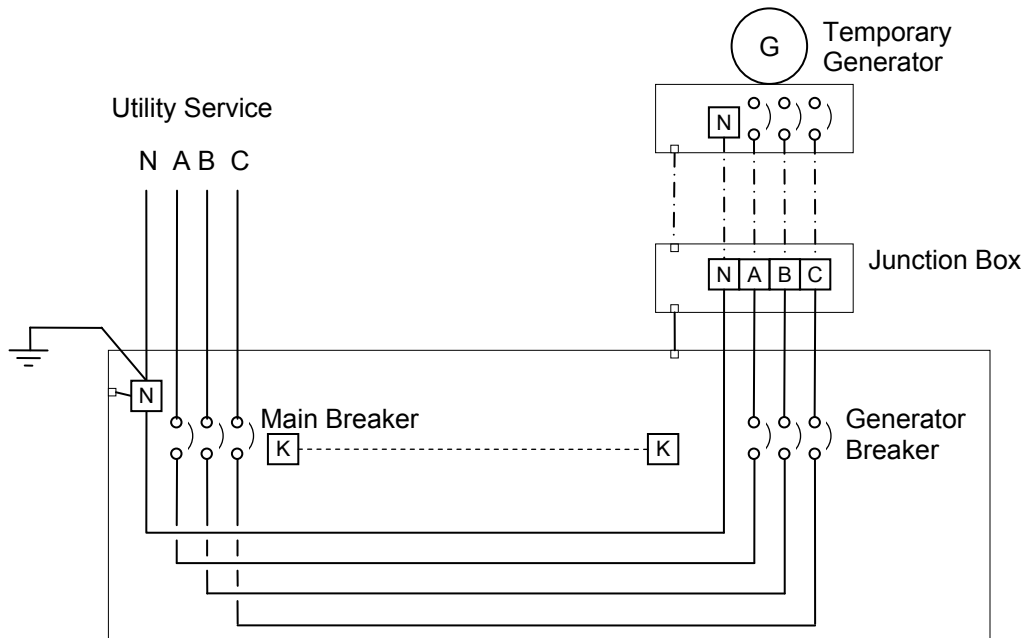


Figure 11-3: Temporary Generator Connection - 3Ø4W

Note: The above assumes a grounded wye connected generator.

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12 HAZARDOUS LOCATIONS

12.1 General

1. Prepare comprehensive hazardous location drawings for all facilities containing a hazardous area, in accordance with Section 18.2.7.
2. Design, installation, selection of equipment and materials, shall be based on the Hazardous Location Drawings produced for the facility.
3. Hazardous locations should be selected based on the requirements of:
 - 3.1 Winnipeg Electrical Bylaw
 - 3.2 Canadian Electrical Code (CSA 22.1)
 - 3.3 NFPA 820
4. It is recommended that API Standard 505 be utilized as a reference document.

12.2 Wastewater Facilities

All wastewater facilities will typically have hazardous locations. Utilize NFPA 820, along with appropriate engineering analysis to determine appropriate area classifications. Plan drawings that clearly indicate the hazardous locations shall be created for all facilities.

12.3 Design Requirements

12.3.1 Class I, Zone 0 Locations

1. Hazard:
 - 1.1 An explosive gas mixture is present continuously or for long periods of time, at a level above the Lower explosive limit (LEL).
 - 1.2 Common areas are spaces inside vessels or chambers containing flammable mixtures, liquids, or spaces around vents from such sources.
2. Zone 0 Installation Requirements:
 - 2.1 Where possible, electrical equipment shall not be installed in Zone 0 locations.
 - 2.2 Where required, electrical equipment that can be used in Class I, Zone 0 locations shall be:
 - 2.2.1 Approved for equipment protection level Ga (IEC);
 - 2.2.2 Approved as being intrinsically safe, type i, or ia;
 - 2.3 Ensure code requirements for Zone 0 locations are met.

12.3.2 Class I, Zone 1 Locations

1. Hazard:
 - 1.1 An explosive gas mixture is likely to occur in normal operation.
 - 1.2 Common areas are locations adjacent to Class I Zone 0 locations, from which explosive gas mixtures could be dispersed.

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2. Zone 1 Installation Requirements:
- 2.1 Transformers and capacitors shall be installed in electrical equipment vaults with no doorway between the room and the Zone 1 classified area. Provide adequate ventilation in vault. Vents shall be provided to contain electrical explosions and convey the pressure and gases safely outside the building.
 - 2.2 Cable glands shall be of sealing type, and suitable for Class I, Division 1, or Zone 1
 - 2.3 Wiring method shall be threaded rigid metal conduit or cables approved for the hazardous location with associated cable glands.
 - 2.4 All boxes, enclosures, fittings shall be threaded type for connection to conduit and cable glands.
 - 2.5 All fittings between the conduit seal and the explosion proof rated enclosures must be explosion proof type to contain any explosion and withstand the same pressures built up in the enclosure.
 - 2.6 Splices and taps shall not be located in fittings which are only compound filled (non-pressure withstand).
 - 2.7 The use of single conductor metallic armoured cable in Zone 1 locations is not permitted. Armoured single conductor cables with high currents are a possible ignition source due to high magnetic field and consequent energy available in the cable.
 - 2.8 It is preferred to use three-conductor power cables with balanced loadings on all three conductors to cancel out the magnetic effect on armour.
 - 2.9 Cable trays can be used in Zone 1 locations, however they should be bonded to prevent occurrence of circulating currents.
 - 2.10 Conduits shall be sealed when crossing Zone 1 boundaries to prevent migration of gas vapours into other areas.
 - 2.11 Explore the possibility of reducing the hazard by incorporating ventilation in Zone 1 along with failure protections, which may lead to modification of the hazardous location to less severe Zone 2, thereby enabling use of lower rated and classified equipment. It should also be noted that electrical maintenance in Zone 2 locations is more straightforward.
 - 2.12 Electrical equipment that can be used in Class I, Zone 1 locations shall be:
 - 2.12.1 Approved for Class I or Class I, Div 1 locations;
 - 2.12.2 Approved for equipment protection level Ga or Gb (IEC);
 - 2.12.3 Approved as being intrinsically safe, type i, ia, or ib;
 - 2.12.4 Approved as being flameproof d;
 - 2.12.5 Approved as being increased safety e
 - 2.12.6 Approved as being oil immersed o
 - 2.12.7 Approved as being pressurized p
 - 2.12.8 Approved as being powder filled q
 - 2.12.9 Approved as being Encapsulated m
 - 2.13 Ensure equipment temperature code classification is appropriate for the installation. See Table 12-1.
 - 2.14 Ensure that equipment is suitable for the applicable gas group.
 - 2.15 Increased safety e motors shall incorporate thermal protection.
 - 2.16 Lighting fixtures shall be provided with guards to prevent breakage damage or shall be built of break resistant construction.

Table 12-1 : Hazardous Area Temperature Codes

Temperature Code	Maximum Surface Temperature
T1	450°C
T2	300°C
T2A	280°C
T2B	260°C
T2C	230°C
T2D	215°C
T3	200°C
T3A	180°C
T3B	165°C
T3C	160°C
T4	135°C
T4A	120°C
T5	100°C
T6	85°C

Notes:


1. *If the equipment is installed in a higher ambient than the rated ambient, then the actual surface temperature will be higher than the above marked ratings for the full load operating condition. The designer must ensure that this does not compromise the safety.*
2. *The minimum ignition temperature of the gas should be greater than the Temperature Code rating.*

12.3.3 Class I, Zone 2 Locations

1. Hazard:
 - 1.1 An explosive gas mixture is not likely to occur in normal operation, and if they do occur, they will exist for a short time only.
 - 1.2 Common areas are locations adjacent to Class I Zone 1 locations from which explosive gas mixtures could be communicated.
2. Zone 2 Installation Requirements:
 - 2.1 Transformers, capacitors, solenoids and other winding type equipment that do not incorporate sliding or make and break type contacts, heat producing resistance elements and arcing or spark producing elements are permitted for use in Zone 2 locations.
 - 2.2 Non-classified enclosures are permitted for use in Zone 2 provided they contain:
 - 2.2.1 Non-arcing connections and connecting devices like joints, splices, etc (non-sparking type)
 - 2.2.2 Load break isolating switches interlocked to load break contactor or breaker.
 - 2.2.3 Not more than ten sets of approved fuses; or

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- 2.2.4 Not more than 10 lighting circuit breakers that are not used as switches.
- 2.3 Cable glands shall be of sealing type, and suitable for Class I Division 1, Division 2 or Zone 0, 1, or 2.
- 2.4 Wiring method shall be threaded rigid metal conduit or cables approved for hazardous location with associated cable glands.
- 2.5 Type TC cables, installed in cable tray is acceptable.
- 2.6 Armoured cables types TECK 90, ACWU90, ACIC, and copper sheathed RC90 with PVC overall jacket are acceptable.
- 2.7 All boxes, enclosures, fittings shall be threaded type for connection to conduit and cable glands.
- 2.8 All fittings between the conduit seal and the explosion proof rated enclosures must be explosion proof type only to contain any explosion and withstand same pressures built up in the enclosure.
- 2.9 Splices and taps shall not be located in fittings which are only compound filled (non-pressure withstand).
- 2.10 Any single conductor metallic armoured cable in Zone 2, carrying >400A is a possible ignition source due to high magnetic field and consequent energy available in the cable:
- 2.10.1 Bond metallic armour of single conductor cables every 1.8 m, so as to equalize the field (sheath voltage) between them and prevent any sparks due to sheath voltage difference between the cables.
- 2.10.2 PVC jacketed single conductor armoured cable should be bonded only in the hazardous area and not at the other end. However there will be a sheath voltage present at the non-bonded end which may be a shock hazard. Bonding at both ends will lead to presence of circulating currents which is an incensive source for ignition.
- 2.10.3 A separate bonding conductor in parallel with the cable is required to bond both sides of the cable route, at the two enclosures.
- 2.11 It is preferred to use 3 conductor power cables with balanced loadings on all three conductors to cancel out the magnetic effect on armour.
- 2.12 Cable trays can be used in Zone 2 locations, however they should be bonded to prevent occurrence of circulating currents.
- 2.13 Conduits shall be sealed when crossing Zone 2 boundaries to prevent migration of gas vapours into other areas.
- 2.14 Electrical equipment that can be used in Zone 2 shall be:
- 2.14.1 approved for Class I, Division 2 locations;
- 2.14.2 approved as non-incensive;
- 2.14.3 approved as providing equipment protection level Ga, Gb, or Gc;
- 2.14.4 approved as providing a method of protection "n"; or
- 2.14.5 equipment permitted in Zone 1.
- 2.15 Ensure equipment temperature code classification is appropriate for the installation. See Table 12-1.
- 2.16 Ensure that equipment is suitable for the applicable gas group.
- 2.17 Increased safety e motors shall incorporate thermal protection.
- 2.18 Lighting fixtures shall be provided with guards to prevent breakage damage or be break resistant construction.

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13 ARC FLASH

13.1 General

The purpose of an arc flash study is to identify and quantify potential arc flash hazards associated with electrical distribution equipment, and establish safe working guidelines for personnel. The safe working guidelines consist of identifying arc flash protection boundaries and the personnel protective equipment (PPE) required for each piece of electrical equipment. This information is identified on a label, which is to be applied to each piece of electrical equipment.

The arc flash hazard analysis is to be performed in association with a short circuit study and protection device coordination study. Results of the short circuit study are used to determine the available fault current levels at each piece of equipment and results from the coordination study determine the time required for the electrical circuit protective devices to clear the fault condition. The results of these two studies are combined to calculate the incident energy at assigned working positions from the electrical equipment and categorize the arc flash hazard to determine the required PPE to provide adequate protection. These studies should be completed at design time so as to identify and mitigate any potential issues before construction begins.

The City has standardized on Power*Tools software provided by SKM Systems Analysis, Inc (also known as SKM). A model of the electrical distribution should be created using this software that includes any equipment that may need to be accessed by City personnel. Tag equipment within the model using the City's identification guideline. The SKM project file shall be supplied to the City, in native electronic format, upon completion of the arc flash study.

13.2 Design Requirements

1. All new and modified electrical designs shall ensure that arc flash energies are within the ratings specified in Table 13-1.
2. The electrical designer shall model the arc flash energies during design time and specify equipment as required to ensure that the design arc flash ratings are maintained.

Table 13-1 : Arc Flash Design Requirements

Equipment	Arc Flash Hazard / Risk Rating		Notes
	Recommended Maximum	Absolute Maximum (See Note 1)	
Control Panels, <= 600V	0	1	
Distribution Panel, <= 600V	2	3	
Distribution Panel, <= 600V, Main Breaker	3	4	2
Motor Control Centre, 600V	2	3	
Motor Control Centre, 600V, Main Breaker	3	4	2
Panelboard, 208/120V	0	2	
Panelboard, 347/600V	1	2	
Switchgear, <= 600V	3	4	
Switchgear, <= 600V, Main Breaker	4	4	
Switchgear, Medium Voltage	3	4	
Switchgear, Medium Voltage, Main Breaker	4	4	
Transformers	4	-	3

Notes:

1. *The City must approve all cases where the arc flash energies exceed recommended maximum values.*
2. *The main breaker must be in a separate compartment to permit a separate rating.*
3. *It is not typical to require live work on energized transformers.*

13.3 Typical Arc Flash Labels

1. Arc flash labels are to utilize metric units.
2. Certain types of equipment, such as transformers, contain multiple voltage levels. The arc flash incident energy needs to be evaluated at all voltage levels present and the highest incident energy computed will need to be shown on the arc flash label. The approach distances on the labels must always reflect the highest voltage level present within the equipment, regardless of which voltage level generates the highest incident energy.
3. The arc flash label format used for equipment rated Category 0 through Category 4 is shown in Figure 13-1 and Figure 13-2. Warning labels are to utilize an orange heading with the word "Warning".

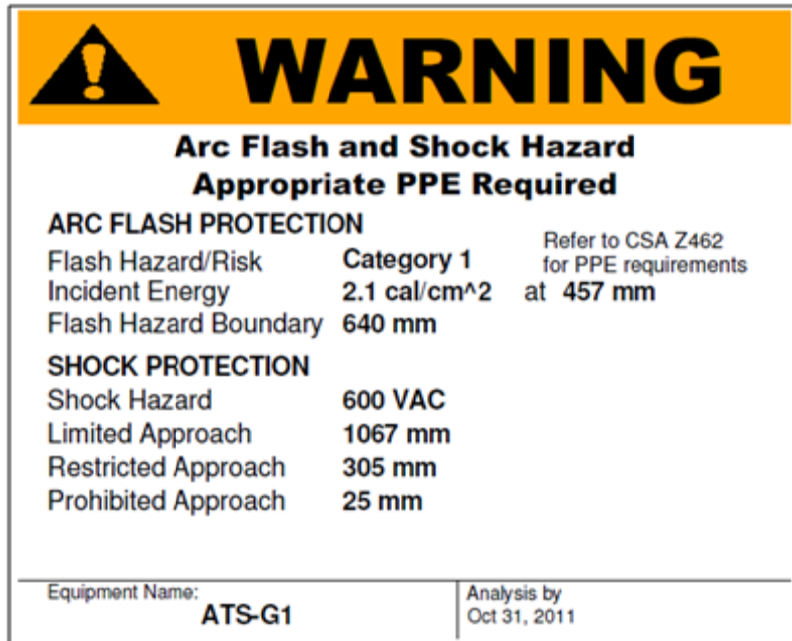


Figure 13-1 : Arc Flash Warning Label, Category 0 through 4 - Small



Figure 13-2 : Arc Flash Warning Label, Category 0 through 4 - Large

For equipment that is given a Dangerous category rating, the arc flash labels are to utilize a red heading with the word “Danger”. A sample arc flash label of this type is shown in Figure 13-3.



	DANGER
NO SAFE PPE EXISTS ENERGIZED WORK PROHIBITED	
ARC FLASH PROTECTION	
Flash Hazard/Risk	Dangerous! <small>Refer to CSA Z462 for PPE requirements</small>
Incident Energy	482 cal/cm² at 0.91 m
Flash Hazard Boundary	563.72 m
SHOCK PROTECTION	
Shock Hazard	13800 VAC
Limited Approach	1.52 m
Restricted Approach	0.66 m
Prohibited Approach	0.18 m
Equipment Name:	SGR-M701
	Analysis by Oct 18, 2012

Figure 13-3 : Arc Flash Danger Label, Category Dangerous!

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14 GROUNDING

14.1 General

1. See Section 3.4 for system grounding requirements.
2. Reference IEEE-142 and IEEE-399 for grounding system design practices.
3. All grounding and bonding are to utilize copper conductors.
4. All ground rods to be copper-clad steel, 19mm diameter, and minimum 3m long. Where six meter long ground rods are required, utilize two 3m long rods with a threadless connector.
5. Minimum grounding conductor size for grounding electrode and buried conductors:
 - 5.1 600V systems: 2/0 AWG
 - 5.2 Medium Voltage systems: 4/0 AWG
 - 5.3 Grounding conductor sizing for connection of transformers, generators, etc should not be less than required for the equivalent bonding conductor, and never less than 6 AWG.
6. Burial depth of grounding conductors:
 - 6.1 600V systems: 300 mm – 500 mm
 - 6.2 Medium voltage systems: 500 mm below rough grade

14.2 Equipment Bonding and Grounding

This refers to the bonding and grounding of non-current carrying metal parts like panel enclosures, motor frames, switchgear, and switchyard structures, etc.

14.2.1 General

1. All non-current-carrying metal equipment parts shall be bonded to station ground grid.
2. All metal building columns shall be bonded and connected to ground using 2/0 AWG copper conductors.
3. All tanks, vessels and piping shall be bonded to ground.
4. A grounding system consisting of a grid or network of buried soft drawn bare copper conductors and electrodes will be provided for each facility. The individual ground grid will be tied together with interconnecting ground cables. The grounding system will be designed to limit the overall resistance to earth to a level satisfactory for the safe operation of the equipment and for the safety of the personnel.

14.2.2 Low Voltage Systems (< 750V)

1. All major electrical equipment rated 1200 A and above, such as transformers, switchgear, large motors, motor controller, etc., must be connected to the ground, at minimum through two paths. Two-path grounding is recommended for other systems as well.

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14.2.3 Medium Voltage System

The following are applicable to medium voltage systems.

1. Prior to detail design execution, the design team must locate and obtain sufficient site soil data, as it is required for calculations and design development. Soil characteristics and seasonal changes must be fully documented. If such data is not available or is insufficient; the project design team shall commission an appropriate soil resistivity survey with a competent and qualified specialized enterprise.
2. The design of the grounding system shall be based on calculated requirements to maintain safe *touch* and *step* potentials required by the Canadian Electrical Code.
3. Provide a switchyard ground grid in accordance with requirements of IEEE-80 to achieve required touch voltage and step voltage limitations.
4. The minimum grounding conductor size for connection of grounding electrodes and ground grids is 2/0 AWG. The use of 4/0 AWG or larger conductors is recommended to be utilized for applications with transformers rated 1 MVA or greater.
5. All electrical equipment frames shall be connected to ground grid using 2/0 AWG or larger copper conductors.
6. All metal columns, pedestals, supports shall be bonded and connected to ground using 2/0 AWG copper conductor.
7. Provide ground grid conductor around the building perimeter, to reduce touch and step potentials, unless it can be demonstrated with study/analysis that this will not be an issue.
8. The type of power system grounding selected must be in accordance with the utility requirements and following the latest practice, codes and standards. Values of resistivity to ground must be carefully established to provide the most suitable equipment protection.
9. All medium voltage electrical equipment will be connected to the ground, at minimum through two paths.
10. All metallic fencing; property perimeter, outdoor substations and any other, required to protect property, equipment or to restrict access to designated plant facilities will be connected to an appropriate grounding system.
11. Metal fencing around medium voltage stations:
 - 11.1 Locate fence at least 1m inside the periphery of the station ground grid conductor.
 - 11.2 Connect the fence to station ground grid in accordance with CEC.
 - 11.3 Where there is an external metal boundary fence, in proximity to the station fence, the touch voltages within 1m of all parts of the metal boundary fence shall not exceed the tolerable step voltage limits given in CEC Table 52.

14.3 Lightning Protection

Perform a risk analysis as per NFPA 780 for all new facilities. Review acceptable risks with the City. Where required, install appropriate lightning protection.

A minimum level of lightning protection, as required by local codes, shall be allowed for to protect property, personnel and equipment. Subject to the results of an evaluation, the complexity of the design required shall depend on the severity or level of incidence of lightning strokes in the area of the project plant; as well as the type of plant and risks in the event of lightning strokes. Statistical or statutory meteorological data must be consulted to make a proper determination of the degree of protection required.


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Buildings and structures will be adequately grounded to prevent damage from a lightning stroke or discharge. In the absence of project specific standards, the design will follow NFPA 780 and CSA B72.

Ensure that the grounding system for the lighting protection is segregated from the electrical safety ground system and only interconnected as required in the codes and standards.

14.4 Grounding Study

1. As per Canadian Electrical Code requirements, appropriate review and calculation of the ground resistance is required for medium voltage systems. However, for certain applications with high voltages, more formal, documented analysis in the form of a grounding study is required to identify grounding system safety hazards and provide for a safe grounding system design.
2. A grounding study report shall be provided for all systems where line-to-line voltages exceed 7500V within the City's electrical distribution system. A grounding study shall include the following:
 - 2.1 Identify the existing and proposed electrical grounding and bonding.
 - 2.2 Testing of the soil resistivity.
 - 2.3 Test results of any fall-of-potential testing performed on any existing ground electrodes. The requirement for testing existing electrodes shall be determined on a case-by-case basis.
 - 2.4 Coordinate with the utility to obtain relevant utility supply information.
 - 2.5 Determine the available fault currents at various points within the electrical distribution. This information may be obtained from a short circuit study.
 - 2.6 Create a model of the grounding system in specialized grounding software. Alternately, manual calculations may be utilized for small systems.
 - 2.7 Perform a safety analysis utilizing the software model (or manual calculations for small systems).
 - 2.8 Fully document the results of the safety analysis in the report.

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15 POWER FACTOR CORRECTION

15.1 General

1. It is generally recommended that the electrical power factor for each facility be corrected to 0.95 or better. However, the economic payback for power factor correction should be calculated for all cases where the requirement for power factor correction is not clear.
2. Correction of the power factor to past 0.95 leading shall not be permitted under any circumstance.
3. For small facilities with a limited number of loads, power factor correction connected to the individual motor loads is preferred. For example, connection of capacitors to motor loads is appropriate in most wastewater lift stations.
4. For facilities supplied at 600V, with numerous motor loads and potential harmonics, connection of one or more power factor correction banks is preferred. Perform a harmonic review of the existing and potential future installation, and install detuning capacitors if potentially damaging harmonics are present.
5. Ensure that capacitors do not create a resonance condition.
6. Where any point in the electrical distribution has non-linear loads exceeding 15% of the upstream transformer capacity, a harmonic study must be performed to determine the appropriate application of power factor correction.
7. Capacitors connected directly to the bus without an upstream contactor require special permission from the City.
8. For facilities supplied at medium voltage, the appropriate configuration of power factor correction must be determined on a case-by-case basis.
 - 8.1 Switching and control of power factor correction equipment shall be given special attention. The transient and dynamic behaviour of this equipment under various operating conditions must be supported by calculations and studies. The design adopted shall ensure safe operation and protection of associated equipment.

15.2 Configurations

1. The configuration of power factor correction is classified into three types:
 - 1.1 Load Power Factor Correct (See Section 15.2.2)
 - 1.2 Decentralized Bulk Power Factor Correction (See Section 15.2.3)
 - 1.3 Centralized Bulk Power Factor Correction (See Section 15.2.4)
2. Typical configurations for power factor correction are identified in Table 15-1. However, determination the appropriate configuration shall be reviewed for each facility.

Table 15-1 : Power Factor Correction Configuration Application

Application	Typical Configuration	Notes
Land Drainage / Underpass Pumping Station	Load Power Factor Correction	
Regional Water Pumping Station	Load Power Factor Correction (MV) Decentralized Bulk Power Factor Correction (600V)	
Wastewater Flood Station	Load Power Factor Correction	Review the economic benefit considering occasional use.
Wastewater Lift Station	Load Power Factor Correction	
Wastewater Flood and Lift Station (combined)	Load Power Factor Correction	Review the economic benefit considering occasional use.
Wastewater Treatment Facility	Decentralized Bulk Power Factor Correction (preferred) or Centralized Bulk Power Factor Correction	
Water Treatment Plant	Decentralized Bulk Power Factor Correction (preferred) or Centralized Bulk Power Factor Correction	

15.2.2 Load Power Factor Correction

The power factor correction equipment may be installed close to the load equipment exhibiting poor power factor, to improve the power factor, reduce load cable currents and losses, and provide for starting kVAR for heavy loads which require heavy inductive kVAR at start.

1. Before applying power factor correction, the power factor, actual load current, individual harmonic components of individual loads and the power supply source needs to be reviewed.
2. Power factor correction capacitors may be installed and switched in line with motors ensuring that such a design is in compliance with Canadian Electrical Code.

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3. Capacitors should not be installed at the terminals with larger size AC induction motors with high inertia loads due to risk of self-excitation, after the motor is switched off. Self-excitation may lead to presence of over-voltages at motor/capacitor terminals. The capacitor rated current should be less than the no-load magnetizing current of the induction motor.
4. Individual Motor Power Factor Correction
 - 4.1 Connection Type A1 – Motor Terminals
 - 4.1.1 Connection of power factor correction capacitors at the motor terminals is acceptable for full voltage started motors only.
 - 4.1.2 Do not apply to motors started by soft starters or VFDs.
 - 4.1.3 Do not apply to motors which are subject to plugging, jogging, high-inertia, reversing, or open transient compound starting.
 - 4.1.4 Maximum capacitor size as per motor nameplate or such that capacitor current \leq motor no-load current.
 - 4.1.5 The overload setting must be adjusted to account for the reduced motor current. This reduced overload setting must be clearly documented on the drawings.
 - 4.2 Connection Type A2 – Overload Load Terminals
 - 4.2.1 Same as Connection Type A1, except the capacitors may be located at the motor starter instead of the motor.
 - 4.3 Connection Type B1 – After Contactor and Before Overload
 - 4.3.1 Connection of power factor correction capacitors in this manner is acceptable for full voltage started motors only.
 - 4.3.2 Do not apply to motors started by soft starters or VFDs.
 - 4.3.3 Do not apply to motors which are subject to plugging, jogging, high-inertia, reversing, or open transient compound starting.
 - 4.3.4 Maximum capacitor size as per motor nameplate or such that capacitor current \leq motor no-load current.
 - 4.4 Connection Type B2 – Overload Cancelled
 - 4.4.1 Same as Connection Type B1, except the power factor correction conductors are routed back through the overload CTs to cancel the PFC current and allow the overload setting to match the motor FLA.
 - 4.5 Connection Type C – Separate Contactor
 - 4.5.1 Connection of power factor correction capacitors in this manner is acceptable for most motors.
 - 4.5.2 Do not apply to motors started VFDs.
 - 4.5.3 Capacitor size should be less than the motor kVAR rating. Note that the capacitors in this configuration may be slightly larger than the previous connection types.
 - 4.5.4 When configured with a soft start, the capacitor contactor should only close after the motor is up to speed.
5. VFDs
 - 5.1 Capacitors are not typically required to provide displacement power factor correction, but rather to filter harmonics.
 - 5.2 Capacitors should never be applied to VFDs without appropriately designed filtering reactors.

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6. In harmonic rich environments, the use of power factor correction on individual motors is generally discouraged. For smaller facilities, such as wastewater lift stations and flood stations, where harmonics are present it may be appropriate to install detuning reactors on individual capacitors.

15.2.3 Decentralized Bulk Power Factor Correction

The power factor correction equipment may be installed in various locations in a facility on busses such as motor control centers and switchgear. The primary advantage of this arrangement compared to centralized bulk power factor correction is that the power factor correction can reduce feeder currents and associated losses within the facility.

1. Before applying power factor correction, the power factor, actual load current, individual harmonic components of individual loads and the power supply source needs to be reviewed.
2. It is recommended to consider the use of detuned power factor correction banks whenever harmonic currents are present or may arise in the future.
3. Capacitor banks shall be designed in steps to prevent electrical resonance. Each step will be controlled based on desired power factor setting.
4. Provide a programmable PF/VAR controller with adjustable/programmable settings so as to control the centralized capacitor bank.


15.2.4 Centralized Bulk Power Factor Correction

The Centralized Bulk Power Factor Correction utilizes capacitor banks that are installed close to the power source. Its primary aim is to improve overall facility power factor. Reduction in the facility power factor provides for reduced demand billing, release of capacity from a loaded supply transformer, and reduction in upstream transformer and cable losses. Power factor correction can also assist with voltage stabilization.


1. Before applying centralized bulk power factor correction, a proper electrical study should be carried out to study the kVA, kVAR, power factor, actual load current, individual harmonic components at the given power source.
2. Calculate the maximum kVA capacity that can be released by using centralized PF capacitor banks instead.
3. It is recommended to consider the use of detuned power factor correction banks whenever harmonic currents are present or may arise in the future.
4. Capacitor banks shall be designed in steps to prevent electrical resonance. Each step will be controlled based on desired power factor setting.
5. Provide a programmable PF/VAR controller with adjustable/programmable settings so as to control the centralized capacitor bank.
6. Provide capacitors with detuning reactors so as not to permit providing a low impedance path for harmonics present on the system.

15.3 Capacitor Units

1. Oil filled capacitors are not acceptable. Provide metalized polypropylene dielectric thin film impregnated self-healing capacitors.
2. Capacitance tolerances to be within -5% to +10%.
3. Ampacity of feeders supplying capacitors shall be 135% of the rated capacitor current.

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4. Rated voltage of the capacitors shall be 110% of the system nominal voltage.
5. Rated over-current capability of capacitors shall be 135% of the nominal.
6. Capacitors shall be provided with integral discharge devices complying with Code requirements for residual voltage decay.
7. Capacitors shall be provided with integral fuses, coordinated to prevent the capacitor case from bursting on a short circuit fault inside the capacitor case.
8. The capacitive power overload of a capacitor due to overload in voltage or current must not exceed 135% of its nominal rated kVAR.
9. Provide capacitor units with low dielectric losses.

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16 OTHER SYSTEMS

16.1 Fire Alarm System

16.1.1 General Requirements

1. The requirement for a fire alarm system is dependent upon the type of facility and applicable code requirements. Where a fire alarm system is required as part of mandatory code requirements or good design practice, advise the City early in the design process.
2. Fire alarm systems are presently required for (but not necessarily limited to):
 - 2.1 The South End Water Pollution Control Centre
 - 2.2 The Water Treatment Plant
 - 2.3 Regional Water Pumping Stations.
3. Where fire alarm systems are to be installed, install in accordance with the National Building Code of Canada, the Canadian Electrical Code, and CAN/ULC-S524 – *Installation of Fire Alarm Systems*.
4. All fire alarm wiring shall be entirely independent from all other wiring. Each breaker feeding fire alarm equipment shall be coloured red and lockable in the “on” position.
5. The environmental conditions in some process areas are too harsh for commercial grade components to have sufficient operating life. In general, components in process areas should be industrial grade. However, the areas where industrial grade components will be necessary should be determined during the fire alarm design.
6. Each fire alarm device shall have a lamacoid adjacent to the device indicating the device ID as specified in the City’s Identification Guidelines.
7. At minimum, an alarm and trouble signal shall be sent from the fire alarm panel to the main facility control system.
8. The requirement for central monitoring is to be determined on a case-by case basis. Where provided, it shall be installed in accordance with CAN/ULC-S561.

16.1.2 Drawing Requirements

1. Prepare fire alarm plan drawings in accordance with Section 18.2.4.
2. Prepare fire alarm riser diagrams in accordance with Section 18.2.5.

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16.2 Voice Communications

The specific requirements for communications systems are dependent upon the scope of work for each project. At minimum, the electrical design shall include provision of space, conduits and/or cabling for the communication systems.

16.2.1 Telephone

1. Hardwired telephone communication infrastructure shall be provided for all facilities that are occupied on a routine basis.
2. Utilize analog telephone systems for small to medium sized facilities.
3. Consider utilization of IP based telephony for large facilities.
4. Allocate space for the central telephone backboard in a clean, conditioned space. For large facilities, this will ideally be in a server room or similar environment. For smaller / medium sized facilities, preference would be to typically locate in an electrical room, but at least 1m away from electrical equipment.
5. Provide boxes and wallplates with jacks for all telephone connections.
6. All cabling is to be as per Data Communications requirements in Section 16.3. No "Cat-3" or telephone-grade cabling is permitted.


16.2.2 Public Address (PA) System

1. The requirement for a PA system will be made on a case-by-case by the City, however it is expected that only large facilities will typically require a PA system.

16.3 Data Communications

16.3.1 Cabling

1. Copper data cabling in wastewater lift stations, regional water pumping stations, and other small to medium sized facilities may utilize Cat-5e wiring systems. Utilize Cat-6 wiring systems for larger facilities, such as wastewater treatment facilities.
2. Utilize multi-mode fibre-optic cabling where required due to distance or potential electrical interference
 - 2.1 Fibre optic cables shall be indoor/outdoor direct burial rated loose tube, rodent protected and constructed with 50/125 multi-mode glass fibres, spiral interlocked armour, and outer polyethylene jacket.
 - 2.2 All fibre cables are to meet TIA 492-AAAC (OM3) designation at minimum. Where required for distance and bandwidth, TIA 492-AAAD (OM4) fibres may be required.
 - 2.3 All fibre terminations are to include buffer tube fan out kits, connectors, termination/distribution panels, and wall mount enclosures.
 - 2.4 Where possible, standardize on LC fibre connectors.
3. Utilize single-mode fibre for long distance communication requirements.
4. All communication cables shall be supported at intervals not exceeding 1.0 m.

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16.3.2 Raceways

1. Communication conductors shall be installed in separate raceways and cable trays from power conductors.
2. Where communication conductors cross power conductors, they shall cross perpendicularly.
3. Segregation of cable systems shall be as per Table 4-8.

16.4 Security Systems

16.4.1 Basic Requirements

1. Each facility shall, at minimum, be provided with basic security monitoring; however additional requirements may apply. Coordinate with the City to determine the specific requirements for each facility.

16.4.2 Wastewater Treatment Facilities

1. The basic security system for all process areas, consisting of door, window and motion sensors as applicable, will typically be connected with the plant control system rather than a commercial-style security system. Video systems will be treated independently of the security systems connected to the plant control system. Refer to the Automation Design Guide for additional information.
2. Basic requirements include:
 - 2.1 Intrusion monitoring for all exterior plant doors.
 - 2.2 Intrusion monitoring for all exterior windows that are not within the plant perimeter fence (if any).
 - 2.3 Motion detectors for critical areas only.
3. Video surveillance systems for security purposes are not typically required unless indicated by the City; however video monitoring of specific processes and operations may be required.

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17 ELECTRICAL ROOMS

17.1 General Requirements

Requirements of electrical rooms include the following:

1. Ensure bare concrete floors are covered, painted, or sealed to reduce the build-up of concrete dust on electrical equipment. Use of conductive surface hardeners for concrete floors is not permissible.
2. Locate electrical rooms at or preferably above grade.
3. Locate electrical rooms to allow for access of cables and conduits from all sides.
4. No process piping shall run through the electrical room.
5. No washroom or kitchen facilities shall be allowed directly above an electrical room.
6. Hot water or glycol heating pipes or heaters shall not be located above electrical rooms or anywhere such that a leak of liquid or steam could conceivably enter an electrical room.
7. Housekeeping pads:
 - 7.1 It is generally preferred that electrical equipment be installed on housekeeping pads. Housekeeping pads are required in any application where there is potential for water leakage on the floor.
 - 7.1.1 Housekeeping pads may be omitted where not compatible with certain types of draw-out switchgear.
 - 7.2 Size housekeeping pads to extend 50mm past the equipment.
 - 7.3 Housekeeping pads to be between 110 and 152 mm high.
 - 7.4 Provide 10M rebar spaced at maximum 300 on center and anchor to the floor.

17.2 Ventilation Requirements


1. Design ventilation and mechanical cooling as required to keep electrical rooms cool. Minimum requirements are shown in Table 17-1.

Table 17-1 : Electrical Room Temperature Requirements

Type	Heating		Cooling	
	Occupied	Unoccupied	Occupied	Unoccupied
Standard	20°C	10°C	27°C	27°C
Small & Non-Critical	20°C	10°C	35°C	35°C

Note: Electrical Rooms may only be considered small if they distribute power for less than 100 KVA of load. Electrical rooms may only be considered non-critical if the loads powered from the room can be turned off at any time for a complete day with minimal consequence. An example of a small electrical room would be an electrical room for a small storage building.

2. Perform a heat load calculation for electrical rooms to ensure the ventilation system is adequately sized to reject the heat.

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3. Where air quality is a concern, ensure that the electrical room is positively pressurized relative to surrounding areas. Pressurization is required in any area containing hazardous locations.
4. Where corrosive gases are present, ensure that electrical rooms maintain a G1 – Mild classification as per ISA 71.04-1985. Where required, install a scrubber to address corrosive gases.
5. Ensure sufficient ventilation is provided to exhaust any potential hydrogen off-gas from batteries.
6. Filters are required on the air intake of all electrical rooms.
7. Humidity control may be required if electrical equipment within the room is sensitive to this or if environmental conditions warrant it.

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18 ENGINEERING DESIGN TEAM RESPONSIBILITIES

18.1 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 electrical 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. For example: partial single line drawings are not permitted.
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 Single line drawings must always be updated, such that a complete set of single line diagrams is provided for the facility.
 - 4.1.2 Panel schedule drawings must always be updated, such that a complete set of panel schedules is provided for the facility.
 - 4.1.3 Update of existing motor starter schematics and loop diagrams is typical, where significant changes are being made to the content of the specific drawings.
 - 4.1.4 The update of existing electrical 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 electrical drawings is dependent upon the design engineer's scope of work, as agreed to with the City.
5. As-Built Drawings:
 - 5.1 All electrical 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. External, 3rd Party Consultants:
 - 6.1 Expertise and assistance may be required, from external 3rd party specialized consultants, outside of the primary electrical design team.
 - 6.2 Areas where an external 3rd party consultant may be utilized, with permission from the City, are:
 - 6.2.1 Analysis and design of grounding system.
 - 6.2.2 Design of project specific specialized systems and equipment.
 - 6.2.3 Medium-voltage protection systems.
 - 6.2.4 Fire detection, protection and alarm systems.
 - 6.2.5 Corrosion protection systems.
 - 6.2.6 Area classification.

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- 6.3 The design team shall be responsible for monitoring the activities and progress of each 3rd party consultant.
- 6.4 It is the responsibility of the design engineer to ensure that the deliverables follow all City standards and guidelines.
- 7. Site Visits:
 - 7.1 The electrical 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.

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8. Demolition Requirements

- 8.1 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. Specific requirements include:
 - 8.2 Where demolition requirements are significant, create dedicated demolition drawings.
 - 8.3 Generally, abandoned equipment, wiring, etc shall be removed unless specifically requested by the City that the equipment/wiring be retained, or removal is not practical.

9. Acceptance Testing

- 9.1 Acceptance testing requirements shall be defined for every project. Acceptance tests shall utilize NETA standards as a reference.
- 9.2 Acceptance testing forms shall be completed for every projected and included with the O&M manuals.
- 9.3 The Design Team is responsible for reviewing the completed acceptance test forms to ensure that the installation complies with the specifications.

18.2 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 electrical 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 a general lack of detail are not acceptable.

18.2.1 Cable Tray Layouts

1. Requirement


- 1.1 Cable tray layouts are required for all work that includes cable trays.

2. Content:

- 2.1 All new and existing cable trays shall be shown, to scale, on the layout.
- 2.2 All potentially interfering mechanical equipment, if applicable, shall be shown with a lighter line weight.
- 2.3 All relevant equipment identifiers are to be shown on the drawing.
- 2.4 Provide sections and elevations where sufficient detail cannot be provided in plan.
- 2.5 Provide 3 dimensional views of the cable tray layouts where required to clarify the layout.
- 2.6 The requirement to produce cable tray layouts in a 3D model, together with mechanical equipment, shall be evaluated and established on a per project basis.

3. Format:

- 3.1 All cable tray layout drawings are to be produced on a standard A1 size drawing.
- 3.2 Drawing Scale:
 - 3.2.1 Recommended: 1:30 or 1:50
 - 3.2.2 Maximum: 1:75

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18.2.2 Electrical Room Layouts

1. Requirement
 - 1.1 Electrical Room Layouts shall be prepared for every project.
2. Content:
 - 2.1 All new and existing equipment shall be shown, to scale, on the layout.
 - 2.2 All mechanical equipment, if applicable, shall be shown with a lighter lineweight.
 - 2.3 All equipment identifiers are to be shown on the drawing.
 - 2.4 Provide sections and elevations where sufficient detail cannot be provided in plan.
3. Format:
 - 3.1 All equipment plan layout drawings are to be produced on a standard A1 size drawing.
 - 3.2 Drawing Scale:
 - 3.2.1 Recommended: 1:30
 - 3.2.2 Maximum: 1:50

18.2.3 Equipment Plan Layout Drawings

1. Requirement:
 - 1.1 Equipment Plan Layout Drawings shall be prepared for every project.
2. Content:
 - 2.1 All new and existing equipment shall be shown, to scale, on the equipment plan layout.
 - 2.2 All mechanical equipment shall be shown with a lighter lineweight.
 - 2.3 All equipment identifiers are to be shown on the drawing.
 - 2.4 Provide sections and elevations where sufficient detail cannot be provided in plan.
 - 2.5 Show all convenience and welding receptacles with circuiting indicated.
3. Format:
 - 3.1 All equipment plan layout drawings are to be produced on a standard A1 size drawing.
 - 3.2 Drawing Scale:
 - 3.2.1 Recommended: 1:50
 - 3.2.2 Maximum: 1:100

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18.2.4 Fire Alarm Plan

1. Requirement
 - 1.1 Fire Alarm Plan Drawings are required for all facilities with a fire alarm.
2. Content
 - 2.1 Prepare plan drawings that show the detailed location and type of each detector, isolator, horn, strobe, pull station, etc.
 - 2.2 Provide the equipment identifier adjacent to each device. Where the room number is clearly shown on the drawing, the room number portion of the identifier may be implied.
 - 2.3 All spacing shall be designed per CAN/ULC-S524 by the design engineer. Indication of general detection requirements for detailed design by the Contractor is not acceptable.
 - 2.4 Where flat ceilings are not provided, provide sections or other details to clarify the installation requirements, including installations in beam pockets.
 - 2.5 Show the routing of major conduits on the plan drawing.
 - 2.6 Show all isolators.
3. Format:
 - 3.1 All fire alarm drawings are to be prepared on a standard A1 size drawing.
 - 3.2 Drawing Scale:
 - 3.2.1 Recommended: 1:50 – 1:100
 - 3.2.2 Maximum: 1:150

18.2.5 Fire Alarm Riser Diagram

1. Requirement
 - 1.1 Fire Alarm Riser Diagrams are required for all facilities with a fire alarm.
2. Content
 - 2.1 Provide a riser diagram for both the detection system and the notification system. For small systems this may be on a common drawing, but for large systems, these systems should be on separate drawings.
 - 2.2 Provide the equipment identifier adjacent to each device. Where the room number is clearly shown on the drawing, the room number may be implied.
 - 2.3 Clearly show all zone, devices, and wiring interconnections between devices.
 - 2.4 Show all booster power supplies.
3. Format:
 - 3.1 All fire alarm drawings are to be prepared on a standard A1 size drawing.


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18.2.6 Grounding Diagrams

1. Requirement
 - 1.1 Grounding Diagrams are required for all facilities.
2. Content:
 - 2.1 Provide plan and elevation drawings as required to indicate the routing and connection of grounding conductors.
 - 2.2 The drawings are to clearly represent the grounding conductors within the building(s) and the exterior ground electrode layout, as well as interconnections.
3. Format:
 - 3.1 All grounding diagrams are to be produced on a standard A1 size drawing.
 - 3.2 Drawing Scale - Interior:
 - 3.2.1 Recommended: 1:50
 - 3.2.2 Maximum: 1:100
 - 3.3 Drawing Scale - Exterior:
 - 3.3.1 Recommended: 1:50 - 1:100
 - 3.3.2 Maximum: 1:150
 - 3.4 Provide details and sections at a lower scale as required to clarify grounding requirements.

18.2.7 Hazardous Location Plan Drawings

1. Requirement
 - 1.1 Hazardous location plan drawings are required for all wastewater facilities, and should cover all floor areas.
 - 1.2 Hazardous location plan drawings are also required for any other facility where a hazardous location is present.
2. Content:
 - 2.1 Plan drawings of the facilities clearly showing the hazardous locations via hatching.
 - 2.2 It is recommended to also show Canadian Electrical Code Category 1 (wet) and Category 2 (corrosive) locations on the same plans via hatching.
 - 2.3 Show temperature codes for hazardous locations.
 - 2.4 For indoor locations where the hazardous classification is related to ventilation, clearly indicate the design ventilation rate on the drawings.
3. Format:
 - 3.1 All hazardous location plan drawings are to be produced on a standard A1 size drawing.
 - 3.2 Drawing Scale:
 - 3.2.1 Recommended: 1:50
 - 3.2.2 Maximum: 1:100
 - 3.3 Provide details and sections at a lower scale as required to clarify hazardous locations around equipment.

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18.2.8 Lighting Plan Drawings

1. Requirement:
 - 1.1 Lighting Plan Drawings are to be prepared for every project.
 - 1.2 Do not combine the Lighting Plan Drawings with the Equipment Plan Layout Drawings unless specifically approved by the City.
2. Content:
 - 2.1 Include all primary and emergency lighting.
 - 2.2 Indicate circuit numbers beside each fixture.
 - 2.3 All lighting plan drawings shall reference a luminaire schedule. Where an existing luminaire schedule exists for a building or building area, the existing luminaire schedule shall be updated and utilized. Avoid multiple luminaire schedules for the same area.
3. Format:
 - 3.1 All lighting plan drawings are to be produced on a standard A1 size drawing.
 - 3.2 Drawing Scale – Interior Drawings:
 - 3.2.1 Recommended: 1:50
 - 3.2.2 Maximum: 1:100
 - 3.3 Drawing Scale: - Exterior Drawings:
 - 3.3.1 Maximum: 1:100

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18.2.9 MCC Layout Drawing

1. Requirement:
 - 1.1 A MCC layout drawing is required for every MCC.
2. Content:
 - 2.1 The primary content of the drawing is a front elevation of the MCC structure.
 - 2.2 Label all vertical sections with a number starting at 1. Label all horizontal rows with a letter, as per manufacturer identification.
 - 2.3 Each bucket / wrapper shall be sized appropriately and identified with the load equipment identifier and description.
 - 2.4 Label spare units as SPARE and space available for future starters/feeders as SPACE.
 - 2.5 Provide a table with the following MCC design requirements clearly identified:
 - 2.5.1 Equipment Identifier
 - 2.5.2 Enclosure Type
 - 2.5.3 Mounting
 - 2.5.4 Depth
 - 2.5.5 Supply voltage, phase, frequency
 - 2.5.6 Incoming neutral termination
 - 2.5.7 Control voltage
 - 2.5.8 Wiring Class
 - 2.5.9 Minimum bus rating (amps) for horizontal and vertical bus.
 - 2.5.10 Suitable for service entrance
 - 2.5.11 Neutral Bus
 - 2.5.12 Bus Bracing
 - 2.5.13 SCCR
 - 2.5.14 Series SCCR Permitted
 - 2.5.15 Bus Material
 - 2.5.16 Manufacturer / Model (To be completed at As-Built stage if competitive procurement)
3. Format:
 - 3.1 All MCC Layout Drawings are to be produced on a standard A1 size drawing.
 - 3.2 Drawing Scale:
 - 3.2.1 Recommended: 1:10

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18.2.10 MCC Schedule

1. Requirement:
 - 1.1 A MCC Schedule is required for every MCC.
2. Content:
 - 2.1 Identify in tabular format:
 - 2.1.1 MCC Identifier
 - 2.1.2 Description
 - 2.1.3 Location
 - 2.1.4 Volts
 - 2.1.5 Amp Rating
 - 2.1.6 Phases
 - 2.1.7 Wires
 - 2.1.8 Main Breaker
 - 2.1.8.1 Rating
 - 2.1.8.2 Type
 - 2.1.8.3 Settings
 - 2.1.9 Total Connected Load
 - 2.1.10 Total Demand Load
 - 2.1.11 Legend
 - 2.2 For each unit within the MCC, provide a row within the table with the following clearly identified:
 - 2.2.1 Unit Location
 - 2.2.2 Load Identifier
 - 2.2.3 Load Description
 - 2.2.4 Motor Load (kW/hp/FLA)
 - 2.2.5 Non-Motor Load (kW)
 - 2.2.6 Starter
 - 2.2.6.1 NEMA Size
 - 2.2.6.2 Type
 - 2.2.6.3 Overload
 - 2.2.7 Circuit Protection
 - 2.2.7.1 Rating
 - 2.2.7.2 Type
 - 2.2.8 Notes
3. Format:
 - 3.1 All MCC Schedules are to be produced on a standard A1 size drawing.

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18.2.11 Motor Connection Diagram

1. Requirement:
 - 1.1 A dedicated motor connection diagram shall be prepared for every motor starter.
2. Content:
 - 2.1 The connection diagram will include all power and control field wiring external to the motor starter or control panels. The cables and conductors will be individually labelled along with all the terminations.
 - 2.2 All cable identifiers and sizes / types will be shown on the connection diagram.
3. Format:
 - 3.1 All motor connection diagrams are to be produced on a standard A1 size drawing.
 - 3.2 Space permitting, the Motor Connection Diagrams will be located together with the Motor Starter Schematics, occupying the right side of the drawing.

18.2.12 Motor Starter Schematics

1. Requirement:
 - 1.1 A dedicated motor schematic shall be prepared for every motor starter.
2. Content:
 - 2.1 The schematic will include the power distribution for the motor as well as the complete control circuit including terminal and wiring identification.
3. Format:
 - 3.1 All motor starter schematics are to be produced on a standard A1 size drawing.
 - 3.2 For typical 600V motors, with minor to medium complexity, it is typical that the motor connection diagram is integrated with the schematic on the same drawing.

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18.2.13 Panel Schedules

1. Requirement:
 - 1.1 A dedicated panel schedule shall be prepared for every panelboard and distribution panel.
2. Content:
 - 2.1 The information provided for each panel shall include in tabular format:
 - 2.1.1 Panel identifier
 - 2.1.2 Amp rating, volts, phases, wires
 - 2.1.3 Surface / flush mount
 - 2.1.4 Top / bottom feed
 - 2.1.5 Description
 - 2.1.6 Location
 - 2.1.7 Manufacturer / Model
 - 2.1.8 Interrupting Rating
 - 2.1.9 Main Breaker
 - 2.1.10 Main Breaker Settings
 - 2.2 Show for each circuit:
 - 2.2.1 Circuit number
 - 2.2.2 Load description
 - 2.2.3 Notes
 - 2.2.4 Wire size
 - 2.2.5 Breaker rating
 - 2.2.6 Load (VA)
 - 2.2.7 Phase
 - 2.3 Total Connected Load (kVA)
 - 2.4 Total Connected Load Per Phase (kVA & Amperes)
 - 2.5 Reference the applicable single line diagram feeding each panel on the drawing.
3. Format:
 - 3.1 All panel schedules are to be produced on a standard A1 size drawing in tabular format.

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18.2.14 Power Distribution Switching Diagrams

1. Requirement:
 - 1.1 Power Distribution Switching Diagrams are required for all facilities where the electrical distribution cannot fit on one or two single line drawings.
2. Content
 - 2.1 A Power Distribution Switching Diagram is utilized to represent the overall power distribution of a larger facility on a single diagram, with less detail than a Single Line Diagram. Multiple switching diagrams should be avoided if possible.
 - 2.2 The level of detail on the drawings shall be reduced to a level to allow the entire electrical distribution to be shown. A primary purpose of the drawing shall be to allow electrical maintenance personnel to perform switching. All relevant equipment identifiers associated with switching shall be shown. Include all:
 - 2.3 Switching devices including disconnects fuses, breakers, interlocks, etc.
 - 2.4 Key Interlocks including identification numbers.
 - 2.5 Equipment including transformers, generators, major pumping units, feeders and buses, etc.
 - 2.6 For facilities with medium voltage distribution, it is acceptable to limit the scope of the facility switching diagram to the medium voltage distribution system. Additional switching diagrams may be required for the low voltage distribution systems.
3. Format:
 - 3.1 All switching diagrams are to be produced on a standard A1 or A0 size drawing.

18.2.15 Single Line Diagrams

1. Requirement:
 - 1.1 Single Line Diagrams are critical and shall be prepared for every facility.
2. Content
 - 2.1 The organization of the single line diagrams is highly dependent upon the type of project, but it should be fully detailed and indicate the full electrical distribution from the source to the load.
 - 2.2 All 600V loads shall be shown in detail on the single line diagrams.
 - 2.3 Each cable shall have an identifier and cable size/type shown.
 - 2.4 Each piece of equipment shall have the equipment identifier shown, as well as major equipment ratings.
 - 2.5 Any notes or reference drawing information shall be noted on the drawing.
3. Format:
 - 3.1 All single line drawings are to be produced on a standard A1 size drawing. If a facility can not fit on a single drawing, utilize multiple drawings, preferably split per process area. See Single Line Overview Drawings for overview drawings
 - 3.2 Orient power flow vertically from top to bottom.
 - 3.3 Where possible without adding complexity to the drawing, orient loads to reflect the physical orientation as seen by someone viewing the equipment from the front. Group loads from the same vertical section of a MCC.
 - 3.4 Partial single line diagrams for renovations are not permitted.

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18.2.16 Switchgear Three-Line Diagram

1. Requirement:
 - 1.1 A switchgear three-line diagram shall be prepared for any switchgear containing PTs or CTs and associated protection or metering.
2. Content:
 - 2.1 A Switchgear Three-Line Diagram is utilized to represent the power distribution and associated protection and metering for power distribution switchgear.
 - 2.2 The appearance of a Three-Line Diagram is similar to a single Line Diagram, except each phase conductor is shown, along with all CTs, PTs, CPTs, and other protection and metering devices.
3. Format:
 - 3.1 All three-line diagrams are to be produced on a standard A1 size drawing.
 - 3.2 It is useful to contain some level of correlation in the arrangement to the actual physical orientation of the switchgear and the single line diagram.

18.3 Other Documents

18.3.1 Cable Schedule

1. Requirement:
 - 1.1 A cable schedule is required for every project.
2. Content:
 - 2.1 All power and control cables shall be uniquely identified on the cable schedule. Cables shall not be entered as typical.
 - 2.2 Where individual wires are routed in conduit, the wires shall be identified as an item in the cable schedule. This is not applicable for minor circuits, such as lighting, receptacles, etc.
 - 2.3 The cable schedule shall include the following fields:
 - 2.3.1 Cable Identifier
 - 2.3.2 Cable Type (e.g. 3C, 250 kcmil, TECK90, 1000V)
 - 2.3.3 From
 - 2.3.4 To
 - 2.3.5 Spacing (0 – 100% applicable to cables in tray)
 - 2.3.6 Length (Estimate)
 - 2.3.7 Routing (Brief description)
 - 2.3.8 Notes
 - 2.3.9 Revision of last change.
 - 2.4 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.

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18.3.2 Lamacoid Schedule

1. Requirement:
 - 1.1 A lamacoid schedule is required for every project.
 - 1.2 It has been noted 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 minimal effort above that required to thoroughly review a Contractor produced lamacoid schedule.
2. Content:
 - 2.1 All electrical lamacoids shall be uniquely identified on the lamacoid schedule, except as follows:
 - 2.1.1 Lamacoids for cables may reference the cable schedule.
 - 2.2 The lamacoid schedule shall at minimum include the following fields:
 - 2.2.1 Item
 - 2.2.2 Line 1
 - 2.2.3 Line 2
 - 2.2.4 Line 3
 - 2.2.5 Text Size
 - 2.2.6 Notes
 - 2.2.7 Revision of last change.
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.

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18.4 Design Calculations and Studies

18.4.1 General

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. Methods and calculation formulae used shall be that permitted by company approved procedures and manuals or as specifically approved for the project. The software tools or vendor packages, utilized for the required calculations must be approved by the Lead Engineer for each specific project.
3. The general requirements for design calculations and studies are identified in Table 18-1.
4. Calculations done by subcontractors, contractors or vendors will be permitted if the calculation requires specialized knowledge or experience that a typical electrical 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.
 - 4.1 If the design calculation is proposed to be performed by the Contractor or Vendor, and the City will incur an additional cost for the design calculation, the design engineer shall indicate this in their proposal to the City.
5. The calculations and studies shall only be deferred to the Contractor after review and agreement with the City.

18.4.2 Harmonic Studies

1. Harmonic studies are required to be performed prior to the installation of new non-linear loads at a facility. Manitoba Hydro mandates that the total voltage distortion (i.e. THD) must not exceed 3.5% and any individual harmonic or inter-harmonic voltage distortion must not exceed 2% at the point of common coupling and for supply voltages of 69kV and less. A harmonic study should be performed if 20% or more of the facility load consists of harmonic producing sources.
2. The harmonic study is the responsibility of the design engineer; however, the design engineer may utilize services provided by third party consultants and/or contractors with specialization in this area. In these cases, it is the responsibility of the design engineer to ensure that the calculations and recommendations meet local codes and requirements as well as all City standards and guidelines.

Table 18-1 : Design Calculations and Studies

Deliverable	Notes
Arc Flash Study	Required for all new work and the scope of the work must address the entire facility.
Cable Ampacity Calculations – Tray and Conduit	
Cable Ampacity Calculations – Underground	
Cable Pulling Calculations	Only required by the design engineer for major feeders. Contractor may be required to calculate for other cable pulls.
Cable Tray Loading Calculations	Not required for minor trays if load is self evident.
Coordination Study	
Electrical Rooms Heat Loading	Utilized for ventilation design.
Grounding Resistance Calculations	
Grounding Study	Typically only required for medium voltage systems. See Section 14.4.
Harmonic Study	Only required for systems with significant harmonic sources. See Section 18.4.2
Heat Tracing Calculations	
Lighting Illumination Calculations	
Load Tabulation	
Load Flow Study	Determine power flows and voltages in a power system. Ensure power flows are within equipment ratings. Ensure voltages are within acceptable operating limits.
Motor Starting Analysis	Typically only required for larger motors.
Power Factor Correction Calculations / Study	A formal study would only be provided for larger installations, where identified by the City as a deliverable.
Short Circuit Calculations / Study	
Soil Resistivity Survey	Typical for medium voltage systems.
Voltage Drop Calculations	Formal calculations would only be typical for major feeders. May be part of the Load Flow Study.

18.5 Example - Typical Deliverables for a Lift Station


Typical electrical deliverables for a wastewater lift station are shown in Table 18-2.

Table 18-2 : Wastewater Lift Station Electrical Typical Deliverables

Deliverable	Preliminary	Detailed Design	Notes
Single Line Diagram(s)	Y	Y	
Electrical Room Layout	Y	Y	
Cable Trench Layout		Y	
Demolition Drawings (as required)		Y	
Hazardous Location Plan		Y	
Electrical Equipment Plans (all levels)		Y	Show all equipment and convenience receptacles.
Lighting Plan (all levels)		Y	
Emergency Lighting Riser Diagram		Y	May be on lighting plans.
Distribution Panel Elevation		Y	
Motor Control Center Elevation		Y	
Motor Control Center Schedule		Y	
Panelboard Schedules		Y	
Luminaire Schedule		Y	
Emergency Lighting Battery Schedule		Y	May be on schedules drawing
Lift Pump Motor Starter Schematic		Y	Typical drawings not permitted.
Lift Pump Motor Starter Connection Diagram		Y	Typical drawings not permitted.
Panel Layout – Lift Pump Motor Starters		Y	
Motor Starter Schematics and Connection Diagrams (Other motors)		Y	Typical drawings not permitted.
Electrical Details		Y	
Telephone Network Details		Y	
Grounding Diagram and Details		Y	
Short Circuit, Coordination, and Arc Flash Study		Y	

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19 SAMPLE DRAWINGS

SK-101	Single Line Diagram, MCC-M710
SK-102	Single Line Diagram, 4160V Electrical Distribution
SK-201	Motor Starter Schematic, P-L01, Wastewater Lift Pump
SK-202	Connection Diagram, P-L01, Wastewater Lift Pump
SK-203	Motor Starter Schematic, P-M541, Sump Pump


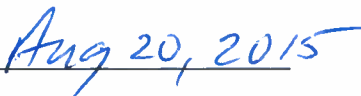


The City of Winnipeg
Winnipeg Sewage Treatment Program

Architectural Design Guideline

Document Code:

Revision: 00

Approved By:	 <hr/> Duane Griffin, Branch Head - Wastewater Planning & Project Delivery	 <hr/> Date
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REVISION REGISTER				
Rev.	Description	Date	By	Approved
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1 INTRODUCTION

This document identifies the standard architectural design requirements that are applicable to any work within the City of Winnipeg wastewater treatment facilities.

1.1 Scope of the Standard

These design requirements will apply to the following facilities:

- Wastewater treatment plants

1.2 Application

The scope and intent of this document is to convey general design guidance and expectations regarding architectural systems. This document does address specifics related to design type, selection, and configuration; however the indicated requirements are presented without knowledge of the specific building implementation. It is not within the scope of this document to provide detailed design direction, and it will be the responsibility of the respective architectural designers to fully develop the architectural details with general conformance to the concepts presented herein. This standard shall not be construed as comprehensive architectural / engineering design requirements or negate the requirement for professional architectural / engineering involvement. Any design must be executed under the responsibility and seal of the respective architect / engineer in each instance, and must be performed in conformance with all applicable codes and standards, as well as good engineering practice.

Existing facilities do not necessarily comply with this standard. The expectations regarding application of this standard to maintenance and minor upgrades at existing facilities must be assessed on a case-by-case basis; however general guidelines for application are presented as follows:

- All new buildings are expected to comply with this standard.
- All major upgrades to a building are expected to comply with this standard; however in some cases, compromise with the configuration of the existing facility design may be required.
- All minor upgrades should utilize this standard as far as practical for new work; however in some cases, compromise with the configuration of the existing facility design may be required.

1.3 Deviations from Standard

It is expected that there will be occasional situations where the design architect / engineer will propose a deviation from this design guideline. The rationale for potential deviations from the design guideline may include:

- Evolution of technology,
- Updates to standards and regulations,
- Practical limitations due to existing conditions on site, or
- Significant cost benefits to the City due to specific project constraints.

For each proposed deviation from this standard, fully complete a *WSTP Standards Deviation Form* and submit to the City project manager for approval. Do not proceed with the proposed deviation unless approval is received from the City project manager.

1.4 Acronyms and Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
AHJ	Authority Having Jurisdiction
CMU	Concrete Masonry Unit
FRP	Fibreglass Reinforced Plastic
NBC	National Building Code
NFC	National Fire Code
NFPA	National Fire Protection Association
OSHA	Occupational Safety and Health Administration
PPE	Personal Protective Equipment
STC	Sound Transmission Class
UL	Underwriters Laboratory, Inc.
ULC	Underwriters' Laboratories of Canada
WSTP	Winnipeg Sewage Treatment Program

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2 GENERAL

2.1 Design Codes and Standards

All designs shall comply with municipal, provincial, and national codes and bylaws. This includes but is not limited to:

- Manitoba Building Code (National Building Code of Canada with Manitoba Amendments)
- Manitoba Energy Code (National Energy Code with Manitoba Amendments)
- National Fire Code of Canada (NFC)

2.2 Referenced Standards

The following standards are to be referenced during the design; however application of these standards shall not necessarily be comprehensive:

- National Fire Protection Association (NFPA) standards, including:
 - NFPA 101 Life Safety Code
 - NFPA 820 Fire Protection in Wastewater Treatment and Collection Facilities

2.3 Other City Standards

1. While not exclusive, ensure that the following City Standards are adhered to:
 - 1.1 Water and Waste Department Identification Standard
 - 1.2 City Of Winnipeg Accessibility Design Standards (For Administration Buildings)

2.4 Units

All drawings and documentation shall use the International System of Units (SI units). Imperial units will be provided in parenthesis after the metric unit, where requested or appropriate. Specific requirements are as follows:

1. All building dimensions are to be in millimeters.
2. All elevations are to be in meters, in the format EL. ###.### (example EL. 273.520).

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3 BUILDING CODE CLASSIFICATION

All facilities will be designed in accordance with applicable codes for life safety, fire protection, and occupational health and safety. Only buildings having administration functionality will be designed in accordance with building code requirements for accessibility for persons with disabilities. Industrial and normally-unoccupied facilities are exempt by the building code from complying with such requirements.

It is expected that existing buildings were designed in compliance with the codes and standards applicable at that time. Renovations within existing building and upgrades limited to the equipment replacement should not typically affect building Use Group and Occupant Load classification as defined in the National Building Code of Canada (NBC). The type of the alteration and repairs within existing buildings must be reviewed with the Authorities Having Jurisdiction (AHJ) to define which areas might need further upgrades to meet current codes and standards. Ensure that buildings renovations and upgrades are carried out with the indicated design intent to maintain the degree of safety within all existing areas.

Where new structures need to be attached to existing buildings, firewall separation may need to be provided. Ensure that the proposed design approach will satisfy the requirements of applicable building code in terms of fire safety and protection for both new and adjacent existing structures.

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4 BUILDING COMPONENTS

4.1 Exterior Treatment and Materials

1. Design structure exteriors to be practical and functional with emphasis on durability and minimum maintenance requirements.
2. Ensure exteriors are complementary to existing structures on the site.
3. Consider the use of local construction materials and techniques where practical and cost effective.

4.2 Exterior Walls

1. Design exterior walls using cavity wall construction with Concrete Masonry Unit (CMU) or concrete backup wall faced with air barrier, insulation, air space, and wall facing of either:
 - Face brick
 - Architectural Concrete Masonry Unit (ACMU)
 - Stone
 - Metal siding
2. Select the facing material based on the appearance of adjacent buildings, material cost and durability.
3. Design insulation to meet the greater of the following:
 - 3.1 The requirements and recommendations of the National Energy Code; or
 - 3.2 A minimum R value of 20
4. Wall insulation requirements do not necessarily apply to tank walls.

4.3 Roofs

1. Ensure that the design arrangements of roofs, canopies, fascias, parapets, overhangs, or other roof elements will be in harmony with the massing and materials of the structures, and to control runoff and direct drainage away from equipment, doorways, sidewalks, ramps, or other occupied areas.
2. For flat roofs, provide with a with Modified Bitumen Roofing assembly. Ensure slopes to drains are provided with tapered insulation. Design overflow roof drains or scuppers to satisfy building code requirements.
3. For sloped roofs, design using an insulated metal roofing assembly.
4. Design roof assemblies to achieve a minimum R value of 40 and meet the requirements of the National Energy Code, whichever is greater.
5. Where required for equipment removal and replacement, provide removable skylights.
6. Consider the use of insulated aluminum or FRP dome covers over circular process tanks as an alternate to a conventional building roof and make a recommendation based upon the best lifecycle cost for the City.

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7. Provide access to all roof levels via maintenance access hatches or exterior caged ladders.
8. Ensure travelled pathways on the roof are protected by concrete pavers.

4.4 Exterior Doors, Windows, and Louvers

1. General Requirements
 - 1.1 Design sills, thresholds, flashing, and trim to prevent water penetration to the interior of the building.
 - 1.2 Provide corrosion-resistant hardware, accessories, fasteners, and operating mechanisms.
2. Exterior doors
 - 2.1 Use extruded aluminum sections with factory-applied protective coatings.
 - 2.2 Ensure locksets and keying arrangements match the existing keying systems with a minimum of 6 pins
3. Windows
 - 3.1 Use extruded aluminum sections with factory-applied protective coatings.
 - 3.2 Provide glazing with tinted, insulated glass. Use tinted, insulated tempered glass for exterior doors, sidelights and transoms.
4. Equipment and vehicle doors
 - 4.1 Provide motorized operation for doors frequently utilized by personnel (weekly or more frequent).
 - 4.2 Provide manual backup for emergency hand operation of motorized doors.
5. Louvres
 - 5.1 Provide extruded aluminum sections with factory-applied protective coatings.
 - 5.2 Provide storm-proof louvre assemblies complete with bird screens, filters, dampers, blank-off panels, acoustical treatment, or other required features. Design louvres to prevent infiltration of rain and provide positive drainage to the exterior.

4.5 Open Grating Platforms, Railings, Ladders and Guardrails

1. Provide permanent access ladders and working platforms as required for operation and maintenance of equipment, instrumentation, and other systems. Permanent installations are required where:
 - 1.1 Operations or maintenance access is required at a typical frequency of once a month or greater; or
 - 1.2 The hazard / risk of performing the work is not within City safe work standards.
2. Select the material for interior and exterior open grating stairs, platforms, railings, and guardrails based on the specific local conditions and exposure to corrosive materials.
3. See Table 4-1 for a general guideline of materials.

Table 4-1 : Open Grating Platforms, Railings, and Guardrails Materials

Location	Material	Notes
Exterior	Aluminum	
Interior with no / minimal chlorine content	Aluminum	
Areas with corrosive chemicals such as chlorine	FRP (Fibreglass Reinforced Plastic)	Ensure anti-slip surface finish is provided.

4. Ensure adequate fall restraint provisions for the servicing of any roof top equipment such as condensing units and around tanks or locations where there is a significant drop in elevation.

4.6 Interior Treatment and Materials

1. Design structure interiors to be practical and functional with emphasis on durability with minimum maintenance requirements.
2. Consider using local construction materials and techniques where practical.
3. Design interior components and finishes with minimum flammability and smoke developed characteristics.

4.6.2 Interior Walls

1. Design interior walls within process areas of concrete or concrete masonry units (CMU). Where sound isolation is required, design with a minimum STC of 50.
2. Design interior walls within administrative/personnel areas of metal stud framing with sound attenuation blankets and applied gypsum board as finish materials with a minimum STC of 50.
3. Where required for fire separations, design walls in accordance with recognized tested ULC assemblies.

4.6.3 Floors

1. Select floor and base materials based on a minimum maintenance requirements and durability.
2. Provide a hard surface flooring material in process areas. Provide bases of suitable material and height to protect wall finishes.
3. Locker rooms, washrooms and shower areas: Ceramic tile as floor and base finish in washroom areas.
4. Design floors, ramps, and steps with non-slip finishes. Provide abrasive nosing inserts.
5. Access ramps shall be designed to have a maximum slope of $\leq 5\%$ to ensure safe access for mobile maintenance equipment.
6. Provide anti-slip finish in areas where the floors may be slippery, such as polymer preparation rooms.
7. Provide floor slopes to drains in areas where process cleanup and hosedown may be required.

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4.6.4 Ceilings

1. Ceilings will be designed to be integrated with the building services and lighting systems. Where required, provide ceiling materials and finishes that enhance the acoustic properties of the spaces.
2. Ensure that exposed structural elements in process areas are coated with the appropriate protection system.
3. Provide suspended acoustical tile ceilings in administrative areas.

4.6.5 Interior Doors, Frames, Sidelights, Transoms, and Windows:

1. Design interior doors, frames, sidelights, transoms, and windows of appropriate materials to meet fire-ratings (as applicable) and corrosion resistance of the environment. General standards of acceptance are as follows:
 - 1.1 Use painted steel components within general interior applications and fire-rated assemblies.
 - 1.2 Use corrosion resistant components in applications where additional corrosion resistance is required.
 - 1.2.1 Consider the use of aluminum components in spaces with moderate H₂S gases, but no chlorine content.
2. Provide glazing in the upper half of all interior doors except for bathrooms, janitor closets and private offices.
3. Provide clear tempered glazing for all interiors where glazing is not required to be labelled as a fire separation.
4. Provide corrosion-resistant hardware, accessories, fasteners, and operating mechanisms.
5. Ensure room identification is provided on all interior doors.

4.6.6 Roof Access, Hatches and Floor Doors

1. Specify roof access hatches and floor doors as manufactured items.
 - 1.1 This does not eliminate the requirement of the engineer to fully detail out the configuration, dimensions, opening mechanism and other relevant details.
2. Unless in an area with chlorine content, design single or double leaf units to utilize aluminum components.
3. Provide for locking.
4. Design units subject to vehicle traffic for AASHTO H-20 loading, as a minimum. Higher ratings shall be provided based on the vehicles utilized.
5. Ensure that the units can be safely operated by personnel without the use of special equipment, such as a portable crane. Access hatched shall be hinged and manual lifting weight shall be limited to 23kg (50lb).

4.6.7 Painting and Protective Coatings

1. Where practical, the design should include factory finishes of interior items.
2. Provide field-applied finishes and protective coatings to all other building elements that are not supplied with factory-applied protective coatings.
3. Ensure coatings provide long-term service use with minimum maintenance requirements.

4.6.8 Chemical Resistant Coating Systems

1. In secondary containment areas, design chemical resistant coating systems to provide a minimum of 48-hour immersion protection against spills or leaks of stored chemicals.
2. Concrete coating systems shall include primer, fibreglass mat, saturant, and two trowel-applied coats of vinyl ester resin with silica filler.
3. Provide anti-slip finish on all horizontal surfaces with chemical resistant coating systems.

4.6.9 Noise Control

1. Perform noise calculations as indicated in Section 5.4.1. Coordinate with other disciplines as required.
2. Design appropriate acoustical treatment for areas subject to elevated noise levels.
3. Design the following spaces with indicated maximum ambient noise levels:

3.1	Administration & Office Spaces	50 dBA
3.2	Main Control Room	50 dBA
3.3	Control Rooms (Other than main)	55 dBA
3.4	Electrical Rooms	60 dBA
3.5	Server Rooms	70 dBA
4. Design all installations to meet the noise exposure limits as defined by the Manitoba Workplace Safety and Health Regulation (217/2006). An excerpt is included below for reference:

Hearing protection

12.3 *If a worker is or is likely to be exposed to noise in a workplace that exceeds 80 dBA Lex but does not exceed 85 dBA Lex, the employer must*

(a) inform a worker about the hazards of the level of noise; and

(b) on the request of the worker, provide him or her with

(i) a hearing protector that complies with CAN/CSA Standard-Z94.2-02, Hearing Protection Devices X Performance, Selection, Care, and Use, and

(ii) information about the selection, use and care of the hearing protector.

Control measures if exposure exceeds 85 dBA Lex

12.4(1) *When a noise exposure assessment conducted under this Part indicates a worker is exposed to noise in the workplace that is more than 85 dBA Lex, and if reasonably practicable, an employer must implement sound control*

measures that reduce the noise to which the worker is exposed to 85 dBA Lex or less.

12.4(2) *When it is not reasonably practicable to implement sound control measures, or the sound control measures implemented by an employer do not reduce the worker's noise exposure to 85 dBA Lex or less, an employer must*

(a) inform the worker about the hazards of the level of noise;

(b) provide the worker with

(i) a hearing protector that

(A) complies with CAN/CSA Z94.2-02, Hearing Protection Devices X Performance, Selection, Care, and Use, and

(B) reduces the worker's noise exposure to 85 dBA Lex or less, and

(ii) information about the selection, use and care of the hearing protector; and

(c) at the employer's expense, provide the worker with the following audiometric tests:

(i) an initial baseline test as soon as is reasonably practicable but not later than 70 days after the worker is initially exposed to that noise level,

(ii) a further test at least once every year after the initial baseline test.

5. The acceptable noise level depends on the time of the exposure and the noise source. Absolute maximum noise exposure limits are indicated in Table 4-2; however these limits do not necessarily indicate minimum design requirements.

Table 4-2 : Noise Exposure Level Limits

Noise Level dbA	Maximum Permitted Daily Duration (Hours) (1)
85	8
88	4
91	2
94	1
97	0.5
100	0.25

Notes:

1. *Table 4-2 is based upon Canadian Center for Occupational Health and Safety requirements. The table is provided for reference and does not necessarily indicate minimum design requirements.*

6. The following shall be utilized as guidance regarding application of Manitoba Workplace Safety and Health Regulation clause 12.4(2), which provides an exemption regarding practicality of sound control measures.
- 6.1 The requirements of Table 4-3 are considered to be minimum requirements where acoustical treatment, noise reduction and/or reduction of worker exposure are required.
- 6.2 Where the calculated noise exposure for any space is above 85 dB after any proposed mitigation, provide complete documentation indicating the design rationale and demonstrating impracticability of further noise reduction.
- 6.2.1 Include operating assumptions.
- 6.2.2 Include applicable information from manufacturers.
- 6.2.3 Include calculations.
- 6.3 Design installations with high noise levels such that operational and maintenance activities in the space are minimized. For example, additional automation, locating control panels outside the room and providing a window to view the equipment from outside the room may reduce noise exposure.
- 6.4 Cost factors may be utilized as an argument regarding practicality only where approved by the City.

Table 4-3 : Acoustical Treatment Minimum Requirements

Typical Operational Use (1)	Maximum Noise Level dbA	Noise Level Without Treatment dbA	Acoustical Treatment / Noise Reduction Required	Hearing Protection PPE Requirements
Occupancy >= 2h / day	85	<= 85	No	N/A
		> 85	Yes	
Occupancy: 1 – 1.9h / day	88	<= 88	No	Mandatory (2)
		> 88	Yes	
Occupancy: 0.5 – 0.9h / day	91	<= 91	No	Mandatory (2)
		> 91	Yes	
Occupancy: 0.26- 0.5 / day	94	<= 94	No	Mandatory (2)
		> 94	Yes	
Occupancy: 0.01- 0.25 / day	97	<= 97	No	Mandatory (2)
		> 97	Yes	
Unoccupied spaces	115	> 115	Yes	Mandatory (2)

Notes:

- Operational Use is based upon typical daily operations, not including infrequent maintenance or special operating scenarios.
- As per the Manitoba Workplace Safety and Health Regulation, hearing protection PPE is required for all spaces with a noise level above 85 dBA.

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3. *Hearing protection is not readily available for noise levels above 115 dB, and thus shall be considered an upset maximum limit for noise exposure for any space, regardless of occupancy.*

7. Where practical, select / specify / design equipment such that noise is reduced at the source.
 - 7.1 Utilize acoustical equipment covers where appropriate / required.

8. Design acoustical wall and ceiling panels to reduce ambient noise levels in rooms requiring acoustical treatment, in accordance with Table 4-3:
 - 8.1 The type and location of the acoustical panels shall be incorporated into the design drawings. This may require that an acoustical sub-consultant be utilized during the design phase.
 - 8.2 Coordinate the location of the panels with the equipment, piping and ducting, cabling, lighting etc.
 - 8.3 Ensure that the acoustical panels do not impede operation or maintenance activities.

9. For very high noise areas, consider whether access to the space should be provided with a vestibule to buffer the noise.

10. Spaces with noise levels above 85 dBA shall not be pathways through the plant required to access or egress from a space. For example, it shall not be required to pass through a noisy compressor room to reach a quieter mechanical room to change a filter.

11. For spaces with noise levels above 85 dBA the designer shall:
 - 11.1 Provide and document administrative controls to minimize worker exposure to the high noise levels.
 - 11.2 Minimize the instrumentation and other maintainable equipment within the noisy space. For example, control panels shall be located outside the noisy area. Coordinate with other disciplines as required.

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5 ARCHITECTURAL DESIGN TEAM RESPONSIBILITIES

5.1 General

1. Responsibility for deliverables
 - 1.1 All drawings and other deliverables related to a design are the responsibility of the design architect / engineer.
2. Ensure all architectural deliverables are sealed by a qualified professional architect / engineer.
3. Completeness of drawings:
 - 3.1 All drawings shall be comprehensive in nature to allow for effective use in construction.
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. Coordinate with the City to understand the specific requirements. Typical requirements include.
 - Update existing building floor plans.
 - The update of architectural detail drawings for existing works is not expected to be required.
5. Design reviews:
 - 5.1 Issue the design documents to the City for review at appropriate intervals in accordance with the City's expectations.
 - 5.2 Incorporate all WSTP comments into the design. Where a WSTP comment is not accepted by the design team, provide a complete response, including rationale, to the City Project Manager.
6. As-Built Drawings:
 - 6.1 All architectural deliverables shall be updated to "as-built" status at the end of the project. The "as-built" documents shall incorporate contractor mark-ups and all relevant information from inspections performed by the design team, change orders, RFIs, and other communication between the Contractor and Design Team.
 - 6.2 Unless otherwise specified by the City and agreed to by the Design Team, as-built drawings are not required to be sealed (Otherwise known as record drawings).
7. External, 3rd Party Consultants:
 - 7.1 Expertise and assistance may be required, from external 3rd party specialized consultants, outside of the primary architectural / design team.
 - 7.2 Areas where an external 3rd party consultant may be utilized, with permission from the City, are:
 - Fire protection systems.
 - Acoustic systems
 - 7.3 The design team shall be responsible for monitoring the activities and progress of each 3rd party consultant.
 - 7.4 It is the responsibility of the design architect/engineer to ensure that the deliverables follow all City standards and guidelines.

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8. Site Visits:
 - 8.1 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 buildings.
9. Demolition Requirements
 - 9.1 It is generally required that the architect / 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.
 - 9.2 Where demolition requirements are significant, create dedicated demolition drawings.

5.2 Drawings

The drawings indicated in this section are minimum requirements for new construction, unless otherwise approved by the City.

5.2.1 General Requirements

1. Provide scale bar on all scaled drawings to allow for measurement takeoff and avoid any potential confusion regarding scale, regardless of the format or size reproduction of the document.
2. Show a north arrow on all plan drawings.

5.2.2 Legend

Provide a legend drawing showing the symbols and abbreviations utilized. Ensure that the legend is consistent with the City's practices.

5.2.3 Building Code Matrix

1. Provide a building code matrix for all new and modified buildings.

5.2.4 Life Safety Plan

1. Provide a life safety plan showing all occupied areas of the facility along with egress paths and distances to the nearest exit.

5.2.5 Floor Plans

1. Provide detailed floor plans for all building elevations.
2. Ensure all rooms are identified in a manner consistent with the Identification Standard.
 - 2.1 Ensure that the proposed room numbering coexists with the existing room numbering at the facility.

5.2.6 Elevation Drawings

1. Provide detailed building elevation drawings for all building exterior faces.
2. Ensure all exterior materials are clearly identified.

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5.2.7 Stair Plan and Sections

1. Provide a comprehensive set of building stair plans and section drawings.
2. Ensure all materials of construction and dimensions are clearly identified.

5.2.8 Building Section and Detail Drawings

1. Provide a comprehensive set of building section and detail drawings to fully describe the construction of the building.
2. Ensure all materials of construction and dimensions are clearly identified.

5.2.9 Schedule Drawings


1. Provide a room finish schedule.
2. Provide a louvre schedule.
3. Provide a door schedule complete with hardware data and room identification requirements.
4. Provide a hatch schedule.

5.2.10 Window Elevation Drawings

1. Provide window elevation drawings for all large multi-panel windows.

5.2.11 3D Model

1. When 3D design is required by the City, or proposed by the Consultant, this section shall be complied with in its entirety. 3D models and associated drawings are not mandatory for all projects.
2. The 3D model shall include all architectural elements to allow for full representation of the entire facility, including all other disciplines.
3. In addition to the 3D model provide:
 - 3.1 3D elevation and section drawings to convey the complete building configuration.
 - 3.2 3D detail drawings of all areas with significant interdisciplinary coordination requirements.

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5.3 Fire Safety Plan

1. Prepare drawings to be updated or included in the facility Fire Safety Plan, in accordance with the Guidelines for Preparation of Fire Safety Plans and Required Maintenance Procedures for all buildings coming under the Manitoba Fire Code, as adopted by the Fire Prevention By-Law 150/2004. The drawings required are as follows:
 - 1.1 Site plan showing at minimum: gas shut-off, electrical shut-off, fire hydrant, and muster/meeting points. Provision of this plan is required where the project work modifies the site plan in any way.
 - 1.2 Fire plan drawings for each level of each building showing at minimum emergency exits, fire alarm pull stations, fire extinguishers, fire alarm control panels, fire dept. access, electrical shut-off, gas shut-off, self-contained breathing apparatus, primary exit routes, emergency generator location. Provision of these drawings is required for any building where the project work modifies the fire safety plan in any way.
2. Incorporation of the drawings provided and packaging of the complete fire safety plan will be by the City.

5.4 Calculations

5.4.1 Noise Calculations

Coordinate with other disciplines and provide noise calculations, based upon design equipment and materials, for all rooms and spaces with noise levels above 80 dBA. Coordinate with other disciplines as required. The calculations are to be performed and presented to the City during the detailed design stage, prior to construction.


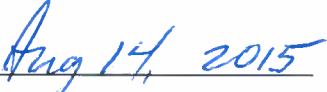
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The City of Winnipeg
Winnipeg Sewage Treatment Program

Building Mechanical Design Guideline

Document Code:
 Revision: 00

Approved By:	 Duane Griffin, Branch Head - Wastewater Planning & Project Delivery	 Date
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REVISION REGISTER				
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1 INTRODUCTION

This document identifies the standard building mechanical design requirements that are applicable to any work within the City of Winnipeg wastewater treatment facilities.

1.1 Scope of the Standard

These design requirements shall apply to the following facilities:

- Wastewater treatment plants

1.2 Application

The scope and intent of this document is to convey general design guidance and expectations regarding building mechanical systems. This document does address specifics related to design type, selection, and configuration; however the indicated requirements are presented without knowledge of the specific building mechanical system implementation. It is not within the scope of this document to provide detailed design direction, and it will be the responsibility of the respective building mechanical and HVAC designers to fully develop the system details with general conformance to the concepts presented herein. This standard 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 engineer in each instance, and must be performed in conformance with all applicable codes and standards, as well as good engineering practice.

Existing facilities do not necessarily comply with this standard. The expectations regarding application of this standard to maintenance and minor upgrades at existing facilities must be assessed on a case-by-case basis; however general guidelines for application are presented as follows:

- All new buildings are expected to comply with this standard.
- All major upgrades to a building are expected to comply with this standard; however in some cases, compromise with the configuration of the existing facility design may be required.
- All minor upgrades should utilize this standard as far as practical for new work; however in some cases, compromise with the configuration of the existing facility design may be required.

1.3 Deviations from Standard

It is expected that there will be occasional situations where the design architect / engineer will propose a deviation from this design guideline. The rationale for potential deviations from the design guideline may include:

- Evolution of technology,
- Updates to standards and regulations,
- Practical limitations due to existing conditions on site, or
- Significant cost benefits to the City due to specific project constraints.

For each proposed deviation from this standard, fully complete a *WSTP Standards Deviation Form* and submit to the City project manager for approval. Do not proceed with the proposed deviation unless approval is received from the City project manager.

1.4 Acronyms and Abbreviations

ACH	Air Changes per Hour
AHU	Air Handling Unit
ANSI	American National Standards Institute
ASHRAE	American Society of Heating, Refrigerating, and Air Conditioning Engineers
CGA	Canadian Gas Association
CSA	Canadian Standards Association
CO	Carbon Monoxide
DX	Direct Expansion
FRP	Fiber Reinforced Plastic
H ₂ S	Hydrogen Sulphide
HVAC	Heating Ventilation and Cooling
MAU	Make-up Air Unit
MCC	Motor Control Center
MERV	Minimum Efficiency Reporting Value
NBC	National Building Code
NFC	National Fire Code
NFPA	National Fire Protection Association
PLC	Programmable Logic Controller
RH	Relative Humidity
PCS	Process Control System
SMACNA	Sheet Metal and Air Conditioning Contractors National Association
UL	Underwriters Laboratory, Inc.
VFD	Variable Frequency Drive
WSTP	Winnipeg Sewage Treatment Program

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2 GENERAL

2.1 Design Codes and Standards

All designs shall comply with municipal, provincial, and national codes and bylaws. This includes but is not limited to:

- National Building Code of Canada with Manitoba Building Code Amendments
- National Energy Code of Canada for Buildings 2011
- National Fire Code of Canada
- Province of Manitoba Workplace Health and Safety Act
- City of Winnipeg WWD Hydrogen Sulphide Monitoring Program
- National Plumbing Code of Canada with Manitoba Plumbing Code Amendments
- CSA B149.1-10 Natural Gas and Propane Installation Code
- ANSI Z358.1-2009, Standard for Emergency Eyewash and Shower Equipment
- CSA B64.4-11 Reduced Pressure Principle (RP) Backflow Preventers
- CSA B64.5-11 Double Check Valve (DCVA) Backflow Preventers

2.2 Referenced Standards

The application of NFPA 820 Standard for Fire Protection in Wastewater Treatment and Collection Facilities shall be as per Section **Error! Reference source not found..**

The following standards are to be referenced during the design; however application of these standards will not necessarily be comprehensive:

- ASHRAE Standard 62.1 Ventilation for Acceptable Indoor Air Quality
- NFPA 90A Standard for the Installation of Air Conditioning and Ventilation Systems
- ASHRAE Standard 90.1 for building energy efficiency

2.3 Other City Standards

1. While not exclusive, ensure that the following City Standards are adhered to:
 - 1.1 Water and Waste Department Identification Standard
 - 1.2 WSTP Piping Color Standard
 - 1.3 WWD Hydrogen Sulfide Monitoring Program

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2.4 Units

All drawings and documentation shall use the International System of Units (SI units). Imperial units may be provided in parenthesis after the metric unit, where requested or appropriate. Specific requirements are as follows:

1. All building dimensions shall be in millimeters.
2. All elevations shall be in meters, in the format EL. ###.### (example EL. 273.520)
3. All pipe sizes to be in mm.
4. All duct sizes to be in mm.
5. All liquid flow rates shall be l/s.
 - 5.1 Alternate units may be considered for flows less than 0.1 l/s or greater than 10,000 l/s.
6. All airflow rates shall be in l/s.
 - 6.1 Design airflow rates shall also be expressed in ACH for process areas.
7. All liquid pressures shall be in kPa (kilopascals).
8. All HVAC air pressures shall in Pa (Pascals).

3 HVAC SYSTEMS

3.1.1 General Requirements

1. General design concept for the entire system shall be well defined.
2. Ensure each system is designed to be complete in every respect for a trouble free operation, including AHU's, fans, pumps, expansion units, ducting, refrigerant and drain piping, thermal and vapor insulation for ducts and pipes, grilles, registers, diffusers, louvers, dampers, sound attenuators, vibration isolators, air coolers, electric air heaters, air filters, etc.
3. Ensure design takes into consideration sufficient redundancy capacities (see Section 3.4.4) and safety margins.

3.2 Design Parameters

3.2.1 Outdoor Design Parameters

1. Ensure outdoor design parameters based on NBC design data for Winnipeg weather conditions are followed:

Table 3-1 : Outdoor Temperature Design Criteria

Winter:	-35°C DB (Dry Bulb)
Summer:	30°C DB (Dry Bulb)
	23°C WB (Wet Bulb)

3.2.2 Indoor Temperature

- The design of building HVAC system shall be carried out based on the criteria below:

Table 3-2: General Indoor Design Criteria

Space	Heating ¹	Cooling ²	
	Design Temp	Design Temp	Type ³
Administration / Office	20°C	22°C	M
Control Room	20°C	22°C	M
Generator Room	18°C	35°C	HR
Blower room	18°C	35°C	HR
Process Area	18°C	35°C	M
Chemical Area	18°C	35°C	HR
Mechanical Room	18°C	35°C	HR
Electrical Room	20°C	27°C	M
Electrical Room – Small & Non-Critical ⁴	20°C	35°C	M / HR
Server Room	20°C	21°C	M
Storage room	18°C	-	-
Washroom and Janitor Room	18°C	30°C	V
Gallery/Tunnel	18°C	-	-
Vestibule, Stairs	18°C	-	-

Notes:

- The heating design temperatures are minimum indoor temperatures under the coldest design day condition.
 - The cooling design temperatures are maximum minimum temperatures under the hottest design day condition.
 - HR= Heat Relief (does not imply air conditioning), *M=Mechanical, *V=Ventilation
 - Electrical Rooms may only be considered small if they distribute power for less than 100 KVA of load. Electrical rooms may only be considered non-critical if the loads powered from the room can be turned off at any time for a complete day with minimal consequence. An example of a small electrical room would be an electrical room for a small storage building.
- The design shall allow for occupied and unoccupied temperature setpoints.
 - Provide recommended initial setpoints for occupied and unoccupied states in both heating and cooling modes.
- Ensure the minimum and maximum temperature setpoints are specified to protect the assets.
 - Ensure that the minimum temperature setpoint protects against freezing and protects the asset to achieve the expected asset life.
 - Ensure the maximum temperature setpoint is set to provide the expected asset life.

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3.2.3 Humidity Control Criteria

1. Humidity control shall be considered in specific areas if deemed necessary where sensitive electrical equipment is present such as the server room, control room and electrical rooms. Where humidity control is necessary, effort shall be taken to maintain humidity levels at % R.H 50±10.

3.2.4 Noise Criteria

1. Refer and adhere to the noise control criteria as defined in the WSTP Architectural Design Guideline.
 - 1.1 Provide noise attenuation such as acoustical enclosures when the equipment has a high noise level and is located in a regularly accessed area which would impact on operations. It shall be noted that fan selection shall not be based solely on noise generation.
2. Ensure that the air handling units and make-up air units are equipped with internal vibration isolators or pads and insulation on casing.
3. Provide duct silencers for the exhaust/supply fans if required to minimize the HVAC equipment noise level.
4. Provide silencers for generator rooms and blower room air intake and exhaust louvers to meet the design criteria.
5. Specify equipment noise limits based upon acceptable noise levels.
6. Ensure the design takes into account the cumulative noise impact of all equipment operating simultaneously.

3.3 Space Pressurization

1. In general, ensure that negative pressure (approx. -25 Pascal) is maintained for process areas where odour or off-gas occurs in accordance with NFPA 820.
2. Ensure ventilation systems serving the control rooms, electrical rooms and administration office area keep a positive pressure of roughly 25 Pascal under all operating conditions.

3.4 Design Requirements

3.4.1 Protection against Fire and Explosion Hazards

1. Application of NFPA 820 shall be comprehensive, except as approved by the City during the preliminary design phase of a project.
2. Preliminary design stage:
 - 2.1 During the preliminary design stage, review and make recommendations regarding the application of NFPA 820 to the project. Review the lifecycle capital and operating costs for the proposed ventilation rate and associated electrical classification.
 - 2.1.1 Consider heating costs in the application of NFPA 820.
 - 2.1.2 Propose ventilation rates to the City for review, along with corresponding annual heating costs.

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2.1.3 Review the proposed ventilation strategy with the City and implement as per City direction.

3. Electrical classification vs. ventilation:

3.1 For many spaces, NFPA 820 permits a lower ventilation rate provided that a higher level of electrical classification is provided. The higher ventilation rate and lower electrical classification shall be utilized in all cases, except as follows:

3.1.1 The total lifecycle costs of the higher ventilation rate is significantly greater than the lifecycle costs of electrical classification;

3.1.2 The proposed lower ventilation rate will provide adequate ventilation to remove any toxic gases, including H₂S, in any area that is routinely occupied;

3.1.3 The proposed ventilation rate and electrical classification does not impede maintenance activities; and

3.1.4 The proposed lower ventilation rate is accepted by the City.

3.2 In spaces that are routinely occupied or have a significant level of maintenance requirements, an electrical classification of Class I, Zone 1 (Div. 1) presents much greater maintenance challenges than a Class I, Zone 2 (Div. 2) electrical classification. The City will not typically accept a Class I, Zone 1 (Div. 1) electrical classification in any routinely occupied space or a space with significant maintenance requirements.

3.4.2 Protection Against Toxicity Or Biological Hazards

1. Provide appropriate ventilation to address toxic and/or biological hazards to allow personnel to enter all spaces requiring routine access without special entry requirements. This may require ventilation over and above that required in Section 3.4.1.
2. Ventilation at the source of the hazard is preferred to minimize overall ventilation requirements.

3.4.3 General Ventilation Requirements

1. Follow ASHRAE and National Fire Code guidelines as well as good practice for ventilation requirements in chemical areas.
2. For non-process area or auxiliary area and service areas, ventilation shall follow ASHRAE 62.1 for minimum outdoor air and exhaust.
3. For areas with no established standards (NFPA 820, ASHARE and NFC), design the ventilation in terms of air changes to follow good engineering practice in Manitoba. Consider heating costs when determining proposed ventilation rates.
4. Ensure that ventilation air flow rates into air-conditioned areas are included in the cooling load calculations.
5. Ensure spaces are pressurized such that leakage airflow is from the cleanest space to the most odorous space.
 - 5.1 Utilize NFPA 820 as a guide for space pressurization.
 - 5.2 Electrically classified spaces shall always be negatively pressurized.
 - 5.3 Electrical and control rooms shall always be positively pressurized.
 - 5.4 Ensure that harmful gases do not migrate into stairwells or escape routes.
6. Where gas detection systems are provided, ensure that a hardwired interlock is provided to engage the high-rate of ventilation (if provided). In addition to the ventilation interlock, all gas

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detection systems shall provide the current detected gas level to the PCS, except that this requirement is not mandatory for carbon monoxide sensors.

7. Provide low and high speed control ventilation system for chemical areas with dual ventilation rates via VFD control to meet ventilation requirements as per National Fire Code and ASHRAE standards.
8. Provide local exhaust fans for washrooms and janitor rooms as required.

3.4.4 Equipment Redundancy

1. Provide ventilation system redundancy where required. Minimum requirements are as follows:
 - 1.1 For routinely occupied areas (frequency of daily or greater) with a direct source of odorous, toxic or combustible gases (such as open tank areas), ensure that at minimum 50% of the maximum ventilation rate can be provided with any single point of mechanical failure. Provide parallel fans as required.
 - 1.2 For electrically classified spaces, supply and exhaust fans shall be redundant such that at minimum 50% of the maximum design ventilation rate is provided upon fan failure. Higher level of redundancy requirements shall be evaluated on a case-by-case basis.

3.4.5 Heating Systems

1. The use of central hot water boilers to service the heating loads of sewage treatment facilities is preferred. In case of additions or modification to a facility, review hydronic heating systems and central boilers serving the existing facility to determine whether upgrades are warranted to accommodate the new increased heat loads.
 - 1.1 Hot water coils shall not be utilized for applications heating outdoor air. Utilize a heat exchanger loop with glycol running through coil to prevent coil freezing in event of a system failure.
 - 1.2 Boiler water treatment is required for all boiler systems.
 - 1.3 Provide automation for boiler water treatment systems to limit operational involvement.
2. Gas fired air-handlers are preferred in areas of the facility where the use of hydronic heating is not practical.
3. Electric heat may be utilized where hydronic or gas-fired heating is not practical.

3.4.6 Heat Recovery

1. Heat recovery systems shall be investigated for all systems with airflows greater than 1000 l/s. Consider both flushing water heat recovery and glycol runaround loops. Other heat recovery technologies may be considered for clean-air applications.
 - 1.1 Calculate the capital, operating and maintenance costs for the entire lifecycle of the facility. Calculate the economic payback of the heat recovery system. Consider available subsidies from local utilities (i.e. Manitoba Hydro).
 - 1.2 Provide written recommendations to the City.
2. Unless otherwise directed by the City, provide heat recovery systems for all systems where there is an economic payback of less than ten years. Where the economic payback is greater than ten years, proceed based upon direction of the City.

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3.4.7 Air Conditioning System

1. Provide DX split AC unit or air handling unit with built-in DX refrigerant coil and outdoor air-cooled condenser for control rooms, server rooms and main electrical rooms for cooling in summer to meet required indoor design temperature.
2. Size air conditioning system based on the heat gains from the electrical and control equipment in the associated space plus the ventilation loads and base loads from the building structures.
3. Ensure sufficient safety margin is taken into account in all design calculations.

3.5 Equipment and Material Design Requirements

3.5.1 General Layout Requirements

1. Ensure all equipment is accessible and has clearance to allow for maintenance.
2. Provide a minimum of 1000 mm clearance in front of all equipment.
3. For all equipment with a motor power rating of 7.5 kW (10 hp) or greater, provide a minimum clearance of 800mm between the outermost extremities of adjacent pieces of equipment, and between a wall and the equipment.
4. Provide a minimum of 800mm clearance between open doors (including electrical panel doors) and adjacent pieces of equipment, walls or obstacles.
5. Ensure adequate clearance above or below units is provided for the lifting / removal down of equipment for repair or replacement. Ensure clearance is provided for anchored/load rated lifting devices.
6. Provide sufficient clearances for removal and refitting of the serviceable components of all installed equipment without removal or dismantling of other equipment or assets. For clarity this includes planned service requirements throughout the life of the asset and non-routine unplanned failures.
 - 6.1 Provide sufficient clearances to replace air handling unit filters.
7. Provide sufficient clearances to replace air handling unit coils and fans.
8. Coordinate clearances with all engineering disciplines to ensure that the final commissioned installation meets all clearance requirements.
9. Locate equipment outside of corrosive locations. HVAC equipment may only be installed in corrosive locations with the approval of the City.
10. Equipment shall be located such that accumulation of snow on the roof does not hinder their operation, either under normal or extreme snow conditions.
11. Equipment should be located at sufficient distance from the edge to avoid use of barricades. Alternately, provide permanent guardrails to allow for safe working access to all maintainable aspects of the equipment.
12. Dampers
 - 12.1 Ensure dampers and damper actuators are accessible.
 - 12.2 Provide hinged access doors for actuated dampers to allow for maintenance.
 - 12.3 Locate motorized dampers (and pneumatic dampers where applicable) in indoor locations. Outdoor applications of motorized dampers should be avoided if possible.

3.5.2 Outdoor Air Filtration Criteria

1. Provide outdoor air filtration in accordance with Table 3-3.

Table 3-3: Outdoor Air Filtration Criteria

Filtration Type	Description	Typical Application
A	Pre-filter MERV ¹ 8 (30~35 percent efficiency), Chemical Filters Stage 1 & Stage 2, After-filter and Final filter MERV ¹ 13 (80~90 percent efficiency)	Control Rooms, Server Rooms & Electrical Rooms where corrosive gases may be present
B	Pre-filter MERV ¹ 13 (80~90 percent efficiency)	Administrative Areas Control Rooms, Server Rooms & Electrical Rooms where corrosive gases are not typically present
C	Pre-filter MERV ¹ 8 (30~35 percent efficiency)	Process Areas

Note(s):

1. *Minimum Efficiency Reporting Value (MERV) for filters as per ASHRAE Standard 52.2.*
2. Provide bird screens for rooftop air handling unit intake louvers.
3. Provide air filters for air handling units or make-up air units with differential pressure gauges and switches that will automatically alert plant personnel via the PCS when filters require replacement.
4. Where there is a potential for corrosive gases, ensure stage 1 (carbon) and stage 2 (permanganate) filters are provided for control rooms and electrical rooms or MCC rooms air handling units or pressurization units to filter the hydrogen sulphide in the air intake stream.
 - 4.1 Provide additional filter stages as required to address the atmosphere present.
 - 4.2 Coordinate with the City to ensure the filter size is compatible with existing equipment to reduce the number of filter types the City needs to manage.

3.5.3 HVAC Equipment Selection Criteria

1. Provide corrosion resistance for HVAC equipment by using chemical resistant coatings on HVAC equipment, or using FRP or stainless steel exhaust fans in corrosive environments.
2. Provide premium efficiency motors.
3. Ensure provision of removable insect screens for any air intake dampers and supply fans and also on the vent ducts/pipes for process as required.
4. Provide AMCA Type A or Type B spark resistant fans in all fans serving electrically classified spaces.

3.5.4 Ductwork

1. Provide ductwork as per the below criteria:

Location	High Humidity	Corrosive Gases or Chemicals	Material	Notes
Process Areas	No	No	Aluminium	
	Yes	No	Aluminium	
	Yes	Mild H ₂ S	Aluminium	
	Yes	Yes	FRP Stainless Steel	Potential for corrosion. Select appropriate corrosion resistant material.
Non-process areas.	No	No	Aluminum or Galvanized steel	

2. Ductwork specifications shall be written such that Sheet Metal and Air Conditioning Contractors National Association (SMACNA) standards for duct construction are adhered to. This standard stipulates duct thickness based on size and pressure ratings.
3. Utilize round ductwork wherever possible. Where rectangular ductwork is required, limit aspect ratios to a maximum of 4:1.
4. Ensure that the maximum duct pressure drop is 25 Pascal per 30 metres of duct.
5. Provide access doors where required for inspection and maintenance, including but not limited to control dampers and fire dampers.

3.6 HVAC System Monitoring and Controls

3.6.1 HVAC Controls

1. All HVAC control and monitoring shall be by PLC, consistent with the WSTP Automation Design Guide. No exceptions shall be permitted except for the following:
 - 1.1 Natural gas fired air handlers may utilize proprietary packaged controls for the natural gas burner and associated devices. However, the proprietary packaged controls shall not monitor or control any equipment or instrumentation outside of the air handler unit. Any liquid coils in the air handler shall be controlled by the PLC.
 - 1.2 Boilers and chillers may utilize packaged controls that do not fully comply with the WSTP Automation Design Guide. Ensure sufficient integration into the plant PCS to meet operational requirements.
 - 1.3 Small out-buildings with a ventilation rate of 100 l/s or less may utilize non-PLC based controls, provided the control is very basic. For example, a single unit heater may be controlled by a wall-mounted thermostat.
2. All HVAC systems shall be monitored by the plant PCS.
3. Provide room temperature sensors for control and monitoring. Provide low and high temperature alarms to operations personnel via the PCS.

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4. Unit heater control (including all mounted baseboard heaters, convectors, etc.):
 - 4.1 Ensure all heater control is integrated into the overall PLC based control system. Ensure that simultaneous heating and cooling of the space is prevented.
 - 4.2 Where there is a risk of building freezing due to the PLC being out of service, provide backup thermostats to override the PLC control upon low temperature.
5. Provide duct smoke detectors only where required by the National Building Code or local code requirements.
6. Install freeze stats for hydronic heating coils and glycol heat recovery coils of air handling units or make-up air units.
 - 6.1 Ensure provision of a freezing alarm to the plant PCS.
7. Provide normal (low) ventilation and emergency (high) ventilation for air handling units, make-up air units or supply/exhaust fans designed for chemical areas.
 - 7.1 High speed ventilation shall be triggered by a local push button manually outside of the entrance of chemical areas to activate the emergency exhaust fans and supply fans.

3.6.2 Gas Detection

1. General Requirements
 - 1.1 Provide gas detection systems to monitor all potential hazardous gases, considering that the wastewater treatment plants service a combined sewer collection system.
 - 1.2 A sufficient quantity of gas detection systems shall be provided to adequately cover the space. Do not assume that a single gas detection sensor is sufficient to cover an entire room or space.
 - 1.3 Ensure gas detection systems are located appropriately to detect hazardous gases within the coverage area. Review ventilation flow patterns and locate the sensors appropriately. For example, it is not appropriate to locate a gas detection sensor adjacent to a supply air grille.
 - 1.4 Locate gas detection systems at the appropriate elevation, considering the hazardous gas density, ventilation patterns, and location of personnel.
 - 1.5 Where a dual-rate ventilation system is provided, interlock the gas detection with the ventilation system to ensure that a high-rate of ventilation is provided upon detection of a hazardous gas.
 - 1.6 Ensure provision of detected gas levels to plant PCS. The only exception is that carbon monoxide sensors may simply transmit an alarm to the plant PCS.
2. Provide H₂S sensors for process areas with a risk of hydrogen sulphide.
 - 2.1 When the hydrogen sulphide level in the associated space exceeds the pre-set monitoring level, as per the City of Winnipeg's WWD Hydrogen Sulphide Monitoring Program criteria, the ventilation system shall remain at a high-flow rate to provide required air changes for classified areas per NFPA 820.
3. Provide a Combustible Gas Detection system for process areas as required by NFPA 820 and interlock with space ventilation or odour control make-up air system when gas levels exceed 10 percent of the lower explosive limit as per NFPA 820.
4. Provide Carbon Monoxide (CO) sensors for direct gas-fired air handling units or make-up air units to monitor incomplete combustion of the natural gas. When CO levels of the unit discharge air is higher than the pre-set point, ensure that the unit gas burner automatically shuts down.

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5. Provide Oxygen Deficiency sensors in spaces where there is a risk of oxygen displacement.
6. Provide other gas detection systems as appropriate for the gases that may be present.

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4 PLUMBING SYSTEMS

4.1 Plumbing System Concepts

1. Comply with the National Plumbing Code of Canada with Manitoba Code for sanitary drainage, storm drain, potable water, and plant service water system design. Comply with CSA B149.1 for natural gas piping system design.
2. Provide potable water for washroom/janitor room's plumbing fixtures and combination shower/eyewash stations.
3. For interior hose valves in process area, provide 25mm or 40 mm globe valves with hose thread adapters.
4. For potable hot water, selection of hot water heating shall be as follows:
 - 4.1 Utilize electric heating for all low usage requirements.
 - 4.2 Consider the use of gas water heaters for high-usage requirements such as locker rooms. Review and make recommendations based upon the life-cycle cost of the equipment.
5. Design all sanitary drains and wash down gutter/floor drains to be collected in sanitary sumps in the basement.
 - 5.1 Provide sump pump systems to pump the sanitary drainage to the discharge location.
 - 5.2 Ensure provision of high sump level alarms to be sent to plant PCS.
 - 5.3 Ensure the sump pumps are discharged into an appropriate location in the plant. City approval is required for all discharge locations other than the headworks.
6. Provide gutter drains for basement tunnels, pipe galleries, perimeter walls as required to collect floor wash down drain and underground seepage water.
7. Provide floor drains for process areas, mechanical rooms, washrooms, janitor rooms, locker rooms as required.
 - 7.1 Coordinate with the structural discipline to ensure that floors are sloped to the drains.
 - 7.2 For process areas ensure that floor drains have sufficient capacity to cope with flows associated with washing floors with industrial hoses up to 25 mm diameter.
 - 7.3 Provide additional floor drainage in process areas associated with sludge pumping and / or processing, and inlet screening.
 - 7.4 Provide trench drains with industrial quality gratings in areas where routine wash down is expected or heavy spillage in preparation for maintenance activity could occur. Areas subject to infrequent spillage may have point drainage.
 - 7.5 Provide mechanically secured gratings for all drains.
8. Provide hub drains for mechanical equipment including air conditioning units to collect overflow drain and condensate drain as required.
9. All floor/gutter drains and hub drains that are infrequently used shall have primed P-traps.
10. Water source for trap priming shall be either non-potable water (preferred) or flushing water.
11. Provide ganged traps where allowed by codes, otherwise provide individual traps for floor drains/gutter drains and hub drains.
12. Provide conventional roof drains and overflow drains for all new buildings. Design individual rain water leaders to discharge to grade or to be collected and discharged into the plant storm drainage system if available.

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13. Drainage system piping and appurtenance material section shall be appropriate for the location to ensure corrosion resistance.
14. Provide a proximity switch for the safety shower/eyewash.
 - 14.1 An alarm signal shall be sent to the plant PCS to notify staff in the control room that the equipment is being used.
 - 14.2 Insulate and heat trace piping in the outdoor emergency showers to prevent piping freezing.
15. Provide natural gas piping and regulators to each natural gas fired air handling unit as required.
 - 15.1 Install natural gas piping either underground (buried) or, if possible, on building roof. Installation of natural gas piping within the basement galleries will not be accepted without approval of the City.
 - 15.2 The natural gas meter and gas regulator at the plant gas main shall be coordinated with Manitoba Hydro for new gas loads.

4.2 Piping

1. Provide corrosion resistant piping on sump pump suction lines. Standard of acceptance is stainless steel.
2. Ensure piping is primed and painted in accordance with the WSTP Piping Color Standard.

4.3 Insulated Plumbing Piping

1. Provide insulation for the following pipes:
 - Cold potable water
 - Cold non-potable water (including pump seal water)
 - Hot Potable Water and Recirculation
 - Refrigerant and Gas Piping
 - Roof/Overflow Drain Pipes
2. Insulation for plastic cold water piping may be eliminated where piping material characteristics will reasonably eliminate condensation and not cause any personnel safety or asset damage.

4.4 Plumbing Fixtures

1. In buildings designed in accordance with building code requirements for accessibility for persons with disabilities, provide water closets and lavatories in the washroom with barrier-free plumbing fixtures for the physically disabled.
 - 1.1 As per the WSTP Architectural Design Guideline, only buildings having administration functionality will be designed in accordance with building code requirements for accessibility for persons with disabilities.
2. Toilets shall be wall-mounted or floor-mounted, flush-valve-type complete with dual-flow control.
3. Provide mop sinks for janitor room.

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4. Provide wall-hung, flush-valve-type urinals for washroom as required.

4.5 Emergency Safety Equipment

1. Provide emergency eyewash and shower stations with control mixing valves for tempered water for process areas and chemical areas wherever required for safety protection.
2. Ensure that the safety mixing valve is pre-set to 26.7 deg. Celsius (80 deg. Fahrenheit) by the manufacturer for the mixing temperature of cold and hot water supply.

4.6 Water Conservation

1. Specify and install low water consumption plumbing fixtures and trim in accordance with the requirements of the Manitoba Building Code.
2. Provide high-efficiency plumbing fixtures for water use reduction.
3. Provide water meters for main water usage facility as per City Standards

4.7 Cross-Connection Control

1. Provide cross-connection control in accordance with the CSA standards.
2. Install backflow prevention assemblies for the following: potable cold water main entrances into each new building with a double check valve back-flow prevention assembly and non-potable water main entrance into each new building with a reduced pressure backflow prevention assembly.
3. Provide local reduced pressure backflow preventers for the HVAC heating system and glycol heat recovery system make-up water as required.

4.8 Plumbing Equipment

1. Include plumbing equipment for sump pumps and hot water heaters.
2. Building sanitary drains for plumbing system shall be discharged by gravity drain to available plant main sanitary systems.
 - 2.1 Where gravity drain is not possible, duplex sanitary sump pumps shall be provided in the basement of process areas and pipe galleries to collect sanitary drainage from washrooms, floor/gutter drains and seepage drains, and the drainage flow shall be pumped and discharged into the plant head works via basement tunnels.
 - 2.2 Provide sump pits for the basement tunnel as required.
3. Provide gas or electric domestic hot water heaters/tanks for potable hot water to washrooms/janitor rooms and to emergency shower/eyewash station mixing valves.
 - 3.1 Install hot water recirculation pumps to compensate for hot water piping heat loss for remote plumbing fixtures and safety shower/eyewash station as required.

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5 FIRE PROTECTION SYSTEMS

1. Co-ordinate with the architect for the design of sprinkler systems and standpipe system for locations of required fire pump and fire protection water supply.
2. Determine if fire pump is required to boost the fire protection water pressure to meet the required pressure for sprinkler system or standpipe system.
3. Prepare the detailed design and installation of sprinkler system and standpipe system and ensure that it is certified by a Fire Protection Engineer.
4. Provide a comprehensive design for portable fire extinguishers as required and coordinate with the architectural drawings. All fire extinguishers shall be identified as per the City WWD Identification Standard.
 - 4.1 Supply of the portable fire extinguishers will be by the City, based upon the design provided.
5. Ensure provision of fire dampers on the ductwork penetrating any fire-rated walls, and floor slabs as required per codes.
6. Where duct smoke detectors are required, ensure smoke detector alarm contact is connected to the fire alarm panel.

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6 BUILDING MECHANICAL DESIGN TEAM RESPONSIBILITIES

6.1 General

1. Responsibility for deliverables
 - 1.1 All drawings and other deliverables related to a design are the responsibility of the design engineer. Under a Design-Bid-Build project delivery methodology, delegation of design responsibility to the contractor is not acceptable.
2. Ensure all building mechanical deliverables are 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.
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. Coordinate with the City to understand the specific requirements. Typical requirements include.
 - Updating existing building floor plans.
 - Updating P&ID drawings.
 - The update of detail drawings for existing works is not expected or required.
5. Design reviews:
 - 5.1 Issue the design documents to the City for review at appropriate intervals in accordance with the City's expectations.
 - 5.2 Incorporate all WSTP comments into the design. Where a WSTP comment is not accepted by the design team, provide a complete response, including rationale, to the City Project Manager.
6. As-Built Drawings:
 - 6.1 All building mechanical 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.
 - 6.2 Unless otherwise specified by the City and agreed to by the Design Team, as-built drawings are not required to be sealed (Otherwise known as record drawings).
7. External, 3rd Party Consultants:
 - 7.1 Expertise and assistance may be required, from external 3rd party specialized consultants, outside of the primary architectural / design team.
 - 7.2 Areas where an external 3rd party consultant may be utilized, with permission from the City, are:
 - Fire protection systems.
 - Acoustic systems.
 - 7.3 The design team shall be responsible for monitoring the activities and progress of each 3rd party consultant.
 - 7.4 It is the responsibility of the design engineer to ensure that the deliverables follow all City standards and guidelines.

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8. Site Visits:
 - 8.1 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 buildings.
9. Demolition Requirements
 - 9.1 It is generally required that the architect / 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.
 - 9.2 Small demolition works (less than ~1/3 of the drawing) shall generally be shown by revision of existing drawings. Where demolition requirements are significant (approximately more than 1/3 of a drawing), create dedicated demolition drawings.

6.2 Drawings

The drawings indicated in this section are minimum requirements for new construction, unless otherwise approved by the City.

6.2.1 General Requirements

1. *Provide scale bar on all scaled drawings to allow for measurement takeoff and avoid any potential confusion regarding scale, regardless of the format or size reproduction of the document.*
2. *Show a north arrow on all plan drawings.*

6.2.2 Legend

1. Requirement
 - 1.1 Provide a legend drawing showing the symbols and abbreviations utilized. Coordinate with the City regarding re-use of any existing legend drawings.
2. Content
 - 2.1 Ensure that the legend is consistent with the City's practices. Symbols shall be the same as process mechanical symbols for common items (i.e. valves).
3. Format:
 - 3.1 Produce drawings in an A1 size format.

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6.2.3 Process and Instrumentation Diagrams (P&IDs)

1. Requirement
 - 1.1 Provide P&ID's for the complete HVAC system, including all hydronic systems, unit heaters and associated controls.
 - 1.2 Provide P&IDs for the complete plumbing system. All components shall be shown on the P&IDs except for floor drainage systems.
2. Content
 - 2.1 P&ID's shall depict all equipment and ductwork, including AHUs, fans, cooling coils, heating coils, filters, dampers, etc.
 - 2.2 All automation and control components including instrumentation such as pressure gauges, temperature sensors, RH sensors and manometers shall also be indicated.
 - 2.3 Indicate the appropriate Pipe / Duct identification codes for all pipework and ductwork, as per the WWD Identification Standard.
3. Format
 - 3.1 Produce drawings in an A1 size format.
 - 3.2 The P&IDs shall be in the same format as the process P&IDs.
 - 3.3 The P&IDs shall be in a format compliant with the City WWD Identification Standard and ISA 5.1.

6.2.4 Schematic Airflow Diagram

1. Requirement:
 - 1.1 Provide a schematic airflow diagram for the complete HVAC system.
2. Content:
 - 2.1 Show all ventilated spaces and flow of air through each space.
 - 2.2 Show all airflow rates.
 - 2.3 Show room pressurization.
 - 2.4 Show all fans and air handling units.
3. Format:
 - 3.1 Produce drawings in an A1 size format.

6.2.5 Building Mechanical Plan Drawings

1. Requirement
 - 1.1 Building mechanical plan drawings are required for every floor elevation, including the roof.
2. Content:
 - 2.1 Show the arrangement of all HVAC equipment, including ductwork and piping.
 - 2.2 Show all AHU's, condensing units, volume control dampers, fire dampers, grilles, registers, unit heaters, ventilation fans and all other accessories.
 - 2.3 Show duct sizes and duct elevations.
 - 2.4 Indicate the appropriate Pipe / Duct identification codes for all pipework and ductwork, as per the WWD Identification Standard.

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2.5 Provide a scale bar to allow for scale takeoffs.

3. Format:

3.1 Produce drawings in an A1 size format.

3.2 Scale:

3.2.1 Recommended: 1:75

3.2.2 Maximum: 1:100

6.2.6 Building Mechanical Section and Detail Drawings

1. Requirement

1.1 Provide building mechanical section and detail drawings to completely make clear the required installation of the mechanical systems.

2. Content

2.1 Ensure all materials of construction and dimensions are clearly identified.

2.2 Indicate the appropriate Pipe / Duct identification codes for all pipework and ductwork, as per the WWD Identification Standard.

2.3

3. Format:

3.1 Produce drawings in an A1 size format.

3.2 Scale:

3.2.1 Recommended: 1:50

3.2.2 Maximum: 1:100

6.2.7 Schedule Drawings

1. Requirements

1.1 Provide schedule drawings for all building mechanical equipment.

2. Content

2.1 The content of the schedule drawings shall include but not be limited to:

2.1.1 AHU schedules

2.1.2 Fan schedules

2.1.3 Grille/louvre/diffuser schedules

2.1.4 Unit heater schedules

2.1.5 Heat exchanger schedules

2.1.6 Pump schedules

2.1.7 Expansion tank schedules

2.1.8 Heater schedules

2.1.9 Air conditioning unit schedules

2.1.10 Condensing unit schedules.

2.1.11 Damper schedules.

3. Format:

3.1 Produce drawings in an A1 size format.

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6.2.8 Pipe Work Layout Drawings

1. Provide drawings clearly showing piping layouts and associated pipe accessories.
2. Provide isometrics for piping.
3. Include pipe schedules and sizes.

6.2.9 Fire Fighting Layout Drawings

1. Provide drawings showing the firefighting equipment and piping layouts.
2. Provide fire extinguisher, fire hose reel and hydrant schedules.

6.2.10 Installation Detail Drawings

1. Requirements
 - 1.1 Provide piping detail drawings.
 - 1.2 Provide plumbing detail drawings.
 - 1.3 Provide HVAC detail drawings.
 - 1.4 Existing City piping detail drawings may be referenced if available and appropriate for the project.
2. Content
 - 2.1 Content requirements include, but are not limited to:
 - 2.1.1 Typical duct support requirements for all duct configurations.
 - 2.1.2 Duct connection details, including odour control connections to tanks and channels.
 - 2.1.3 Duct insulation details.
 - 2.1.4 Fan installation details (i.e. roof mounted fan)
 - 2.1.5 Typical pipe supports for all piping configurations.
 - 2.1.6 Piping floor/wall/roof penetration installation details.
 - 2.1.7 Duct floor/wall/roof penetration installation details.
 - 2.1.8 Piping flushing connection details.
 - 2.1.9 Instrumentation installation details.
 - 2.1.10 Pipe marking details.
 - 2.1.11 Hose rack and other appurtenances details.
 - 2.1.12 Pipe insulation details.
3. Format:
 - 3.1 Produce drawings in an A1 size format.

6.2.11 3D Model

1. When 3D design is required by the City, or proposed by the Consultant, this section shall be complied with in its entirety. 3D models and associated drawings are not mandatory for all projects
2. The 3D model shall include all pipework, ductwork and equipment to allow for full representation of the entire facility, including all other disciplines.

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3. In addition to the 3D model provide:
 - 3.1 3D elevation and section drawings to convey the complete building mechanical configuration.
 - 3.2 3D detail drawings of all areas with significant interdisciplinary coordination requirements.
4. 3D drawings shall be rendered. Simple 3D line representations are not acceptable.

6.2.12 Coordination with Other Disciplines

1. Structural / Architectural
 - 1.1 Ensure that openings for ductwork, louvres, and other openings are coordinated with, and shown on the structural and architectural drawings.
 - 1.2 Ensure all equipment weights are coordinated with the structural design.
 - 1.3 Where new equipment is installed on an existing floor/roof, the engineer is responsible for coordinating the appropriate structural review to ensure that the weight of the equipment is supported. Upgrade the existing structure as required.
 - 1.4 Where new penetrations are made to an existing structure, ensure that structural elements are not affected. Coordinate the appropriate structural review and upgrade as required.
 - 1.4.1 Where penetrations are made through reinforced concrete, care should be taken during the design planning and construction stages to minimize the cutting of reinforcement.

6.3 Design Calculations

1. As a minimum, provide the following non-exhaustive list of HVAC and building mechanical design data and calculations:
 - Tabulation of interior heat loads (heat dissipation).
 - Calculation of heating load.
 - Calculation of the cooling load.
 - Calculation of air flow rates.
 - Calculation of make-up air flow rates for the building pressurization.
 - Calculation of static duct pressure drops.
 - Sizing of ducts, grilles, registers, diffusers, valves, dampers, louvers, filters, cooling coils, air heaters, fans, compressors, condensers, refrigerant and drain pipes.
 - Plumbing and firefighting piping and equipment design calculations.

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The City of Winnipeg
Winnipeg Sewage Treatment Program

Structural Design Guideline

Document Code:


Revision: PB

Approved By:	 <hr/> Duane Griffin, Branch Head - Wastewater Planning & Project Delivery	 <hr/> Date
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REVISION REGISTER				
Rev.	Description	Date	By	Approved
PA	Issued for Internal Draft Review	2015-05-28	C. Reimer	-
PB	Issued for Inclusion in RFPs	2015-06-05	C. Reimer	

CAUTION

This document is currently in a draft state. All design shall be based upon the approved issue of this document, which will be provided prior to award.

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1 INTRODUCTION

This document identifies the standard design requirements that are applicable to any structural work within the City of Winnipeg wastewater treatment facilities.

1.1 Scope of the Standard

These design requirements will apply to the following facilities:

- Wastewater treatment plants

1.2 Application

The scope and intent of this document is to convey general design guidance and expectations regarding structural design. This document does address specifics related to design type, selection, and configuration; however the indicated requirements are presented without knowledge of the specific building implementation. It is not within the scope of this document to provide detailed design direction, and it will be the responsibility of the respective structural designers to fully develop the structural details with general conformance to the concepts presented herein. This standard shall not be construed as comprehensive structural engineering design requirements or negate the requirement for professional structural engineer's 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.

Existing facilities do not necessarily comply with this standard. The expectations regarding application of this standard to maintenance and minor upgrades at existing facilities must be assessed on a case-by-case basis; however general guidelines for application are presented as follows:

- All new buildings are expected to comply with this standard.
- All major upgrades to a building are expected to comply with this standard; however in some cases compromise with the configuration of the existing facility design may be required.
- All minor upgrades should utilize this standard as far as practical for new work; however in some cases compromise with the configuration of the existing facility design may be required.

1.3 Deviations from Standard

It is expected that there will be occasional situations where the design architect / engineer will propose a deviation from this design guideline. The rationale for potential deviations from the design guideline may include:

- Evolution of technology,
- Updates to standards and regulations,
- Practical limitations due to existing conditions on site, or
- Significant cost benefits to the City due to specific project constraints.

For each proposed deviation from this standard, fully complete a *WSTP Standards Deviation Form* and submit to the City project manager for approval. Do not proceed with the proposed deviation unless approval is received from the City project manager.

1.4 Acronyms and Abbreviations

ACI	American Concrete Institute
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ASTM	American Society of Testing and Materials
CAC	Cement Association of Canada
CISC	Canadian Institute of Steel Construction
CSA	Canadian Standards Association
NBC	National Building Code
WSTP	Winnipeg Sewage Treatment Program

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2 GENERAL

2.1 Design Codes and Standards

Ensure all designs shall comply with municipal, provincial, and national codes and bylaws. This includes but is not limited to:

- 2010 National Building Code of Canada with 2011 Manitoba Amendments (NBC)
- CSA A23.3-04, Design of Concrete Structures
- ACI 350-06, Code Requirements for Environmental Engineering Concrete Structures
- CSA S16-09, Limit States Design of Steel Structures
- CSA S136-12, North American Specification for the Design of Cold-Formed Steel Structural Members
- CSA S157-05, Strength Design in Aluminum
- CSA S304.1-04, Design of Masonry Structures
- Concrete design shall be in accordance with CSA A23.3, except for facilities or portions of facilities that are considered hydraulic structures. Design hydraulic structures in accordance with ACI 350. Design steel structures in accordance with CSA S16.
- Masonry shall be designed in accordance with CSA S304.1.

2.2 References

The following list of references shall be used in the design:

- CAC Concrete Design Handbook, latest edition (currently Third Edition)
- CISC Handbook of Steel Construction, latest edition (currently Tenth Edition)
- AISC Design Guide 27, Structural Stainless Steel

2.3 Other City Standards

1. While not exclusive, ensure that the following City Standards are adhered to:
 - 1.1 Water and Waste Department Identification Standard

2.4 Units

All drawings and documentation shall use the International System of Units (SI units). Imperial units will be provided in parenthesis after the metric unit, where requested or appropriate. Specific requirements are as follows:

1. All structural dimensions are to be in millimeters.
2. All elevations are to be in meters, in the format EL. ###.### (example EL. 273.520).
3. All loads are to be expressed in kPa, N, or kN.
 - Crane or hoist loads may be expressed in kg.

3 DESIGN LOADS

3.1 General

1. Classify project structures and facilities as post-disaster buildings.
2. Use climatic data for the City of Winnipeg.

3.2 Dead Loads

Reference shall be made to CISC Handbook of Steel Construction, Part 7. The following values for mass of materials are to be considered as typical as per the CISC Handbook:

Table 3-1 : Dead Loads

Description	Typical Value
Roof Dead Loads	
4-ply asphalt and gravel:	0.32 kPa
Insulation:	0.21 kPa (assuming 300 mm thick)
Tiled ceiling:	0.20 kPa
Floor Dead Loads	
Additional concrete due to floor slope	1.5kPa (assume 50 mm thick)
Wall Dead Loads	
300 mm CMU:	2.9 kPa
200 mm CMU:	2.1 kPa
100 mm Brick:	1.9 kPa

3.3 Collateral Loads

Collateral loads are dead load allowances for suspended utilities such as small piping, ducts, lights, conduit, cable trays, and sprinklers.

Table 3-2 : Collateral Load Values

Description	Typical Value
Roof Collateral Load:	1.0 kPa
Floor Collateral Load:	1.0 kPa

3.4 Live Loads

Table 3-3 : Live Load Values

Description	Typical Value
Roof Live Load (not including snow):	1 kPa min
Electrical Rooms:	15 kPa (see Note 1)
Grating, Checkered Plate and Hatch Covers:	Same as surrounding floor area, 5 kPa minimum
Mechanical Rooms:	10 kPa (see Note 1)
Process Areas (slabs, beams, and girders):	15 kPa (see Note 1)
Process Areas (columns and foundations):	10 kPa (see Note 1)
Office and Laboratory Areas:	5 kPa
Stairs, Landings, Platforms, and Corridors:	5 kPa
Storage Areas:	Actual stored weight, 10 kPa minimum
Unrestricted Vehicular Areas:	HS 20-44

Notes:

- In addition to designing for this minimum uniform load, the engineer will design structure to support actual equipment and tank loads. Where this minimum uniform load is not possible (i.e., in existing spaces), the maximum allowable load shall be noted on drawings.*
- See Impact Loads and Other Machinery Loads for other equipment related live loads.*

3.5 Seismic Loads

Per Manitoba amendments to the NBC, specifically pertaining to Section 4.1.8.1, the value of $S_a(0.2) = 0$. Therefore, the seismic loads can be ignored.

3.6 Wind Loads

As per NBC, the following are the wind parameters for the City of Winnipeg.

Table 3-4 : Hourly Wind Pressure Loads

Description	Design Value
Hourly Wind Pressures:	
1/10	0.35
1/50	0.45
Exposure Factor	Calculate for open terrain

3.7 Snow Loads

The following are the snow parameters for the City of Winnipeg to allow for calculation of the snow load as per the NBC.

Table 3-5 : Snow Loads

Description	Design Value
S_s :	1.9 kPa
S_r :	0.2 kPa

Note: Determine snow drift loads and sliding snow loads specifically for each structure.

3.8 Rain Loads

Consider rain loads associated with blockage of the primary roof drainage system where applicable or due to ponding.

Utilize the following rain parameters for the City of Winnipeg:

- One Day Rain Fall: 108mm

3.9 Ice Loads

Design items such as exterior exposed wires and cables, piping, ductwork, support structures, etc. for ice loads where applicable.

As per CSA S37, ice parameters for the City of Winnipeg are as follows:

- Minimum Design Ice Thickness: 10mm

3.10 Impact Loads

Confirm equipment loading, including any impact loads due to equipment, with data sheets requested from the manufacturers.

Table 3-6 : Impact Loads

Description	Design Value
Light machinery (shaft or motor driven):	Increased load by 20 percent minimum or manufacturer's recommendation for impact, whichever is greater.
Reciprocating machinery or power-driven unit:	Increase loads by 50 percent minimum or manufacturer's recommendations for impact, whichever is greater.
Torsional and thrust force:	Obtain maximum torsional and thrust forces from vertical turbines from equipment manufacturer. Identify any other torsional and thrust forces.
Vertical impact due to lifting devices:	The maximum wheel loads of the crane shall be increased by the following percentages: <ul style="list-style-type: none"> • Cab operated, or radio-operated cranes (powered): 25 percent • Pendant or hand-operated cranes: 10 percent
Lateral force due to cranes:	The lateral force applied perpendicular to the crane runway beams shall be calculated as 20 percent of the sum of the rated capacity of crane and the weight of the hoist and trolley.
Longitudinal force due to cranes:	The longitudinal force on crane runway beams shall be calculated as 10 percent of the maximum wheel loads of the crane.

3.11 Thermal Loads

Consider thermal loads for facilities with structural members that will be permanently exposed or partially exposed to exterior condition.

Design temperature range for the City of Winnipeg:

Table 3-7 : Thermal Loads

Description	Design Value
Temperature Range	-33 °C to +30 °C

3.12 Liquid Loads

1. Define groundwater and flood levels in the geotechnical report. Consider wall loads and uplift pressures due to groundwater level based on groundwater levels given. Weight of the structure shall be used to counteract uplift whenever possible.
2. The factor of safety for buoyancy shall be 1.1 against 100-year flood levels. The factor of safety for buoyancy shall be 1.25 against typical high groundwater levels.
 - 2.1 Where the weight of the structure is insufficient, such as for empty tanks, provide a weeping tile system to an appropriate drain.
3. Tanks shall be designed for maximum liquid levels at overflow. Where there is no overflow, tanks shall be designed for maximum liquid level at top of the walls.

3.13 Earth Loads

1. Define lateral design loads due to earth pressure and other geotechnical design.
2. Surcharge loads as recommended by the geotechnical report are to be applied to the design of buried walls.

3.14 Test Loads

1. Ensure all liquid-containing tanks are tested for water-tightness.
 - 1.1 Adjacent tanks shall be tested independently.
2. Tanks shall be designed for testing prior to backfilling.
3. Determine test loads for foundation support elements from geotechnical recommendations.
4. Design structure taking into consideration test loads for equipment and piping.

3.15 Blast Loads

1. Include blast loads as part of the design where appropriate.

3.16 Insurance Load Requirements

1. There are no known insurance load requirements that exceed loads listed above.

3.17 Load Combinations

1. Building Structures:
 - Limit states design-NBC, Division B, Part 4
2. Hydraulic Structures:
 - Overflow liquid level with no backfill (water-tightness test condition), as per Section 3.12.
 - Empty basin with backfill in place

3.18 Deflection Criteria

Table 3-8 : Deflection Criteria

Description	Load Type	Design Value (Maximum)
Roof Members	Dead+ Live	L/240
	Live Only	L/360
	Snow Only	L/360
Floor Members	Dead+ Live	L/240
	Live Only	L/360
Steel Floor Plates and Grating	Live	L/360
Crane Suspension Systems		
Monorail Crane	Dead+ Live	L/800
Bridge Crane	Dead+ Live	L/1000
Beams and Lintels Supporting Masonry		
Vertical Support	Dead+ Live	Lesser of L/720 or 8 mm
Structural Members bracing out-of-plane loads	Dead+ Live	L/360
Exterior Walls and Interior Partitions	Live, Snow, or Wind	L/240

3.19 Vibration Design Criteria

1. Consult equipment manufacturers for vibration-related information such as frequencies, unbalanced loads, use of vibration isolators or dampeners, and support requirements.
2. Mount all rotating equipment that produces vibrations of sufficient magnitude on concrete foundations or concrete support systems.
3. Design the concrete support and surrounding structure such that the natural frequency shall be less than 0.5 times or more than 1.5 times the normal operating frequency of the equipment. Special consideration shall be given to variable frequency equipment.
4. Where vibration is significant, anchorage to concrete foundations shall be by embedded anchor bolts, not post installed anchors

3.20 Structural System Requirements

Ensure new materials that will be used will meet the following criteria:

Table 3-9 : Structural System Requirements

Description	Requirement
Concrete	Exposure Class S-2 or S-3
Concrete Masonry	CSA A165
Reinforcing Steel (unless otherwise noted)	CAN/CSA G30.18, Grade 400(R)
Structural Steel (unless otherwise noted)	CAN/CSA G40.21, Grade 350W
Anchor Bolts	ASTM A 307
Structural Bolted Connections	ASTM A 325
Stainless Steel	AISI, Type 316
Aluminum	Alloy 6061-T6 or 6351-T6

Note:

1. *Ensure that all materials utilized are compatible with the specific environment within the building or process area, including consideration for all chemicals utilized.*

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4 MAINTENANCE AND SAFETY

4.1 Maintenance

1. Provide appropriate lifting devices to allow for maintenance and removal of equipment. Coordinate with other disciplines as required.
2. All permanent lifting devices shall be designed and detailed by the design engineer. Design responsibility shall not be deferred to the contractor except when using a design-build procurement model.

4.2 Safety

1. Provide systems to accommodate safe access to all areas of the facility, including tanks, conduits, and channels. Minimum requirements include, but are not limited to the following:
 - 1.1 Where practical, provide embedded safety davit bases to accommodate a portable safety davit to allow for safe personnel access to tanks, conduit, and channels.
 - 1.2 Surface mount davits may be utilized where embedded davit bases are not acceptable.
 - 1.3 Provide permanent ladders where portable ladders are not effective or where personnel access is frequent (> once per month).

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5 STRUCTURAL DESIGN TEAM RESPONSIBILITIES

5.1 General

1. Responsibility for deliverables
 - 1.1 All drawings and other deliverables related to a design are the responsibility of the structural designer / engineer.
2. Ensure all structural design deliverables are sealed by a qualified professional structural engineer.
3. Completeness of drawings:
 - 3.1 All drawings shall be comprehensive in nature to allow for effective use in construction.
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. Coordinate with the City to understand the specific requirements. Typical requirements include.
 - Update existing building structural details when necessary.
 - The update of structural detail drawings for existing works is not expected to be required, except to show required modifications.
5. As-Built Drawings:
 - 5.1 All structural design 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 are not required to be sealed (Otherwise known as record drawings).
6. External, 3rd Party Consultants:
 - 6.1 Expertise and assistance may be required, from external 3rd party specialized consultants, outside of the primary structural design team.
 - 6.2 The design team shall be responsible for monitoring the activities and progress of each 3rd party consultant.
 - 6.3 It is the responsibility of the design engineer to ensure that the deliverables follow all City standards and guidelines.
7. Site Visits:
 - 7.1 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 buildings.
8. Demolition Requirements
 - 8.1 It is generally required that the structural designer / 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.
 - 8.2 Where demolition requirements are significant, create dedicated demolition drawings.

5.2 Drawings

Provide a comprehensive set of drawings to detail the structural construction requirements. The drawings indicated in this section are minimum requirements for new construction, unless otherwise approved by the City.

5.2.1 General Requirements

1. All structural drawings are to be produced on a standard A1 size drawing.
2. All structural drawings shall be to scale.
3. All dimensions required for construction shall be shown.
4. Indicate north direction on all plan drawings.
5. Provide scale bars on drawings to allow for simplified scale takeoff on the drawings.
6. Differentiate new work from existing work via bold lines.

5.2.2 Legend

1. Provide a legend drawing showing the symbols and abbreviations utilized. Ensure that the legend is consistent with the City's practices and other disciplines.

5.2.3 General Notes Drawing

1. Provide a general notes drawing for each type of structure.
2. Content
 - 2.1 Include general construction notes.
 - 2.2 Provide building design criteria including key design loads
 - 2.3 Provide foundation design criteria.
 - 2.4 Provide concrete requirements.
 - 2.5 Provide concrete reinforcing requirements.
 - 2.6 Provide masonry requirements as applicable.
 - 2.7 Provide structural steel and metal fabrication requirements.

5.2.4 Foundation / Piling Drawings

1. Provide detailed foundation / piling drawings comprehensive of all new and modified areas.
2. Content
 - 2.1 To be developed.

5.2.5 Pile Schedule and Details

1. Provide pile schedule and detail drawings where piles are utilized.
2. Content
 - 2.1 To be developed.

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5.2.6 Structural Plan Drawings

1. Provide detailed structural plan drawings comprehensive of all new and modified areas.
2. Content
 - 2.1 To be developed.

5.2.7 Structural Section and Detail Drawings

1. Provide detailed structural section and detail drawings comprehensive of all new and modified areas to completely define the required work.
2. Content
 - 2.1 To be developed.

5.2.8 Concrete Reinforcing Drawings

1. Provide a comprehensive set of drawings to fully detail the concrete reinforcing requirements,
2. Content
 - 2.1 To be developed.

5.2.9 Detail Drawings

1. Detail drawings shall include, but not be limited to:
 - 1.1 Access hatch configuration, including dimensions, hinge and handle configuration, sill configuration, and materials.
 - 1.2 Concrete embeds such as studded anchor plates and angles to support masonry veneers, process beams, slabs and girders.
 - 1.3 Monorail hoists, bridge cranes, large diameter piping supports, structural steel stair cases in stair wells, etc.
 - 1.4 Guardrail, ladder, and gate details including dimensions and detailed layout.
2. Content
 - 2.1 To be developed.

5.2.10 3D Model

1. When 3D design is required by the City, or proposed by the Consultant, this section shall be complied with in its entirety. 3D models and associated drawings are not mandatory for all projects.
2. The 3D model shall include all structural elements (other than concrete reinforcing) to allow for full representation of the entire facility, including all other disciplines.
3. In addition to the 3D model provide:
 - 3.1 3D elevation and section drawings to convey the complete structural configuration.
 - 3.2 3D detail drawings of all areas with significant interdisciplinary coordination requirements.

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5.3 Structural Design Calculations

1. Provide detailed design calculations in accordance with the relevant codes and authorized local and national bodies taking into account the most unfavorable condition of dead load, live load, wind load, construction load etc. for all structures. Design calculations shall be submitted with the design drawings as part of the review cycle to allow for parallel review.


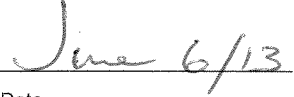
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The City of Winnipeg
Water & Waste Department

Identification Standard

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Revision: 00

Approved By:		
	Geoff Patton, Manager of Engineering	Date

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Rev.	Description	Date	By	Checked	Approved
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1 INTRODUCTION

This Water and Waste Department Identification Standard is to be referenced for consistent and accurate identification for all process, mechanical, electrical, and automation equipment. The standard also provides guidance regarding architectural room identification and communication equipment. This document provides clear guidance to department personnel, as well as external consultants, regarding appropriate equipment identification. A consistent standard has been developed for all Water and Waste groups, including Collections, Land Drainage, and Solid Waste (as applicable), however it is acknowledged that some exceptions for various groups may be required due to special circumstances, or existing established precedent.

1.1 Scope of the Standard

This identification standard applies to all City-owned Water and Wastewater facilities, which includes the following facilities:

- The Water Treatment Plant
- Regional water pumping stations
- The Shoal Lake Intake Facility
- Remote water facilities, including standpipes, valve chambers, boathouses, etc.
- Wastewater treatment facilities
- Wastewater lift stations
- Flood pumping stations
- Underpass sites
- Wastewater diversion stations
- Deep well locations
- Fountain locations
- Land drainage facilities
- Combined Sewer Overflow facilities
- Current and future remote wastewater sites (outfalls, valve chambers, etc).

1.2 Application

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

- All new facilities must comply completely with this standard.
- All major upgrades to a facility, or a larger facility's process area, must completely comply with this standard. Any existing equipment within the area being upgraded should be re-identified.
- All minor upgrades should utilize this standard as far as practical for new equipment, however in some cases compromise with the existing facility identification practice may be required.

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For example, if adding a single pump to the WEWPCC facility, it is recommended to identify the pump as S230-P, rather than P-S230.

1.2.1 Re-identification

When equipment is re-identified to this new standard, it is recommended that the following be implemented:

- All equipment lamacoids and labels are to be replaced with the new identifier.
- All drawings that are being modified as part of the work are to utilize the new identifier. Major drawings such as P&IDs and Single Line Diagrams should display both the new and the old identifiers, in the following format:

New-Identifier
(was Old-Identifier)

- Generate a master equipment list with the new identifier, old identifier, and equipment description.

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2 GENERAL

2.1 General Identification Requirements

General identification requirements are as follows:

- Unambiguous Identity
 - All equipment identifiers shall be unique. No two pieces of equipment within the same facility are to share a common identifier.
- Consistency
 - The identification system is to be consistent across all facilities.
 - Prior to addition of a new identifier type, all new additions to the standard should be vetted by a group, to avoid inconsistent additions to the standard.
 - Spaces within identifiers are not permitted. For example, PNL M10 is not a substitute for PNL-M10.

Allowable characters in equipment identifiers are as follows:

- Uppercase letters A through Z
- Numerals 0 through 9
- Hyphen “-“ (or underscore “_” in software packages where hyphens are not supported)
- Period “.”(or underscore “_” in software packages where periods are not supported)

No other symbols or characters or spaces shall be utilized in an identifier.

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2.2 Facility Code

Each City of Winnipeg facility is assigned a unique, four-digit facility code. The facility code is to be used on drawings and documentation as required. The facility code appears within all City drawing numbers, but need not be shown within the content of the drawing. The facility code is deemed an optional component of equipment and instrument identifiers, with the preference to omit the facility code to reduce the overall length of identifiers.

Systems such as a central Supervisory Control and Data Acquisition (SCADA) system that monitors multiple facilities are to make use of the facility code to segregate components by facility. The implementation of the facility code may be by means of a hierarchical directory system whereby individual components are stored under a folder that is named by the facility code. If the database or system where the identifier is being stored supports an additional field for the facility code, or is based upon a hierarchical system where the identifier can be placed as a component off of a root facility branch, it is deemed to be acceptable to omit the Facility Code in the instrument identifier. For example, the City's current Computerized Work Management System (CWMS) has an integral asset list, where a field is provided for the facility. In this case, the facility code for the equipment identifier would not be entered.

A complete list of facility codes is provided in Appendix A.

2.3 Process Area

The process area code identifies the physical area or building in which the equipment is located. A single letter character from A to Z represents a process area. Some specific recommendations regarding implementation and designation of process areas are:

- For new construction, ensure that process areas are allocated for a large enough area, such that the 26 available process area codes are not exhausted.
- The process area represents the physical location of the equipment, not the equipment function. For example, a hot water pump located in the P area is designated as having a P process area, not a B (Boilers) process area. This is much more straightforward for both assignment and maintenance personnel.
 - Note however, that in some cases there are multiple pieces of equipment, all associated with the same primary piece of equipment, but in different physical process areas. In this case, the equipment process area should be selected based upon the major or primary equipment. For example, the motor starter for pump P-M101 would be identified as MS-M101, even if the motor starter is in the S process area. The motor starter is directly associated with the pump and it would be confusing and unsafe to have different identifiers. An example is provided in Section 6.6.1.
- For similar facilities, it is beneficial, but not mandatory, that similar process codes are utilized. For example, ideally the letter P should represent the Primary Clarifier process area at all wastewater treatment plants, but would represent something different for water facilities.

The process areas for existing facilities are listed in Appendix B.

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2.4 Functional Designations

The functional designation represents the function of the equipment. A complete list functional designations, for all disciplines, is shown in Appendix C.

It may be required to add new functional designations, where the existing list does not cover a new application. It is recommended that the following be reviewed prior to the addition of new designations:

- Functional designations for equipment are to be limited to a maximum of four characters. While most instrument designations will be four characters or less, it is possible to have up to five characters in a instrumentation designation, as per ISA 5.1.
- Utilize general, rather than specific, functional designations. For example, utilize the general pump designation P and avoid specific pump designations such as:
 - CWSP Chilled Water Supply Pump
 - CHRP Chilled Water Return Pump
 - ELP Effluent Lift Pump
 - CFP Chemical Feed Pump
 - SLP Sludge Pump
- Update the master list in Appendix C, and ensure there is no overlap with other disciplines.
- It is acceptable to re-utilize an existing designation at an existing facility, even if is not listed in Appendix C, if it is deemed that there are too many existing documentation references to modify. In this case, the designation will be a unique special case, and is not to be added to Appendix C.
- Consider the use of the letter U to designate the equipment if the quantity of the equipment is low.

2.5 Equipment Number

2.5.1 Uniqueness

The equipment number is a number utilized to identify a specific instance of a piece of equipment within a certain process area. Equipment numbers may be re-used within different process areas.

Generally, equipment numbers should be unique for each piece of equipment, but equipment that is functionally related, and has a one-to-one relationship, may (but is not required to) share a common equipment number. The overall equipment identifier must still be unique. See Figure 2-1 for an example.

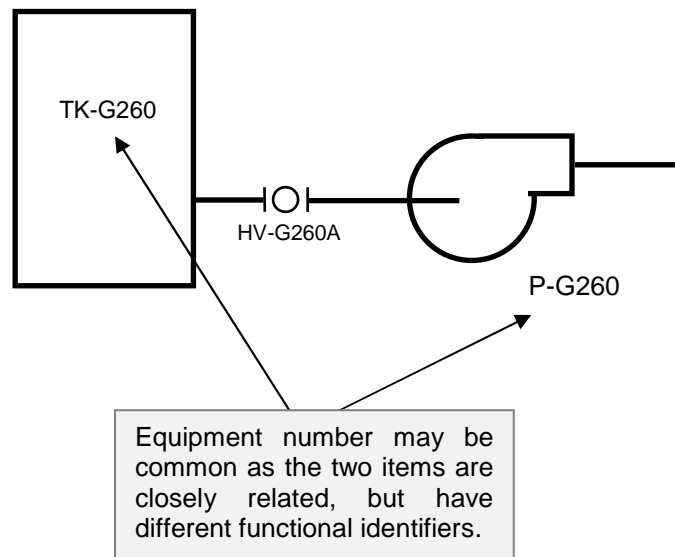


Figure 2-1: Equipment Number Example – Functionally Related

Note that electrical and mechanical equipment, that is not functionally related, must not share a common equipment number. For example, a MCC-M100, and a P-M100 should not exist within the same facility.

2.5.2 Number of Digits

Equipment numbers will typically be comprised of three digits in medium to large size facilities. However in small facilities, with less than 50 equipment identifiers, it is permissible to utilize two digit equipment numbers. Use of two digit equipment numbers will be typical for most Collections facilities, such as wastewater lift stations and flood pumping stations. Note that where two digit equipment numbers are utilized, the instrument loop number will also be shortened by a digit, to a total of three digits.

2.5.3 Equipment Number Ranges

For each facility, the equipment numbers are grouped and allocated in ranges to specific process functions. The range allocations are on a site by site basis, although efforts should be made to utilize common ranges for similar types of facilities.

Equipment number ranges are defined in Appendix D.

2.6 Subcomponents

In some cases, it is appropriate for equipment to be designated as a component of another identified piece of equipment, rather than an independent unit. Equipment subcomponents will typically be expressed as using a dot “.” field, followed by the subcomponent identifier.

2.6.1 Subcomponent Identifier Format

E*	.	SSSS	-	N
Equipment Identifier		Subcomponent Functional Designation	-	Subcomponent Number

Where,

- E* is the *Equipment Identifier*, of the base equipment, as designated in this document.
- SSSS is the *Subcomponent Functional Designation*, which is one to four letters. Typical subcomponent designations are shown in other sections of this document.
- N is the *Subcomponent Number*, an optional field to be utilized when there are multiple subcomponents within the base equipment.

Some examples of subcomponents are as follows:

- CMP-R521.LOP Lube oil pump for compressor CMP-R521, where the pump is integrated into the compressor skid and driven by the compressor motor.
- PNL-P712.MCB Panelboard PNL-P712 main breaker
- VFD-G612.RCTR-1 Line reactor for VFD-G612 (integrated in VFD enclosure)

In a full hierarchical system, almost every piece of equipment could potentially be viewed as a subcomponent or child of another system. For example, an agitator could potentially be viewed as a component of a tank. However, this approach would lead to an extensive hierarchical system that is not recommended for general plant identification. Thus, the following rules of thumb are presented as a guide for classification of an item as a subcomponent.

Identification of a device as a subcomponent should be considered when:

- The device is a constituent component that is physically enclosed in, or attached to, the larger equipment;
- The device is normally grouped as a component of the larger equipment when the equipment is purchased; and
- Operations personnel would normally refer to the device as a component of the larger equipment, rather than a separate device.

2.6.2 Use of Subcomponent System

It is deemed that there are numerous benefits to utilizing the subcomponent system, as indicated below:

- Due to the naming structure of subcomponents, it is clear as to what parent component the subcomponent belongs to.
- Subcomponents allow for smaller instrument bubbles to show functionality such as limit switches, without wasting drawing space. For devices such as large multi-turn actuators, with internal torque switches, hand switches, and limit switches, as well as many other types of equipment, this can be a significant savings in drawing space without any loss of identification capability.
- The use of subcomponents helps avoid the case where the subcomponent devices are placed on the equipment or instrument list, and confuse personnel because they cannot be found in the field. This is also particularly important to construction personnel, who must coordinate the purchase, storage, installation, and commissioning of these devices.
- The use of subcomponents aligns more closely with the current direction of control system software implementations, where the database and system model have hierarchical attributes, rather than a simple linear list of tags.

2.6.3 Subcomponent Examples

Two examples of the use of subcomponents are shown in Figure 2-2 and Figure 2-3.

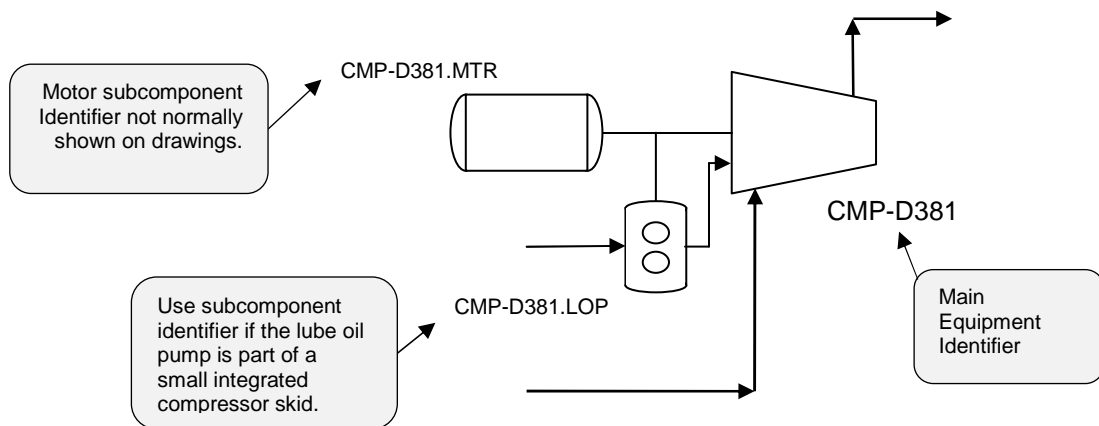


Figure 2-2 : Lube-Oil Pump Subcomponent Example

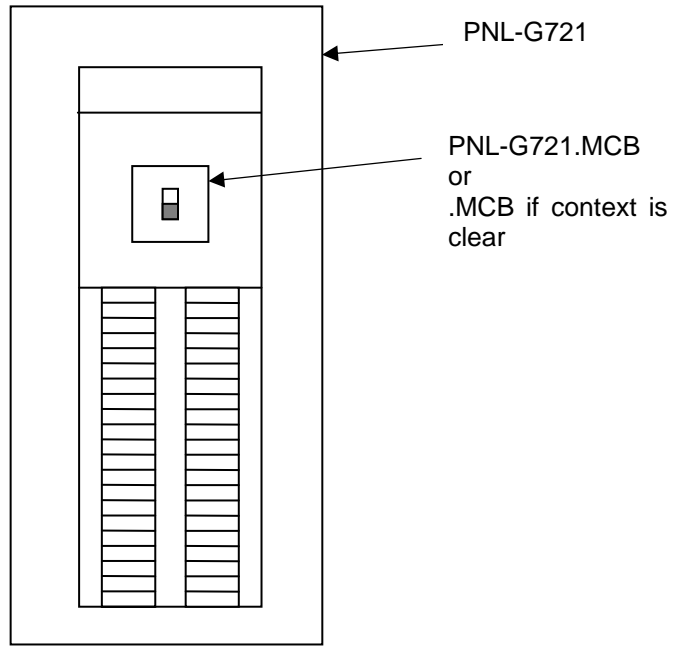


Figure 2-3 : Electrical Subcomponent Example – Main Circuit Breaker

3 ARCHITECTURAL

3.1 Buildings

3.2 Room Identifier

It is required to identify room numbers for architectural purposes and to allow for identification of specific equipment that is associated with rooms. Fire alarm system and security system component identification, as discussed in Sections 6.7 and 6.8, are associated with room numbers. Room numbers will be identified as follows:

FFFF	-	RM	-	P	-	L	RR	S
Facility Code (Optional)	-	Room Designation	-	Process Area	-	Level	Room Number	Suffix (Optional)

Where,

- FFFF is the *Facility Code*, from Appendix A. The *Facility Code* will typically be implied, and would only be fully written where required.
- RM is the *Room Designation*, which is comprised of the letters RM.
- P is the *Process Area*, which is based on Section 2.3.
- L is the *Level*, which shall typically be one or two characters, as described in Section 3.2.1.
- RR is the *Room Number*, which shall typically be two digits, except as described in Section 3.2.1.
- S is the *Suffix*, which can be utilized to indicate room divisions as required.

Examples:

- RM-S-115 Room 15 in the Secondary Clarifier process area, on the main level.
- RM-M-222 Room 22 in the Main Building process area, on the second level.
- RM-G-BA9 Room 9 in the Grit process area, lower level 2.

Note: A hyphen is utilized between the process area and level, to ensure that room numbers are not potentially confused with equipment numbers.

3.2.1 Building Level Designation

The building level designation shall be based upon Table 3-1 below.

Table 3-1 : Building Level Identifiers

Level	Description	Room Number Digits	Example
4	Fourth Floor	2	RM-M-405
3	Third Floor	2	RM-M-320
2	Second Floor	2	RM-M-251
1	Main / First Floor	2	RM-M-123
B	Lower Level 1 / Basement	2	RM-M-B52
BA	Lower Level 2	1	RM-M-BA5
BB	Lower Level 3	1	RM-M-BB1
EX	Exterior (See Note 4)	1	RM-M-EX1

Notes:

1. *Level 1 should be the uppermost floor entered at grade or at most, one half stair flight above.*
2. *Large mezzanines shall be numbered as a whole floor. Example: When a mezzanine exists between the first floor and the next whole floor, it will be numbered as the second floor and the next whole floor would be the 3rd floor.*
3. *Usable attic floors and penthouse levels should be numbered as if they are whole floors. For example, a two-story penthouse atop a three floor building will be numbered as the fourth and fifth floors. Do not use prefixes such as "R" for roof level.*
4. *Use of the EX designation for exterior spaces is optional. One example where this designation may be required is for outdoor security equipment. It is recommended that the outdoor space be designated into zones, which replace the room number.*

3.2.2 Drawing Representation

Room numbers on drawings may be presented as shown in Figure 3-1. Note that the room designation “RM” may be omitted on drawings, when used with the ellipse symbol.

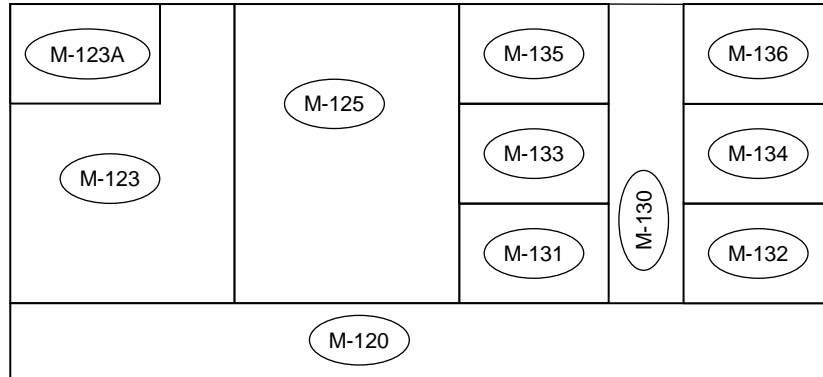


Figure 3-1 : Room Numbering on Drawings – Plan View

3.2.3 Room Numbering Guidelines

Utilize the following as a guide for room numbering:

- Numbers should flow from one end of the building to the other.
- Where corridors are present, use odd numbers on one side of a corridor and even numbers on the other side.
- Skip numbers as required to maintain succession of room numbering
 - In some instances, room numbers on one side of a corridor shall be skipped in order to maintain succession with the room numbers on the opposite side of the corridor. This may occur, for example, when a suite of rooms or large space is accessed through a single door and there are no other doors on that same side until further down the corridor. This will allow for future renovations that may convert suites or large spaces into separate or small rooms with a corridor door.
- Use alphabetic suffixes for small rooms entered from other rooms
 - For example, a small storage space off of room M-123 could be designated as M-123A.
- Provide all accessible spaces with room numbers.
 - In addition to rooms, all interior spaces that can be directly accessed, such as corridors, vestibules, stairwells, elevator shafts, and accessible pipe spaces shall be numbered in a manner as consistent as possible with standard room spaces. Where doors or walls separate different areas of these spaces, each area shall receive its own unique number.

- Identify stairwells with a single room identifier, with the main floor as the level. If the stairwell is not accessible from the main floor, utilize the access level closest to the main floor as room level designation. See Figure 3-2 for examples.

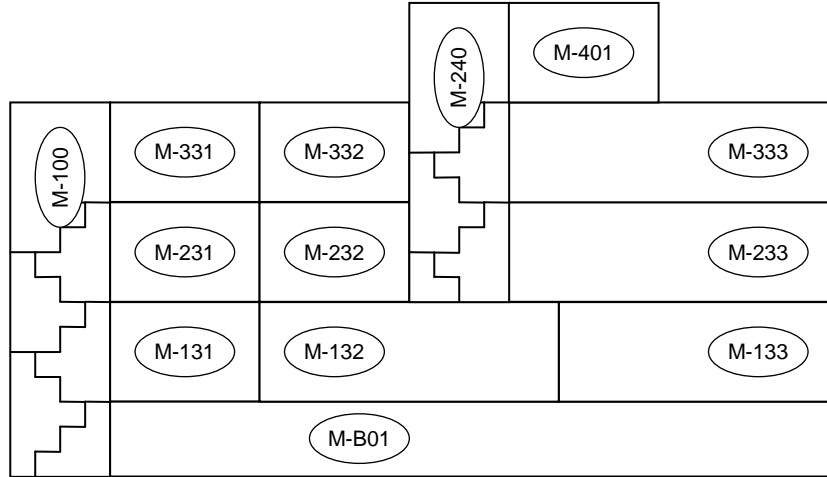


Figure 3-2 : Stairwell Identification Examples – Elevation View

- Rooms that span multiple levels should be identified with a level corresponding to the primary access level. See Figure 3-2 for examples of multi-level room identification.

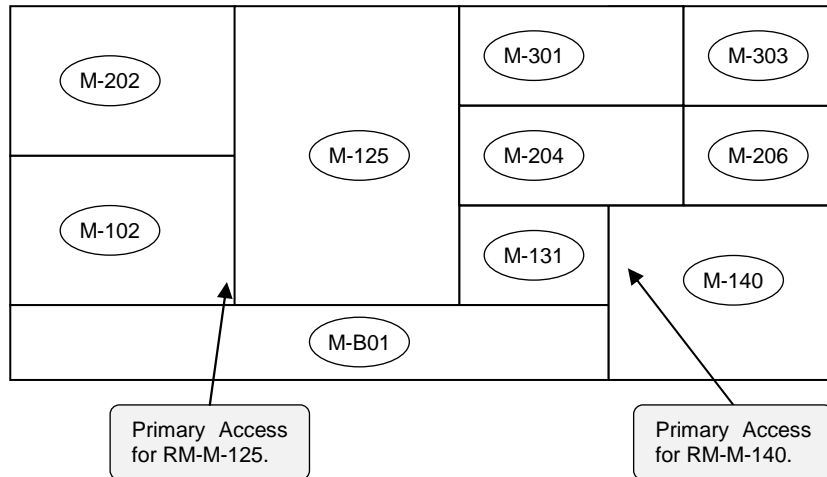


Figure 3-3 : Multi-Level Room Examples – Elevation View

4 MECHANICAL / PROCESS EQUIPMENT

4.1 Identifier Format

Mechanical / process equipment will be identified as follows:

FFFF	-	EEEE	-	P	NNN
Facility Code (Optional)	-	Equipment Functional Designation	-	Process Area	Equipment Number

Where,

- FFFF** is the *Facility Code*, from Appendix A. The *Facility Code* will typically be implied, and would only be fully written where required.
- EEEE** is the *Equipment Functional Designation*, which is comprised of 1 to 4 characters from Section 4.2.
- P** is the *Process Area*, which is based on Section 2.3.
- NNN** is the *Equipment Number* of the associated equipment. This will be three digits for medium to larger facilities, but will be two digits for smaller facilities, such as Collections facilities.

Examples:

- CMP-G201** A compressor in the G process area.
- P-M645** A glycol pump in the M process area.
- R-R102** An oxygen reactor in the R process area.
- SF-F61** A supply fan in a flood station. Note the two digit equipment number for Collections facilities.
- P-L01** The first lift pump in a wastewater lift station. Note that the equipment number for collections facilities in only two digits long.

4.2 Functional Designations

The functional designation represents the function of the equipment. A complete list functional designations is shown in Table 4-1.

Table 4-1 : Process / Mechanical Equipment Functional Designations

Functional Designation	Description	Notes
AD	Air Dryer	
AF	Aeration Fan	
AG	Agitator	
AHU	Air Handling Unit	Includes make-up air unit.
B	Blower	
BD	Balance Damper	See Section 4.3.
BFP	Back Flow Preventer	
BLR	Boiler	
BS	Bar Screen	
CAL	Calibration Column	
CC	Cooling Coil	
CDR	Condenser	
CE	Centrifuge	
CHLR	Chiller	
CM	Clarifier Mechanism	
CMP	Compressor	
CNV	Conveyor	Includes skimmers
CRN	Crane	
CT	Cooling Tower	
CU	Condensing Unit	
CV	Check Valve	See Section 5.2
EF	Exhaust Fan	
F	Fan - General	
FA	Flame Arrestor	
FC	Fan Coil	
FD	Fire Damper	Utilize same equipment number as air handler.
FDR	Feeder	Examples screw feeder, chlorinator, glycol make-up unit
FEX	Fire Extinguisher	
FG	Flap Gate	
FIL	Filter	
GR	Grille – General	See Section 4.3.
GRD	Grille – Diffuser	

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Functional Designation	Description	Notes
HC	Heating Coil	
HCE	Heating Coil, Electric	Duct based heater.
HE	Heat Exchanger	
HO	Hoist	
HOP	Hopper	
HP	Heat Pump	
HRC	Heat Recovery Coil	
HTR	Heater	General heaters, radiant, convectors, etc.
HUM	Humidifier	
HV	Hand/Manual Valve	See Section 5.2
INJ	Injector	
MXR	Mixer	
OD	Overhead Door	
P	Pump	
R	Reactor (various processes)	
RES	Reservoir	Large water containment structure.
S	Skid Package	
SA	Sampler	
SCBR	Scrubber	
SF	Supply Fan	
SL	Stop Logs	
SLG	Sluice Gate	
STR	Strainer	See Section 5.2
TK	Tank	
TU	Terminal Unit (HVAC)	Includes CAV/VAV/Dual Duct boxes. Dampers are to be identified as per Section 7.1 – Instrumentation.
U	Miscellaneous Equipment Not In List	e.g. water softener
UH	Unit Heater	
UVR	Ultra-Violet (UV) Reactor	
V	Vessel, Pressure Vessel	e.g. air receiver, glycol expansion tank
W	Weir	
WGB	Waste Gas Burner	

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Notes:

1. *Equipment Functional Designations are to be unique, including electrical, automation, communication, and security equipment. Instrument Functional Designations may overlap Equipment Functional Designations.*
2. *See Appendix C for a master list of Equipment Functional Designations.*

4.3 HVAC Miscellaneous Components

Miscellaneous HVAC components will be identified as follows:

FFFF	-	EEEE	-	P	NNN	-	XX
Facility Code (Optional)	-	Equipment Functional Designation	-	Process Area	Equipment Number	-	Component Number

Where,

- FFFF** is the *Facility Code*, from Appendix A. The *Facility Code* will typically be implied, and would only be fully written where required.
- EEEE** is the *Equipment Functional Designation*, which is comprised of 2 to 4 characters from Section 4.2.
- P** is the *Process Area*, which is based on Section 2.3.
- NNN** is the *Equipment Number* of the associated equipment. Where an equipment number is not associated, allocate an equipment number.
- XX** is the *Component Number*, which can be one or two digits, and will increment starting at 1.

Examples:

- FD-G601-5 the fifth fire damper associated with air handling unit AHU-G601.
- GD-M645-1 The first diffuser grille associated with SF-M645.
- GR-P682-22 The 22nd grille associated with SF-P682.

4.4 Subcomponents

The following designations are to be utilized for mechanical equipment subcomponents. See Section 2.6 for general rules on application of subcomponents.

Table 4-2 : Mechanical Equipment Subcomponents

Subcomponent Designation	Description	Notes
CMP	Compressor	e.g. component of a chiller.
F	Fan	
LOP	Lube Oil Pump	
MTR	Motor	
SWP	Swash Plate	
VSD	Variable Speed Drive	Includes fluid couplings and magnetic couplings. Utilize electrical VFD designation for variable frequency drives.

Examples:

P-G261.MTR	The motor associated with P-G261.
CMP-M502.LOP	The lube oil pump associated with compressor CMP-M502.
CHLR-M621.CMP-1	Compressor 1 of chiller CHLR-M621.

5 PIPING

5.1 Pipe Designation

The identification format for piping is as follows.

P	-	CCC	-	MMNN	-	LLLL
Pipe Nominal Size	-	Fluid Commodity Code	-	Pipe Specification Code (Optional)	-	Line Number (Optional)

Where,

- P** is the nominal pipe size in metric millimetres, and may be from 1 to 4 digits. See Table 5-1. For rectangular conduits and ducts, express the size as width x height. See example below.
- CCC** is the *Fluid Commodity Code*, which is 2 to 4 characters from Section 5.1.2.
- MMNN** is the optional *Pipe Specification Code*, where MM is the material, and NN is a number referencing the specific specification. Note that MM must be letters. See Notes 1 and 2.
- LLLL** is the optional *Line Number*. The *Line Number* must be unique across the entire facility, for each *Fluid Commodity Code*. See Note 3.

Note:

- It is recommended that a common set of pipe specifications be developed for each type of facility.*
- For existing facilities, where the exact pipe specification is not known, the Pipe Specification Code may be omitted.*
- It is not expected that Line Numbers will be utilized on all projects. Coordinate with the City project manager for specific requirements regarding the applicability of Line Numbers.*
- The Fluid Commodity Code together with the Line Number must be unique across the facility, where Line Numbers are utilized.*

Examples:

- | | |
|------------------|---|
| 150-PW-CS11 | A 150mm (6") potable water pipe, with specification code CS11. No line numbers utilized. |
| 600-RAS | A 600mm (24") Return Activated Sludge pipe, with an unknown pipe specification and no line number. |
| 600x1200-SE | A 600 x 1200mm secondary effluent conduit. The pipe/conduit specification and line number are not specified. |
| 25-CLG-SS31-1151 | A 25mm (1") chlorine gas pipe, with pipe specification SS31, and line number 1151. |
| 400-RW-CS52-1151 | A 400mm (16") chlorine gas pipe, with pipe specification SS31, and line number 1151. Note that this could be in the same facility as piping 25-CLG-SS31-1151. |

1350-TRW-040

A 1350mm diameter treated water pipe. The pipe specification code is omitted. The line number code 040 is differentiated from the pipe specification code in that it does not begin with a letter.

5.1.1 Nominal Pipe Sizes

Table 5-1 : Nominal Pipe Sizes (Metric)

mm	Inches	mm	Inches	mm	Inches	mm	Inches
3	1/8	75	3	275	11	750	30
6	1/4	90	3 1/2	300	12	800	32
10	3/8	100	4	350	14	850	34
12	1/2	112	4 1/2	400	16	900	36
20	3/4	125	5	450	18	950	38
25	1	150	6	500	20	1000	40
32	1 1/4	175	7	550	22	1100	44
38	1 1/2	200	8	600	24	1200	48
50	2	225	9	650	26	1300	52
65	2 1/2	250	10	700	28	1400	56

5.1.2 Fluid Commodity Codes

Table 5-2 : Fluid Commodity Code Designations

Code	Commodity - Water	Commodity - Wastewater
AA	Aqua Ammonia	
AHP	Air, High Pressure	
ALP	Air, Low Pressure	Air, Low Pressure
AS	Air Scour	
BS	Brine Solution	
BWS	Backwash Supply	
BWW	Backwash Wastewater	
CA	Compressed Air	Compressed Air
CCW	Circulating Cooling Water	
CDR	Condenser Water Return	Condenser Water Return
CDS	Condenser Water Supply	Condenser Water Supply
CE		Centrate
CG		Calibration Gas
CHR	Chilled Water Return	Chilled Water Return
CHS	Chilled Water Supply	Chilled Water Supply
CL2	Chlorine	Chlorine
CLG	Chlorine Gas	
CLS	Chlorine Solution	
CO2	Carbon Dioxide	Carbon Dioxide
CON		Condensate
CRW	Clarified Discharge Water	
CS	Caustic (Sodium Hydroxide)	Combined Sewer
CWR	Cooling Water Return	Cooling Water Return
CWS	Cooling Water Supply	Cooling Water Supply
D	Drain	Drain
DCW	Domestic Cold Water	Domestic Cold Water
DD	Deacon Effluent (Post UV)	
DDW	Demineralized Water	
DEA	Dilute Acid	
DEC	Dilute Caustic	
DF	DAF Float	
DG		Digester Gas
DGH		Digester Gas, High Pressure
DFR	Diesel Fuel Return	
DFS	Diesel Fuel Supply	

Code	Commodity - Water	Commodity - Wastewater
DHR	Domestic Hot Water Return	Domestic Hot Water Return
DHW	Domestic Hot Water	Domestic Hot Water
DL		Decant Liquor
DP		Dry Polymer
DRA	Drainage (Floors)	
DRN	Drains (Clean Drains)	
DRS	Subdrain	
DS	Deacon Suction	Digester Sludge
DSW	Distilled Water	
DU	Deacon UV (Pre UV)	
EE	Engine Exhaust	
ES	Electric Supply	Electric Supply
EXP	Expansion Tank Equalizer Line	
FC	Ferric Chloride	Ferric Chloride
FE		Final Effluent
FED	Filter Media Education	
FIN	Filter Influent	
FIR	Firewater	
FOA		Foul Air
FOR	Fuel Oil Return	
FOS	Fuel Oil Supply	
FOV	Fuel Oil Vent	
FPW	Fire Protection Water	
FSL		Fermenter Sludge
FSU		Fermenter Supernatant
FSW		Flushing Water
FTR	Filter To Recycle	
FW	Filtered Water	
GE		Grit Effluent
GOX	Gaseous Oxygen	
GR	Glycol Return	Glycol Return
GS	Glycol Supply	Glycol Supply
HCO	Hydraulic Oil	Hydraulic Oil
HFS	Hydrofluosilicic Acid	
HFW		Hot Flushing Water
HP	Hydrogen Peroxide	
HPS	High Pressure Steam	
HR	High Pressure Condensate	

Code	Commodity - Water	Commodity - Wastewater
HST	12% Hypochlorite Solution	
HWS		Hot Water Supply
HWR		Hot Water Return
H2		Hydrogen
HYP	0.8% Hypochlorite Solution	
IAS	Instrument Air Supply	Instrument Air Supply
LCP		Liquid Concentrated Polymer
LDS		Land Drainage Sewer
LGO	Lubricating Oil	Lubricating Oil
LOX	Liquid Oxygen	Liquid Oxygen
LPC	Low Pressure Condensate	
LPS	Low Pressure Steam	Low Pressure Steam
MET		Methanol
ML		Mixed Liquor
MP		Mixed Polymer
MPC	Medium Pressure Condensate	
MPS	Medium Pressure Steam	
MU	Make-Up Water	
N2		Nitrogen
NG	Natural Gas	Natural Gas
O2		Oxygen
OF	Overflow	
OZG	Ozone Off Gas	
OZO	Ozonated Oxygen	
OZW	Ozonated Water	
PRO	Propane	
PC	Pumped Condensate	
PD		Process Drain
PE		Primary Effluent
PEF	Phosphate Feed	
PLD	Dry Polymer	
PLS	Polymer Solution	
PO		Process Overflow
PS		Primary Sludge
PSW	Plant Service Water	
PV		Process Vent
PW	Potable Water	Potable Water
R	Refrigerant	Refrigerant

Code	Commodity - Water	Commodity - Wastewater
RAS		Return Activated Sludge
RD	Roof Drain	
RS		Raw Sewage
RW	Raw Water	
RWL	Raw Water Leader	
SA		Soda Ash
SAM	Sample	
SAN	Sanitary Drainage	
SBS	Sodium Bisulphite	
SC		Scum
SCA	Sulphuric Acid	
SDR	Saturated Recycle Water	
SE		Secondary Effluent
SEA		Service Air
SHC	Sodium Hypochlorite	
SLC		Sludge Cake
SLO	Seal Oil	
SLU	Sludge	
SP	Sprinkler Pipe	
SPD	Sump Pump Discharge	Sump Pump Discharge
SRS		Storm Relief Sewer
STD	Salt Dry	
SUB		DAF Subnatant
SUP	Supernatant	
SW	Seal Water	Seal Water
SWD	Stormwater Drainage	
TBS		Thickened Bottom Sludge
TCE		Treated Centrate
TDW	Tempered Domestic Water	
TO		Thermal Oxidizer
TRW	Treated Water	
TS		Thin Sludge
TW	Tempered Water	
TWAS		Thickened Waste Activated Sludge
VAC	Vacuum	Vacuum
VTA	Vent To Atmosphere	Vent to Atmosphere
W		Water

Code	Commodity - Water	Commodity - Wastewater
WA		Waste Air
WAS		Waste Activated Sludge
WS	Softened Water	
WWS		Wastewater Sewer

5.1.3 Piping Material

Table 5-3 : Piping Material

Designation	Description
AA	Aluminum Alloy
BA	Aluminum Bronze
CG	Galvanized Carbon Steel
CS	Carbon Steel
DI	Ductile Iron
KB	Concrete
PA	ABS (Acrylonitrile-butadiene styrene)
PD	HDPE (High Density Polyethylene)
PP	PP (Polypropylene)
PV	PVC (Polyvinyl Chloride)
SS	Stainless Steel

5.2 Piping Components

5.2.1 Manual Valve Identifier Format – Minor Valves

The identification format for minor manual valves, without instrumentation, is as follows.

FFFF	-	HV	-	P	NNN	S
Facility Code (Optional)	-	Manual Valve Designation	-	Process Area	Equipment Number	Suffix

Where,

FFFF	is the <i>Facility Code</i> , from Appendix A. The <i>Facility Code</i> will typically be implied, and would only be fully written where required.
HV	is the Manual Valve Designation.
P	is the <i>Process Area</i> , which is based on Section 2.3.
NNN	is the <i>Equipment Number</i> of the associated equipment.
S	is the <i>Suffix</i> , a single letter to designate the specific valve.

Notes:

1. *The Equipment Number will typically be the nearest associated equipment. In some cases, Equipment Numbers may be designated for allocation of manual valves.*
2. *Manual valves, check valves, and strainers may utilize common equipment numbers and suffixes. For example, it is acceptable to have a HV-G638A and a CV-G638A.*
3. *Large valves and controlled valves will be identified via the instrumentation standard identified in Section 7.1.*
4. *Typically, significant valves not associated with a specific piece of equipment would be identified as per Section 5.2.2, however the designers discretion may be applied.*

Examples:

- HV-G201A A manual valve in the G process area, associated with pump P-G201.
- HV-M645B A manual valve in the M process area.
- HV-R102A A manual valve in the R process area.

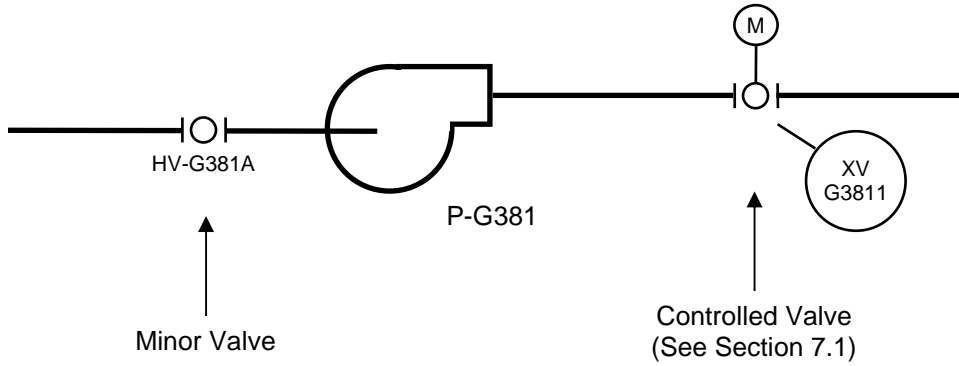


Figure 5-1 : Valve Identification

5.2.2 Manual Valve Identifier Format – Major Valves and Valves with Instrumentation

The identification format for major valves and any manual valve with instrumentation, is based upon the instrumentation standard identified in Section 7.1. The format of the identifier is as follows.

FFFF	-	HV	-	P	NNN	T
Facility Code (Optional)	-	Manual Valve Designation	-	Process Area	Equipment Number	Instrument Number
					Loop Number	

Where,

FFFF	is the <i>Facility Code</i> , from Appendix A. The <i>Facility Code</i> will typically be implied, and would only be fully written where required.
HV	is the Manual Valve Designation.
P	is the <i>Process Area</i> , which is based on Section 2.3.
NNN	is the <i>Equipment Number</i> of the associated equipment. If no equipment is associated, allocate <i>Equipment Numbers</i> specific for the applicable valve.
T	is the <i>Instrument Number</i> , where the number increments from the number 1 through 9. Use of the number 0 should be infrequent, except for special instruments, or those where the instrument ending with 0 is a common instrument that serves other instruments.
NNNT	is the Loop Number, comprised of the <i>Equipment Number</i> together with the <i>Instrument Number</i> .

Notes:

1. *The Equipment Number will typically be the nearest associated equipment. In some cases, Equipment Numbers may be designated for allocation of manual valves.*

Examples:

HV-G2011	A manual valve in the G process area, associated with pump P-G201, and contains open and closed limit switches.
HV-M6451	A manual valve in the M process area, with a position transmitter.
HV-R1022	A manual valve in the R process area, with a limit switch.

5.2.3 Check Valve and Strainer Identifier Format

Check valves and strainers, with no instrumentation, are to be identified as follows:

FFFF	-	EEE	-	P	NNN	S
Facility Code (Optional)	-	Equipment Functional Designation	-	Process Area	Equipment Number	Suffix

Where,

- FFFF is the *Facility Code*, from Appendix A. The *Facility Code* will typically be implied, and would only be fully written where required.
- EEE is the *Equipment Functional Designation*, which is comprised of 2 to 4 characters from Section 4.2. Specifically in this case, CV for Check Valve or STR for strainer.
- P is the *Process Area*, which is based on Section 2.3.
- NNN is the *Equipment Number* of the associated equipment.
- S is the *Suffix*, a single letter to designate the specific valve.

Notes:

1. *The Equipment Number will typically be the nearest associated equipment. In some cases, Equipment Numbers may be designated for allocation of manual valves.*
2. *Manual valves, check valves, and strainers may utilize common equipment numbers and suffixes. For example, it is acceptable to have a HV-G638A and a CV-G638A.*
3. *Controlled valves will be identified via the instrumentation standard identified in Section 7.1.*

Examples:

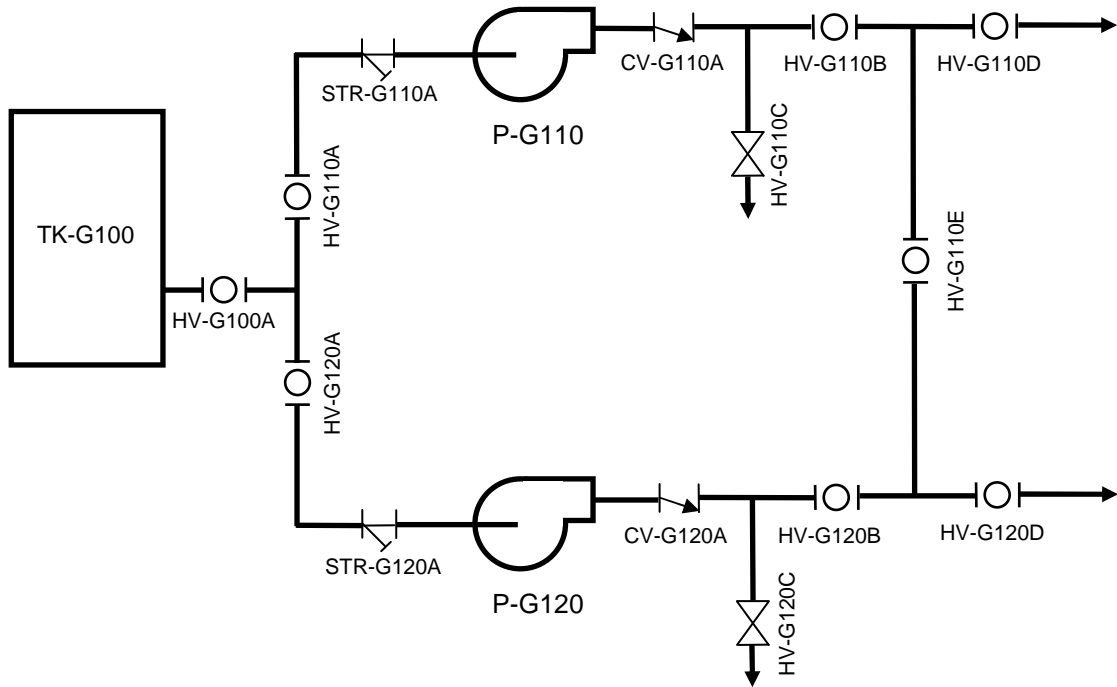
- CV-G201A A check valve in the G process area, associated with pump P-G201.
- CV-M645B A check valve in the M process area.
- STR-R102A A strainer in the R process area.

5.2.4 Cathodic Protection Components

The identification of cathodic protection system elements is to be developed at a later date.

5.2.5 Sample P&ID

See Figure 5-2 for a sample P&ID segment depicting the identification of manual valves, check valves, and strainers.



Note: All devices above have an implied facility code prefix of 0102- (or similar).

Figure 5-2 : Sample P&ID – Manual Valve, Strainer, and Check Valve Indication

6 ELECTRICAL

6.1 Equipment Identifier Format

The identification format for electrical equipment is as follows.

FFFF	-	EEEE	-	P	NNN	T	-	S
Facility Code (Optional)	-	Equipment Functional Designation	-	Process Area	Equipment Number	Type Modifier (Optional)	-	Suffix (Optional)

Where,

- FFFF** is the *Facility Code*, from Appendix A. The *Facility Code* will typically be implied, and would only be fully written where required.
- EEEE** is the *Equipment Functional Designation*, which is comprised of 2 to 4 characters from Section 6.2.
- P** is the *Process Area*, which is based on Section 2.3.
- NNN** is the *Equipment Number*. Select numbers consistent with the ranges in Appendix D.
- T** is the *Type Modifier*, an optional field that is utilized to designate essential or UPS powered equipment. See Section 6.3.
- S** is the *Suffix*, an optional numeric or letter code to distinguish between multiple pieces of equipment with a common equipment number. Generally, numbers are utilized for equipment in series, and letters for equipment in parallel.

Examples:

- | | |
|---------------|--|
| 0101-MCC-M001 | A MCC located in the M process area of the NEWPCC facility. |
| DS-G510 | A disconnect switch for pump P-G510. |
| CB-M023-B | The second (alternate) breaker feeding PNL-M023. |
| PNL-S025E | Essential power panelboard located in the S process area. |
| XFMR-H711 | Transformer within a regional water pumping station. |
| MCC-L71 | MCC within a wastewater lift station (Note the two digit equipment number) |

6.2 Electrical Functional Designations

Table 6-1 : Electrical Equipment Functional Designations

Functional Designation	Description	Notes
ATS	Automatic Transfer Switch	
BAT	Battery	
BC	Battery Charger	
BUS	Busway	
C	Cable (Power)	
CAP	Capacitor	Typically individual unit. See PFC.
CB	Circuit Breaker	Includes air, vacuum, SF6, and moulded case circuit breakers
CBUS	Cable Bus	
CON	Contactora	
CP	Control Panel	
CPR	Cathodic Protection Rectifier	
CSTE	Customer Service Termination Equipment	
DP	Distribution Panel	Typically 600V panel, for distributing power to other points of the electrical distribution system.
DS	Disconnect Switch (non-fusible)	
ELB	Emergency Lighting Battery Pack	May have integrated lights.
FAAP	Fire Alarm Annunciator Panel	
FACP	Fire Alarm Control Panel	
FAS	Fire Alarm System	
FDS	Fusible Disconnect Switch	
FU	Fuse	
GEN	Generator	
HCC	Heater Coil Controller	Includes SCR and contactor based controllers.
HF	Harmonic Filter	
JB	Junction Box	
K	Interlocking Key (Kirk Key)	See Section 6.4.5
LC	Lighting Contactor	
LDB	Load Bank	
MCC	Motor Control Centre	
MCP	Motor Circuit Protector	
MCS	Moulded Case Switch	

MMS	Manual Motor Starter	
MS	Motor Starter	
MSP	Motor Starter Panel	
MTR	Motor	
MTS	Manual Transfer Switch	
NGR	Neutral Grounding Resistor	
PB	Pull Box	
PFC	Power Factor Correction Unit	
PM	Power Meter	
PNL	Panelboard	
PS	Power Supply	24VDC power supply
PSP	Power Supply Panel	Panel containing 24VDC power supplies, fire alarm booster power supply.
RCPT	Receptacle	
RCTR	Reactor	Includes VFD line and load reactors.
SCR	Silicon Controlled Rectifier	
SGR	Switchgear	
SPL	Splitter	
SS	Soft Starter	
SW	Switch	
TVSS	Transient Voltage Surge Suppressor	
UPS	Uninterruptible Power Supply	
VFD	Variable Frequency Drive	
XFMR	Transformer	

6.3 Type Modifier

Electrical equipment that is deemed critical to the operation of a facility is typically backed up by one or more generators or some form of uninterruptible power supply. Electrical equipment of this nature is to be identified with a type modifier to provide indication that the equipment is critical in nature.

The following type modifiers will be used on electrical equipment based on the type of backup power system it is supplied by:

Type Modifier	Description
E	Essential – Distribution is deemed to be of higher criticality and is typically backed up by a generator, or at minimum has a transfer switch between multiple sources.
U	Uninterruptible – The distribution equipment is powered by a UPS

Notes:

1. *The Type Modifier is utilized only for essential and uninterruptible power systems.*
2. *The Type Modifier is not to be used on generators or UPS units as these devices are the sources of the backup power supply.*

6.4 Device-Specific Identifier Formats

6.4.1 Receptacle Identifiers

Receptacles are not necessarily required to be uniquely identified, but where they are, the receptacle identification is as follows.

RCPT	-	P	NNN	-	KK	S	-	MM
Receptacle Designation	-	Process Area	Equipment Number of Source Panel	-	Circuit Number	Switched Sub-Circuit (Optional)	-	Incrementing Number (Optional)

Where,

- RCPT** is the receptacle designation.
- P** is the *Process Area*, which is based on Section 2.3.
- NNN** is the *Equipment Number* of the source panel.
- KK** is the *Circuit Number* of the source panel. Where circuit numbers are not applicable, utilize an incrementing number beginning with 1.
- S** is the optional *Switched Sub-Circuit* utilized to identify cables that are switched.
- MM** is an optional *Incrementing Number*, utilized to indicate the specific receptacle powered by the circuit.

Examples:

- RCPT-S022-14-2** A uniquely identified receptacle fed from Circuit 14 of PNL-S022. In this case, it is the 2nd receptacle on the circuit.
- RCPT-M701-1** A uniquely identified receptacle fed from MCC-M701. In this case, it is the only receptacle on the circuit, and as circuit numbers are not typically applied to MCCs, the number 1 is assigned to the circuit number.

6.4.2 Power Cables Associated with Identified Equipment

The identification format for power cables is as follows.

C	-	P	NNN	-	S
Cable Designation	-	Process Area	Equipment Number of Load	-	Suffix (Optional)

Where,

- C** is the Cable Designation. For power cables, the letter C is utilized. For busway, BUS is utilized.
- P** is the *Process Area*, which is based on Section 2.3.
- NNN** is the *Equipment Number* of the load equipment.
- S** is the *Suffix* utilized to identify the specific cable associated with the equipment. The Suffix is not required if a single cable is associated with the equipment. Utilize sequential numbers for cables in series, or for different purposes, and letters for cables in parallel. Utilize the letter T to designate tie connections. Where the load equipment identifier has a suffix in the identifier, set the suffix of the cable to be the suffix of the load identifier plus an additional digit (See receptacle example below)

Notes:

1. *In the event the cable does not serve a specific load, such as a tie cable between two MCCs, select one of the two units of equipment as the prime equipment number for the cable.*
2. *See Section 7.3 for automation cable identification.*

Examples:

- C-G683-1 The feeder for a motor disconnect, DS-G683.
- C-G683-2 The motor cable feeding exhaust fan EF-G683, and fed from disconnect switch DS-G683.
- C-M002 The feeder for MCC-M002
- C-M003-A The normal power feeder to ATS-M003.
- C-M003-B The emergency power feeder to ATS-M003.
- C-M001-T A cable used as a tie between MCC-M001 and DP-M002.
- C-L01 Cable feeding Lift Pump P-L01 in a wastewater lift station.
- C-M710-21 The cable feeding receptacle RCPT-M710-2.

6.4.3 General Purpose Cables – Lighting & Receptacles

The identification format for general purpose cables, for single phase loads, is as follows.

C	-	P	NNN	-	KK	S
Cable Designation	-	Process Area	Equipment Number of Source Panel	-	Circuit Number	Switched Sub-Circuit (Optional)

Where,

- C is the Cable Designation.
- P is the *Process Area*, which is based on Section 2.3.
- NNN is the *Equipment Number* of the source panel.
- KK is the *Circuit Number* of the source panel
- S is the optional *Switched Sub-Circuit* utilized to identify cables that are switched.

Note:

1. *It is expected that three-phase loads will all have equipment numbers assigned.*

Examples:

- C-S022-14 Circuit 14 of PNL-S022.
- C-S022-14A Switched sub-circuit of circuit 14, fed from PNL-S022.

6.4.4 Junction Boxes - Power

The identification format for power junction boxes is as follows.

JB	-	P	NNN	T	-	S
Junction Box Designation	-	Process Area	Equipment Number	Circuit Number	-	Suffix (Optional)

Where,

- JB** is the Junction Box designation.
- P** is the *Process Area*, which is based on Section 2.3.
- NNN** is the *Equipment Number* of the load equipment. If not associated with a specific piece of equipment, use a unique *Equipment Number* in the electrical equipment range, not associated with other equipment, in accordance with the *Equipment Number* ranges in Appendix D.
- T** is the *Type Modifier*, optional to electrical equipment as per Section XX.
- S** is the *Suffix* utilized to identify multiple junction boxes associated with an equipment number.

Examples:

- JB-U421 Junction box associated with pump P-U421.
- JB-C001 Junction box associated with MCC-C001.
- JB-R600 Junction Box associated with numerous pieces of equipment, within a wastewater treatment facility.
- JB-M751 Junction Box associated with numerous pieces of equipment, within a regional water pumping station.

6.4.5 Interlock Keys

The identification format for interlock (Kirk) keys is as follows.

K	NNNN
Interlocking Key Designation	Number

Where,

K is the *Interlocking Key* designation.

NNNN is the *Key Interchange Number*, which is unique for each facility. The *Key Interchange Number* can be from 1 to 4 digits long. For larger facilities, a drawing should be created with an index of Key Interchange Numbers for reference.

Note:

1. *The interlock key identifier will be the same for all interlocks associated with the system. Thus, for a system with four breakers interlocked with four locks and three keys, all four interlocks and keys have the same identifier.*
2. *Process codes are not utilized as key interlocks could span over multiple process areas.*

Example:

K1 First key interlock system for a facility.

K52 52nd key interlock system associated with a facility.

6.4.6 Wire Tags

6.4.6.1 Lighting and Receptacle Circuits - AC

The identification format for lighting and receptacle circuits is as follows.

P	NNN	-	C	S
Process Area	Equipment Number of Source	-	Circuit Number or Neutral Designation	Switched Sub-Circuit (Optional)

Where,

- P** is the *Process Area*, which is based on Section 2.3.
- NNN** is the *Equipment Number* of the source panelboard.
- C** is the *Circuit Number* of the source panelboard, or N for a neutral wire.
- S** is the *Switched Sub-Circuit Designation*, and is an incrementing letter for a conductor that is switched.

Note: The Equipment Functional Designation, typically PNL, is implied to reduce the length of the wire tags.

Examples:

- G701-32 Line (Hot) conductor of circuit 32, associated with PNL-G701.
- W752-N Neutral conductor associated with PNL-W752.
- S702-12B The second switched sub-circuit line (hot) conductor, associated with PNL-S702 circuit 12.

6.4.6.2 DC Power Circuits

DC power circuits, such as from large switchgear DC power supply units require unique identification as follows:

P	NNN	-	C	S	D
Process Area	Equipment Number of Source	-	Circuit Number	Switched Sub-Circuit (Optional)	Power Designation

Where,

- P is the *Process Area*, which is based on Section 2.3.
- NNN is the *Equipment Number* of the source panelboard.
- C is the *Circuit Number* of the source panelboard.
- S is the *Switched Sub-Circuit Designation*, and is an incrementing letter for a conductor that is switched.
- D is the *Power Designation*, which is based on Table 6-2.

Note: The *Equipment Functional Designation*, typically PNL, is implied to reduce the length of the wire tags.

Table 6-2 : DC Power Circuit Wire Tag Power Designations

Power Designation	Description
C	DC Common (0V)
G	Ground
+	DC Positive
-	DC Negative

Note: The *Ground designation* is not typically required, provided that the ground wire is green.

Examples:

- G751-22+ Positive wire of circuit 22, fed from PNL-G751.
- G751-22- Negative wire of circuit 22, fed from PNL-G751.
- G751-22A+ Positive wire of switched circuit 22, fed from PNL-G751.

6.4.6.3 Three Phase Power Wiring

The identification format for three phase power wire tags is as follows.

P	NNN	-	X	H
Process Area	Equipment Number	-	Sequence Number (Optional)	Phase

Where,

- P is the *Process Area*, which is based on Section 2.3.
- NNN is the *Equipment Number* of the load equipment. If not associated with a specific piece of equipment, use of *Equipment Number* in the electrical range is preferred, in accordance with the *Equipment Number* ranges in Appendix D.
- X is an optional *Sequence Number* that is typically a numeric character, utilized when there are multiple power cables associated with an *Equipment Number*.
- H is the *Phase*, and should be labelled A, B, C, or N.

Three phase power wiring wire tagging is required, except where the conductors are color coding, are in a dedicated cable or conduit, and the routing is obvious.

Examples:

- G681-A Phase A conductor of a power cable associated with EF-G681. The wire is in common conduit with other power cables.
- W151-2B Phase B conductor of the second power circuit associated with centrifuge CE-W151.
- No wire tags are needed for the conductors of a pump, fed via a Teck power cable, where the conductors are color coded and the overall cable is identified and labelled.

6.4.6.4 Motor Control Circuits

The identification format for motor control circuits is as follows:

P	NNN	-	WWW	S
Process Area (Optional)	Equipment Number (Optional)	-	Wire Number	Suffix (Optional)

Where,

- P** is the *Process Area*, which is based on Section 2.3. It is not required for wires exclusively within the motor starter.
- NNN** is the *Equipment Number* of the associated equipment. It is not required for wires exclusively within the motor starter.
- WWW** is the *Wire Number*, an incrementing number.
- S** is an optional *Suffix*, and is utilized where it is desired to utilize the same wire number, but the signal has changed.

Notes:

- It is desirable, but not mandatory, that the wire number in a motor starter match the terminal number.*
- It is deemed acceptable to omit the Process Area and Equipment Number for wires exclusively within the motor starter, as it is common industry practice, and MCC manufacturers only typically provide numeric wire numbers.*

Examples:

- 8** Control wire 8 located in the motor starter for AHU-G652, and lands on terminal 8 in the motor starter.
- 8A** Control wire 8A located in the motor starter for AHU-G652, which does not land on a terminal strip.
- G652-8** Control wire 8, located in external field wiring, associated with AHU-G652.

6.4.7 Tie Circuit Breakers

Tie breakers are used to connect electrical buses together. The identification format for electrical equipment is as follows.

FFFF	-	EEEE	-	P	NNN	-	T	-	S
Facility Code (Optional)	-	Equipment Functional Designation	-	Process Area	Equipment Number	-	Tie Designation	-	Suffix (Optional)

Where,

- FFFF** is the *Facility Code*, from Appendix A. The *Facility Code* will typically be implied, and would only be fully written where required.
- EEEE** is the *Equipment Functional Designation*, which is comprised of 2 to 4 characters from Section 6.2. Typically, this is CB for circuit breaker, but could be DS for disconnect switch.
- P** is the *Process Area*, which is based on Section 2.3.
- NNN** is the *Equipment Number*. Select the equipment number of the bus that the tie breaker is more closely associated with.
- T** is the *Tie Designation*, which is always the single letter T.
- S** is the *Suffix*, an optional numeric or letter code to distinguish between multiple tie breakers.

Examples:

- CB-U001-T A tie breaker between SGR-U001 and SGR-U002
- CB-P001-T A tie breaker between SGR-P001 and SGR-P002

Figure 6-1 illustrates a sample electrical single line diagram with tie breakers.

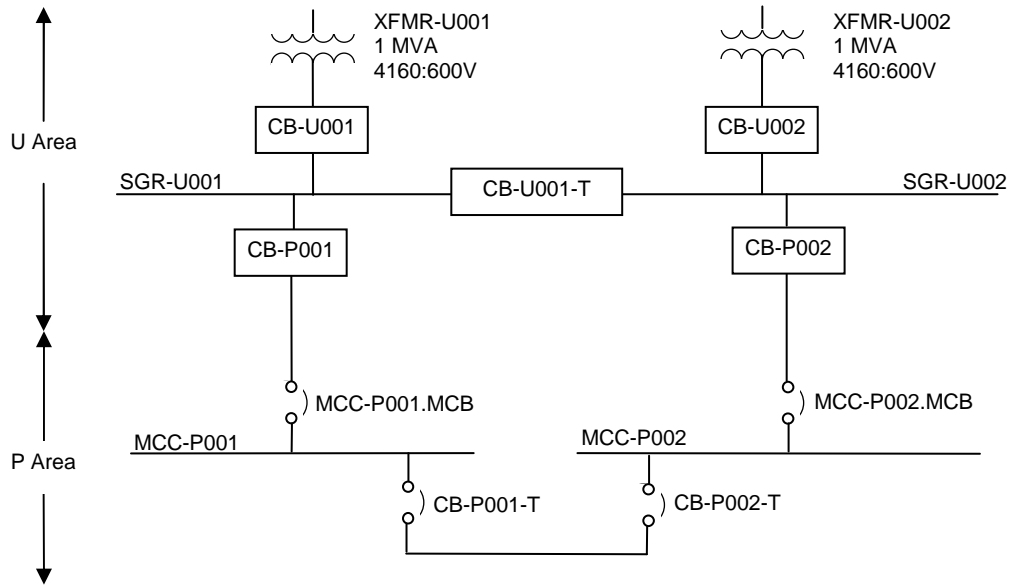


Figure 6-1 : Sample Tie Breaker Identification

6.5 Subcomponents

The following designations are to be utilized for electrical equipment subcomponents. See Section 2.6 for general rules on application of subcomponents. Note that numerous equipment functional designations, shown in Table 6-1, can also be utilized as subcomponent designations, as shown in Table 6-3 below.

Table 6-3 : Electrical Equipment Subcomponents

Subcomponent Designation	Description	Notes
AM	Ammeter	
B	Bus	
CAP	Capacitor	
CON	Contactator	
CPT	Control Power Transformer	
CR	Control Relay	
DS	Disconnect Switch	
F	Fan	
FDS	Fused Disconnect Switch	
FU	Fuse	
M	Motor Contactor	
MCB	Main Circuit Breaker	
MCP	Motor Circuit Protector	
MCS	Moulded Case Switch	
MMC	Motor Management Controller	Also known as intelligent overload.
OL	Overload Relay	
PM	Power Meter	
PS	Power Supply	
R	Reactor	
RLY	Protection Relay	Utilize IEEE Number for Suffix
SCR	Silicone Controlled Rectifier	
TVSS	Transient Voltage Surge Suppressor	
VM	Voltmeter	

Notes:

1. *A motor starter is not typically deemed to be a subcomponent.*

Subcomponent Examples:

- | | |
|---------------|--|
| MS-G261.CAP | A capacitor that is an internal component of MS-G261. If the capacitor were a separate component mounted externally, it would be identified as CAP-G261. |
| MCC-P011.MCB | Integrated Main Circuit Breaker for Motor Control Centre MCC-P011 |
| MCC-P011.TVSS | Transient Voltage Suppressor integrated into MCC-P011 |

A sample single line diagram with subcomponents is shown in Figure 6-2. Note that the full identifier is not written out, provided that the parent identifier is clear from the drawing context.

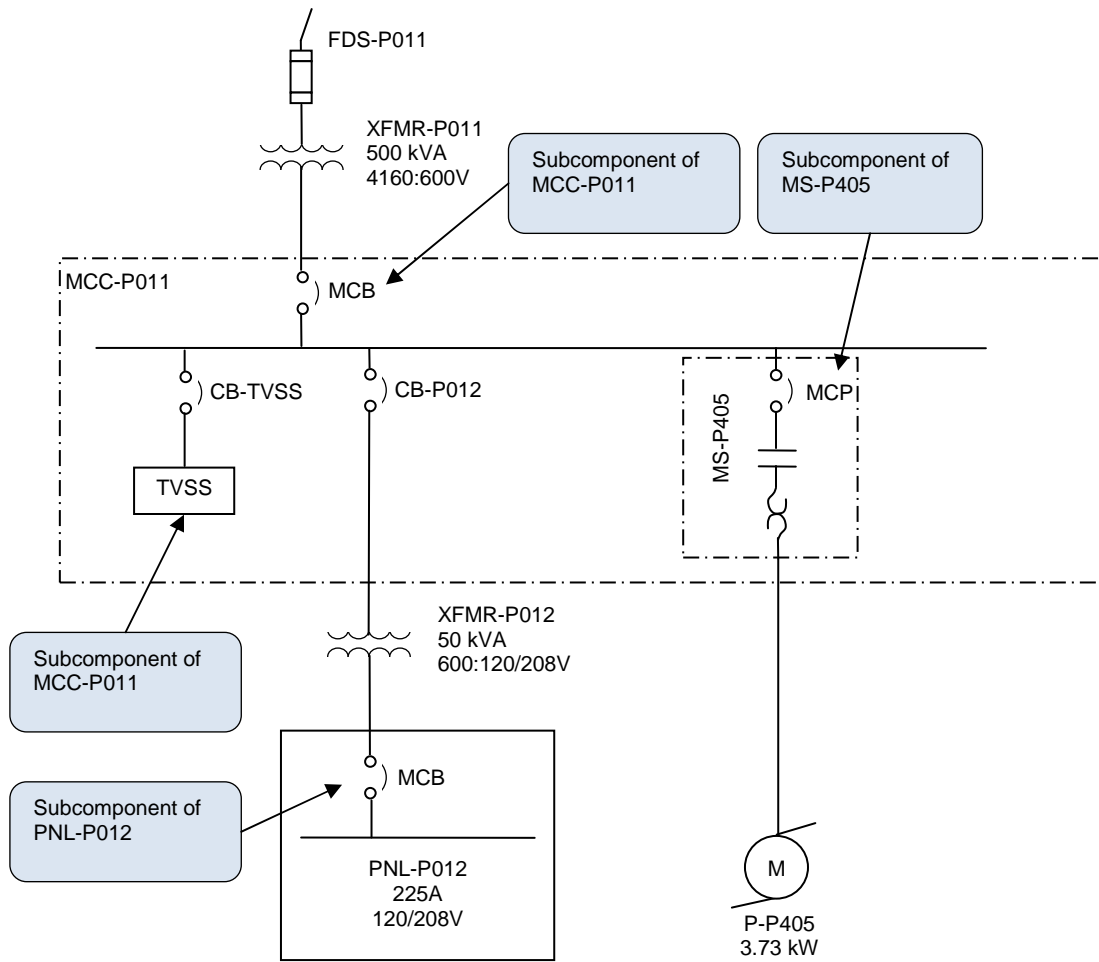


Figure 6-2 : Subcomponents – Electrical Equipment

6.6 Examples

6.6.1 Identification by Load Equipment

An example of a single line diagram, where the identification of a breaker is by the load equipment is shown in Figure 6-3.

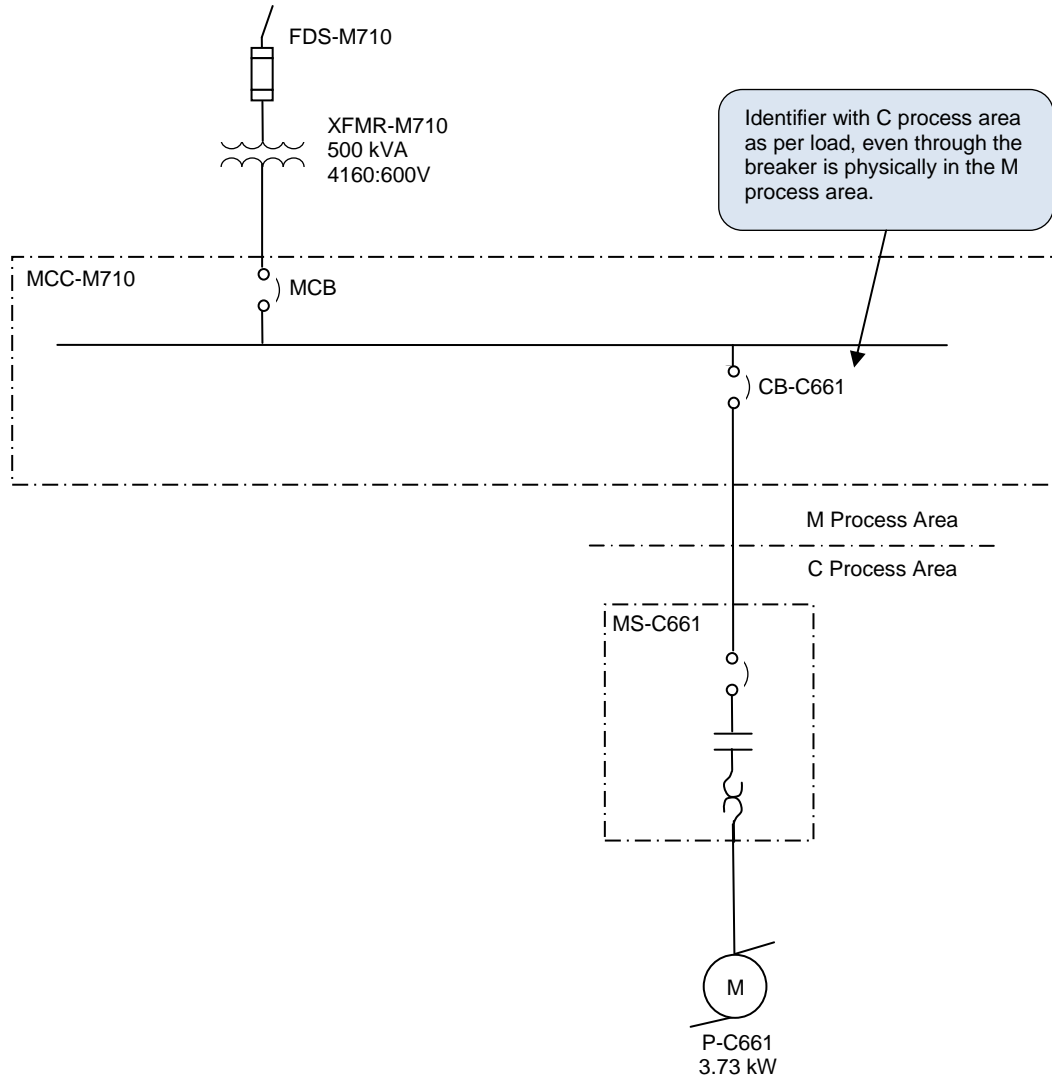


Figure 6-3 : Example Identification by Load Equipment

6.7 Fire Alarm System Devices

6.7.1 Identifier Format

The identification of all fire alarm system components is based upon room numbers rather than equipment numbers. This allows for more rapid recognition of the component location, and avoids utilization of a significant portion of the equipment numbering range for fire alarm system components.

FFFF	-	FAS	-	P	-	L	RR	D	NN
Facility Code (Optional)	-	Fire Alarm Designation	-	Process Area	-	Level	Room Number	Device Designation	Device Number
				From Room Number Designation					

Where,

- FFFF is the *Facility Code*, from Appendix A. The *Facility Code* will typically be implied, and would only be fully written where required.
- FAS is the *Fire Alarm Designation*, which is comprised of the letters FAS.
- P is the *Process Area*, which is based on Section 2.3.
- L is the *Level*, which shall typically be one or two characters, as described in Section 3.2.
- RR is the *Room Number*, which shall be assigned as described in Section 3.2.
- D is the *Device Designation*, which is comprised of a single letter from Section 6.7.2
- NN is the *Device Number*, which uniquely identifies a specific device within a room.

Examples:

- FAS-S-115-D01 The first smoke detector in room 15 on the main level of the Secondary Clarifier process area.
- FAS-M-222-A02 The second horn/strobe in room 22 on the second floor of the M process area.

6.7.2 Fire Alarm Device Designations

Table 6-4 : Fire Alarm Device Designations

Device Designation	Description
A	Annunciation Device (Horn / Strobe)
C	Control Relay Module
D	Detection Device (Heat / Smoke)
E	End-of-line Device
I	Isolation Module
M	Addressable Monitor / Input Module
P	Pullstation
R	Automatic Door Release Device
S	Signal Module

6.7.3 Drawing Format

The format of fire alarm system devices on drawings will typically be as shown in Figure 6-4 below. Note a significant portion of the device identifier is determined via context. Where the context is not clear, use full device identifiers.

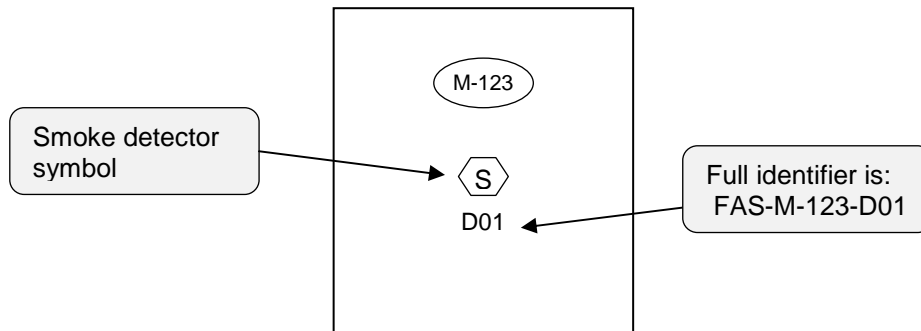


Figure 6-4 : Room Numbering on Drawings – Plan View

6.8 Security Devices

6.8.1 Device Identifier Format

The identification of all security system components is based upon room numbers rather than equipment numbers. This allows for more rapid recognition of the component location, and avoids utilization of a significant portion of the equipment numbering range for security system components.

FFFF	-	SCY	-	P	-	L	RR	D	NN
Facility Code (Optional)	-	Security Designation	-	Process Area	-	Level	Room Number	Device Designation	Device Number
				From Room Number Designation					

Where,

- FFFF is the *Facility Code*, from Appendix A. The *Facility Code* will typically be implied, and would only be fully written where required.
- SCY is the *Security Designation*, which is comprised of the letters SCY.
- P is the *Process Area*, which is based on Section 2.3.
- L is the *Level*, which shall typically be one or two characters, as described in Section 3.2. For outdoor locations, it is recommended that the EX designation be utilized, as described in Section 3.2.
- RR is the *Room Number*, which shall be assigned as described in Section 3.2.
- D is the *Device Designation*, which is comprised of a single letter from Section 0.
- NN is the *Device Number*, which uniquely identifies a specific device within a room.

Examples:

- SCY-S-115-D01 The first door switch in room 15 on the main level of the Secondary Clarifier process area.
- SCY-M-222-A02 The second horn/strobe in room 22 on the second floor of the M process area.
- SCY-S-115-R01 The access card reader outside the door to room 15 on the main level of the Secondary Clarifier process area.
- SCY-A-EX1-VC01 An outdoor video camera in the A process area, exterior zone 1.

6.8.2 Security Device Designations

The security device designations are independent of the Process / Mechanical / Electrical / Automation designations, and may overlap those designations.

Table 6-5 : Security Device Designations – Room Specific

Device Designation	Description	Type Modifiers (See Note 2)
A	Annunciation Device (Horn / Strobe)	H Horn S Strobe
C	Camera	FM Flush Mount PTZ Pan/Tilt/Zoom SM Surface Mount
D	Detector	DS Door Switch GB Glass Break MD Motion Detector
E	End-of-line Device	
I	Isolation Module	
K	Keypad	
M	Addressable Monitor / Input Module	
P	Panic Button	
R	Access Card Reader (See Note 1)	
X	Exit Button	

Note:

1. Access Card Readers will be designated by the room number that access is being granted to.

6.8.3 Security Equipment Designations

Some security equipment is preferable identified as major equipment, and not associated with a specific room. The Security equipment designations are shown in Table 6-6.

Table 6-6 : Security Equipment Designations

Equipment Designation	Description
ACP	Access Control Panel
SCP	Security / Intrusion Alarm Control Panel
SVM	Security Video Monitor
SVR	Security Video Recorder

Note:

1. The above equipment will be identified in a manner consistent with Section 6.1.

6.8.4 Equipment Subcomponent Designations

Table 6-7 : Security Equipment Subcomponent Designations

Equipment Subcomponent Designation	Description
ES	Electric Strike (Subcomponent of Door)
MOD	Input / Output Module
PS	Power Supply
PU	Processing Unit

Note:

1. *The above equipment will be identified in a manner consistent with Section 6.5.*

7 AUTOMATION

7.1 Instrumentation

7.1.1 Instrument Identifier Format

The identification format for instrumentation is as follows.

FFFF	-	XXXX	-	P	NNN	T	-	S
Facility Code (Optional)	-	Instrument Functional Designation	-	Process Area	Equipment Number Loop Number	Instrument Number	-	Suffix

Where,

- FFFF** is the *Facility Code*, from Appendix A. The *Facility Code* will typically be implied, and would only be fully written where required.
- XXXX** is the *Instrument Functional Designation*, which is typically comprised of 2 to 4 characters from Section 7.1.3. Note that five character *Instrument Functional Designations* are possible, but should be quite rare.
- P** is the *Process Area*, which is based on Section 2.3.
- NNN** is the *Equipment Number* of the associated equipment. If no equipment is associated, allocate *Equipment Numbers* specific for the applicable instrumentation. Do not suppress 0's for equipment numbers, as all loop numbers at a site should have the same number of digits in the loop number.
- T** is the *Instrument Number*, where the number increments from the number 0 through 9. Utilize the number 0 for instruments directly associated with motor starters and control. The *Instrument Number* does not increment for every instrument, but rather increments for every instrument loop.
- NNNT** is the Loop Number, comprised of the *Equipment Number* together with the *Instrument Number*. Medium to large facilities will utilize four digit loop numbers, while smaller facilities such as wastewater collections facilities will use three digit loop numbers.
- S** is the *Suffix*, which is used in the cases of multiple instruments on the same or redundant loops. All suffixes are to be numeric.

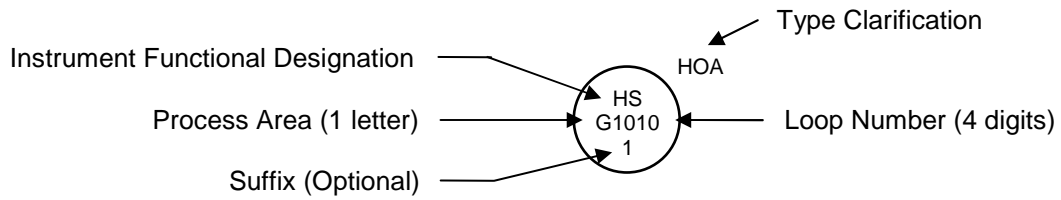
Examples:

- | | |
|---------------|---|
| XY-G2501 | A solenoid for the valve XV-G250, where the solenoid is remote from the valve. |
| LT-M1011-2 | Redundant Wet Well level transmitter. |
| 0650-PT-M3011 | A pressure transmitter associated with pump M301 at the Hurst Pumping Station. Note that the facility code is optional. |
| HSR-R1100 | A start pushbutton associated with pump P-R110. |

- | | |
|-----------|---|
| TY-B1500 | A temperature relay that takes signals from TT-B1501, TT-B1502, TT-B1503, and TT-B1504 and converts to a Modbus protocol. |
| ZSS-F3212 | A safety switch for CNV-F321. |
| HS-L010 | A start pushbutton for P-L01 at a wastewater lift station. |

7.1.2 Drawing Format

The format for instrumentation on drawings, such as P&IDs, is shown below:



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7.1.3 Instrument Functional Designations

An instrument functional designation represents the function of the instrument, and is based upon ISA 5.1. Note that it is possible for an instrument functional designation to be common with a mechanical equipment functional designation, as they will be differentiated by the identifier format. Instrument identifiers will have a four digit loop number, compared with mechanical equipment, which has a three digit equipment number. Thus, even without context, it is possible to differentiate between instruments and other equipment.

Due to the many types of instruments available, a comprehensive list of instrument identifiers is not provided, but rather instrument identifiers are derived from Table 7-1 in a manner that is consistent with ISA 5.1. An instrument functional designation is selected as follows:

- Select the first character from the first column of Table 7-1, based upon the measured or initiating variable of the loop. Optionally, select a second character from the second Modifier column, to indicate a special function associated with the measured or initiating variable. For example, an instrument ultimately part of a safety loop associated with level would have the first two characters designated as LS.
- Select the next character (second or third, depending on whether a second column Modifier is utilized), from either the third or fourth columns. The third column is for Readout or Passive Functions, while the fourth column is for Output Functions.
- Finally, if appropriate, append a letter from the fifth Modifier column, to clarify the function of the instrument. In some cases two characters may be selected from the fifth Modifier column.

A list of common instrument functional designations is provided in Table 7-2.

Table 7-1 : Instrument Functional Designations

	First Letter		Succeeding Letters		
	Measured or Initiating Variable	Modifier	Readout or Passive Function	Output Function	Modifier
A	Analysis		Alarm		
B	Burner, Combustion				
C	Conductivity (1)			Control (2)	Close
D	Density (3)	Difference, Differential			Deviation
E	Voltage		Sensor, Primary Element		
F	Flow, Flow Rate	Ratio			Failure / Fault (14)
G			Glass, Gauge Viewing Device (4)		
H	Hand (Manual)				High
I	Current		Indicate (5)		
J	Power		Scan		
K	Time, Schedule	Time Rate of Change		Control Station	
L	Level		Light (6)		Low
M	Moisture, Humidity (7)				Middle, Intermediate
N					
O	Torque		Orifice, Restriction		Open
P	Pressure		Point (Test Connection)		
Q	Quantity	Integrate, Totalize	Integrate, Totalize		
R	Radiation		Record		Run (8)
S	Speed, Frequency	Safety (9)		Switch	Stop (10)
T	Temperature			Transmitter	
U	Multivariable		Multifunction	Multifunction	
V	Vibration, Mechanical Analysis			Valve, Damper, Louver	
W	Weight, Force		Well, Probe		
X	Unclassified (11)	X Axis	Unclassified	Unclassified	Unclassified
Y	Event, State, or Presence	Y Axis		Auxiliary Device (12)	
Z	Position, Dimension	Z Axis, Safety Instrumented System (13)		Driver, Actuator, Unclassified Final Control Element	

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Notes for Instrument Functional Designations:

1. *The use of the letter C for conductivity is a City specific user assignment.*
2. *Utilize the output designation C for an automatic device or function that receives an input signal and generates a variable output signal that is used to modulate or switch a valve or otherwise control a final drive element. Do not utilize the C designation for a control valve, unless the valve independently measures the process variable and determines the appropriate valve position. Thus, the use of TCV, FCV, or LCV is not common. The use of PCV is more common, for pressure regulators.*
3. *The use of the letter D for density is a City specific user assignment.*
4. *Utilize the letter G for all pressure gauges (i.e. PG), thermometers (i.e. TG), and viewing glasses (e.g. LG).*
5. *The Readout/Passive Function letter I is to be utilized for analog or digital readouts of a measurement or input signal. Do not utilize for indication of discrete on/off signals.*
6. *The Readout/Passive Function letter L is to be utilized for indication of discrete on/off states. Do not utilize for alarms, which should utilize the A designation.*
7. *It is recommended to utilize the initial letter M as a designation for moisture, which is common industry practice. The City has historically applied the letter M for Motor, however this use is not consistent with ISA 5.1 and it is recommended that this use be discontinued.*
8. *Utilize the modifier R to designate a Run or Start modifier. Note that this designation was added in the 2009 revision to ISA-5.1.*
9. *Utilize the letter S as a modifier for safety components not part of a Safety Instrumented System (SIS). The letter S modifier is to be utilized for self-actuated emergency protective primary and final control elements only when used in conjunction with Measured/Initiating Variables flow [F], pressure [P] or temperature [T]. An example is a PSV for a pressure safety relief valve utilized to protect against emergency conditions that are not expected to normally occur.*
10. *Utilize the modifier S to designate a Stop modifier. Note that this designation was added in the 2009 revision to ISA-5.1.*
11. *The letter X is to be defined at the time of use, and may be used for multiple definitions where no other letter is applicable. The letter X is commonly applied to controlled on-off valves, where the initiating variable is not clearly defined.*
12. *The use of output function Y is to be utilized for a device that connects, disconnects, transfers, computes, and/or converts air, electronic, electric, or hydraulic signals or circuits. Use for a current to pressure signal converter would be appropriate.*
13. *Variable modifier Z is to be utilized for all components of a safety instrumented system (SIS). An example is a SIS system pressure transmitter, designated PZT.*
14. *The use of the letter F as a Modifier to represent Failure or Fault is an extension to ISA-5.1.*

Table 7-2 : Common Instrument Functional Designations

Designation	Direct Translation	Example
AA	Analysis Alarm	Gas detection horn / strobe
AAH	Analysis High Alarm	H ₂ S gas detection high level alarm
AT	Analysis Transmitter	H ₂ S gas detection transmitter
DT	Density Transmitter	Density transmitter without local indication
EG	Voltage Viewing Device	Capacitive voltage indicator
EL	Voltage Light	Pilot light indicating voltage is present
EI	Voltage Indicator	Voltage meter with numeric scale, or digital meter
ES	Voltage Switch	General voltage relay
ESL	Voltage Switch - Low	Undervoltage relay
ET	Voltage Transmitter	Voltage transducer
FAL	Flow Alarm - Low	Pilot light indicating low flow
FCV	Flow Control Valve	Integrated valve to limit the flow below a setpoint. The valve is not externally controlled.
FE	Flow Element	Magnetic flowtube, orifice plate
FIT	Flow Indicating Transmitter	Magnetic flowmeter transmitter with local indication
FT	Flow Transmitter	Magnetic flowmeter transmitter without local indication
FV	Flow Valve	Butterfly valve with positioner, modulated by a signal initiated by a flowmeter.
HS	Hand Switch	Hand/Off/Remote switch
HSR	Hand Switch – Start/Run	Start pushbutton
HSS	Hand Switch - Stop	Stop pushbutton, including emergency stop pushbuttons, unless associated with a Safety Instrumented System.
JIT	Power Indicating Transmitter	Power meter
KS	Time Switch	Timing relay
LSH	Level Switch - High	Sump pit high level switch
LSL	Level Switch - Low	Sump pit low level switch
LE	Level Sensor	Ultrasonic level transducer
LIT	Level Indicating Transmitter	Ultrasonic level transmitter with local indication
LT	Level Transmitter	Ultrasonic level transmitter without local indication
ME	Moisture Sensor	Moisture sensor
OSH	Torque Switch - High	Torque limit switch
PG	Pressure Gauge	Mechanical pressure gauge local to piping
PI	Pressure Indicator	Pressure display remote from piping, with scale.

Designation	Direct Translation	Example
PSL	Pressure Switch - Low	Low pressure switch on air receiving tank
PSH	Pressure Switch - High	High pressure switch on air receiving tank
PT	Pressure Transmitter	Analog pressure transmitter
ST	Speed Transmitter	Speed pulse encoder
TE	Temperature Element	Thermocouple or RTD temperature sensor
TG	Temperature Gauge	Local temperature gauge
TSH	Temperature Switch - High	High temperature switch
TI	Temperature Indicator	Digital temperature indicator or local analog indicator based upon a capillary tube
TSL	Temperature Switch - Low	Low temperature switch
TT	Temperature Transmitter	Analog temperature transmitter
VE	Vibration Sensor	Vibration sensor
VIT	Vibration Indicating Transmitter	Vibration transmitter with local indication
XV	Unclassified Valve	Typically use for on/off valves
ZSC	Position - Closed	Valve closed limit switch
ZSO	Position - Open	Valve opened limit switch
ZT	Position Transmitter	Linear position transmitter

7.1.4 Type Clarification

The instrument *Type Clarification* is an optional additional field on the outside of the instrument tag bubble, as shown in Section 7.1.2. The *Type Clarification* is not part of the identifier, but rather additional information that is useful to the P&ID reader. The site P&ID legend sheet should contain all type clarifications utilized at the site. Examples are provided in Table 7-3 on the next page, and additional examples are provided in Table 5.2.2 of ISA 5.1.

Table 7-3 : Type Clarification Examples

Functional Identifier	Type Clarification	Description
AIT	CO	Carbon monoxide transmitter
AIT	COMB	Combustible gas transmitter
AIT	H2S	Hydrogen sulphide transmitter
AIT	O2	Oxygen transmitter
FE	COR	Coriolis flow element
FE	MAG	Magnetic flow element
FE	US	Ultrasonic flow element
HS	H/O/A	Hand / Off / Auto Switch
HS	H/O/R	Hand / Off / Remote Switch
HS	O/A	Off / Auto Switch
HS	O/O	Off / On Switch
HS	RST	Reset
HSS	EMG	Emergency Stop Switch
LE	CAP	Capacitance level element
LE/LT	DP	Differential pressure level element
LE	RAD	Radar level element
LE/LT	SDP	Submersible differential pressure
LE	US	Ultrasonic level element
PT	ABS	Absolute pressure transmitter
PT	VAC	Vacuum pressure transmitter
TT	TC	Thermocouple temperature transmitter
TT	RTD	Resistance temperature transmitter

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7.1.5 Valve Identification

Historically there has been some confusion regarding valve identification, and the purpose of this section is to clarify the appropriate functional identification for valves, as per ISA 5.1.

7.1.5.1 Manual Valves

All manual valves are to be identified as HV, as per Sections 5.2.1 and 5.2.2.

Valves that have an actuator, but are always operator controlled remotely via a PLC, DCS, or some other control system are to be identified as per Sections 7.1.5.4 and 7.1.5.5.

7.1.5.2 Actuated Valves with Internal Controller

A self actuating valve that has a process signal as an input is a *control valve*, where the initial letter is the measured process variable. Examples are as follows:

- | | |
|-----|--|
| FCV | Flow Control Valve – a valve with an internal mechanism or logic that measures flow and controls it to some setpoint. This could either be a Foundation Fieldbus Controlled valve with an integral PID controller, or a mechanical flow regulator. A valve that controls flow, but receives a position signal from an external controller is not a FCV (as per ISA 5.1). |
| PCV | Pressure Control Valve – a valve with an internal mechanism or logic that measures pressure and controls it to some setpoint. This could either be a Foundation Fieldbus Controlled valve with an integral PID controller, or a pressure regulator. A valve that controls pressure, but receives a position signal from an external controller is not a PCV (as per ISA 5.1). |

7.1.5.3 Actuated Valves with External Controller

A valve with an actuator that is positioned by an external signal is a *control valve*, where the initial letter is the measured process variable. Examples are as follows:

- | | |
|----|---|
| FV | Flow Valve – a valve with or without a positioner, that is positioned by an external controller based upon a measured or initiating flow signal. The signal from the external controller to the valve is a position command signal. Note that many valves control the flow within a pipe, but not all such valves are necessarily <i>Flow Valves</i> , as per ISA 5.1. Only valves that have a control loop with flow as the initiating variable are <i>Flow Valves</i> . |
| LV | Level Valve – a valve with or without a positioner, that is positioned by an external controller, that uses level as its initiating or measured variable. The signal from the external controller to the valve is a position signal. Note that while the valve may control the flow within the pipe, it is not a <i>Flow Valve</i> if the initiating variable is <i>Level</i> . |
| PV | Pressure Valve – a valve with or without a positioner, which is positioned by an external controller based upon level as its initiating or measured variable. The signal from the external controller to the valve is a position command signal. Note that while the valve may control the flow within the pipe, it is not a <i>Flow Valve</i> if the initiating variable is <i>Pressure</i> . |
| UV | Multivariable Valve – a valve with or without a positioner, that is positioned by an external controller based upon multiple variables as input into the controller. The signal from the external controller to the valve is a position command signal. Note that while the valve may control the flow within the pipe, it is not a <i>Flow Valve</i> if there are multiple initiating variables. |

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7.1.5.4 Actuated Valves (Modulated) with Operator Control

A valve with an actuator that is positioned by a signal controlled by a human operator is to be identified by the major initiating variable that the operator would reference. Note that this definition is only marginally consistent with ISA 5.1, as a direct interpretation of ISA 5.1 would likely result in a HV – *Hand Valve* identification. Discussions with City personnel have indicated that it is not desirable to identify these valves as *Hand Valves*, which in their opinion, should be reserved for manual valves. Not that this identification only applies to modulating valves and not to on/off valves.

Examples:

FV-T4061 An valve actuated from a signal, that is controlled by an operator via an HMI interface. The operator periodically monitors a flow rate in the process and manually adjusts the position setpoint for the valve.

7.1.5.5 Actuated On/Off Valves

An on/off valve with an actuator that is controlled by an external controller is to typically be identified as an XV, or *Undefined Valve*. ISA 5.1 is not clear on how to address the identification of on/off valves, and while YV (State Valve) or UV (Multivariable Valve) are potential identifiers, common industry practice is that XV is commonly utilized. Discretion must be applied, and while there are cases where on/off valves with other initial variables would be appropriate, it is recommended that all on/off valves, where the initiating variable is not clear, be identified as XV. On/Off valves with remote operator control are also to be identified as XV, unless the initiating variable that the operator is responding to is absolutely clear.

Examples:

XV-G6011 An on/off intake damper on an air handler, AHU-G601, which closes when the air handler is not in operation.

XV-M1511 An on/off discharge valve on a pump, P-M151, which closes when the pump is not in operation.

LV-S2032 An on/off valve that shuts off when the level in tank TK-S203 exceeds a setpoint. This is an example where the initiating variable is clearly level, and the valve should be identified as such.

XV-R325 An on/off valve that interconnects two forcemains in a wastewater forcemain application, that is actuated by operator control. Note that the loop number is only three digits as this is a *Collections* application.

7.2 Automation Equipment

7.2.1 Identifier Format

The identification format for automation equipment, other than instrumentation, is as follows.

FFFF	-	EEEE	-	P	NNNN	-	S
Facility Code (Optional)	-	Equipment Functional Designation	-	Process Area	Equipment Number	-	Suffix (Optional)

Where,

- FFFF** is the *Facility Code*, from Appendix A. The *Facility Code* will typically be implied, and would only be fully written where required.
- EEEE** is the *Equipment Functional Designation*, which is comprised of 2 to 4 characters from Section 7.2.2.
- P** is the *Process Area*, which is based on Section 2.3.
- NNNN** is the *Equipment Number*. Select numbers consistent with the ranges in Appendix D.
- S** is the *Suffix*, an optional numeric or letter code to distinguish between multiple pieces of equipment with a common equipment number. Generally, numbers are utilized for equipment in series, and letters for equipment in parallel.

Examples:

- 0101-PLC-G801 A PLC located in the Grit process area of the NEWPCC facility.
- PLC-G110 A PLC dedicated to pump P-G110.
- RIO-G110-1 Remote I/O associated with PLC-G110
- JBA-L52 An automation junction box in a Collections Facility.

7.2.2 Functional Designations

Table 7-4 : Automation Equipment Functional Designations

Functional Designation	Description	Notes
ADP	Automation Device Panel	
CA	Cable (Automation)	
CP	Control Panel	
CS	Computer Server	
CW	Computer Workstation - General	
CWD	Computer Workstation - Development	
CWO	Computer Workstation - Operator	
DCS	Distributed Control System	
FDP	Field Device Panel	Use for new installations should not be common.
GDC	Gas Detection Controller	
HMI	Standalone Human Machine Interface (HMI) Terminal	e.g. local touchscreens
JBA	Junction Box (Automation)	
LCP	Local Control Panel	
PLC	Programmable Logic Controller	
PRN	Printer	
RIO	Remote I/O	
RTU	Remote Terminal Unit	

Notes:

1. *Avoid overlap of Automation Equipment Functional Designations with Electrical, Mechanical, or Process Functional Designations.*

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7.2.3 IT Equipment Designations

Equipment within the domain of the City's Information Technology division may utilize a City IT specific identifier. Where this IT identifier is utilized, it is recommended that it is utilized in parallel to the identifiers in this standard. The rationale for this is as follows:

- The IT identifiers are created and tracked by a separate division within the City and are not managed by the same groups responsible for the remainder of the assets of the Water and Waste department.
- The IT identifiers are not consistent with this standard.
- The IT identifiers are applied in a "serial number" style to a specific piece of hardware, and not utilized as an asset identifier, as per the equipment within this standard. For example, if a computer is replaced, the IT identifier would change. However, for computers shown on automation drawings, use of the IT identifier in the automation domain would require that all relevant drawings with identifiers be updated.
- It is recommended to segregate the IT and Automation domains as much as possible.

7.3 Automation Cables

7.3.1 Instrumentation Cables

The identification format for automation cables is as follows. Note that the identification of power cables is discussed in Sections 6.4.2 and 6.4.3.

CA	-	P	NNNT	-	S
Cable Designation	-	Process Area	Loop Number of Instrumentation	-	Suffix (Optional)

Where,

- CA is the *Cable Designation*, which for automation cables is comprised of the letters CA.
- P is the *Process Area*, which is based on Section 2.3.
- NNNT is the *Loop Number* of the associated instrument. Where the cable connects two instrumentation devices with different loop numbers, identify the cable by the device that provides the signal.
- S is the *Suffix* utilized to identify the specific cable associated with the loop. The Suffix is not required if a single cable is associated with the instrument loop. Utilize sequential numbers for cables in series, or for different purposes, and letters for cables in parallel.

Examples:

- CA-G6831 A cable from FSL-G6831 to a control panel.
- CA-S5011-1 A signal cable from a flowmeter to a control panel mounted instrument, FC-S5011.

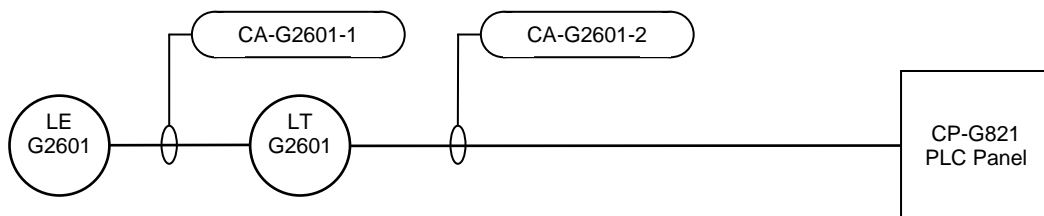


Figure 7-1: Instrument Cable Identification Example – Level Transmitter

7.3.2 Cables Associated with Identified Equipment

The identification format for automation cables is as follows.

CA	-	P	NNN	-	S
Cable Designation	-	Process Area	Equipment Number of Associated Equipment	-	Suffix (Optional)

Where,

- CA is the *Cable Designation*, which for automation cables is comprised of the letters CA.
- P is the *Process Area*, which is based on Section 2.3.
- NNN is the *Equipment Number* of the associated equipment. Where the cable connects two pieces of equipment, identify by the downstream, or serviced piece of equipment.
- S is the *Suffix* utilized to identify the specific cable associated with the equipment. The Suffix is not required if a single cable is associated with the equipment. Utilize sequential numbers for cables in series, or for different purposes, and letters for cables in parallel.

Note: In some cases, a cable could be considered either associated with instrumentation (4 digit loop number as per Section 7.3.1) or equipment (3 digit equipment number as per this section). It is left up to the designer to select the most appropriate cable identifier.

Examples:

- CA-G683-1 A 120 VAC control cable for pump P-G683.
- CA-F723 A control cable for UPS-F723
- CA-P711 A cable with a signal from a breaker status in PNL-P711.



Figure 7-2: Instrument Cable Identification Example – Identified Equipment

7.4 Sample P&ID

A sample pump P&ID is provided below to illustrate typical conventions for identifying instrumentation.

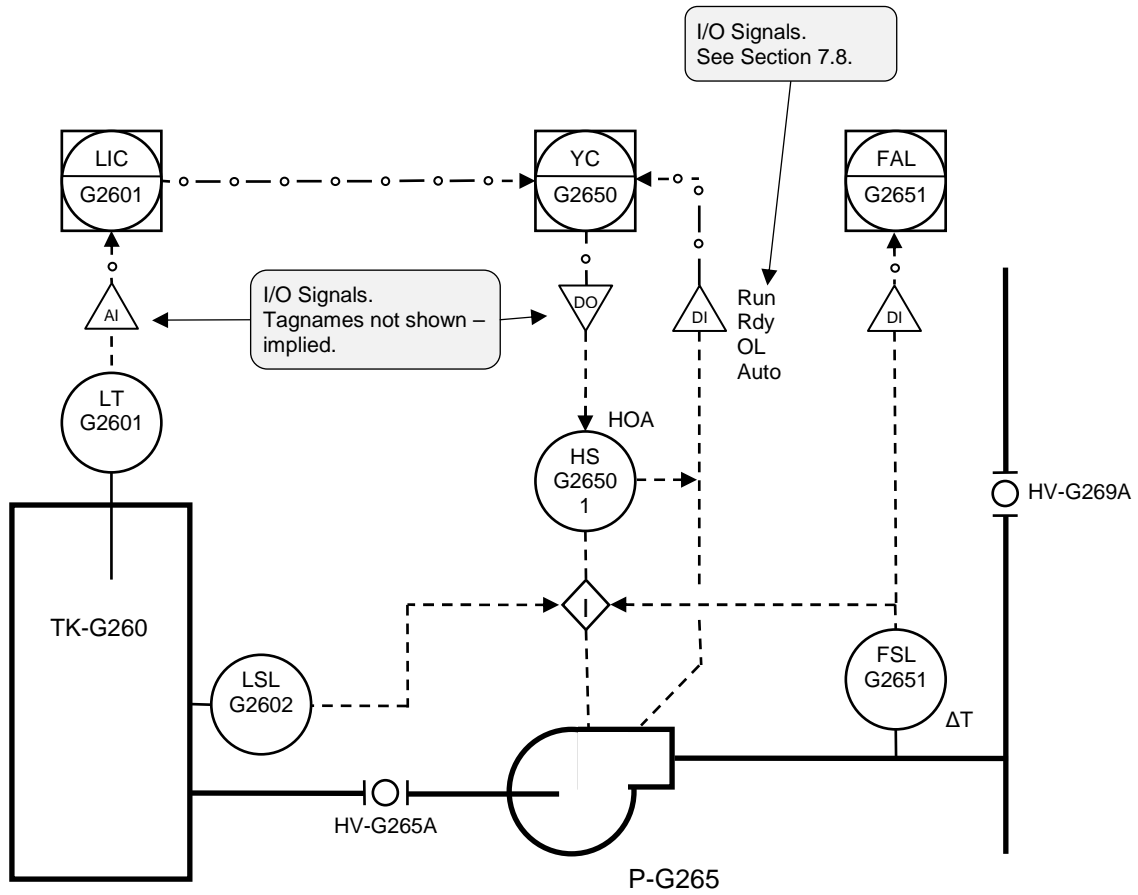


Figure 7-3: Sample Pump P&ID

7.5 Wire Tags

7.5.1 Power Circuits within Control Panels

Power circuits within control panels only require unique identification within the control panel. Where power circuits extend outside the panel, they will typically be based upon the wire tagging scheme identified in Sections 7.5.2 and 7.5.3.

The identification format for power circuit wire tags within control panels is as follows.

D	W
Power Designation	Wire Number

Where,

- D is the *Power Designation*, which is based upon Table 7-5.
W is the *Wire Number*, an incrementing number.

Table 7-5 : Wire Tag Power Designations

Power Designation	Description
C	DC Common (0V)
G	Ground
L	AC Power (Hot)
N	AC Neutral
P	DC Positive
NEG	DC Negative (not grounded)

Note: The Ground designation is not typically required, provided that the ground wire is green.

Examples:

- L1 Main 120VAC circuit within a control panel.
L11 120VAC sub-circuit, after fuse F11.
N1 AC Neutral associated with circuit L1.
P22 24VDC circuit
C1 24VDC common wire (0V)

7.5.2 Control Circuits

The identification format for automation control circuits is as follows:

P	NNN	T	-	W	S
Process Area	Equipment Number	Instrument Number	-	Wire Number	Suffix (Optional)
	Loop Number				

Where,

- P** is the *Process Area*, which is based on Section 2.3.
- NNN** is the *Equipment Number* of the associated equipment. If no equipment is associated, allocate *Equipment Numbers* specific for the applicable instrumentation.
- T** is the *Instrument Number*, where the number increments from the number 1 through 9. Use of the number 0 should be infrequent, except for special instruments, or those where the instrument ending with 0 is a common instrument that serves other instruments.
- NNNT** is the *Loop Number*, comprised of the *Equipment Number* together with the *Instrument Number*.
- W** is the *Wire Number*, which is typically an incrementing number. For power wires the *Wire Number* shall be based on Table 7-5.
- S** is an optional *Suffix*, and is utilized where it is desired to utilize the same wire number, but the signal has changed.

Notes:

1. *It is not required that the Wire Number match the control panel terminal number.*
2. *See Section 6.4.6.4 regarding wire numbering for motor control circuits.*

Examples:

- G6521-11 Control wire 11 associated with TSH-G6521.
- G6521-11A Control wire 11A associated with TSH-G6521.
- G6522-P 24VDC Power wire for FT-G6522.
- G6522-C 24VDC Common wire for FT-G6522.

7.5.3 Analog Signal Circuits - Instruments

The identification format for analog signal circuits associated with instruments is as follows:

P	NNN	T	-	W	A
Process Area	Equipment Number	Instrument Number	-	Wire Number (Optional)	Analog Designation
	Loop Number				

Where,

- P** is the *Process Area*, which is based on Section 2.3.
- NNNT** is the Loop Number, comprised of the *Equipment Number* together with the *Instrument Number*.
- W** is the *Wire Number*, an incrementing number. The wire number may optionally be omitted for two wire control.
- A** is the Analog Designation, which is typically either “+” or “-“. For power wires the designation shall be based on Table 7-5.

Notes:

1. *It is not required that the Wire Number match the control panel terminal number.*
2. *For two-wire signals, use “+” and “-“ designations. Do not utilize a power designation “-P” for two wire signals.*

Examples:

- G6523+ Signal wire + associated with TT-G6523.
- G6523- Signal wire - associated with TT-G6523.
- M4215-1+ Signal wire 1+ associated with FT-M4215
- M4215-P 24VDC power wire associated with FT-M4215 (Four wire signal).

7.5.4 I/O Wiring

I/O wiring within a control panel is designated by the I/O address rather than the connected instrument. This allows for a more straightforward control panel layout, and avoids relabeling internal panel wiring upon reallocation of I/O. The identification format for I/O wiring in a control panel is as follows:

DD	R	.	M	.	N	A
I/O Designation	Rack Number (Optional)		Module Number (Optional)		I/O Number	Analog Designation (Optional)

Where,

- DD is the *I/O Designation*, which is based on Table.
- R is the *Rack Number*, which is typically one or two digits. A Rack Number is not applicable to all I/O systems.
- W is the *Module Number*, which is typically one or two digits. A *Module Number* is not applicable to all I/O systems.
- A is the Analog Designation, if applicable, and typically is either “+” or “-“.

Table 7-6 : I/O Designations

Power Designation	Description
AI	Analog Input
AQ	Analog Output
I	Discrete Input (AC or DC)
Q	Discrete Output (AC or DC)

Notes:

- The I/O Wiring Designation is to be utilized within a control panel only. Utilize wire designations based upon Sections 7.5.2 and 7.5.3 for wiring outside the control panel.*
- It is acceptable for a wire on one side of a terminal to be designated by an I/O designation and to have an alternate identifier for the wire on the other side of the terminal.*

Examples:

- AI1.0.1+ Analog input + wire associated with rack 1, module 0, point 1.
- AQ5.3- Analog output – wire associated with module 5, point 3. The rack number is not applicable.
- I52 Discrete input 52. The rack number and module number are not applicable.
- I5.3.31 Discrete input associated with rack 5, module 3, point 31.
- Q2.1.5 Discrete output associated with rack 2, module 1, point 5.

7.6 Subcomponents

As described in Section 2.6, devices that are an inherent component of a larger unit of equipment or instrumentation are designated as subcomponents. With a strict implementation of ISA 5.1, these subcomponents would potentially be given full identifiers. However, in assigning full identifiers for these signals, the relationship between the subcomponent and its parent piece of equipment is not always clear. Additionally, more identifiers are used as a result of having to assign an identifier to each subcomponent. A good example of instrumentation subcomponents is a valve with limit switches. The limit switches are typically deemed to be a subcomponent of the valve.

As described in Section 2.6, subcomponents can be identified by extending the containing equipment name with a suffix. The parent equipment identifier and suffix are to be separated by a period. This system creates a hierarchy, allowing for rapid identification of subcomponents and reduces programming efforts when integrating these signals into an automation system.

A good example for a mechanical piece of equipment that contains subcomponents is a valve actuator with integrated open and closed limit switches. The limit switches would not typically be labelled separately in the field, as there is no specific discrete equipment to attach the label to, other than the valve actuator as a whole. The suffix would be based upon the subcomponent's functional identification. For example:

A P&ID example with a subcomponent is shown in Figure 7-4. Note that the subcomponents of the valve are the limit switches, identified as follows.

XV-G381.ZSO The open limit switch of the valve XV-G381

XV-G381.ZSC The closed limit switch of the valve XV-G381

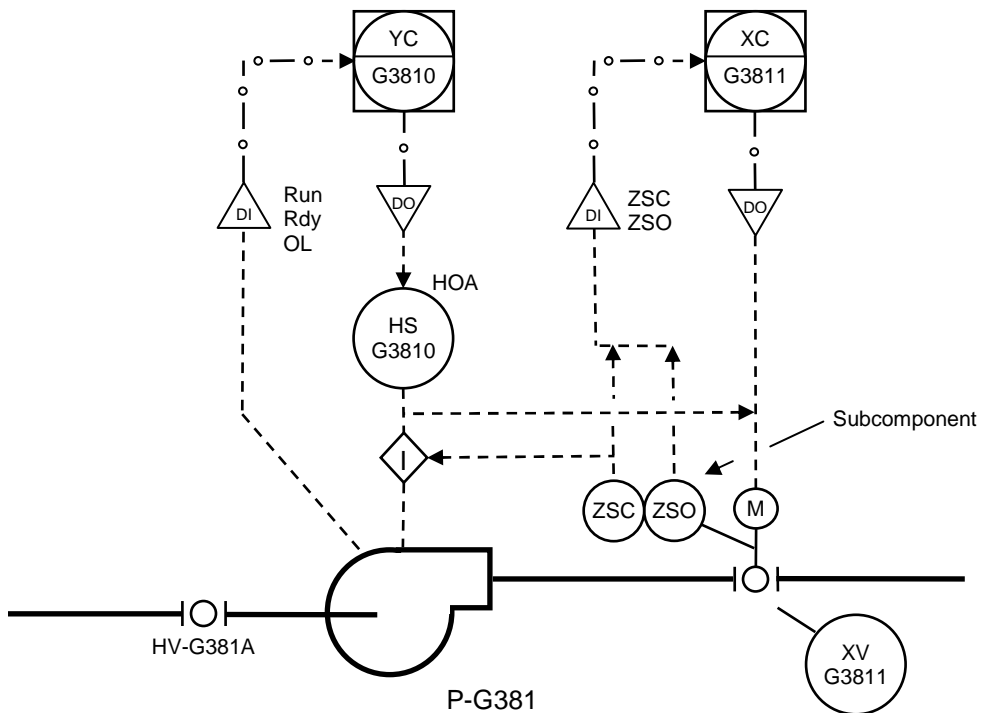


Figure 7-4 : Subcomponents – Mechanical and Process Equipment

7.7 Software Configuration File Naming

Where software to configure automation equipment does not include integral version management, software configuration file names shall be composed as follows.

FFFF		E*		YYYY	MM	DD	-	X
Facility Code (Optional)	-	Equipment Identifier	-	Year	Month	Day	-	Revision Modifier (Optional)
				Date				

Where,

- FFFF is the *Facility Code*, from Appendix A. The *Facility Code* will typically be implied, and would only be included in the filename where required.
- E* is the unique *Equipment Identifier*, as identified by other sections of this document.
- YYYYMMDD is the date of the last edit.
- X is the *Revision Modifier*, which a letter beginning with A, B, C.... used to indicate intra-day revisions.

Examples:

- | | |
|---------------------|--|
| PLC-G250-20120819 | A PLC program for PLC-G250 last edited on August 19, 2012. |
| LT-M1011-20120501-B | A configuration file for level transmitter LT-M1011, dated May 1, 2012, second revision. |
| NSW-C901-20121231 | A network switch configuration file dated December 31, 2012. |

7.8 I/O and Signal Tags

7.8.1 Discrete Input Signals

Identification of discrete input signals (I/O) will be as follows:

E*	.	F	-	S
Source Equipment / Instrument Identifier	.	Functional Signal Designation	-	Suffix (Optional)

Where,

- E* is the *Source Equipment / Instrument Identifier*, based upon other parts of this document.
- F is the *Functional Signal Designation*, which represents the type of discrete signal. The *Functional Signal Designation* shall utilize ISA-5.1 style naming convention where applicable, but if not applicable, shall be based on Table 7-7.
- S is the optional *Suffix*, which is a number utilized to differentiate between multiple similar signals.

Examples:

- HSS-G1050 Stop pushbutton signal from HSS-G1050, which is associated with pump P-G105. Note that no Functional Signal Designation is required, as only a single, unambiguous signal is provided from the switch.
- HS-G1050.Rem The switch in *Remote* signal from the *Hand-Off-Remote* switch HS-G105, which is associated with pump P-G105. A Functional Signal Designation is required to clarify the indicated specific switch position.
- VFD-G101.Fl_t VFD fault signal for pump P-G101. As the fault is associated with the VFD, the VFD is deemed to be the *Source Equipment / Instrument Identifier*.
- AHU-M602.Run Running signal from AHU-M602 motor starter. As the air handling unit is deemed to be the functional source of the running signal, it is deemed to be the *Source Equipment / Instrument Identifier*.
- FT-S6021.Fl_t Fault signal associated with flow transmitter FT-S6021.
- XV-S3810.ZSC Closed limit switch signal from valve XV-S3810.
- XV-S3810.HS_Auto Hand switch in auto signal from valve XV-S3810. This signal name would be appropriate if the valve actuator has an integrated *hand-off-auto* switch. In the event that the *hand-off-auto* switch was independent of the valve actuator, it would have an instrument identifier, and the *Source Equipment / Instrument Identifier* would be based on the switch identifier.

TSH-G1051 A high temperature signal from TSH-G1051.
TSH-G1052-1 A high temperature signal from TSH-G1052-1.
TY-G1053.TSH A high temperature output signal from a temperature relay.

Table 7-7 : Discrete Input Functional Signal Designations – Non ISA

Signal	Description
.Auto	Hand Switch Auto Position
.Byp	Hand Switch Bypass Position
.Flt	Faulted
.HS_*	Signal from Hand Switch Integrated into Equipment. See Note 4.
.Loc	Hand Switch Local Position
.Man	Hand Switch Manual Position
.Occ	Hand Switch Occupied Position
.Off	Hand Switch Off Position
.Rdy	VFD / Motor Starter Ready
.Rem	Hand Switch Remote Position
.Rst	Hand Switch Reset Pushbutton
.Run	Motor Running
.Start	Hand Switch Start Pushbutton
.Stop	Hand Switch Start Pushbutton

Notes:

1. *The above list does not indicate ISA 5-1 style functional designations, based upon Table 7-1, where applicable. This table is to be utilized only when an ISA 5-1 style designation is not appropriate or clear.*
2. *The above list is not exhaustive, and the designer is expected to follow a similar convention to the above when assigning new signal names. Commonly used signal names should be added to the table.*
3. *ISA 5.1 style designations are to utilize capital letters only. Non ISA-5.1 designations are to use a first capital letter, followed by lowercase letters.*
4. *A combination of ISA and non-ISA designations is permissible, provided they are connected via an underscore. For example: HS_Rem represents a hand switch remote position for a non-identified switch on a piece of equipment.*

7.8.2 Discrete Output Signals

Identification of discrete output signals (I/O) will be as follows:

E*	.	Cmd	F	-	S
Controlled Equipment / Instrument Identifier	.	Output Designation	Functional Signal Designation	-	Suffix (Optional)

Where,

- E*** is the *Controlled Equipment / Instrument Identifier*, based upon other parts of this document.
- Cmd** Is the *Output Designation*, utilized to identify all outputs signals.
- F** is the *Functional Signal Designation*, which represents the type of discrete signal. The *Functional Signal Designation* shall be based on Table 7-8.
- S** is the optional *Suffix*, which is a number utilized to differentiate between multiple similar signals.

Examples:

- AHU-M602.CmdRun Motor run output signal for AHU-M602.
- VFD-M602.CmdEnb Enable command to the VFD-M602, which is associated with AHU-M602. The *Controlled Equipment / Instrument Identifier* is deemed to be the VFD, as the enable command is deemed to be specific to the VFD.
- YL-M6011.CmdOn Output signal to turn on pilot light YL-M6011.
- XV-S3810.CmdCls Close signal command to valve XV-S3810.

Table 7-8 : Discrete Output Functional Signal Designations

Signal	Description
.CmdRun	Run Command
.CmdRst	Fault Reset Command
.CmdCls	Close Command
.CmdOpn	Open Command
.CmdEnb	Enable Command

Notes:

- The above list is not exhaustive, and the designer is expected to follow a similar convention to the above when assigning new signal names. Commonly used signal names should be added to the table.
- All discrete outputs are to be prefixed with the Cmd designation.

7.8.3 Analog Signals Generated From Equipment

Identification of analog control system software I/O and signal tags, where the source of the signal is not identified as an instrument, will be as follows:

E*	.	F	_	S
Equipment Identifier	.	Functional Variable		Suffix (Optional)

Where,

- E*** is the *Equipment Identifier*, based upon other parts of this document.
- F** is the *Functional Variable*, which represents the type of analog signal. This field is only required for multivariable transmitters. The *Functional Variable* shall be based on the first column of Table 7-1, with an optional character from the second column. Note that the *Functional Variable* is based upon ISA 5.1.
- S** is the optional *Suffix*, which can be any short designation appropriate to represent the specific signal. Ideally the suffix will be four characters or less. The *Suffix* is separated from the Functional Variable by an underscore.

Note:

1. Do not use this format for analog signals from identified instruments. Refer to Section 7.8.4.

Examples:

UPS-G702.E_Bat	UPS-G702 Battery Voltage Level
UPS-G702.E_In	UPS-G702 Input Voltage Level
UPS-G702.E_Out	UPS-G702 Output Voltage Level
VFD-G101.T	VFD-G101 internal temperature.
CB-M01.RLY.E_An	The voltage signal between phase A and neutral for the protection relay associated with circuit breaker CB-M01.
MS-S501.I_A	The phase A current associated with motor starter MS-S501.

7.8.4 Analog Measured Signals Generated From Instruments

Identification of analog control system software I/O and signal tags, where the source of the signal is an instrument, will be as follows:

I*	.	F	_	S
Instrument Identifier	.	Functional Variable (Optional)	_	Suffix (Optional)

Where,

- I* is the *Instrument Identifier*, based upon other parts of this document.
- F is the *Functional Variable*, which represents the type of analog signal. This field is only required for multivariable transmitters. The *Functional Variable* shall be based on the first column of Table 7-1, with an optional character from the second column. Note that the *Functional Variable* is based upon ISA 5.1.
- S is the optional *Suffix*, which can be any short designation appropriate to represent the specific signal. Ideally the suffix will be four characters or less. The *Suffix* is separated from the *Functional Variable* via an underscore.

Examples:

MT-G6231	Moisture signal of MT-G6231
FT-S5122.P	Pressure signal of differential pressure based flow transmitter FT-S5122.
FT-S5122.F	Flow signal of multivariable transmitter FT-S5122.
FT-S5122.T	Temperature signal of multivariable transmitter FT-S5122.
FV-G6821.Z	Position of damper FV-G6821.
PDT-G4231.P_H	High side pressure of differential pressure transmitter PDT-G4231.
PDT-G4231.P_L	Low side pressure of differential pressure transmitter PDT-G4231.
PDT-G4231.PD	Differential pressure of differential pressure transmitter PDT-G4231.
TT-M613	TT-M613 temperature signal

7.8.5 Analog Output Signals

Identification of analog control system software I/O and signal tags, where the source of the signal is a controller such as a PLC, will be as follows:

E*	.	Cmd	F	-	S
Controlled Equipment / Instrument Identifier	.	Output Designation	Functional Variable	-	Suffix (Optional)

Where,

- E*** is the *Controlled Equipment / Instrument Identifier*, based upon other parts of this document. The *Controlled Equipment / Instrument Identifier* should be the ultimate controlled equipment.
- Cmd** Is the *Output Designation*, utilized to identify all outputs signals.
- F** is the *Functional Variable*, which represents the type of analog signal. The *Functional Variable* shall be based on the first column of Table 7-1, with an optional character from the second column. Note that the *Functional Variable* is based upon ISA 5.1.
- S** is the optional *Suffix*, which can be any short designation appropriate to represent the specific signal. Ideally the suffix will be four characters or less. The *Suffix* is separated from the *Functional Variable* via an underscore.

Examples:

- FV-M215.CmdZ Valve position command signal.
- P-M210.CmdS Pump speed command signal. Note that the pump is the ultimate controlled equipment and not the variable speed drive.
- BLR-B610.CmdT Boiler temperature command signal. This would be appropriate when the boiler has an integral dedicated controller, that is the destination of this signal.
- TC-B610.CmdT Temperature command / setpoint signal to an external temperature controller TC-B610.
- TV-G6822.CmdZ Temperature valve position command signal.

7.8.6 Control System Software Implementation

Where a control system software implementation does not support the use of the “.” character used in the signal identification, it is recommended to replace the period “.” character with an underscore (“_”). For example:

P-G101.FlT would become P-G101_FlT

8 COMMUNICATION EQUIPMENT

8.1 Identifier Format

The identification format for communication equipment is as follows.

FFFF	-	EEEE	-	P	NNN	-	S
Facility Code (Optional)	-	Equipment Functional Designation	-	Process Area	Equipment Number	-	Suffix (Optional)

Where,

- FFFF** is the *Facility Code*, from Appendix A. The *Facility Code* will typically be implied, and would only be fully written where required.
- EEEE** is the *Equipment Functional Designation*, which is comprised of 2 to 4 characters from Section 8.2.
- P** is the *Process Area*, which is based on Section 2.3.
- NNN** is the *Equipment Number*. Select numbers consistent with the ranges in Appendix D.
- S** is the *Suffix*, an optional numeric or letter code to distinguish between multiple pieces of equipment with a common equipment number. Generally, numbers are utilized for equipment in series, and letters for equipment in parallel.

Examples:

- NSW-G901 An Ethernet switch located in the G process area.
- JBN-G110 A networking junction box associated with pump P-G110.
- NJ-G901-1 A networking jack associated with NSW-G901.

8.2 Functional Designations

Table 8-1 : Communication Equipment Functional Designations

Functional Designation	Description	Notes
ANT	Antenna	
CN	Network Cable	
JBN	Junction Box - Network	
MDM	Modem	
NAP	Network Access Point	
NFW	Network Firewall	
NGW	Network Gateway	
NJ	Network Jack	
NJT	Network Jack – Telephone	
NMC	Network Media Converter	
NP	Networking Panel	
NPP	Networking Patch Panel	
NRD	Network Radio	
NRT	Network Router	
NSW	Network Switch, Ethernet	

Notes:

1. *Avoid overlap of Communication Equipment Functional Designations with Electrical, Mechanical, and Automation Functional Designations*

8.3 Network Cables

The identification format for network cables is as follows.

CN	-	P	NNN	-	S
Cable Designation	-	Process Area	Equipment Number of Associated Equipment	-	Suffix (Optional)

Where,

- CN** is the *Cable Designation*, which for network cables is comprised of the letters CN.
- P** is the *Process Area*, which is based on Section 2.3.
- NNN** is the *Equipment Number* of the associated equipment. Where the cable connects two pieces of equipment, identify by the downstream, or serviced piece of equipment.
- S** is the *Suffix* utilized to identify the specific cable associated with the equipment. The Suffix is not required if a single cable is associated with the equipment. Utilize sequential numbers for cables in series, or for different purposes, and letters for cables in parallel. Utilize the letter T to designate tie connections.

Examples:

- CN-G901-1 An uplink network cable for NSW-G901.
- CN-M2531 A network cable that connects level transmitter LT-M2531.
- CN-M801 A network cable that connects PLC-M801 to NSW-M910.

Appendix A Facility Codes

Facility Code	Facility
0001 - 0099	Unused – Future
0100 - 0109	Wastewater Treatment Facilities
0101	North End Water Pollution Control Centre (NEWPCC)
0102	South End Water Pollution Control Centre (SEWPCC)
0103	West End Water Pollution Control Centre (WEWPCC)
0110 - 0399	Collections Facilities – Lift, Flood Pumping, CSO & Diversion Stations
0111	DISCONTINUED – Was Perimeter Road Pumping Station. Utilize WEWPCC Facility Code for the Perimeter Road Pumping Station.
0112	Alexander Diversion Station
0113	Armstrong Diversion Station
0114	Ash Lift and Flood Pumping Stations
0115	Assiniboine Flood Pumping Station
0116	Aubrey Lift and Flood Pumping Stations
0117	Baltimore Lift and Flood Pumping Stations
0118	Bannatyne Flood Pumping Station
0119	Barker Lift Station
0120	Bournais / Mission Gardens Lift Station
0121	Burrows Lift Station
0122	Camiel Lift Station
0123	Chataway Lift and Flood Pumping Station
0124	Clarence Lift Station
0125	Clifton Lift and Flood Pumping Stations
0126	Cloutier Lift Station
0127	Cockburn Lift and Flood Pumping Station
0128	Colony Flood Pumping Station and Diversion Chamber
0129	Spare
0130	Community Lift Station
0131	Conway Lift Station
0132	Cornish - Pumping Station - Flood
0133	Cornish Lift Station
0134	Crane Lift Station
0135	Darcy Lift Station
0136	Despins Lift and Flood Pumping Stations
0137	Dublin Lift Station
0138	Dugald Road Lift Station
0139	Dumoulin Lift and Flood Pumping Stations

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Facility Code	Facility
0140	Elmhurst Lift Station
0141	Ferry Road Lift Station
0142	Galt Flood Pumping Station
0143	Grandmont Lift Station
0144	Hart Lift and Flood Pumping Stations
0145	Hawthorne Lift and Flood Pumping Station
0146	Heritage Lift Station
0147	Holland Lift Station
0148	Jefferson Flood Pumping Station (and Diversion Chamber)
0149	Jessie Lift and Flood Pumping Stations
0150	Spare
0151	Kilkenny Lift Station
0152	King Edward Lift Station
0153	Larchdale Lift Station
0154	Laverendrye - Pumping Station - Flood
0155	Linden Lift and Flood Pumping Stations
0156	Louelda Lift Station
0157	Mager Dr. Lift and Flood Pumping Stations
0158	Manitoba Lift Station
0159	Marion Lift and Flood Pumping Stations
0160	Mayfair Lift and Flood Pumping Stations
0161	Metcalfe Flood Pumping Station
0162	Metcalfe Lift Station
0163	Mission Flood Pumping Station
0164	Montcalm Lift Station
0165	Munroe Diversion Chamber
0166	Newton Flood Pumping Station and Diversion Chamber
0167	Notre Dame Lift Station
0168	Oakgrove Lift Station
0169	Olive Lift Station
0170	Pandora Lift Station
0171	Parklane Lift Station
0172	Parkwood Lift Station
0173	Polson Flood Pumping Station and Diversion Chamber
0174	Portsmouth Lift Station
0175	Pulberry Lift Station
0176	Future (Was Ravelston Land Drainage Pumping Station → moved to 0447)
0177	Ridgedale Lift Station

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Facility Code	Facility
0178	Riverbend Lift Station
0179	Roland Flood Pumping Station
0180	Ryan Lift Station
0181	Selkirk Flood Pumping Station (and Diversion Chamber)
0182	Somerville Lift Station
0183	<i>Future</i>
0184	St. Charles Lift Station
0185	St. Johns Flood Pumping Station (and Diversion Chamber)
0186	St. Norbert / X-Kaley Flood Pumping Station
0187	St. Norbert Lift Station
0188	Strathmillan Diversion Chamber
0189	Syndicate Lift and Flood Pumping Stations
0190	Thibault Lift Station
0191	Trappiste Lift Station
0192	Tuxedo Lift Station
0193	Tylehurst Lift Station
0194	Westwood Lift Station
0195	Wexford Lift Station
0196	Willow Lift Station
0197	Windsor Park Lift Station
0198	Woodhaven Lift Station
0199	Assiniboine Park Lift Station
0200	Canora Flood Pumping Station
0201	Crescent Drive Lift Station
0202	Ducharme High Level Site
0203	Enfield Crescent Lift Station
0204	Fort Rouge Park Flood Pumping Station
0205	Irving Place Lift Station
0206	Kildare & Floodway Flood Pumping Station
0207	Kildonan Park Lift Station
0208	Perimeter West Lift Station
0209	Rainbow Stage Lift Station
0210	Saskatchewan Lift Station
0211	University of Manitoba Lift Station
0212	University of Winnipeg CSO Storage
0213	Victoria Crescent Lift Station

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Facility Code	Facility
0300 – 03xx	Land Drainage – Pumping Sites
0301	Archibald Underpass Station
0302	Bishop Grandin Underpass Station
0304	Keewatin Underpass Station
0305	Kenaston Underpass Station
0306	Kilkenny & Rice (600 LDS) Pumping Station
0308	McPhillips Underpass Station
0309	Metro Route 20 Underpass Station
0310	Metro Route 90 Underpass Station
0311	Osborne Underpass Station
0314	St. James Underpass Station
0316	Turnbull Drive
0400 - 0599	Land Drainage – Storm Retention Basins
0401	1-1 Weston South of Alexander Ave
0412	2-2 St. James, Off Isbister Street north of Hamilton Avenue
0413	2-3 St. James, Southwest of Lumsden Ave and Lake Ridge Rd
0414	2-4 St. James North of South Lake Drive
0415	2-5 Omand's Creek Industrial, North of Whitfield Ave in Omand's Creek Industrial Park
0421	3-1 Maples South-east corner of King Edward St and Selkirk Ave
0422	3-2 Maples North-east corner of King Edward St and Burrows Ave
0423	3-3 Maples North of Burrows Avenue at Benbow Road
0424	3-4 Maples North-east corner of Garton Avenue and Belton Street
0425	3-5 Riverbend North-west of Red River Boulevard and Riverstone Rd
0426	3-6 Maples North of Templeton Avenue and west of McPhillips St
0428	3-8 Maples East of Keewatin St and south of Adsum Dr
0429	3-9 Maples Foxwarren Drive west of Ritchie Street
0430	3-10 Amber Trails West of Amber Trail and Ambergate Dr.
0431	3-11 North Inkster Industrial East of Meridian Dr and Inksbrook Dr
0432	3-12 North Inkster Industrial East of Meridian Dr and north of Commercial Ave
0433	3-13 Amber Trails East of Strasbourg Dr and south of Thorn Dr
0434	3-14 Amber Trails West of Massalia Dr.
0442	4-2 East Kildonan Off Gateway Rd north of Springfield Rd (Bunn's Creek)
0443	4-3 Transcona Cordite Ditch
0444	4-4 Kilcona Park Northeast Park recreation area (Harbourview Complex)
0445	4-5 Transcona North-west corner of Devonshire Dr and Clouston Dr
0446	4-6 Transcona South-east of Devonshire Dr and Kildonan Meadow Dr
0447	4-7 Transcona Deep Pond south-west Ravelston Ave
0448	4-8 Kilcona Park Northeast corner of Lagimodiere Blvd and Springfield

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Facility Code	Facility
0449	4-9 Harbourview South South of McMahon Place off McLellan Drive
0450	4-10 East Kildonan North of Ragsdill between East Spring and West Spring
0451	4-11 Eaglemere South of Eaglemere Drive
0452	4-12 East Elmwood North-west of Lagimodiere Blvd and Callsbeck Ave
0454	4-14 Arrowwood South of Headmaster Row and west of Mitchelson Way
0455	4-15 Harbourview South East of Lagimodiere Blvd and north of Concordia Ave
0461	5-1 St Boniface Industrial West of Beghin Ave at Paquin Rd
0462	5-2 St Boniface Industrial East of Paquin Rd
0463	5-3 St Boniface Industrial South of Camiel Sys. St, east of Ray Marius Rd
0464	Waterside Estates West of Plessis south of Dugald
0465	5-5 Southdale North-east corner of Lakewood Blvd and Edgewater Dr
0466	5-6 Southdale West of Beaverhill Blvd and north of Edgewater Dr
0467	5-7 Southdale North-west corner of Lakewood Blvd and Beaverhill Blvd
0468	5-8 Southdale South of Edgewater between Sweetwater and Beaverhill
0469	5-9 Southdale East corner of Shamrock Dr and Newcroft Rd
0470	5-10 Southdale South of Willowlake Cr at Willow Point Rd
0471	5-11 North St Vital North of Bishop Grandin at Kearney St
0472	5-12 North St Vital North of Bishop Grandin at Glen Meadow Street
0473	5-13 North St Vital North of Bishop Grandin at River Rd
0475	5-15 Island Lakes South of Island Shore Blvd
0476	5-16 St Vital South-west of Burland and Healy Cr
0477	5-17 St Vital South-east of Burland and Westbourne Cr
0478	5-18 St Vital East of Dakota St and south of John Forsythe Ave
0479	5-19 Island Lakes South of Island Lakes Drive
0480	5-20 Island Lakes Northwest of Island Lakes Dr of Blvd de la seigneurie
0481	5-21 Southland Park East and North of Royal Mint Dr
0482	5-22 Royalwood South-west corner of Shorehill Drive and Aubin Drive
0483	5-23 South Transcona North-west of St. Boniface Rd and Murdock Rd
0484	5-24 Royalwood Along Westwater Dr
0485	5-25 Royalwood East of Shorehill Dr and Bridgetown Dr
0488	5-28 Sage Creek North of Warde east of Lagimodiere
0489	5-29 Sage Creek West of Des Hivernants Blvd. north of Woodsage Cr.
0490	5-30 Sage Creek North of Tallgrss Cres. east of Des Hivernants Blvd.
0491	5-31 Sage Creek East of hydro ROW , north of Red Lily Rd. South of Blue Sun Dr.
0492	5-32 Sage Creek North of Warde, west of Blue Sun Dr. and east of Red Lily Rd.
0493	5-33 Sage Creek East of Lagimodier Blvd. west of Burning Glass Rd.

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Facility Code	Facility
0494	5-34 Sage Creek North of David Friesen Rd.between Des Hivernants Blvd and Burning Glass Rd.
0495	5-35 Sage Creek East of Des Hivernants Blvd and west of Hydro ROW
0496	Sage Creek Lake 9- West of Wild Iris Wk & North of Prarie Smoke Dr.
0497	Sage Creek Lake 10- East of Wild Iris Wk & South of Vireo Ln.
0498	Sage Creek Lake 12-South of Warde Av. & East of Robert Bockstael Dr.
0511	6-1 Assiniboine Forest Assiniboine Forest Grant and Chalfont
0514	6-4 West Fort Garry Business Lot 16 Drain west of Waverley
0515	6-5 Fort Garry Industrial Ditch along Bishop Grandin
0516	6-6 Waverley Heights North of Chancellor between Swan Lake and Lake Grove
0517	6-7 Waverley Heights Along Lake Lindero Rd
0518	6-8 Waverley Heights South of Markham Rd at Forest Lake Dr
0519	6-9 Waverley Heights North of Markham Rd west of Forest Lake Dr
0520	6-10 Fort Richmond North of Dalhousie Dr and east of Pembina Hwy
0521	6-11 Fort Richmond South of Dalhousie Dr and east of Pembina Hwy
0522	6-12 St Norbert North of Grandmont Blvd and west of Nolin Ave
0523	6-13 St Norbert South of Grandmont Blvd and west of Delorme Bay
0524	6-14 West Fort Garry Business East of Kenaston Blvd and south of Scurfield Blvd
0525	6-15 Lindenwoods West of Shorecrest Dr
0526	6-16 Richmond WestPoint West Dr
0527	6-17 Whyte Ridge South-west of Scurfield Blvd and Columbia Dr
0528	6-18 Lindenwoods North of Shoreline Dr and south of Queens Park Cr
0529	6-19 Tuxedo West South of West Taylor Dr and west of Dumbarton Blvd
0530	6-20 Whyte Ridge West of Scurfield Dr and south of Vanderbilt Dr
0531	6-21 St Norbert South of Bellemer Dr (Grandmont Park)
0532	6-22 Lindenwoods North of Wilkes Ave and west of Waverly St
0533	6-23 Tuxedo Industrial West of Kenaston Blvd
0534	6-24 Lindenwoods East of Lindenwoods Drive W
0535	6-25 Linden Ridge East of Dovercourt Drive
0539	6-29 Fairfield Park South of Lee Blvd and west of Raphael St
0542	6-32 Waverley West (South Pointe) WW Lake #1, west of Autumn View and east of Cypress Ridge Rd
0543	6-33 Waverley West (South Pointe) WW Lake #2, west of York Valley & north of Kirkbridge Dr.
0544	6-34 Waverley West (South Pointe) WW Lake #3, south of Kirkbridge Dr and west of Waterstone

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Facility Code	Facility
0545	6-35 Waverley West (South Pointe) WW Lake #4, south of Northern Lights Dr & north of Turnstone
0546	6-36 Waverley West (Bridgewater Forerst) WW Lake #1, south of Bridgeland Dr and east of Prominence Pt
0547	6-37 Waverley West (Bridgewater Forerst) WW Lake #2, west of Highland Creek Rd and north of Hunterbrook Rd
0548	6-38 Waverley West (Bridgewater Forerst) WW Lake #3, west of Park Valley Rd and south of North Town Rd
0550	6-40 Waverley West (South Pointe) WW Lake #5, west of Waverly & east of Stan Baile Dr.
0551	Bridewood Estates East of Edward Schreyer opposite Condordia

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Facility Code	Facility
0600 - 0799	Water System Facilities
0600	Shoal Lake Intake Facility
0601	Water Treatment Plant
0620	DISCONTINUED (was Deacon Booster Pumping Station, now part of the Water Treatment Plant)
0630	MacLean Water Pumping Station
0640	McPhillips Water Pumping Station, Control Centre, and Collections Building
0650	Hurst Water Pumping Station
0660	Taché Booster Pumping Station
0701	General Shoal Lake Aqueduct & GWWD
0702	St. Boniface Shops
0703	M17.05 Boathouse
0704	M22.53 RTU
0705	M29.76 RTU
0706	M34.40 RTU
0707	Ross (Yard and Backbone Repeater)
0708	M39.39 Boathouse
0709	M42.05 Boathouse
0710	M56.71 RTU
0711	Hadashville (Yard and Backbone Repeater)
0712	M64.08 Boathouse
0713	M69.51 RTU
0714	M73.63 Boathouse
0715	M77.63 Boathouse
0716	East Braintree
0717	M82.06 Boathouse
0718	M82.44 Backbone Repeater
0719	M83.02 Boathouse
0720	M88.64 RTU
0721	M93.69 RTU
0722	M96.69 Boathouse
0751	Branch 1 Aqueduct
0752	Branch 2 Aqueduct

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Facility Code	Facility
0801	Standpipe Water Service – 1539 Waverly Street
0802	Standpipe Water Service – Portage Avenue at Perimeter Highway (McCarthy St. and Oxbow Bend Rd.)
0812	Pressure Monitoring Location – Gateway Rd and Springfield Rd
0814	Pressure Monitoring Location – Inkster Blvd and Brookside Blvd
0816	Pressure Monitoring Location – John Black Ave and Main St
0818	Pressure Monitoring Location – Lagimodiere Blvd at Offtake to Smuggler’s Cove
0820	Pressure Monitoring Location – Paddington Rd and Charing Cross Cres
0822	Pressure Monitoring Location – Pembina Hwy and Chancellor Matheson Rd
0824	Pressure Monitoring Location – Plessis Rd and Devonshire Dr
0826	Pressure Monitoring Location – Redonda St and Kildare Ave
0828	Pressure Monitoring Location – Redonda St and Kildare Ave
0830	Pressure Monitoring Location – Rue Des Trappistes and Villeneuve Blvd
0832	Pressure Monitoring Location – Sargent Ave and St. James St
0900 - 0999	Unused - Future

Appendix B Facility Process Area Codes

Process Area Codes – Shoal Lake Intake Facility

Process Area	Description
A	General or process area is not applicable
C	Chlorine Area
D	Dechlorination Building
E	Engine Shed
H	Electrical Shed
G	Gatehouse
P	Pumphouse (including Electrical & Control Room)
R	Residences
S	Staff Houses

Process Area Codes – Shoal Lake Aqueduct

Process Area	Description
A	Aqueduct and Related Small Facilities including Boathouses and RTU Sites
R	GWWD Railway

Process Area Codes – Water Treatment Plant

Process Area	Description
A	Administration
B	Main Treatment Plant Building
C	Chemical Feed Systems (Polymer, SBS, Hydrogen Peroxide)
D	Deacon Booster Pumping Station (includes Ultraviolet Light Disinfection)
E	Electrical Substation
F	Filtration
G	Standby Power Generation
H	Plant Utilities
I	Inlet Works and Raw Water Pumping
J	Hypochlorite Generation and Feed Building
K	Enclosed Bridge
L	Dewatering Cells (Freeze Thaw Pond) / Forcemain
M	General Plant Services / Miscellaneous (incl. Fire Pump Room and Electrical Room)
N	Aqueduct Bridges
O	Ozone
P	Flocculation and DAF
R	Residuals Handling
S	Bulk Chemical Storage and Feed Building
T	Treatment Water Storage (Clearwell)
U	<i>Future</i>
V	Civil Maintenance and Aqueduct Storage Building
W	<i>Future</i>
X	Pilot Plant
Y	Yard Piping and Valve Chamber
Z	Deacon Chemical Feed Building

Note: The current application of process areas does not meet the intent of this standard, in that it is not based upon a physical location. For example, the H process area is for all plant utilities across the entire building.

Process Area Codes – Regional Water Pumping Stations

Process Area	Description
A	General or process area is not applicable
B	Collections Building (McPhillips only)
C	Chlorine Building / Area
M	Main Pumping Station Building
R	Reservoir
S	Control Centre Building (McPhillips Only)
Y	Yard Piping and Valve Chambers

Process Area Codes – Wastewater Collections

Process Area	Description
A	General or process area is not applicable
F	Flood Pumping Stations
L	Wastewater Lift Stations
S	Sewer

Process Area Codes – Land Drainage

Process Area	Description
A	General or process area is not applicable
B	Storm Retention Basin (SRB)
L	Pumping Station
U	Underpass Pumping Station
W	Deep Well Pump

Process Area Codes – NEWPCC

Process Area	Description
A	General or process area is not applicable
B	Boilers
C	Centrate Treatment
D	Digesters
F	Phosphorous Removal Facility
G	Pre-Aeration and Grit Removal
H	<i>HOLD – Potentially reserve for Headworks process area. Decision to be made under the sewage treatment upgrade program.</i>
M	Main Building
P	Primary Clarifiers
R	Oxygen Reactors
S	Secondary Clarifiers
U	UV Disinfection Facility
W	Sludge Dewatering
X	Leachate Receiving Facility
Y	Hauled Wastewater Receiving Facility

Process Area Codes – SEWPCC

Process Area	Description
A	General or process area is not applicable
B	Service Building, Boilers, Chemical Storage Building
G	Pump & Screen Building, Grit Building, Standby Generator Building
H	<i>HOLD – Potentially reserve for Headworks process area. Decision to be made under the sewage treatment upgrade program.</i>
M	Administration Building and Septage Facility
P	Primary Clarifiers
R	Oxygen Reactors
S	Secondary Clarifiers
U	UV Disinfection Facility (See Note 1)
Y	<i>HOLD – Possible use for Yard. Decision to be made under the sewage treatment upgrade program.</i>
Z	UV Disinfection Facility (Historical, See Note 1)

Notes:

1. *Most of the existing equipment within the SEWPCC UV Disinfection facility is identified with the Z process area. It is desired that all new work and modifications in this facility utilize the U process letter.*

Process Area Codes – WEWPCC

Process Area	Description
A	General or process area is not applicable
F	Primary Sludge Fermenters
H	Headworks
L	General and Site Works
M	Perimeter Road Pumping Station
P	Primary Clarifiers
S	Secondary Clarifiers and BioReactors
T	DAF (Dissolved Air Flotation) Thickeners
U	Utility Building HOLD – Possible re-allocation for future UV Disinfection
V	HOLD – Possible re-allocation as the Utility Building. (See Note 1)
Y	<i>HOLD – Possible use for Yard. Decision to be made under the sewage treatment upgrade program.</i>

Notes:

1. *Some equipment in the WEWPCC Utility Building has already been re-identified as V.*

Process Area Codes – Solid Waste

Process Area	Description
A	General or process area is not applicable
B	Biosolids and LYW Composting

Appendix C Master Equipment Functional Designations

Functional Designation	Description	Type	Notes
AD	Air Dryer	Mechanical	
ACP	Access Control Panel	Security	
ADP	Automation Device Panel	Automation	
AF	Aeration Fan	Mechanical	
AG	Agitator	Mechanical	
AHU	Air Handling Unit	Mechanical	Includes Make-Up Air Units
ANT	Antenna	Communication	
ATS	Automatic Transfer Switch	Electrical	
B	Blower	Mechanical	
BAT	Battery	Electrical	
BC	Battery Charger	Electrical	
BD	Balance Damper	Mechanical	See Section 4.3.
BFP	Back Flow Preventer	Mechanical	
BLR	Boiler	Mechanical	
BS	Bar Screen	Mechanical	
BUS	Busway	Electrical	
C	Cable (Power)	Electrical	
CA	Cable (Automation)	Automation	
CAL	Calibration Column	Mechanical	
CAP	Capacitor	Electrical	Typically individual unit. See PFC.
CB	Circuit Breaker	Electrical	Includes air, vacuum, SF6, and moulded case circuit breakers
CBUS	Cable Bus	Electrical	
CC	Cooling Coil	Mechanical	
CDR	Condensor	Mechanical	
CE	Centrifuge	Mechanical	
CHLR	Chiller	Mechanical	
CM	Clarifier Mechanism	Mechanical	
CMP	Compressor	Mechanical	
CN	Network Cable	Communication	
CNV	Conveyor	Mechanical	Includes skimmers
CON	Contacto	Electrical	
CP	Control Panel	Electrical	
CP	Control Panel	Automation	

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Functional Designation	Description	Type	Notes
CPR	Cathodic Protection Rectifier	Electrical	
CRN	Crane	Mechanical	
CS	Computer Server	Automation	
CSTE	Customer Service Termination Equipment	Electrical	
CT	Cooling Tower	Mechanical	
CU	Condensing Unit	Mechanical	
CV	Check Valve	Mechanical	
CW	Computer Workstation - General	Automation	
CWD	Computer Workstation - Development	Automation	
CWO	Computer Workstation - Operator	Automation	
DCS	Distributed Control System	Automation	
DP	Distribution Panel	Electrical	
DS	Disconnect Switch (non-fusible)	Electrical	
EF	Exhaust Fan	Mechanical	
ELB	Emergency Lighting Battery Pack	Electrical	May have integrated lights.
F	Fan - General	Mechanical	
FA	Flame Arrestor	Mechanical	
FAAP	Fire Alarm Annunciator Panel	Electrical	
FACP	Fire Alarm Control Panel	Electrical	
FAS	Fire Alarm System	Electrical	
FC	Fan Coil	Mechanical	
FD	Fire Damper	Mechanical	Utilize same equipment number as air handler.
FDP	Field Device Panel	Automation	
FDR	Feeder	Mechanical	Examples: screw feeder, chlorinator, glycol make-up unit
FDS	Fusible Disconnect Switch	Electrical	
FEX	Fire Extinguisher	Mechanical	
FG	Flap Gate	Mechanical	
FIL	Filter	Mechanical	
FU	Fuse	Electrical	
GDC	Gas Detection Controller	Automation	
GEN	Generator	Electrical	

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Functional Designation	Description	Type	Notes
GR	Grille – General	Mechanical	See Section 4.3.
GRD	Grille – Diffuser	Mechanical	See Section 4.3.
HC	Heating Coil	Mechanical	
HCC	Heater Coil Controller	Electrical	Includes SCR and contactor based controllers.
HCE	Heating Coil, Electric	Mechanical	Duct based
HE	Heat Exchanger	Mechanical	
HF	Harmonic Filter	Electrical	
HMI	Standalone Human Machine Interface (HMI) Terminal	Automation	
HO	Hoist	Mechanical	
HOP	Hopper	Mechanical	
HP	Heat Pump	Mechanical	
HRC	Heat Recovery Coil	Mechanical	
HTR	Heater	Mechanical	General heaters, radiant, convectors, etc.
HUM	Humidifier	Mechanical	
HV	Hand/Manual Valve	Mechanical	See Section 5.2
INJ	Injector	Mechanical	
JB	Junction Box	Electrical	
JBA	Junction Box (Automation)	Automation	
JBN	Junction Box - Network	Communication	
K	Interlocking Key (Kirk Key)	Electrical	
LC	Lighting Contactor	Electrical	
LCP	Local Control Panel	Automation	
LDB	Load Bank	Electrical	
MCC	Motor Control Centre	Electrical	
MCP	Motor Circuit Protector	Electrical	
MCS	Moulded Case Switch	Electrical	
MDM	Modem	Communication	
MMS	Manual Motor Starter	Electrical	
MS	Motor Starter	Electrical	
MSP	Motor Starter Panel	Electrical	
MTR	Motor	Electrical	
MTS	Manual Transfer Switch	Electrical	
MXR	Mixer	Mechanical	
NAP	Network Access Point (Wireless)	Communication	
NFW	Network Firewall	Communication	

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Functional Designation	Description	Type	Notes
NGR	Neutral Grounding Resistor	Electrical	
NGW	Network Gateway	Communication	
NJ	Network Jack	Communication	
NJT	Network Jack - Telephone	Communication	
NMC	Network Media Converter	Communication	
NP	Networking Panel	Communication	
NRA	Network Radio	Communication	
NRT	Network Router	Communication	
NSW	Network Switch, Ethernet	Communication	
OD	Overhead Door	Mechanical	
P	Pump	Mechanical	
PB	Pull Box	Electrical	
PFC	Power Factor Correction Unit	Electrical	Bank of capacitors. May contain reactors.
PLC	Programmable Logic Controller	Automation	
PM	Power Meter	Electrical	
PNL	Panelboard	Electrical	
PRN	Printer	Automation	
PS	Power Supply	Electrical	24VDC power supply
PSP	Power Supply Panel	Electrical	Panel containing 24VDC power supplies, fire alarm booster power supply
R	Reactor (various processes)	Mechanical	
RCPT	Receptacle	Electrical	
RCTR	Reactor	Electrical	
RES	Reservoir	Mechanical	Large water containment structure.
RIO	Remote I/O	Automation	
RTU	Remote Terminal Unit	Automation	
S	Skid Package	Mechanical	
SA	Sampler	Mechanical	
SCBR	Scrubber	Mechanical	
SCP	Security Control Panel	Security	
SCR	Silicon Controlled Rectifier	Electrical	
SF	Supply Fan	Mechanical	
SGR	Switchgear	Electrical	
SL	Stop Logs	Mechanical	
SLG	Sluice Gate	Mechanical	

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Functional Designation	Description	Type	Notes
SPL	Splitter	Electrical	
SS	Soft Starter	Electrical	
STR	Strainer	Mechanical	See Section 5.2
SVM	Security Video Monitor	Security	
SVR	Security Video Recorder	Security	
SW	Switch	Electrical	
TBC	Travelling Bridge Collector	Mechanical	
TK	Tank	Mechanical	
TU	Terminal Unit	Mechanical	Includes CAV/VAV/Dual Duct boxes. Dampers to be identified as per Section 7.1 – Instrumentation.
TVSS	Transient Voltage Surge Suppressor	Electrical	
U	Miscellaneous Equipment Not In List	Mechanical	Example: Water Softener
UH	Unit Heater	Mechanical	
UPS	Uninterruptible Power Supply	Electrical	
UVR	Ultra-Violet (UV) Reactor	Mechanical	
V	Vessel, Pressure Vessel	Mechanical	e.g. air receiver, glycol expansion tank
VFD	Variable Frequency Drive	Electrical	
W	Weir	Mechanical	
WGB	Waste Gas Burner	Mechanical	
XFMR	Transformer	Electrical	

Appendix D Equipment Number Ranges

Equipment Number Ranges – Shoal Lake Intake Facility

Process Area	Range	Description
All Process Areas	001 - 049	Major Pumping
	050 - 099	Future
	100 – 499	Process Equipment
	500 – 599	Misc Building Equipment – Air Compressors, Sump Pumps, etc.
	600 - 699	HVAC Equipment
	700 - 799	Electrical Equipment
	800 – 899	Automation Equipment
	900 – 999	Misc, including communication and security

Equipment Number Ranges – Shoal Lake Aqueduct

Process Area	Range	Description
All Process Areas	TBD	Needs to be developed.

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Equipment Number Ranges – Water Treatment Plant

Process Area	Range	Description
C – Chemical Feed	001 - 099	Process – Polymer
	100 – 899	Process – Future
	700-799	Electrical Equipment
	800 – 999	Chemical Systems
	900 – 949	Chemical Systems – Hydrogen Peroxide
	950 – 979	Chemical Systems – Sodium Bisulphite
D - Deacon Booster Pumping Station	001 - 049	Major Pumping
	050 - 099	Future
	100 - 499	Process Equipment
	500 – 599	Misc Building Equipment – Air Compressors, Sump Pumps, etc.
	600 – 699	HVAC
	700-799	Electrical Equipment
	800-899	Automation Equipment
	900 – 999	Misc, including communication and security
F - Filtration	001 – 999	Process
H – Plant Utilities	001 - 099	HVAC
	100 - 199	Fire Pumps
	200 - 299	Auxiliary Building HVAC
	300 - 399	Building Safety and Security
	400 - 499	Process Pumps
	500 - 599	Sanitary Sumps
	600 - 699	Electrical Distribution
	700 - 799	Potable Water
	800 - 899	Unallocated
	900 - 950	Emergency Generator
	951 - 999	Electrical Substation
I – Inlet and Raw Water	001 - 999	Process
J – On-Site Hypochlorite Generation	001 - 999	Process
L – Freeze Thaw Pond	001 - 999	Process
O - Ozone	001 - 999	Process
P – Flocculation and DAF	001 - 999	Process
R – Residuals Handling	001 - 999	Process
S – Bulk Chemical Storage	001 - 999	Process
T – Treated Water Storage and Handling (Clearwell)	001 - 999	Process
U – Ultraviolet Light Disinfection	001 - 999	Process

Process Area	Range	Description
Y – Yard Piping and Valve Chambers	001 - 099	Surge Towers
	100 - 199	Yard Piping
	200 - 299	Yard Lighting
Z – Deacon Chemical Feed Building	001 – 099	Process Equipment
	100 - 199	Chemical Systems – Hydrofluosilicic Acid
	200 - 299	Chemical Systems – Phosphoric Acid
	300 - 499	Process Equipment
	500 - 599	Misc Building Equipment – Air Compressors, Sump Pumps, etc.
	600 - 699	HVAC
	700 - 799	Electrical Equipment
	800 - 899	Automation Equipment
	900 - 999	Misc, including communication and security

Note: The above WTP process ranges are largely based upon existing designations. In the event of future significant upgrades, some realignment may be required to fully align with this standard.

Equipment Number Ranges – Regional Water Pumping Stations

Process Area	Range	Description
All Process Areas	001 - 049	Major Pumping
	050 - 099	Future
	100 – 499	Process Equipment
	500 – 599	Misc Building Equipment – Air Compressors, Sump Pumps, etc.
	600 - 699	HVAC Equipment
	700 - 799	Electrical Equipment
	800 – 899	Automation Equipment
	900 – 999	Misc, including communication and security

Equipment Number Ranges – Collections Facilities

Process Area	Range	Description
L – Wastewater Lift Stations or F – Flood Pumping Station or U – Underpass Pumping Station	01 – 49	Reserved for Process Equipment
	01 - 09	Pumps
	10 – 19	Wet Well / Intake Equipment
	20 - 39	Misc Process
	40 - 49	Discharge / Forcemain
	50 - 59	Misc Building Equipment – Air Compressors, Backflow Preventer, etc.
	60 - 69	HVAC Equipment
	70 - 79	Electrical Equipment
	80 – 89	Automation Equipment
	90 - 99	Misc, including communication and security
S – Sewer	01 – 79	Sewer – Misc.
	80 - 89	Sewer – Before Outfall
	90 - 99	Sewer - Outfall

Note: The Collections facilities utilize two digit equipment numbers due to the limited amount of equipment located within each facility. Instrumentation loop numbers within Collections facilities have three digits.

Equipment Number Ranges – Wastewater Treatment Facilities

Process Area	Range	Description
All Process Areas	001 - 099	Major Process Equipment
	100 – 499	Process Equipment
	500 – 599	Misc Building Equipment – Air Compressors, Backflow Preventer, etc.
	600 - 699	HVAC Equipment
	700 - 799	Electrical Equipment
	800 – 899	Automation Equipment
	900 – 999	Misc, including communication and security

Appendix E Sample Drawings

The following process and instrumentation diagram drawings were created as sample drawings.

South End Water Pollution Control Centre

City Drawing Number	Sheet	Rev	Project / Area	TITLE
1-0102A-SK01	001	00		PROCESS & INSTRUMENTATION DIAGRAM, LEGEND AND DETAILS
1-0102A-SK01	002	00		PROCESS & INSTRUMENTATION DIAGRAM, LEGEND AND DETAILS
1-0102A-SK01	003	00		PROCESS & INSTRUMENTATION DIAGRAM, LEGEND AND DETAILS
1-0102S-SK02	001	00	SECONDARY CLARIFIERS	PROCESS & INSTRUMENTATION DIAGRAM, CLARIFIER 1, PROPOSED IDENTIFICATION
1-0102S-SK03	001	00	SECONDARY CLARIFIERS	PROCESS & INSTRUMENTATION DIAGRAM, CLARIFIER 2, PROPOSED IDENTIFICATION
1-0102S-SK04	001	00	SECONDARY CLARIFIERS	PROCESS & INSTRUMENTATION DIAGRAM, CLARIFIER 3, PROPOSED IDENTIFICATION
1-0102S-SK05	001	00	SECONDARY CLARIFIERS	PROCESS & INSTRUMENTATION DIAGRAM, SECONDARY CLARIFIER EFFLUENT & SAMPLE SYSTEM, PROPOSED IDENTIFICATION
1-0102S-SK06	001	00	SECONDARY CLARIFIERS	PROCESS & INSTRUMENTATION DIAGRAM, RETRUN ACTIVATED SLUDGE PUMP P-S101, PROPOSED IDENTIFICATION
1-0102S-SK07	001	00	SECONDARY CLARIFIERS	PROCESS & INSTRUMENTATION DIAGRAM, REPURN ACTIVATED SLUDGE PUMPS P-S102 & P-S103, PROPOSED IDENTIFICATION
1-0102S-SK08	001	00	SECONDARY CLARIFIERS	PROCESS & INSTRUMENTATION DIAGRAM, REPURN ACTIVATED SLUDGE PUMPS P-S108 & P-S109, PROPOSED IDENTIFICATION
1-0102S-SK09	001	00	SECONDARY CLARIFIERS	PROCESS & INSTRUMENTATION DIAGRAM, RAS HEADER, PROPOSED IDENTIFICATION
1-0102S-SK10	001	00	SECONDARY CLARIFIERS	PROCESS & INSTRUMENTATION DIAGRAM, WASTE ACTIVATED SLUDGE PUMPS P-S202 & P-S203, PROPOSED IDENTIFICATION

Marion Wastewater Pumping Station

City Drawing Number	Sheet	Rev	Project / Area	TITLE
1-0159L-SK01	001	00		PROCESS & INSTRUMENTATION DIAGRAM, WASTEWATER PUMPING
1-0159L-SK02	001	00		PROCESS & INSTRUMENTATION DIAGRAM, VENTILATION

MacLean Water Pumping Station

City Drawing Number	Sheet	Rev	Project / Area	TITLE
1-0630A-SK01	001	00		PROCESS & INSTRUMENTATION DIAGRAM, LEGEND & DETAILS
1-0630A-SK01	002	00		PROCESS & INSTRUMENTATION DIAGRAM, LEGEND & DETAILS
1-0630A-SK01	003	00		PROCESS & INSTRUMENTATION DIAGRAM, LEGEND & DETAILS
1-0630C-SK01	001	00		PROCESS & INSTRUMENTATION DIAGRAM, CHLORINE CYLINDER SHUTOFF VALVES
1-0630C-SK02	001	00		PROCESS & INSTRUMENTATION DIAGRAM, CHLORINATION

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City Drawing Number	Sheet	Rev	Project / Area	TITLE
				SYSTEM
1-0630M-SK02	001	00		PROCESS & INSTRUMENTATION DIAGRAM, SUCTION HEADER
1-0630M-SK03	001	00		PROCESS & INSTRUMENTATION DIAGRAM, PUMP P-M021
1-0630M-SK04	001	00		PROCESS & INSTRUMENTATION DIAGRAM, PUMP P-M022
1-0630M-SK05	001	00		PROCESS & INSTRUMENTATION DIAGRAM, PUMP P-M023
1-0630M-SK07	001	00		PROCESS & INSTRUMENTATION DIAGRAM, PUMP P-M025
1-0630M-SK08	001	00		PROCESS & INSTRUMENTATION DIAGRAM, PUMP P-M026
1-0630M-SK09	001	00		PROCESS & INSTRUMENTATION DIAGRAM, DISCHARGE HEADER
1-0630M-SK10	001	00		PROCESS & INSTRUMENTATION DIAGRAM, COMPRESSED AIR SYSTEM
1-0630M-SK11	001	00		PROCESS & INSTRUMENTATION DIAGRAM, GEN-M751 & GEN-M752
1-0630M-SK12	001	00		PROCESS & INSTRUMENTATION DIAGRAM, MISCELLANEOUS
1-0630R-SK01	001	00		PROCESS & INSTRUMENTATION DIAGRAM, RESERVOIR FILL VALVES
1-0630R-SK02	001	00		PROCESS & INSTRUMENTATION DIAGRAM, RESERVOIR CELLS
1-0630Y-SK01	001	00		PROCESS & INSTRUMENTATION DIAGRAM, DISCHARGE TO FEEDERMANS